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## ASX ANNOUNCEMENT

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27 September 2011

### **LINC ENERGY DISCOVERS SIGNIFICANT OIL SHALE DEPOSIT IN SOUTH AUSTRALIA'S ARCKARINGA BASIN**

- **Significant oil shale deposit approximately 124m thick (406 feet) was intersected at a depth of over 854m (2,801 feet) and covers an area of approximately 93.5km x 12.3km (1,150 km<sup>2</sup> or 284,000 acres).**
- **The most prospective black shale/siltstone within the deposit is around 70m (229 feet) thick (between 899-970m deep) with preliminary analysis indicating potential oil yields of 25 litres to 45 litres per tonne.**
- **Oil shale deposit was discovered within the Stuart Range Formation located in Linc Energy's Petroleum Exploration Licence (PEL) 122 in the Arckaringa Basin, South Australia.**
- **1,153 line kilometres (716 miles) of 2D seismic survey in the Arckaringa Basin has been completed and processing of data is already underway, with preliminary results indicating a substantial number of new and previously unknown target locations.**

Linc Energy Ltd (ASX:LNC) (OTCQX:LNGY) is pleased to announce the discovery of a significant oil shale deposit within the Stuart Range Formation located in Linc Energy's Petroleum Exploration Licence (PEL) 122 and projected to extend into the adjoining PEL 121 in the Arckaringa Basin in South Australia.

The oil shale deposit discovered occurs at depths of over 854m (2,801 feet) covering an area of approximately 93.5km x 12.3km (1,150 km<sup>2</sup> or 284,000 acres).

The oil shale deposit was intersected during the completion of the 'Arck 1' stratigraphic well drilled in PEL 122 as a part of Linc Energy's current South Australian exploration program. The deposit lies in an area proximate to Linc Energy's previously announced oil show at its 'Maglia 1' exploration well.

Rock-Evaluation Pyrolysis testing results on the Stuart Range Formation shales intersected during the drilling program indicate oil shale with potential oil yields of 25 litres to 45 litres of oil per tonne.

Shale oil (or kerogen oil) is an unconventional oil produced from oil shale. Modern technologies make it possible to process the shale oil underground (*in situ* processing),

extracting the oil via oil wells. The resulting oil can be used immediately as a fuel or as oil refinery feedstock.

### Technical information

Our current studies indicate that the Stuart Range Formation shale is expected to be in the oil generation window at depths over 700 metres. Linc Energy has identified a significant section of the Boorthanna Trough, approximately 93.5km long x 12.3km wide, where the Stuart Range Formation shale sits at depths within the oil generation window.

Key results from Linc Energy's exploration program within this area to date include:

- Well 'Arck 1', which identified Stuart Range Formation shale present from 854m to 978m (124m or 406 feet thick), has been fully PQ wireline cored and downhole logged with the standard suite of downhole tools plus acoustic scanner.
- The 'Arck 1' Stuart Range Formation has the most prospective sequence of black shale around 70m (229 feet) thick between 899-970m deep, from which 17 PQ core samples from 899.4m to 970.5m were taken and tested for oil shale appraisal.
- TOC (total organic carbon) contents average 5.4% for the upper sequence and 7.7% for the lower interval of the Stuart Range Formation, with individual samples of >10% TOC encountered (e.g. 10.44% TOC at 954.5m).
- Rock-Eval pyrolysis parameters S1+S2 hydrocarbon shows yield potential up to 25 litres oil per tonne for upper sequence (average 23mg/g) and 45 litres oil per tonne for lower interval (average 40mg/g).
- Additionally, Permian coal intersected during the drilling program appear to be hosting fluorescence source (oil) in cleat and natural fractures, similar to results obtained from Linc Energy's 'Maglia 1' well in the same region. The samples have been dispatched from the field and will be analysed for content and source indicators to obtain further information about the active hydrocarbon system in the area.

In total 24 core samples from the 'Arck 1' well were collected over the most prospective interval and sent to Intertek Geotech (Perth) for geochemical analyses (TOC, Rock Eval, maturity) (see *attached* reports). More detailed yield assessments and feasibility studies will be conducted as the exploration program progresses.

Following completion of the 'Arck 1' well, the drill rig was relocated to the 'Wirrangulla Hill 1' site, approximately 10 kilometres north of 'Arck 1'. (see *Figure 1 and Figure 2 below*). 'Wirrangulla Hill 1' was spudded in late August, with preliminary drilling encountering oil fluorescence in the upper geological sequences and Stuart Range Formation shale thickness similar to 'Arck 1'. Both well locations are within PEL122 and are situated in the southern Boorthanna Trough.

Linc Energy's Chief Executive Officer, Peter Bond, said, "At around 100 metres thick, an oil shale deposit of over 200 billion tonnes may be present".

"The presence of oil fluorescence in the upper sequences at Wirrangulla Hill 1 together with the evolving oil shale story showcases the depth of real energy potential that is sitting untapped within the Arckaringa Basin."

"It is a remarkable prospect that we have only just begun to properly explore. This exploration program and our recent success of discovering what appears to be a multibillion barrel unconventional oil shale play provides significant opportunities for Linc Energy and

the State of South Australia, but frankly it's just the beginning. It is also another example of the incredible depth and quality of the resource assets which Linc Energy holds", Bond said.

In other Linc Energy exploration activities in the Arckaringa Basin, Hunt rig 3 has completed drilling the 'Cootanoorina 2' well to a total depth of 1,420m and has encountered no significant hydrocarbons shows. This is the 3<sup>rd</sup> well of Linc Energy's current 10 well conventional oil & gas exploration program in the Arckaringa Basin. Earlier in the Quarter, Hunt rig 3 completed 'Haystack 1' well to 1056m total depth and the 'William Creek 1' well to 914m total depth. Other than trace gas, both were dry wells with tight formations throughout.

In addition, the 1,153 line kilometres (716 miles) Arckaringa Basin 2D seismic programme was completed in late August, well before the Company's deadline. The processing of data acquired is already underway, with preliminary results indicating a substantial number of new and previously unknown target locations. Finalisation of the technical seismic interpretation is expected to be completed during the 1st Quarter of 2012.

The three oil & gas exploration wells, and the two shale oil / stratigraphic wells, combined with Linc Energy's recently completed 2D Seismic program, add a great deal to the knowledge base and understanding of the Arckaringa Basin.

"With Linc Energy's current focus in South Australia on oil and gas exploration, this crucial seismic and drilling program provides the science behind an exploration platform to not only identify new oil and gas targets for the Company, but in the case of the Arckaringa Basin we are also piecing together the potential for a new hydrocarbon producing region. Excellent results are beginning to come in from the seismic interpretation and we are gaining a suite of new oil and gas targets as a result of this work," Peter Bond said.

Further definition of the Boorthanna Trough is now a key focus in South Australia for Linc Energy, which aims to utilise the current seismic data and drilling program to put together greater definition and detail on the Stuart Range Formation oil shale play.

For more information, visit [www.lincenergy.com](http://www.lincenergy.com) or contact our office on +61 7 3229 0800.



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**TABLE 1**

Linc Energy Arck 1 Stuart Range Formation Shale Oil Rock-Eval Pyrolysis Results Summary

Sample ID	Lower Depth (m)	Tmax	S1	S2	S3	S1+S2	TOC	HI	OI	Unit	
Sharc 024	891.0	435	0.04	1.23	0.33	1.27	1.32	93	25	Upper Black Shale Av TOC = 5.4% Potential oil yield = 25lt oil per tonne	
Sharc 025	894.0	428	0.06	2.19	0.55	2.25	1.68	130	33		
Sharc 026	899.4	429	0.27	16.76	0.31	17.03	4.99	336	6		
Sharc 027	906.7	431	1.02	41.81	0.37	42.83	8.31	503	4		
Sharc 028	912.5	429	0.38	23.26	0.28	23.64	5.14	453	5		
Sharc 047	916.7	434	0.21	12.26	0.21	12.47	3.85	318	5		
Sharc 029	919.1	431	0.32	15.86	0.29	16.18	4.41	360	7		
Sharc 030	923.8	430	0.67	29.91	0.26	30.58	5.96	502	4		
Sharc 031	927.9	429	0.53	20.73	0.22	21.26	4.94	420	4		
Sharc 032	931.6	432	0.44	22.22	0.35	22.66	5.44	408	6		
Sharc 033	935.9	431	0.64	29.97	0.30	30.61	6.75	444	4	Lower Black Shale Av TOC = 7.7% Potential oil yield = 45lt oil per tonne	
Sharc 034	941.6	436	0.54	26.81	0.26	27.35	5.47	490	5		
Sharc 035	954.5	431	1.68	61.22	0.46	62.90	10.44	586	4		
Sharc 036	955.5	426	1.84	52.98	0.46	54.82	9.80	541	5		
Sharc 037	958.1	436	1.29	43.79	0.74	45.08	7.07	619	10		
Sharc 038	961.8	431	0.78	34.01	0.42	34.79	7.00	486	6		
Sharc 039	965.2	437	1.10	42.84	0.22	43.94	7.30	587	3		
Sharc 040	967.3	437	0.49	28.96	0.17	29.45	5.30	546	3		
Sharc 041	970.5	438	0.47	23.82	0.76	24.29	4.46	534	17		
Sharc 042	974.2	436	0.04	0.63	0.15	0.67	1.00	63	15		
Sharc 043	976.7	435	0.04	0.69	0.15	0.73	0.68	101	22		
Sharc 046	980.0	427	0.02	0.31	0.10	0.33	0.62	50	16		
Sharc 044	984.2	nd	nd	nd	nd	nd	0.22	nd	nd		Floor
Sharc 045	993.6	nd	nd	nd	nd	nd	0.17	nd	nd		

**Table 1 Key:**

TMAX = maximum temperature S2 (°C)  
S1 = Volatile hydrocarbons (HC)(mg.g rock)  
S2 = Hydrocarbon generating potential (HC)(mg.g rock)  
S3 = Organic carbon dioxide (HC)(mg.g rock)  
S1+S2 = potential yield (mg.g rock)

TOC= total organic carbon (wt % of rock)  
HI = Hydrogen index; ratio of S2 to TOC in grams; a measure of thermal maturity  
OI = Oxygen index; ratio of S3 to TOC; a measure of thermal maturity and source quality  
Nd =no data

**Figure 1**

Linc Energy Arck 1 well Schematic Section through Arckaringa Basin.

Base Data acknowledgement: Primary Industries and Resources South Australia, 'Petroleum & Geothermal in South Australia; Arckaringa Basin.' Reference 203838\_025, [http://www.pir.sa.gov.au/\\_data/assets/pdf\\_file/0006/26907/prospectivity\\_arckaringa.pdf](http://www.pir.sa.gov.au/_data/assets/pdf_file/0006/26907/prospectivity_arckaringa.pdf)

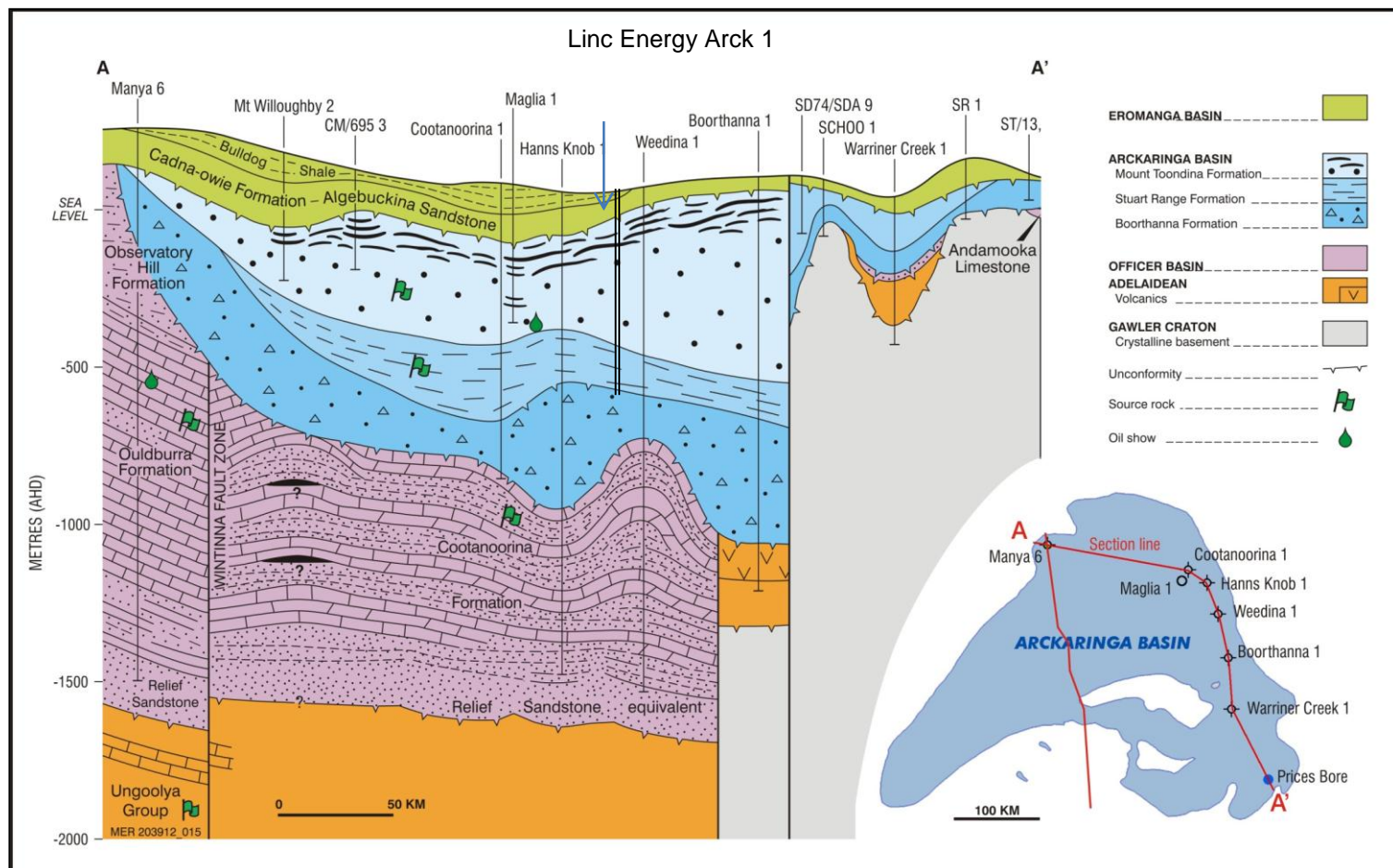
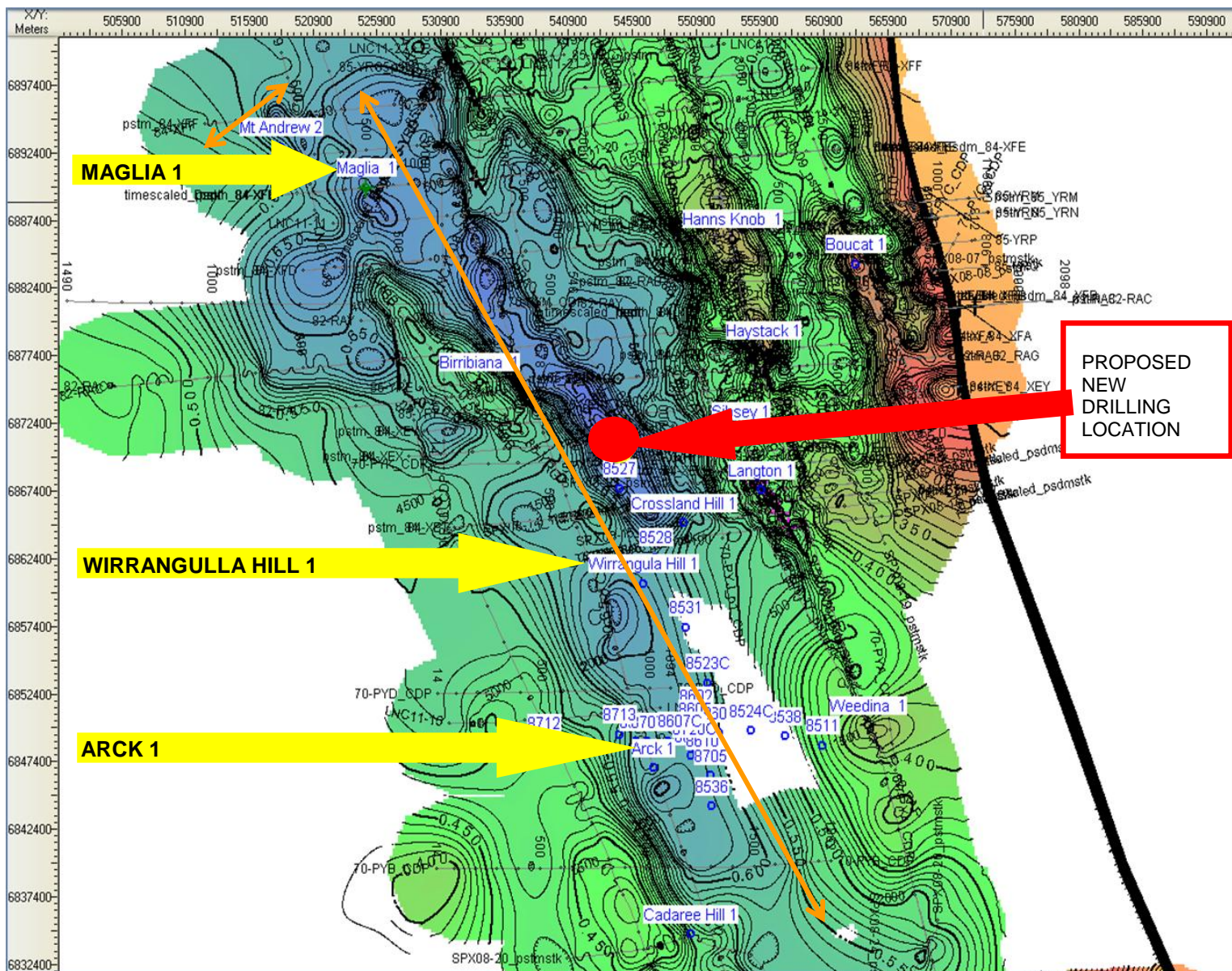


Figure 2

Central Boorthanna Trough, Base of Stuart range Formation (top Boorthanna Formation) Seismic 2 way time TWT contour (reference mean average sea level) and well locations. Potential new drilling location deeper on trough indicated. Linc Energy Arck 1 and Wirrangulla Hill 1 wells arrowed. Approximate area of frame 40km x 40km.



# LINC ENERGY'S TENEMENTS



South Australia

 OIL, GAS, COAL





**Above:** Linc Energy's Wirrangulla Hill 1 drill site on PEL 122, South Australia.



**Above:** Linc Energy's Haystack 1 drill site on PEL 121, South Australia.



## **Company Profile**

Linc Energy is a globally focused, diversified energy company with a strong portfolio of coal, oil and gas deposits. It is Linc Energy's purpose to unlock the value of its resources to produce energy to fuel the future.

A publicly listed company, Linc Energy is the global leader in Underground Coal Gasification (UCG), which delivers a synthesis gas feedstock to supply commercially viable energy solutions – such as electricity, transport fuels and oil production – through gas turbine combined cycle power generation, Gas to Liquids (GTL) Fischer-Tropsch processing and Enhanced Oil Recovery.

Linc Energy has constructed and commissioned the world's only UCG to GTL demonstration facility located in Queensland, Australia. This facility produces the world's only UCG to GTL synthetic diesel fuel. Linc Energy also owns the world's only commercial UCG operation, Yerostigaz, located in Uzbekistan. Yerostigaz has produced commercial UCG synthesis for power generation for 50 years.

Linc Energy is on a rapid global expansion path to commercialise its portfolio of resources, with established offices across three continents in the United States, the United Kingdom and Australia.

Linc Energy is listed on the Australian Securities Exchange (LNC) and can also be traded in the United States via the OTCQX (LNCGY).



# **Arckaringa Basin: Arck 1 source rock potential review**

Prepared for:



Prepared By:

J. Dixon

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## 1 INTRODUCTION

Linc Energy contracted AWT International (AWT) to carry out a preliminary scoping review of geochem results collected in the Arck 1 well recently drilled in the Arckaringa Basin. The scope of this review was to inform Linc Energy of the potential of the source rock intersected by the wellbore.

## 2 DATA SUPPLIED

Linc Energy supplied an Excel spreadsheet with the Geochem results carried out by Geotech. These results can be seen in Table 1 below. The data from this table was used to generate six charts from which indications for the source potential could be gained.



Upp Depth (m)	Low Depth (m)	Tmax	S1	S2	S3	S1+S2	S2/S3	PI	TOC	HI	OI
Sharc 024	891.0	435	0.04	1.23	0.33	1.27	3.73	0.03	1.32	93	25
Sharc 025	894.0	428	0.06	2.19	0.55	2.25	3.98	0.03	1.68	130	33
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Sharc 035	954.5	431	1.68	61.22	0.46	62.90	133.09	0.03	10.44	586	4
Sharc 036	955.5	426	1.84	52.98	0.46	54.82	115.17	0.03	9.80	541	5
Sharc 037	958.1	436	1.29	43.79	0.74	45.08	59.18	0.03	7.07	619	10
Sharc 038	961.8	431	0.78	34.01	0.42	34.79	80.98	0.02	7.00	486	6
Sharc 039	965.2	437	1.10	42.84	0.22	43.94	194.73	0.03	7.30	587	3
Sharc 040	967.3	437	0.49	28.96	0.17	29.45	170.35	0.02	5.30	546	3
Sharc 041	970.5	438	0.47	23.82	0.76	24.29	31.34	0.02	4.46	534	17
Sharc 042	974.2	436	0.04	0.63	0.15	0.67	4.20	0.06	1.00	63	15
Sharc 043	976.7	435	0.04	0.69	0.15	0.73	4.60	0.05	0.68	101	22
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Sharc 044	984.2	nd	nd	nd	nd	nd	nd	nd	0.22	nd	nd
Sharc 045	993.6	nd	nd	nd	nd	nd	nd	nd	0.17	nd	nd

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## 3 REVIEW

### 3.1 Maturity

The maturity of the samples provided was determined by plotting depth against Tmax and Depth against Production Index (PI). This indicated that all the samples were immature based on the depth Vs PI plot using common PI cut off limits (Figure 1). However, when the Tmax Vs Depth plot was used (Figure 2) the samples were immature to early oil generative in maturity. The chance that the samples are in the oil expulsion window is low at these sample depths.

### 3.2 Kerogen Type

The kerogen type was found by plotting the Tmax values against the Hydrogen Index (HI) values for the samples provided. Two distinct pods could be seen on the chart, with the predominant kerogen type falling into the Type II category. A group of five samples fell outside of the main cluster and look to be in the type III kerogen type (Figure 3).

### 3.3 Hydrocarbon Type

By plotting the Oxygen Index against the Hydrogen Index the samples analysed indicate that the source rock at the well location is oil prone (Figure 4). This is correlates well with the low level of maturity seen in Figures 1 & 2.

### 3.4 Yield

Indications for the potential yield of the samples is promising. Two plots were generated to review the potential yield for the samples provided. These plots are a linear plot of TOC against S2 (Figure 5), and a linear plot of TOC against a logarithmic plot of S2 (Figure 6). These plots also show two pods which correlate to a zone of negligible yield to poor to marginal yield, and a larger pod with very good to excellent yield characteristics. These can be seen to correlate to the lower TOC samples and the higher TOC samples.

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## 4 SUMMARY

From the data supplied by Linc Energy it can be seen that the formation has the potential to be a good source rock where it is mature.

- The high TOC values and high S2 values indicate that the potential yield from the source rock is very good to excellent. At depth with higher levels of maturity the source rock potential will increase.
- The majority of samples provided were immature to marginally oil mature. Further work with Vitrinite reflectance data (yet to be received by Linc Energy at the time of writing this) will provide further insight into the maturity level of the source rock at this location. Care must be taken to account for any possible suppression due to the oily nature of the samples.
- The generative potential of the source rock at the well location and low level of maturity is for oil.

Further work is required to provide the potential for Shale Oil. This is outlined in the Recommendations section.



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## 5 RECOMENDATIONS

Further work which could be carried out to provide a better understanding of the Shale oil potential of this formation include

- Coring the formation to determine the following attributes
  - Porosity
  - Permeability
  - Lithology
  - Desorption of gas
- Incorporating Vitrinite reflectance values into the study
- Incorporating cuttings descriptions to determine lithotype of the formation
- Mud logging the well to get an indication of gas readings and lithotypes across potential unconventional reservoirs.
- Incorporation of fluorescence shows with the data for indications of moveable oil.
- Building a burial depth plot to incorporate with the lithology, geochem and vitrinite data in a basin evaluation model. This will help identify areas of source maturity and yield of the source pod in turn high grading areas of greater potential.

6 FIGURES

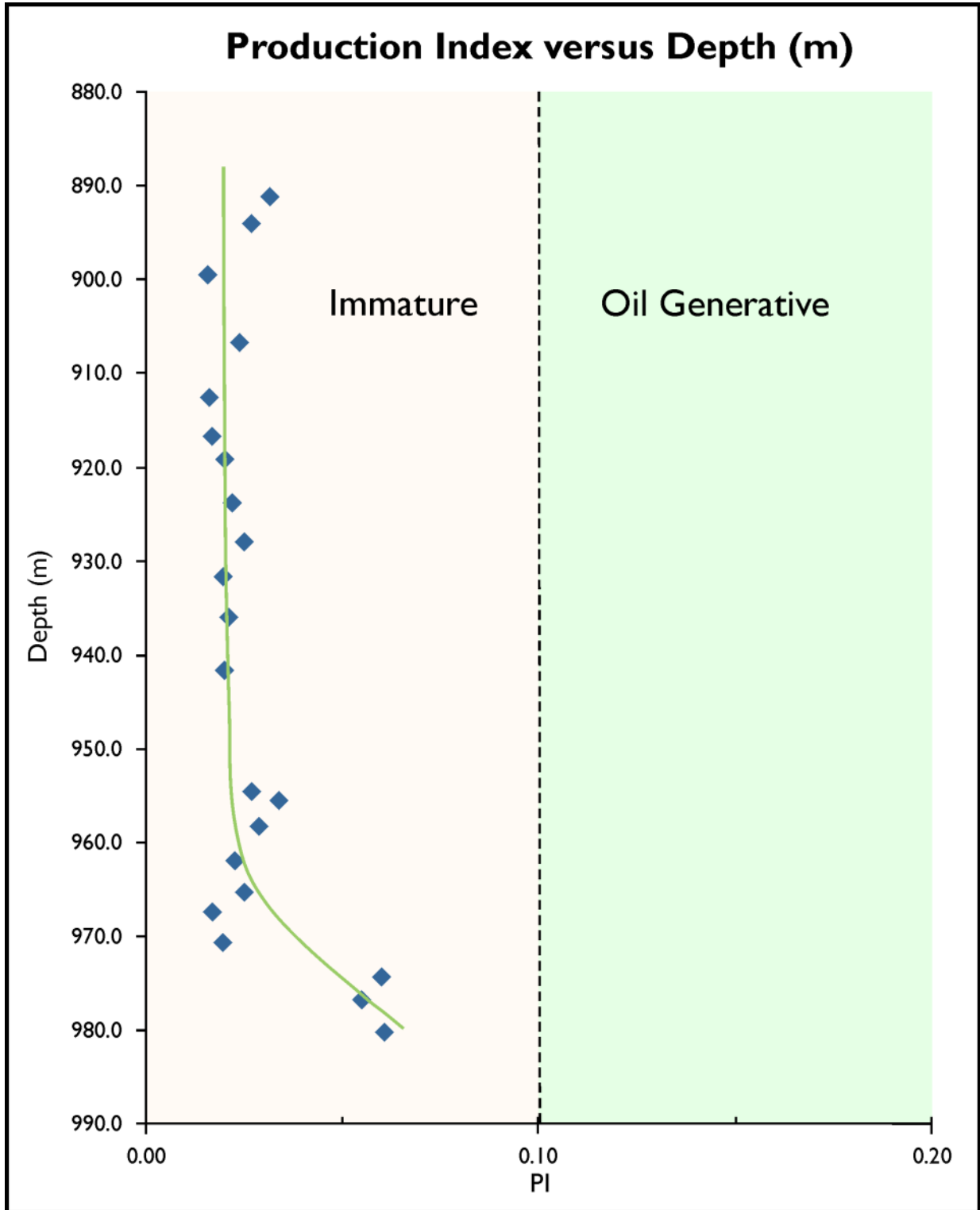


Figure 1 – Depth versus Production Index

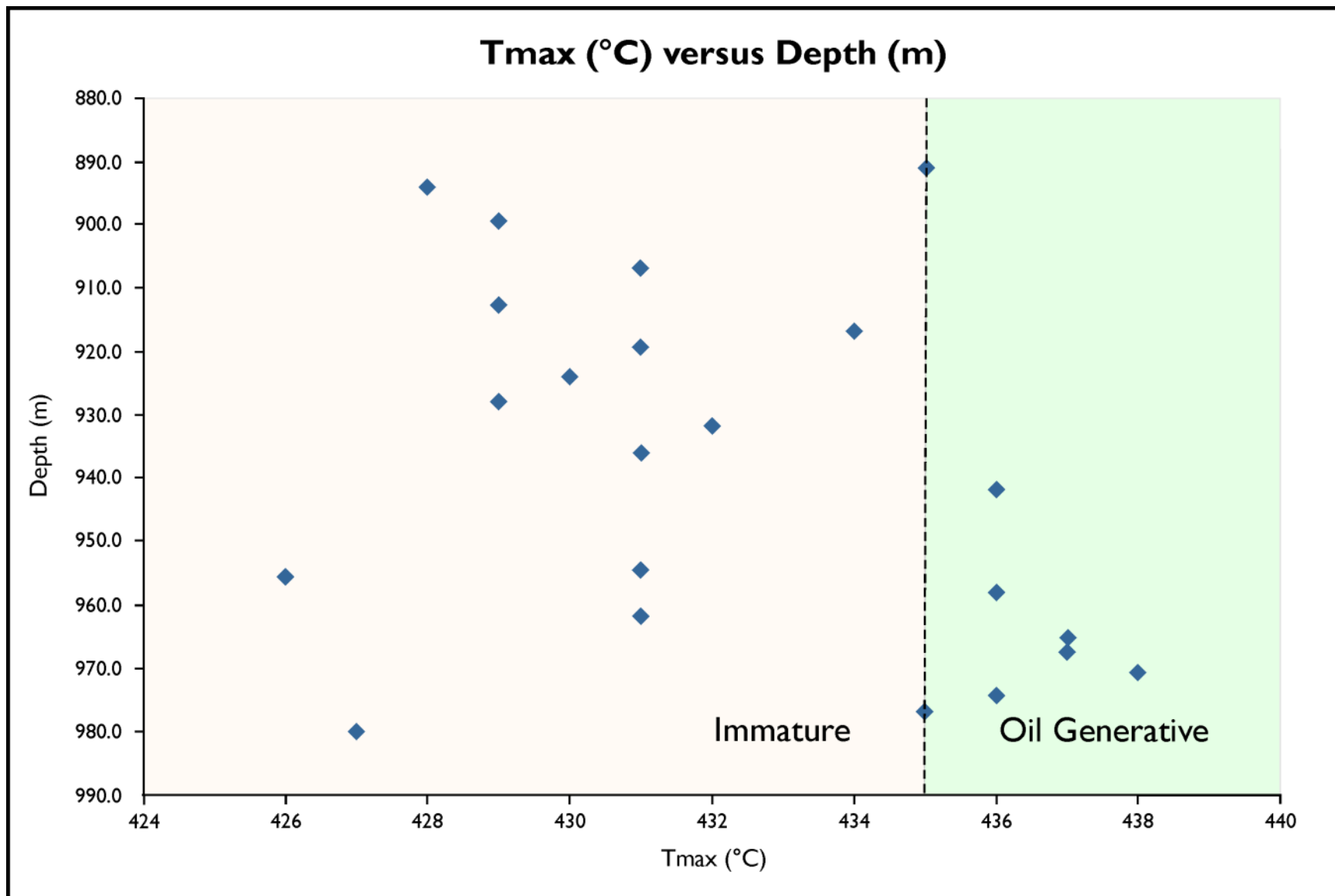


Figure 2 - Tmax (°C) vs. Depth (m)

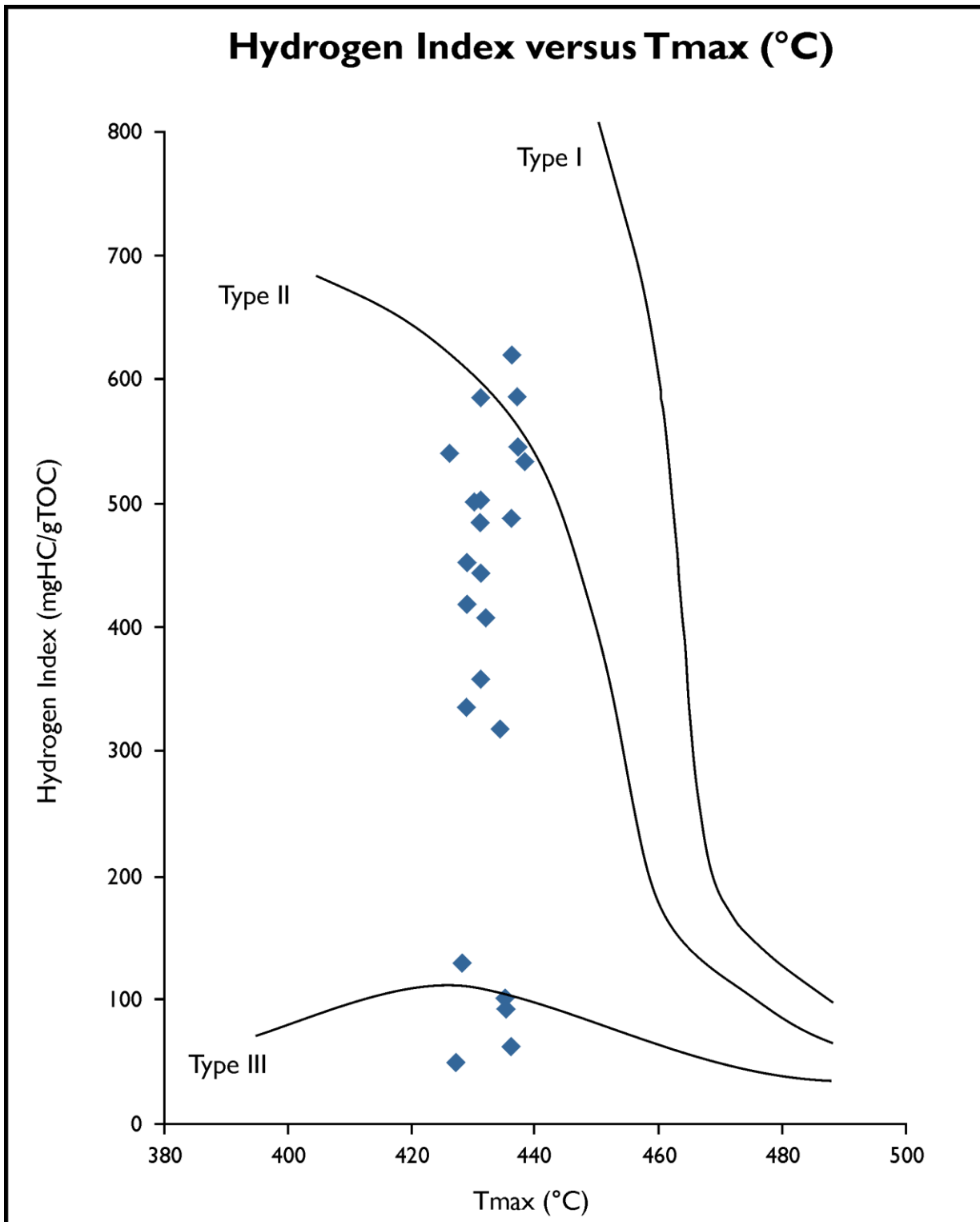


Figure 3 – Tmax vs. Hydrogen Index

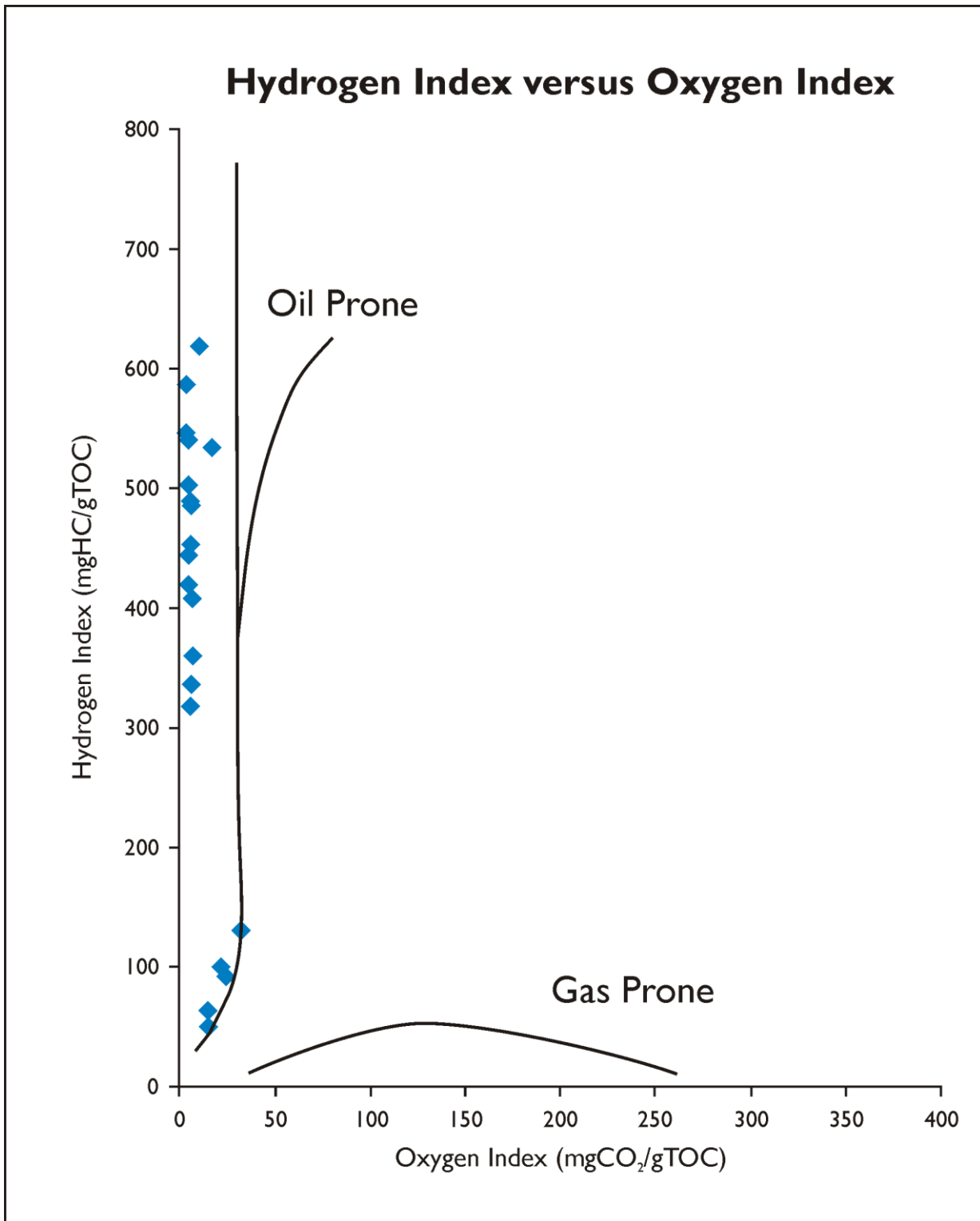


Figure 4 – Hydrogen Index vs. Oxygen Index

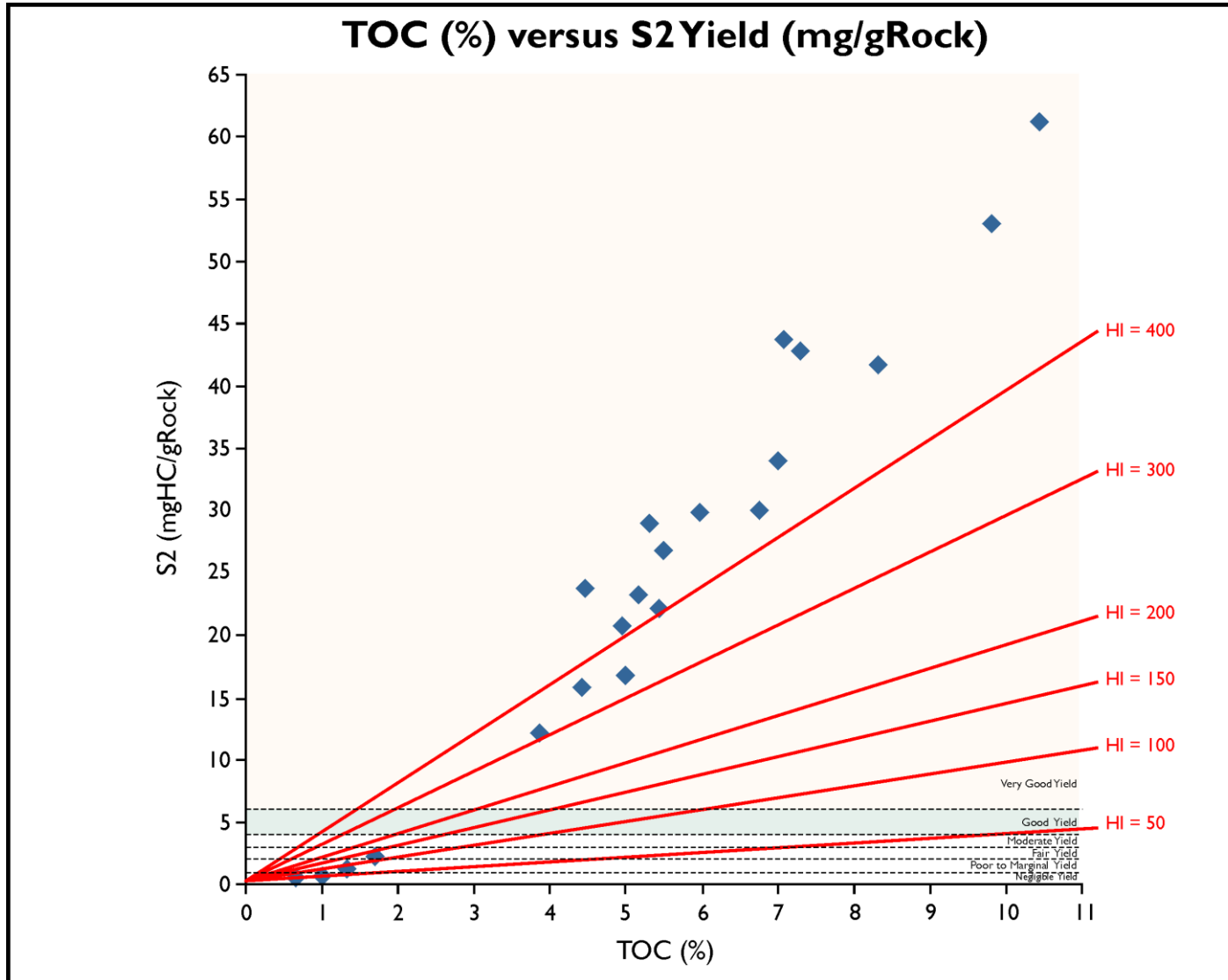


Figure 5 – TOC (%) vs. S2 (mgHC/gRock) Linear

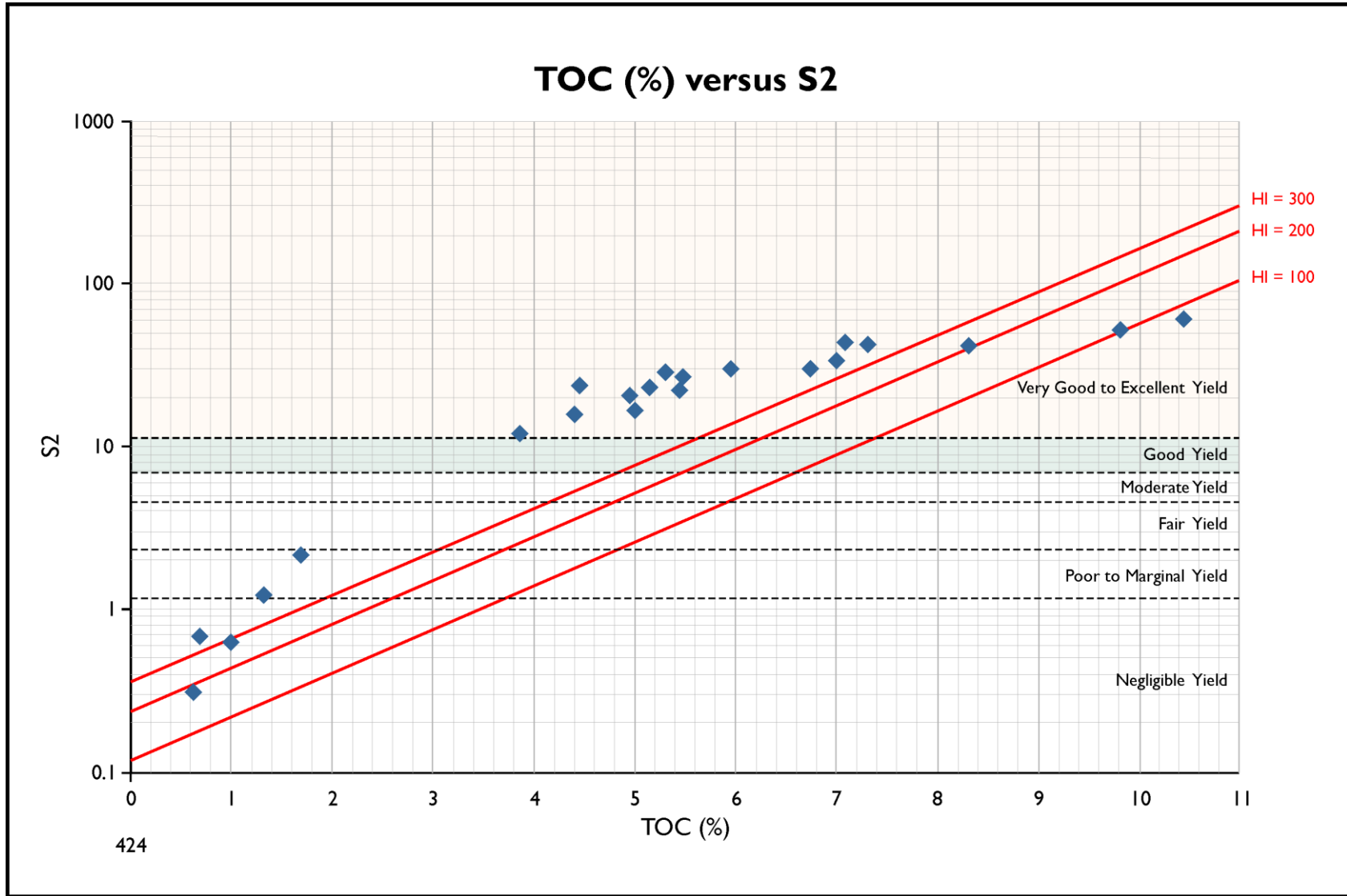


Figure 6 – TOC (%) vs. S2 (mgHC/gRock) Logarithmic

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## 7 GLOSSARY

HC - Hydrocarbons

HI - Hydrogen Index =  $S2/TOC \times 100$  (mg/g TOC)

OI - Oxygen Index =  $S3/TOC \times 100$  (mg/g TOC)

OM - Organic Matter

PI - Production Index =  $S1/(S2+S3)$  (also known as Transformation Ratio)

S1 - Free HCs already generated from the kerogen in nature

S2 - HC products generated from kerogen by pyrolysis (in the lab)

S3 - CO<sub>2</sub> produced by oxidation of OM (by oxygen liberated from kerogen)

Tmax - Temperature (°C) at S2 maximum (increases with maturity)

TOC - Total Organic Carbon



# HYDROCARBON CHARACTERISATION STUDY

ARCK-1

**PROFESSIONAL OPINION**

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September 2011



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## **EXECUTIVE SUMMARY**

A suite of twenty-four samples from Arck-1 was submitted by Linc Energy for geochemical analyses. A program was undertaken to evaluate the organic carbon content and source rock potential of the samples. This report provides an interpretation of the Rock Eval pyrolysis data obtained from analysis of the Arck-1 samples.

TOC contents range from a low of 1.32% at the top of the section up to around 10% in the deeper section, classifying source rock richness as excellent. Hydrogen Indices range from around 50 up to over 600, consistent with the bulk of the section having very good potential for liquids generation. Tmax values approaching 440°C in this interval are consistent with the onset of oil generation.

TOC contents and Rock Eval pyrolysis data indicate the very base of the section, below around 970m, is organically very lean and appears to be gas prone at best.

The organic matter in Arck-1 is comprised primarily of Type I/II kerogen, although the base of the section contains a higher proportion of humic kerogen.

**HYDROCARBON CHARACTERISATION STUDY**  
**ARCK-1**

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<b>APPENDIX A: ANALYTICAL PROCEDURES</b>	

## 1 INTRODUCTION

A suite of twenty-four samples from Arck-1 was submitted by Linc Energy for geochemical analyses. A program was undertaken to evaluate the organic carbon content and source rock potential of the samples. This report provides an interpretation of the Rock Eval pyrolysis data obtained from analysis of the Arck-1 samples.

One electronic copy of this report has been sent to David Carroll at Linc Energy. Any queries related to it may be directed to Cindy Phillips or Dr Birgitta Hartung-Kagi at Geotechnical Services Pty Ltd.

All data and information are proprietary to Linc Energy and regarded as highly confidential by all Geotech personnel.

Geotechnical Services has endeavoured to use techniques and equipment to achieve results and information as accurately as it possibly can. However, such equipment and techniques are not necessarily perfect. Therefore, Geotechnical Services shall not be held responsible or liable for the results of any actions taken on the basis of the information contained in this document. Moreover, this report should not be the sole reference when considering issues that may have commercial implications.

## 2 RESULTS AND INTERPRETATION

A total of twenty-four core samples from Arck-1 (depth range 891m to 980m) were initially submitted for total organic carbon (TOC) determination. Figure 1 presents a depth plot indicating increasing TOC content with depth through much of the section. Values range from a low of 1.32% at the top of the section up to around 10% in the deeper samples, classifying source rock richness as excellent. At the very base of the section, below around 970m, TOC contents rapidly decrease to values as low as 0.17%, indicating these deeper sediments are organically very lean.

On the basis of the TOC data, twenty-two of the core samples were submitted for Rock Eval pyrolysis. Combined S1 + S2 yields range from 0.33 mg/g up to around 63mg/g, the higher values being consistent with excellent source rock quality. S1 yields alone are similarly quite variable, ranging from a low of 0.02mg/g at the base of the section up to 1.84mg/g, the higher values indicating excellent free hydrocarbon richness, in keeping with the TOC data.

The Rock Eval pyrolysis data is displayed in Figures 2 and 3, which show a modified van Krevelen type plot and a cross plot of Hydrogen Index yield TOC content, respectively, illustrating both kerogen type and organic richness of the core samples. The organic matter is comprised primarily of Type I/II kerogen, suggesting a significant contribution of organic matter from marine algae, although the base of the section contains a higher proportion of humic kerogen which likely reflects derivation of organic matter primarily from terrigenous land plant debris. As was indicated by the S1 + S2 yields, source rock quality is quite variable, with Hydrogen Indices ranging from around 50 up to over 600, consistent with the bulk of the section having very good potential for liquids generation. The organically lean base of the section, however, appears to be gas prone at best.

Figure 4 presents a cross-plot of Tmax versus Hydrogen Index for the Arck-1 sediments. Tmax values are fairly uniform, ranging between 427° and 438°, and indicate the section is mature for hydrocarbon generation. Tmax values approaching 440°C in this interval are consistent with the onset of oil generation. The low Production Indices through most of the section similarly indicate the beginning of the oil window. At the base of the section, although Tmax values remain constant, sediments show an increase in Production Indices and a reduction, not only in Hydrogen Indices but also in S2 pyrolysis yields. This data is consistent with sediments that likely had very little source potential to begin with, or sediments which have undergone earlier hydrocarbon expulsion.

FIGURE 1. TOC vs Depth (m)

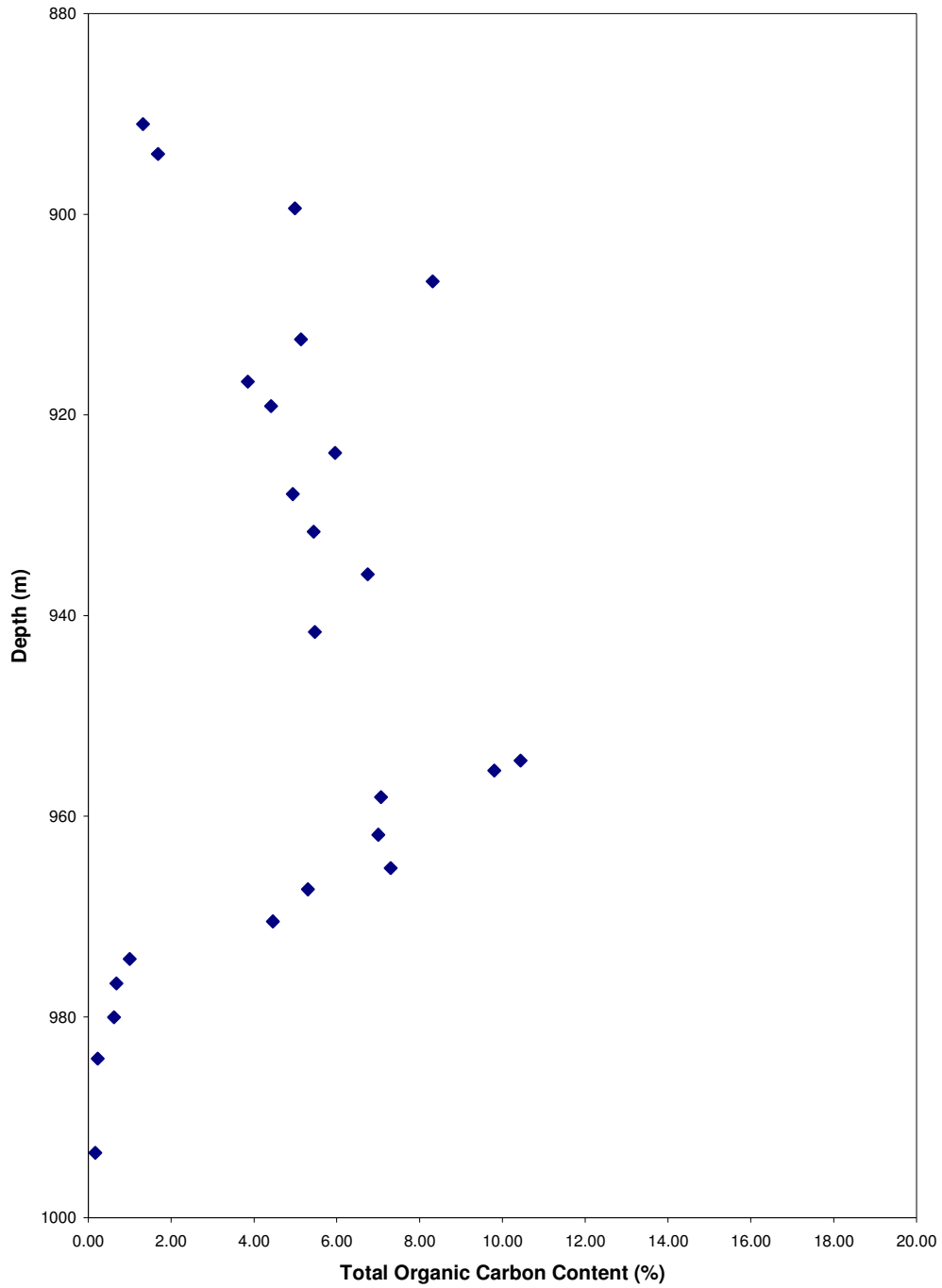


FIGURE 2. Hydrogen Index vs. Oxygen Index

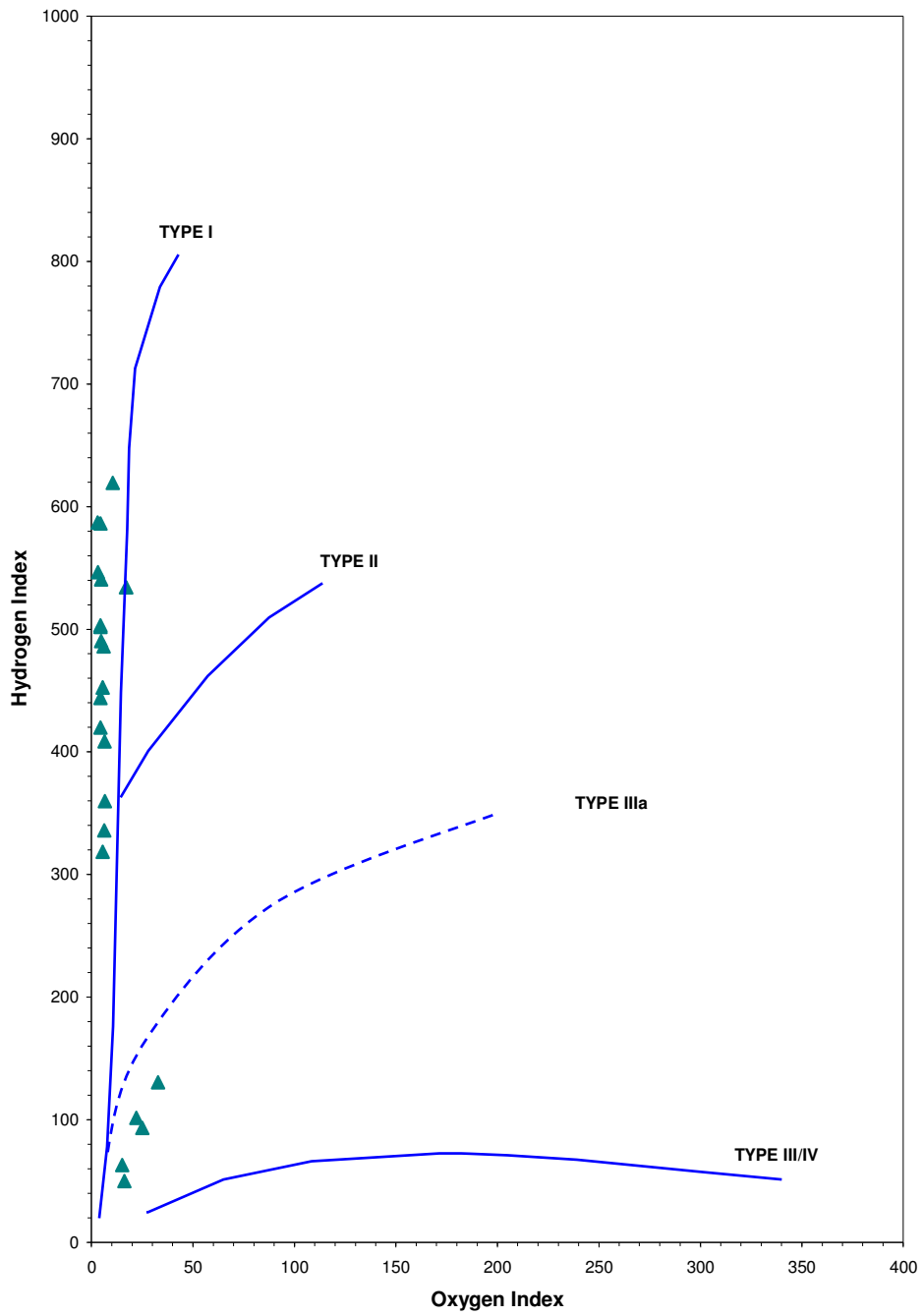


FIGURE 3. Hydrogen Index vs. TOC

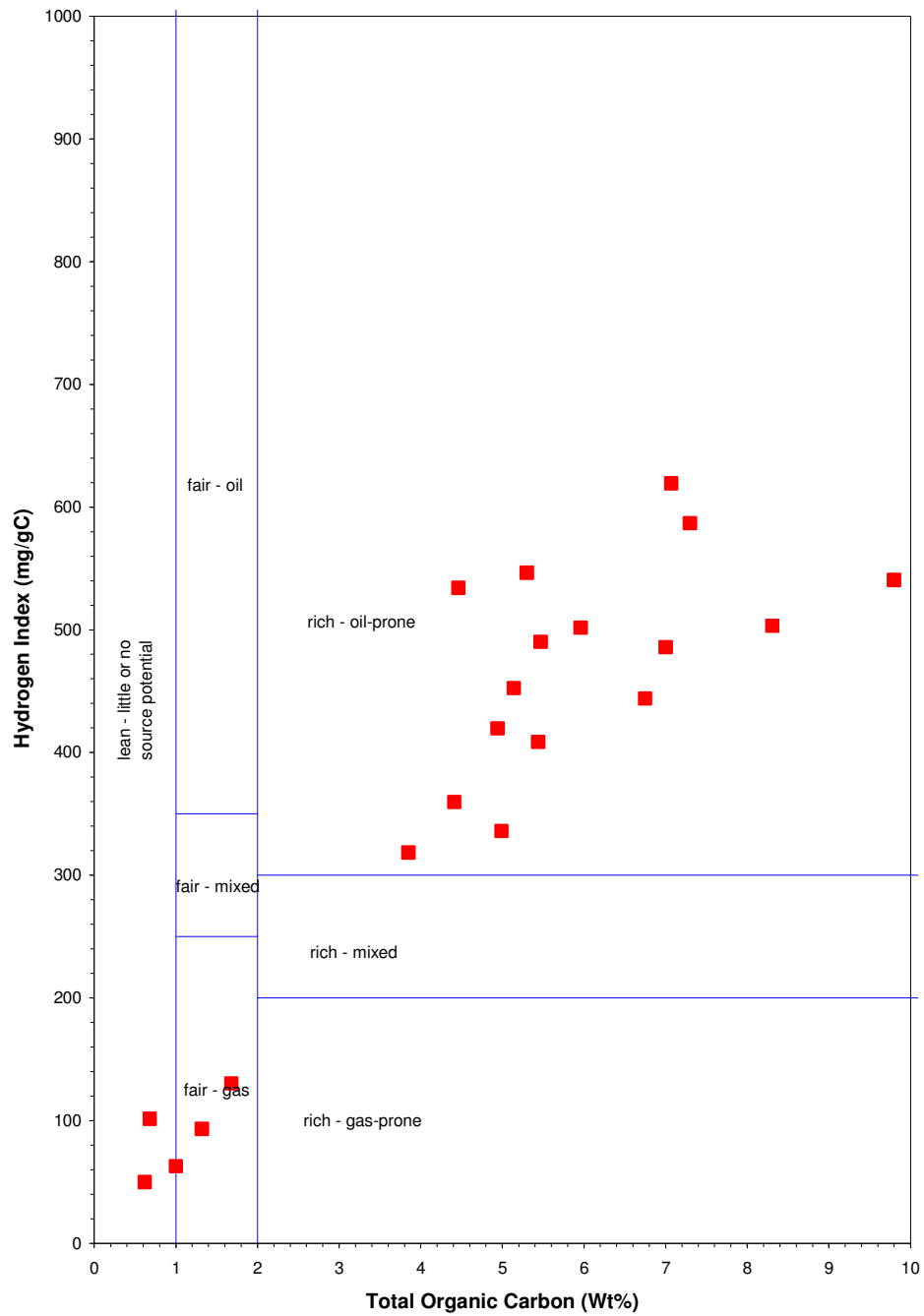
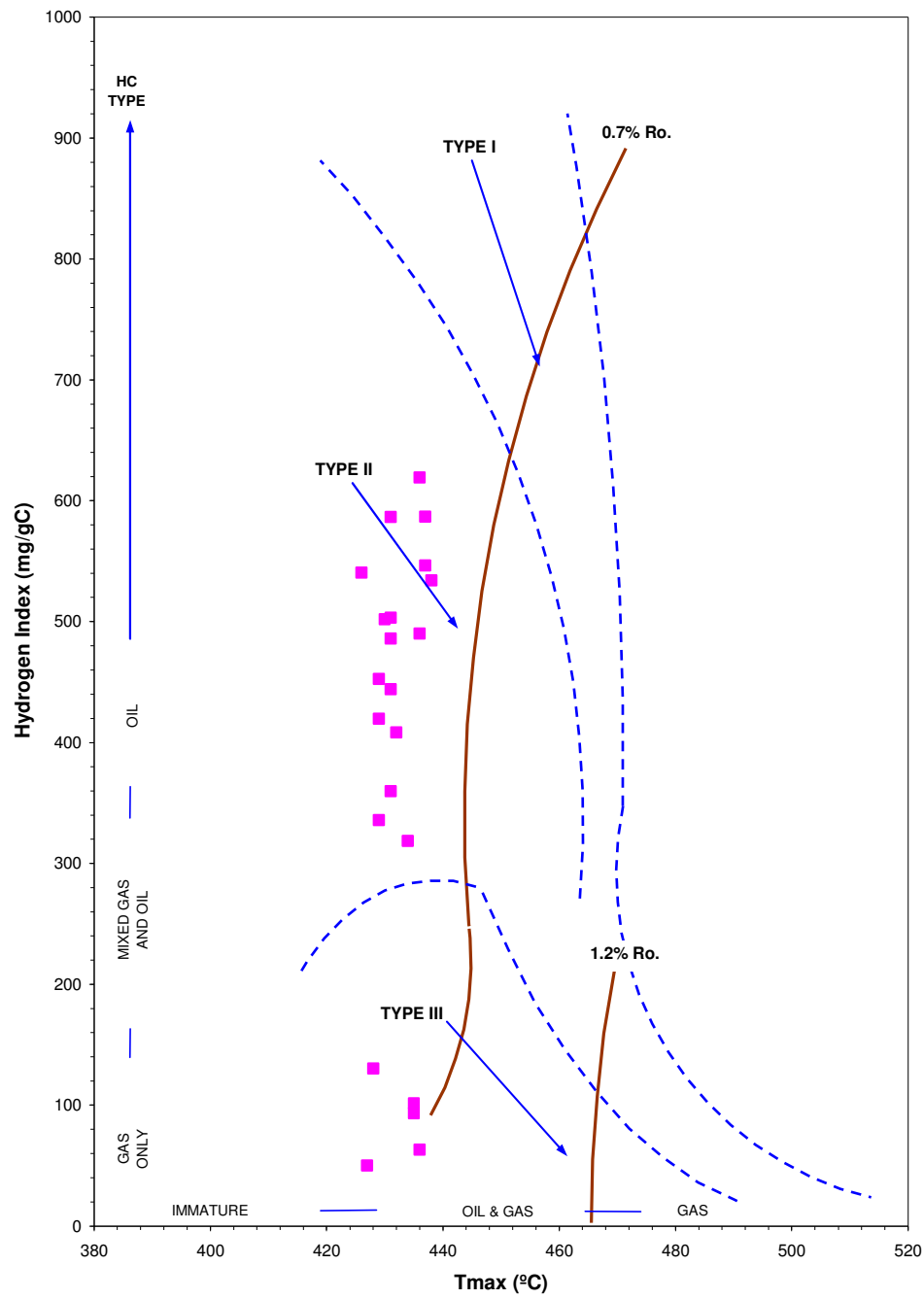




FIGURE 4. Hydrogen Index vs. Tmax



### 3 CONCLUSIONS

TOC contents range from a low of 1.32% at the top of the section up to around 10% in the deeper section, classifying source rock richness as excellent. Hydrogen Indices range from around 50 up to over 600, consistent with the bulk of the section having very good potential for liquids generation. Tmax values approaching 440°C in this interval are consistent with the onset of oil generation.

TOC contents and Rock Eval pyrolysis data indicate the very base of the section, below around 970m, is organically very lean and appears to be gas prone at best.

The organic matter in Arck-1 is comprised primarily of Type I/II kerogen, although the base of the section contains a higher proportion of humic kerogen.

#### 4 REFERENCES

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