TERAKIHI 1

QUANTITATIVE LOG ANALYSIS

Interval: 2837.4 - 3012 mMDKB
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APPENDIX 1

ALGORITHMS AND LOGIC USED IN THE QUANTITATIVE ANALYSIS.

Initial shale volume calculated from GR response.

```
vsh1 = (gr-grmin)/(grmax-grmin)          (Linear Index)
vsh2 = (1.7-sqrt(3.38-((vsh1+0.7)**2)))  (Clavier equation)
vsh  = vsh1*vsh1 + (1-vsh1)*vsh2
```

Apparent shale porosity calculated from density-neutron crossplot algorithm using apparent bulk density of shale and apparent neutron porosity (limestone matrix) of shale.

```
h = 2.71 - rhobsh + phinsh*(rhof-2.71)
   if (h <= 0) rhoma = 2.71 - 0.64*h
   else        rhoma = 2.71 - 0.5*h
phish = (rhoma-rhobsh)/(rhoma-rhof)
```

Bound water resistivity (rwb) calculated via Archie, using apparent shale porosity and apparent shale resistivity.

```
rwb = (rsh*(phish**m))/a
```

Initial estimate of total porosity from density-neutron crossplot algorithms, using bulk density and neutron porosity (limestone matrix, decimal p.u.) log values.

```
h = 2.71 - rhob + nphi*(rhof-2.71)
   if (h < 0) rhoma = 2.71 - 0.64*h
   else       rhoma = 2.71 - 0.5*h
phit = (rhoma-rhob)/(rhoma-rhof)
```

```
rhobc = (rhobh - vsh*rhobsh)/(1 - vsh)
phinc = (phinh - vsh*phinsh)/(1 - vsh)
h  = 2.71 - rhobc + phinc*(rhof-2.71)
   if (h < 0)   rhogc = 2.71 - 0.64*h
   else         rhogc = 2.71 - 0.5*h
```

The apparent matrix density is compared to the analyst input grain density window. If it falls within this window, effective porosity and water saturation are calculated, and the processing sequence finished. If it falls outside the specified grain density window, shale volume is incremented or decremented, and the whole processing sequence repeated, until the calculated grain density falls within the grain density window.

Effective porosity and water saturation are derived from calculated total porosity and water saturation as follows:

```
phie= max(0.001,(phit-(vsh*phish)))
swe = max(swirr,( 1 - ((phit/phie)*(1-swt))))
sxo =1 - ((phit/phie)*(1-sxot))
sxo = min(sxo,swe,1)
   if (vsh > vshco) {
      swt  = 1
      swe  = 1
      sxo  = 1
      phie = 0
   }
   if (vsh > (vshco-0.2)) {
      phie= phie*((vshco-vsh)/0.2)
      swe = 1-((1-swe)*((vshco-vsh)/0.2))
      sxo = 1-((1-sxo)*((vshco-vsh)/0.2))
   }
                 where: vshco is the maximum shale volume
                        for any effective porosity.
```

TERAKIHI 1: QUANTITATIVE LOG ANALYSIS

Wireline log data from the **Terakihi 1** exploration well has been quantitatively analysed over the interval 2837.4 - 3012 mMDKB for effective porosity and effective water saturation. Results are presented in the form of the accompanying depth plots and listing, and are summarised and discussed below.

DATA QUALITY:

<u>Logs Used</u>:

GR	(gamma ray)
LLD	(deep laterolog)
RHOB	(bulk density)
NPHI	(neutron porosity)
DT	(sonic transit time)

Log quality appears to be satisfactory. Minor depth matching was undertaken prior to carrying out the analysis. An unexplained spurious log response occurs in the interval 2835.5 - 2837 mMDKB (low resistivity and density, high neutron). Since this section is interpreteted to be in a non-net interval, it was excluded from the quantitative analysis.

ANALYSIS METHODOLOGY:

Porosities and water saturations were calculated for the total "Coarse Clastic" section using an iterative technique which converges into a preselected grain density window by appropriately incrementing or decrementing shale volume. Initial shale volume is derived from the Gamma Ray response. The model incorporates porosity calculation from density-neutron crossplot algorithms, water saturation from the dual water relationship, hydrocarbon corrections to the porosity logs where applicable, and convergence upon the preselected grain density window (calculated from hydrocarbon and shale corrected density and neutron logs) by shale volume adjustment. Algorithms used are shown in appendix 1 .

CORES:

Two cores were cut in this well, as follows:

	Nominal Depths Cored.	Cut.	Recovered.
CORE 1:	2844.0-2862.0mMDKB	18.5m	12.6m (68.0%)
CORE 2:	2862.5-2881.0mMDKB	18.5m	9.9m (53.3%)

Core gamma logs were recorded by ESSO, and routine core analysis at both ambient and overburden conditions was carried out on a suite of plugs by AMDEL.

A match of core gamma logs to the the downhole wireline GR log suggests that some 3m of section has been lost from the top of Core 1 (rather than all the loss being at the base of the cored interval as is conventionally assumed). The Core 1 plug and core gamma depths were therefore all adjusted down by 3m.

Similarly, comparison of the Core 2 core gamma with the downhole wireline GR log suggests that plug and core gamma depths need to be shifted. Again, it appears that section was lost from the top of the cored interval (3.5m in this instance). However it also appears that after cutting approximately 4.7m of recovered core, another 4.0m of section was lost. Thus core gamma and plug depths from the upper portion of Core 2 (above the "nominal" core depth of approx. 2867.2m) need to be adjusted down by 3.5m, while those from the remainder of the core need to be adjusted down by 7.5.

	Nominal Recovered Depths.	Actual Recovered Depths.
CORE 1:	2844.0-2856.6m	2847.0-2859.6m
CORE 2:	2862.5-2872.4m	{ 2866.0-2870.7m
		{ 2874.7-2879.9m

Depth adjusted core analysis porosities are plotted with the log derived effective porosities in figure 1. A discrepancy is obvious, with the overburden core porosity values commonly being 2-3 porosity units less than the log derived porosity (ambient core porosity values are commonly 1-2 porosity units higher).

Overburden core porosity is generally considered to be the closest measure of in-situ formation porosity. If log derived porosity differs from overburden core porosity, then the log derived data is usually normalised to the core derived data. In the case of Terakihi however, the cored sands are extremely friable and are likely to have been distorted during the process of first cutting the plugs, then placing them under net overburden pressure. This may well have resulted in tighter grain packing (hence lower porosity) when the overburden plug porosity was being measured than is the case in in-situ reservoir.

In view of this, and since the sands in question are clean, and the sonic, density and neutron log porosities agree with each other, the log derived porosity values are judged to be a more accurate estimate of in-situ formation porosity than the core derived porosity values, and are thus left unadjusted.

WATER SALINITY

The apparent formation water salinity of 65000 ppm NaCl equiv. used in this analysis was derived from Rwa calculations in the clean water bearing sands underlying the oil leg, assuming a tortuosity of 1 and a cementation factor of 2.

Water saturation (total) calculated using dual water relationship:

```
1/rt=(swt**n)*(phit**m)/(a*rw)+swt**(n-1)*(swb*(phit**m)/a)*((1/rwb)-(1/rw))
      This is solved for Sw by Newtons solution
       exsw=0
       sw  =0.9
       aa  =((phiti**m)/(a*rwi))
       bb  =((swb*(phiti**m)/a)*((1/rwb)-(1/rwi)))
           repeat
             fx1=(aa*(sw**n))+(bb*(sw**(n-1)))-(1/res)
             fx2=(n*aa*(sw**(n-1)))+((n-1)*bb*(sw**(n-2)))
                if((abs(fx2)) < 0.0001)
                 fx2=0.0001
             swp=sw
             sw =swp-(fx1/fx2)
             exsw=exsw+1
           until (exsw > 4 or (abs(sw-swp)) <= 0.01)
       swt=sw
              [ where:swb = bound water saturation            ]
              [       swb = max(0,(min(1,(vsh*phish/phit)))) ]
```

Sxo is estimated by the relationship Sxo = Sw**Z, where Z is an analyst input.

The bulk density and neutron porosity log responses are then corrected for hydrocarbon effects, using the following algorithms, which incorporate calculated Sxo and analyst input hydrocarbon density (rhoh).

```
 rhobh=rhob+1.07*phit*(1-sxot)*((1.11-0.1*p)*rhof-1.15*rhoh)
 phinh=nphi+(1.3*phit*(1-sxot)*(rhof*(1-p)-1.5*rhoh+0.2))/(rhof*(1-p))
           where:[  p = mud filtrate salinity in parts per unity ]
                 [  p = 0.1778*(3/(rmf*(trmf+7)-1))**(1.05)      ]
```

Total porosity is then recalculated from the density-neutron crossplot algorithm, using the hydrocarbon corrected porosity logs, Sw and Sxo recalculated, and replacement hydrocarbon corrections calculated using the latest Sxo. This process is repeated until the latest total porosity calculated is within 0.008pu (0.8% porosity) of the previously calculated value. At this stage, clay corrections are made to the hydrocarbon corrected bulk density and neutron porosity logs, and apparent matrix density calculated from the density-neutron crossplot algorithm.

DISCUSSION:

The primary objective of the Terakihi 1 exploration well was the package of sands from the Top of Latrobe (predicted at 2871 mMDKB.) down to the 63 MY Sequence Boundary. The Top of Latrobe was intersected at 2836 mMDKB, 35m high to prediction. 204m of Latrobe Group sediments were drilled, of which 18.1m gross at top of porosity (2837.4-2855.5mMDKB) was oil bearing (18.0m net, 99.4% net to gross). Two RFT oil samples were recovered. These samples were from 2841mMDKB and 2851mMDKB and had API gravities of 53 degrees and 52.5 degrees respectively.

Sands through the oil leg have an mean effective porosity of 20.7%, and a mean effective water saturation of 20.6%. The best reservoir quality sand occurs in the interval 2840-2845.5mMDKB, where mean effective porosity is 26.1%, and mean effective water saturation is 6.5%.

ANALYSIS PARAMETERS.

VSH and POROSITY from DENSITY-NEUTRON.

Tortuosity; 'a'................................	: 1.00
Cementation factor; 'm'........................	: 2.00
Saturation exponent; 'n'.......................	: 2.00
Fluid density..................................	: 1.00
Gamma Ray value in clean formation (grmin)......	: 50 api
Gamma Ray value in shale (grmax)................	:120 api
Apparent shale resistivity.....................	: 10 ohmm
Apparent bulk density of shale..................	: 2.55 g/cc
Apparent neutron porosity of shale.............	: 0.30 v/v
Hydrocarbon density............................	: 0.65 (oil)
Lower limit of grain density	: 2.645 g/cc
Upper limit of grain density...................	: 2.675 g/cc
Apparent Formation Water Salinity..................	: 65000 ppm
Measured Rmf...................................	: 0.13
Temperature at which Rmf measured...............	: 18.3 deg.C
Sxo derived from Rxo	
Logged TD......................................	: 3020 m
Logged bottom hole temperature..................	: 60.1 deg.C
Est. sea bed temperature.......................	: 10 deg.C
Water depth....................................	: 424 m
KB height......................................	: 21 m
Irreducible water saturation...................	: 0.025
Vsh upper limit for effective porosity..........	: 0.65

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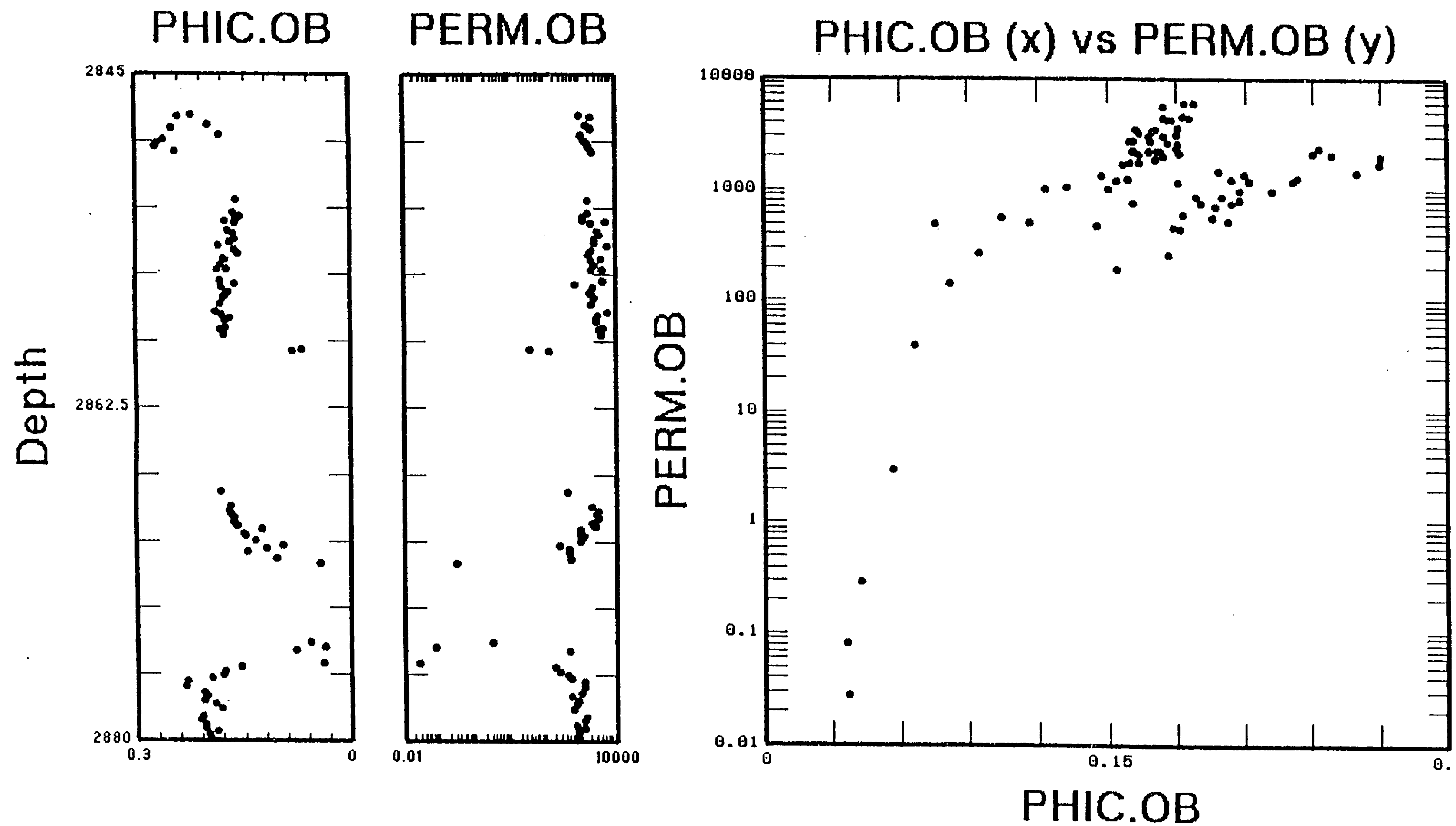
ANALYSIS SUMMARY.

Net porosity cut-off..........: 0.100 volume per volume
Net water saturation cut-off..: 0.500 volume per volume

Net Porous Interval based on Porosity cut-off only.
Both Porosity and Sw cut-offs invoked when generating Integrated Hydrocarbon Pore Volume *

	GROSS INTERVAL (metres) (top) -(base)	Gross Metres	**NET POROUS INTERVAL** Net Metres	Net to Gross	Mean Vsh	(Std.) (Dev.)	Mean Porosity	(Std.) (Dev.)	Porosity Mode	Mean Sw	INTEGRATED HYDROCARBON PORE VOLUME *	
MDKB	2837.4-2840.0	2.6	2.6	100 %	0.297	(0.062)	0.148	(0.015)	0.15	0.396	0.242	OIL
MDKB	2840.0-2845.5	5.5	5.5	100 %	0.036	(0.048)	0.264	(0.027)	0.27	0.065	1.383	OIL
MDKB	2845.5-2849.6	4.1	4.1	100 %	0.093	(0.055)	0.224	(0.022)	0.22	0.107	0.842	OIL
MDKB	2849.7-2855.5	5.9	5.9	100 %	0.007	(0.010)	0.193	(0.005)	0.19	0.264	0.806	OIL
MDKB	2855.5-2891.0	35.5	34.2	96 %	0.058	(0.068)	0.195	(0.027)	0.20	0.999	0.000	WATER
MDKB	2896.9-2946.8	49.9	47.6	95 %	0.070	(0.068)	0.171	(0.027)	0.17	1.000	0.000	WATER
MDKB	2951.9-2953.8	2.0	1.7	85 %	0.199	(0.055)	0.163	(0.025)	0.18	1.000	0.000	WATER
MDKB	2951.9-2953.9	2.0	1.7	85 %	0.199	(0.055)	0.163	(0.025)	0.18	1.000	0.000	WATER
MDKB	2956.9-2968.8	12.0	10.3	86 %	0.284	(0.111)	0.138	(0.027)	0.12	1.000	0.000	WATER
MDKB	2956.9-2968.9	12.0	10.3	86 %	0.284	(0.111)	0.138	(0.027)	0.12	1.000	0.000	WATER
MDKB	2971.9-2990.0	18.1	15.5	86 %	0.318	(0.071)	0.156	(0.026)	0.16	1.000	0.000	WATER
MDKB	2994.9-3005.0	10.1	10.1	100 %	0.038	(0.081)	0.212	(0.028)	0.22	1.000	0.000	WATER
MDKB	3005.0-3012.0	7.0	6.7	96 %	0.310	(0.095)	0.143	(0.024)	0.14	1.000	0.000	WATER

*Integrated Hydrocarbon Pore Volume is the volume of hydrocarbon (in cubic metres) contained in a column of formation of one square metre cross sectional area through the gross interval in question .



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CORE DATA:
Porosity - Permeability crossplot at net overburden conditions. Note the two distinct data trends.

FIGURE #2.

tmf

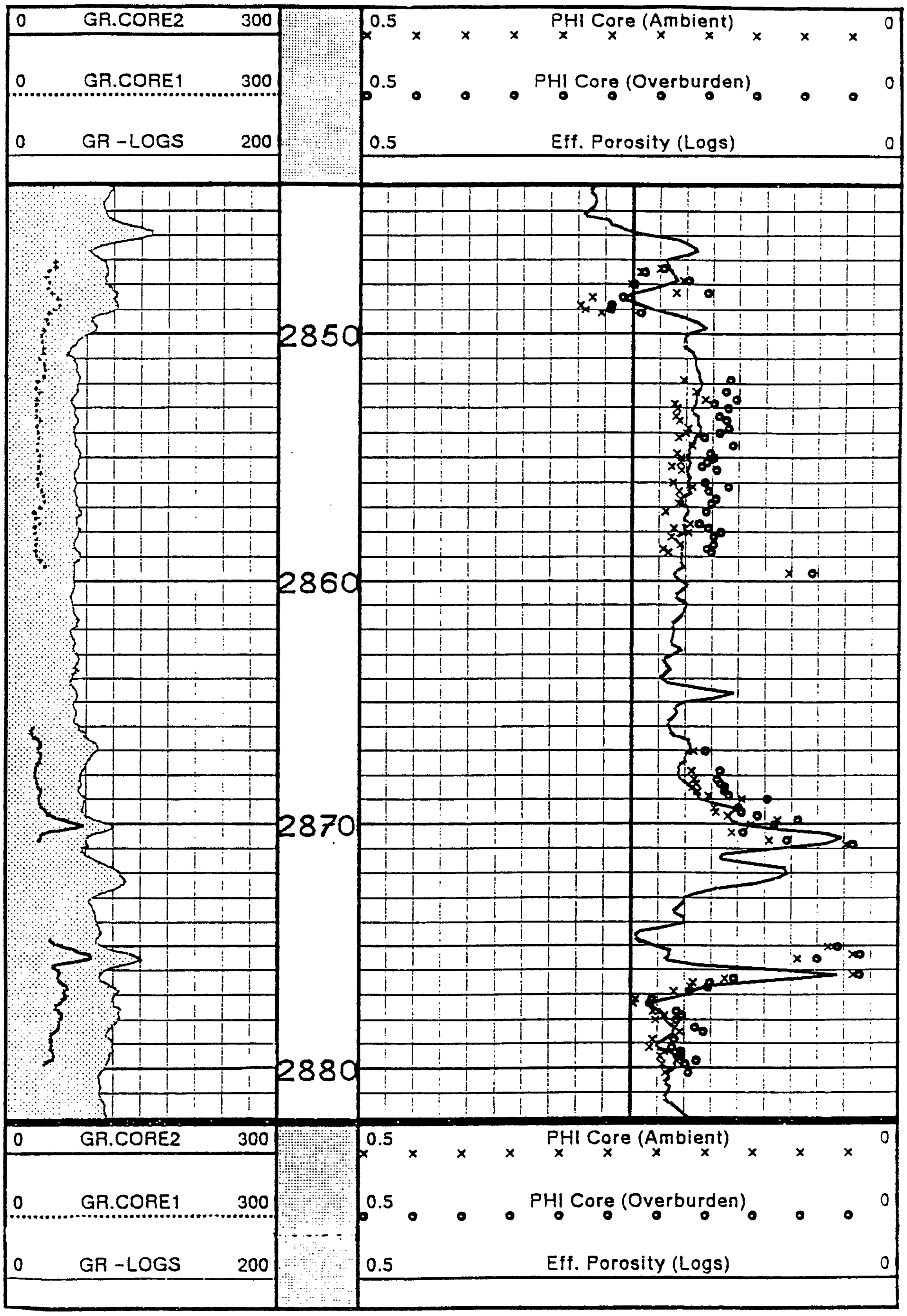

FIGURE #1: Comparison of Core and Log derived data.