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**BULK VOLUME AND WATER SATURATION  
ANALYSIS FOR PERMAFROST AND  
SUB-PERMAFROST SECTIONS OF 5 WELLS,  
BEAUFORT SEA**

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Contract Number 23397-9-0834 / 01SZ

**1990**

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AND SUB-PERMAFROST SECTIONS OF 5 WELLS, BEAUFORT SEA

by

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Contract Number 23397-9-0834/01SZ

Attached are the analysis plots, composite data plots, and  $R_{wa}$  plots for the five Beaufort sea wells included in this study. The five wells and their associated analysis intervals chosen for this project were:

Angasak L-03	500-1500 m
Isserk E-27	183-1509 m (600-4950 ft)
Issungnak O-61	895-1500 m
Pullen E-17	579-1503 m (1900-4930 ft)
Arnak L-30	823-1503 m (2700-4930 ft)

Some of these analysis intervals differ from those listed in the contract. This was necessary because the logs were either recorded inside of casing, or sufficient log data was not available. The effect of casing and cement on the logs is unknown.

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The appropriate log curves were digitized for all wells. These data were plotted and visually compared to the original logs. A composite plot of the log data has been included for your reference. The following figure will explain the location and scales of the log curves on the composite data plot.

0	Gamma Ray	150	.2	Rdeep	2000	60	NPFI	0
	(solid)			(dash)			(dash)	
125	Caliper	375	.2	Rshallow	2000	1.65	Density	2.65
	(dot)			(solid)			(solid)	
						240	Acoustic	40
							(dot)	

Back up scales were also provided for all of the curves.

Apparent formation water resistivity was calculated for each well and plotted. This calculation was based upon Archie's relationships:

$$F = \frac{a}{\phi^m} = \frac{R_T}{R_{wa}}$$

$$R_{wa} = R_T * \phi^m$$

where a is assumed to be 1, and m is 2. This relationship was applied to both the neutron and density porosity data to calculate Rwa(N) and Rwa(D) respectively. These were plotted with the following scales:

0	Gamma Ray	150	.02	Rwa(N)	200
	(solid)			(dash)	
125	Caliper	375	.02	Rwa(D)	200
	(dot)			(solid)	

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ANGASAK L-03

The casing shoe in this well was set at 501 m. Therefore the analysis interval was selected at 500 to 1500 m. The logs used in the analysis were the neutron porosity, bulk density, deep and shallow resistivity, gamma ray and caliper. A pseudo gamma ray curve was derived from the SP log for the interval from 500 to 915 m. This was done to prevent the highly radioactive zone (590 to 725 m.) from appearing as a massive shale.

There is a distinct change in all of the logs at 915 m. As a result the total porosity changes from approximately 30 percent above 915 m, to about 12 percent below this point. Without further data it would be purely speculative to suggest a cause for this change in the log responses.

The resistivity of the formation water,  $R_w$  was assumed to be 0.3 ohmm at standard conditions of 25 degrees C. This value was based upon the average  $R_w$  determined for the other wells in this study. The high resistivities recorded in all of the porous formations would suggest hydrocarbon, and precludes determining  $R_w$  from  $R_{wa}$ .

ISSERK E-27

The casing shoe in E-27 is at 596 feet, therefore the analysis began at 600 feet. The logs that were used are: bulk density, neutron porosity (available only from 2833 to 4950 ft), deep and shallow resistivity, gamma ray and caliper.

The excessively large borehole above 2100 feet has severely affected the log responses. A review of the composite data plot reveals that in the intervals where the caliper reached or exceeded its maximum range of 23 inches, the logs, with the exception of the deep resistivity, appear to record a constant value. This indicates that they are responding to the borehole and not the formation. As a result, the lithology and porosity computations should be viewed sceptically over this bad hole zone.

The formation water resistivity,  $R_w$  was taken to be 0.3 ohmm as determined from  $R_{wa}$  cross-plots.

ISSUNGNAK O-61

The logs used in this analysis were the neutron porosity, bulk density, deep and shallow resistivity, gamma ray and caliper.

$R_w$  was taken to be 0.29 at 25 degrees C, as determined from  $R_{wa}$  cross-plots.

PULLEN E-17

The deep and shallow resistivity, gamma ray, and caliper log curves were available over the total interval of this analysis. However the density curve was the only porosity log recorded from 2000 to 3010 feet. Below 3010 feet the acoustic log was the only porosity log available.

Again, borehole size should be considered in the lower section of this analysis from 3430 to 4910 feet. When the caliper records off-scale as it does in this interval, it suggests that the other logs are recording mud properties, and not the formation.

Rw was assumed to be 0.3 ohmm, based upon the Rwa calculations for the other wells.

ARNAK L-30

The logs used in this analysis were the neutron porosity, bulk density, deep and shallow resistivity, gamma ray and caliper.

Rw was taken to be 0.33 at 75 degrees F, as determined from Rwa cross-plots.