GEUS

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GANK-1

Conventional core analysis on GANK-1 cores, Kuussuaq, Nuussuaq, West Greenland

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DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 1997/84

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Contents

1. Introduction

In May 1995 grønArctic Energy Inc., Canada was awarded an exclusive licence to explore for hydrocarbons on the southern and western part of the Nuussuaq peninsula, West Greenland. As part of the commitments under this licence three slim core holes GANE#1, GANK#1 and GANT#1 were drilled in July and August 1995.

The GANK#1 well was drilled in two sections. The first section is the GANK#1 and the second section is the side-track GANK#1A. The GANK#1 nominal core diameter is 63.5mm in the depth interval 114.9-167.94m and 47.6mm in the interval 167.94-398.98m. The GANK#1A was kicked-off at 218.55m and drilled to 332.84m.

The Core Laboratory at The Geological Survey of Denmark and Greenland has received parts of these two cores for conventional core analysis. Table 1.1 show the analyzed box numbers, depth intervals and measured core size for the analyzed cores:

Table 1.1: List of analyzed cores/boxes.

Core	Box numbers	Top	Bottom	Nom. core size
GANK#1	57 - 101	200.08 m	337.28 m	47.6 mm

The analysis covers the following services:

- Spectral core gamma log
- Gas permeability
- Porosity
- Grain density

The work is performed of the following staff members:

Contribution:	Staffmember:
Data processing and editing	Gert Andersen
Geological description	Morten Kildevang Jensen
Analysis	Gert Grønning Hans Jørgen Lorenzen Marga Jørgensen Gert Andersen

2. Sampling and analytical procedures

Cores were transported from Greenland to Copenhagen in 1,2m boxes. Boxes were made of a toplayer and a bottomlayer only, fixed together without any side walls. Every box contained 3 meters (m) core interval parted in three 1 m lengths. These lengths are named A, B and C from top to bottom in this analysis programme.

The cores were stored in another set of boxes at the arrival to Denmark.

2.1 Spectral core gamma log

Spectral core gamma logs were recorded with a scanning speed of 1 cm per minute with a record at every 10cm. A core bulk density of 2,020g/ccm with a mean core diameter of ø4.76cm was assumed in the data reduction.

2.2 Sampling and plugging

Following the gamma activity recording, the sampling and plugging programme was conducted. Samples were taken at geological important levels, and were plugged as ø1" horizontal plugs if possible.

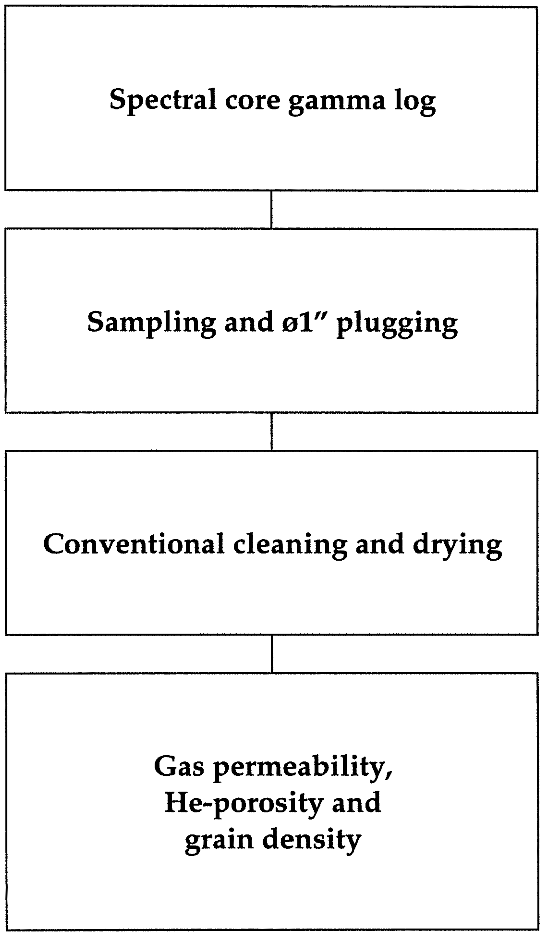
Plug depths were calculated as distance from top of the 3m boxes. The core length expanded for some of the cores during the storage in other boxes and during the spectral core gamma log, and the distance from top of 3m box were calculated by the following algorithm:

- A sections: Measured distance from top of box
- B sections: Measured distance from top of box plus measured length of A
- C sections: Measured distance from top of box plus measured length of A and B

2.3 Conventional core analysis

The plugs were cleaned in Soxhlet extractors and then dried at 110°C. Conventional core analysis including He-porosity and grain density was performed on all samples and permeability was furthermore carried out on the cylinder formed plugs. The permeability was measured using a sleeve pressure of 400 psi.

3. Flow diagram of the analytical procedures



4. Analytical methods

The following is a short description of the methods used by the Core Analysis Laboratory. For a more detailed description of methods, instrumentation and principles of calculation the reader is referred to API recommended practice for core analysis procedure (API RP 40, 1960).

4.1 Spectral core gamma log

The natural gamma radiation of a core is recorded within an energy window of 0.5 - 3.0 MeV, using Tl activated NaI scintillation detectors (Bicron), connected to a multichannel analyzer (Canberra).

The core is passed through a lead shielded tunnel at constant speed while the gamma activity is continuously recorded. Refer to Chapter 2 for the scanning speed used. The integrated gamma activity is recorded at regular intervals, either every 10 cm or every 3". The gamma activity represents the mean activity over a 10 cm or 3" interval, the assigned depth being the middle of the interval. The measured gamma activity is corrected for background activity, and in the case of sleeved core, also for activity of the sleeve.

Gamma activity is normally reported in counts per minute (cpm) at the actual core diameter. The following empirical relationship between "GAPI" from wireline logs and the actual cpm from GEUS core gamma logs (GEUS-cpm) has been established. The relationship should be used as a guideline only:

$$GAPI = GEUS\text{-}cpm * (10cm/d)^2 / 18{,}2$$

where d is the nominal core diameter in cm.

Radiation from decay of potassium and the uranium and thorium decay series are recorded in separate energy windows. Concentrations are calculated using synthetic standards of concrete doped with radioactive minerals in decay equilibrium. Concentrations of K, U and Th are reported as % K, ppm U and ppm Th, respectively. Relevant ratios are given.

4.2 Conventional cleaning and drying

The plugs are drilled and trimmed to a standard size of 1" diameter and 1.5" length. The samples are then placed in a Soxhlet extractor, which continuously soaks and washes the samples with methanol. This process removes water and dissolves salt precipitated in the pore space of the rock. Extraction is terminated when no chloride ions are present in the methanol. Samples containing hydrocarbons are then cleaned in toluene until a clear solution is obtained. Samples are vacuum dried at 90°C or 110°C, or they are humidity dried at 60°C and 40% relative humidity until constant weight occurs, depending on the requirements of the client.

4.3 Gas permeability

The plug is mounted in a Hassler core holder, and a confining pressure of 400 psi applied to the sleeve. The specific permeability to gas is measured by flowing nitrogen gas through a plug of known dimensions at differential pressures between 0 and 1 bar. No back pressure is applied. The readings of the digital gas permeameter are checked regularly by routine measurement of permeable steel reference plugs.

4.4 He-porosity and grain density

The porosity is measured on cleaned and dried samples. The porosity is determined by subtraction of the measured grain volume and the measured bulk volume. The Helium technique, employing Boyle's Law, is used for grain volume determination, applying a double chambered Helium porosimeter with digital readout, whereas bulk volume is measured by submersion of the plug in a mercury bath using Archimedes principle. Grain density is calculated from the grain volume measurement and the weight of the cleaned and dried sample.

4.5 Precision of analytical data

The Table below gives the precision (reproducibility) at the 68% level of confidence (+/- 1 standard deviation) for routine core analysis measurements performed at the GEUS Core Analysis Laboratory.

Measurement	Range, mD	Precision
Grain density		0.003 g/cc
Porosity		0.1 porosity-%
Gas Permeability	0.001-0.01 0.01-0.1 > 0.1	25% 15% 4%

The precision of the fluid saturation determination depends on the pore volume of the plug. The greater the volume of the plug and the greater the porosity of the plug, better precision is obtained. The following Table gives the precision in absolute percent-point.

Porosity	1" x 1.5" plugs	1.5" x 3" plugs
> 20%	5%	1%
10-20%	10%	2%
5-10%	20%	5%
< 5%	> 20%	> 5%

Certain factors might alter the stated precision of the fluid saturation determination. Loss of material during handling of the plug will result in an increase in the calculated oil saturation, and a similar decrease in the calculated gas saturation. This may occur for fragile or loosely consolidated rocks or if the rock contains dissolvable matter like halite. As the lost material usually has a greater density than oil, it may happen that the estimated volume of oil and the measured volume of water all together take up more space than the actual pore volume after cleaning.

The precision of the total gamma activity analysis is calculated from counting statistics. The following list shows the dependency of reproducibility on count rate at 2 standard deviations.

Count rate (cpm)	Reproducibility (cpm)
125	7.1
250	10.0
500	14.2
1000	20.1
2000	28.4
4000	40.2

Reproducibility (precision) of the amount af uranium, thorium and potassium from gamma radiation is dependent on concentration. Two values for reproducibility are given, one for normal to high concentration range, and one for low concentration range. The latter also defines the detection limit (LLD). The reproducibility values are applicable to total gamma activity above and below 800 cpm, respectively.

	K(%)	U(ppm)	Th(ppm)
Reproduceability			
Normal to high range	0.06	0.80	0.91
Low range (LLD)	0.02	0.19	0.35
Accuracy	0.05	0.19	0.37

Accuracy is calculated as mean deviation from the accepted concentration of one internal standard. This value is only applicable to low concentrations. For high concentrations the high range reproducibility may serve as an approximation to accuracy. Accuracy is reported as an arithmetic mean.

5. Results

5.1 Spectral core gamma log

Spectral core gamma logs are presented in the log sheet below. Boxes with boxnumbers are shown in the log sheet. Please note: The log "Total gamma (cps)" are in cps without correction for differences in core dimensions.

GANK 1

Core gamma log

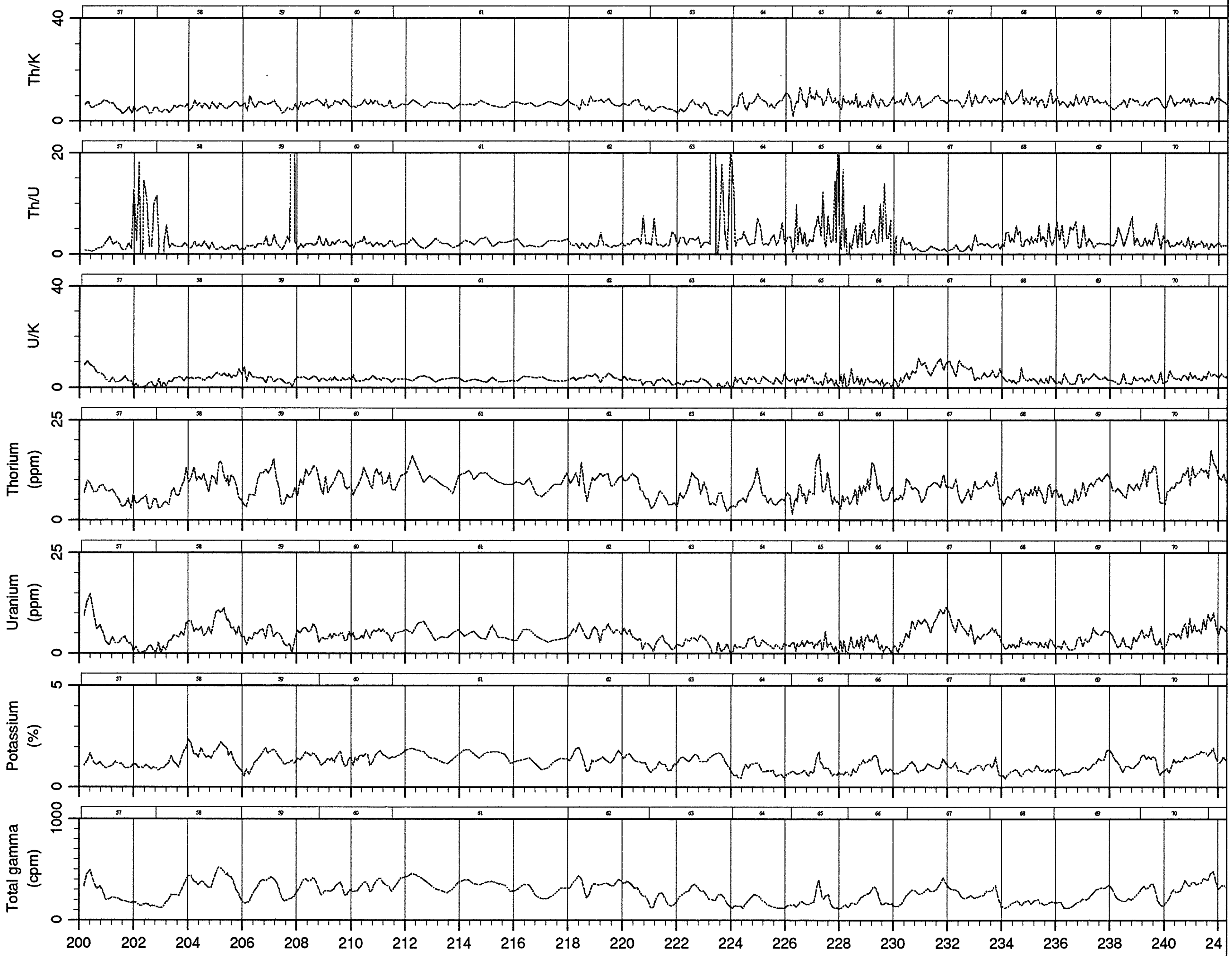
Nom. ø47.6 mm

Depth vs.
- Th/K
- Th/U
- U/K
- Thorium
- Uranium
- Potassium
- Total Gamma

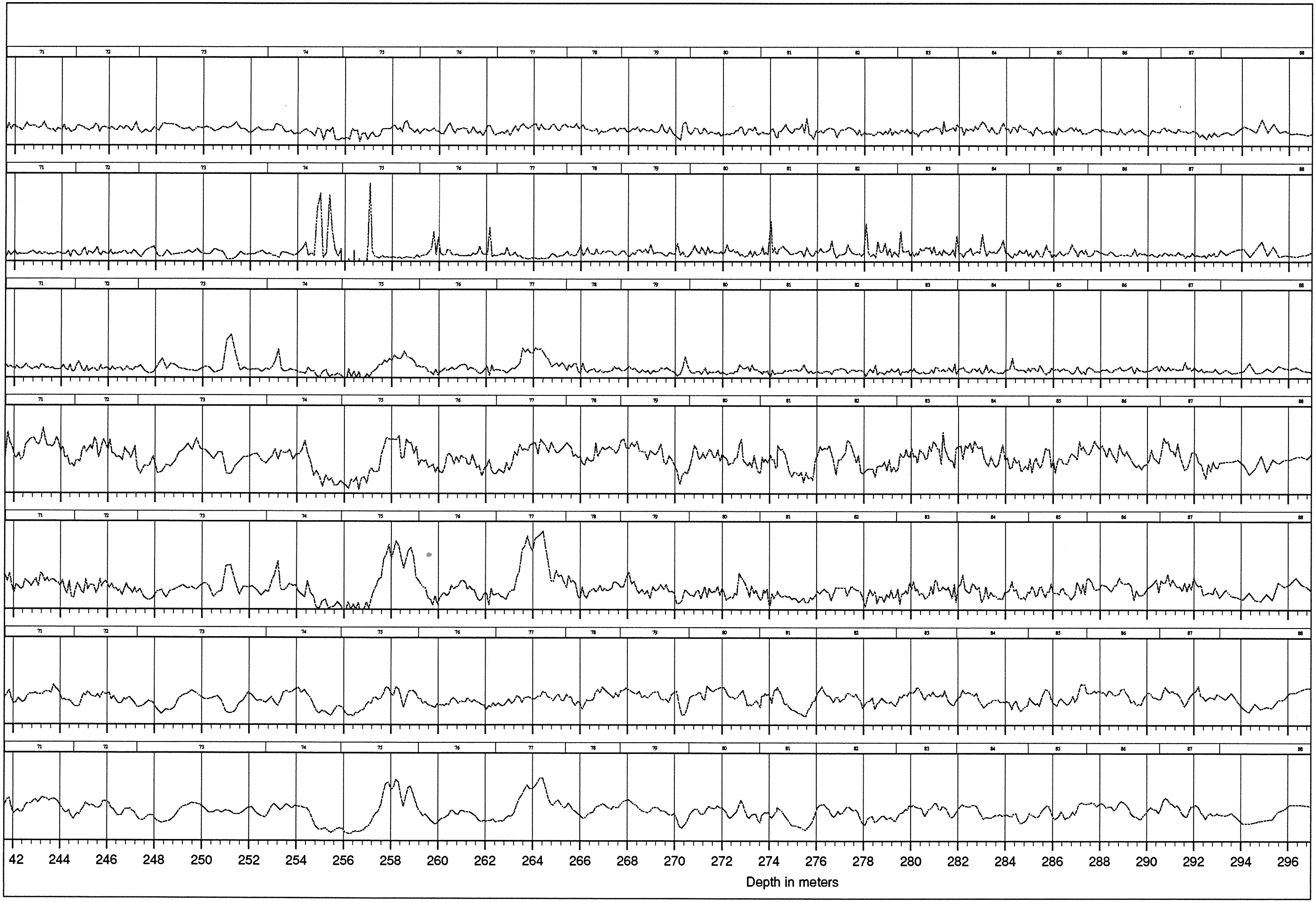
Scale 1:200

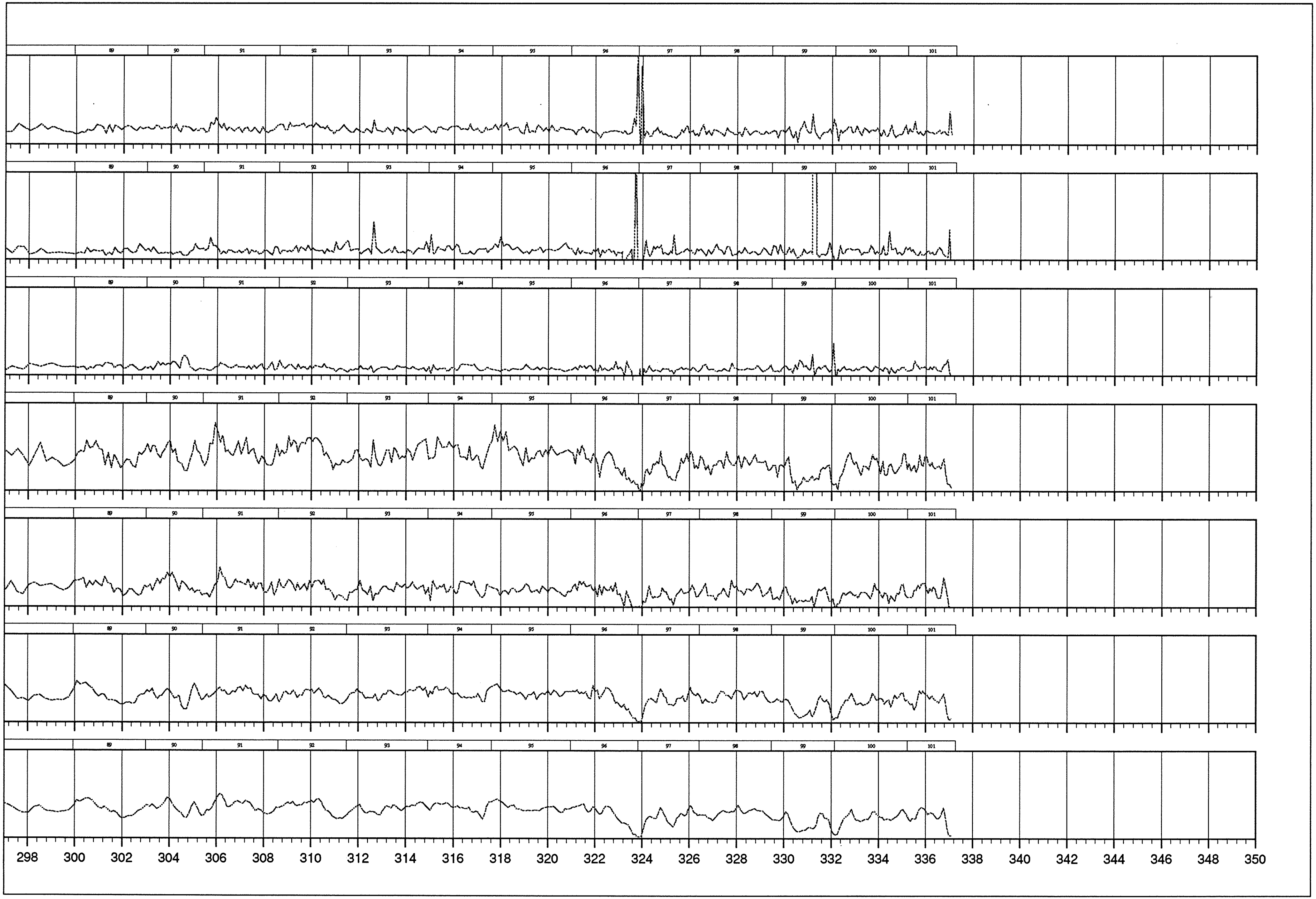
Legend

Gank1



GEUS Core Analysis Laboratory, 17-JUN-97


42 244 246 248 250 252 254 256 258 260 262 264 266 268 270 272 274 276 278 280 282 284 286 288 290 292 294 296
Depth in meters



89 90 91 92 93 94 95 96 97 98 99 100 101
298 300 302 304 306 308 310 312 314 316 318 320 322 324 326 328 330 332 334 336 338 340 342 344 346 348 350

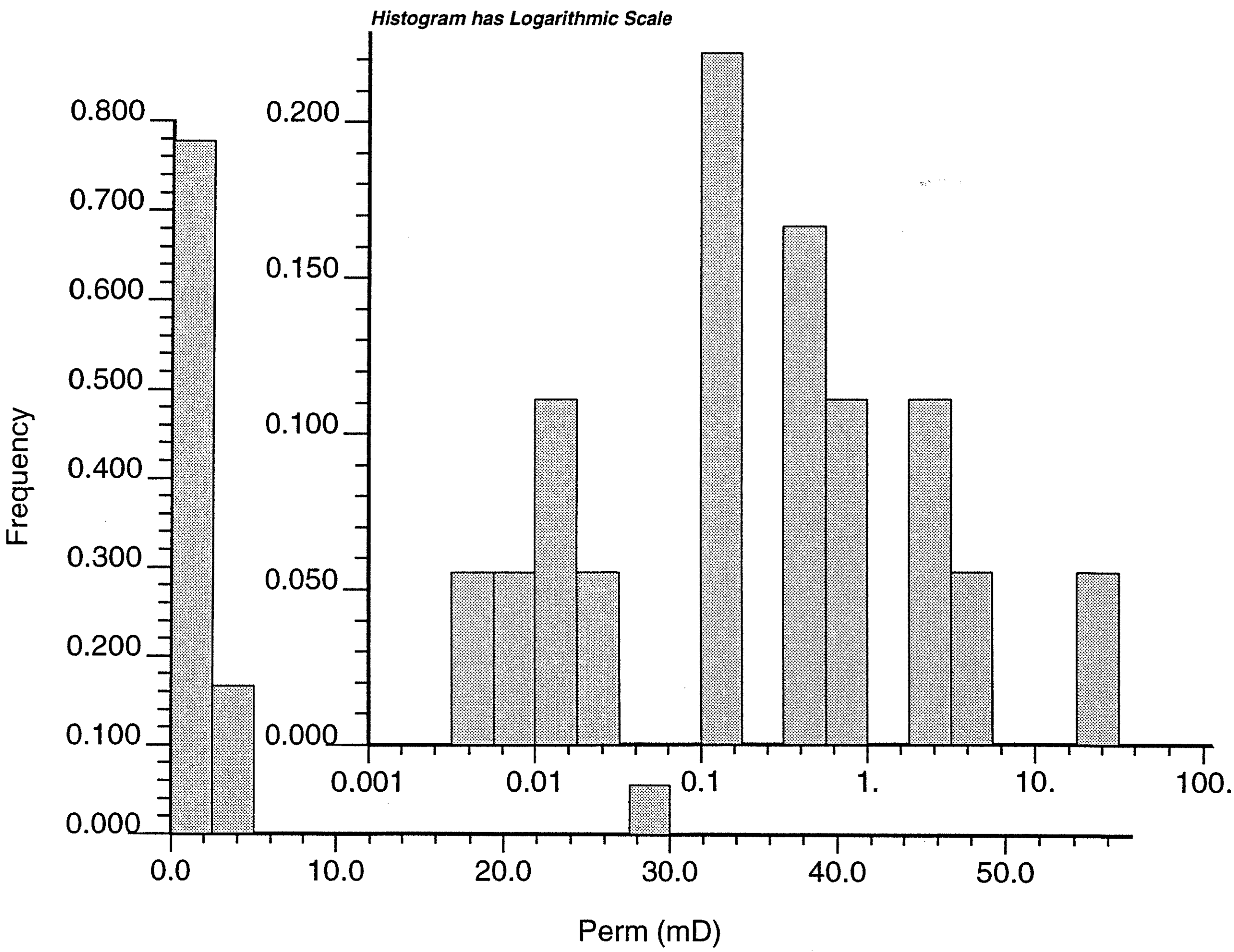
5.2 Sample distributions and statistics

Frequency plots of gas permeability, porosity and grain density and cross plots are given together with statistical information on the plotted data.

Statistical information on a reduced dataset are added on the plots for porosity and grain density. This reduced dataset are similar to the dataset for the permeability plots.

5.2.1 GANK#1, Gas permeability

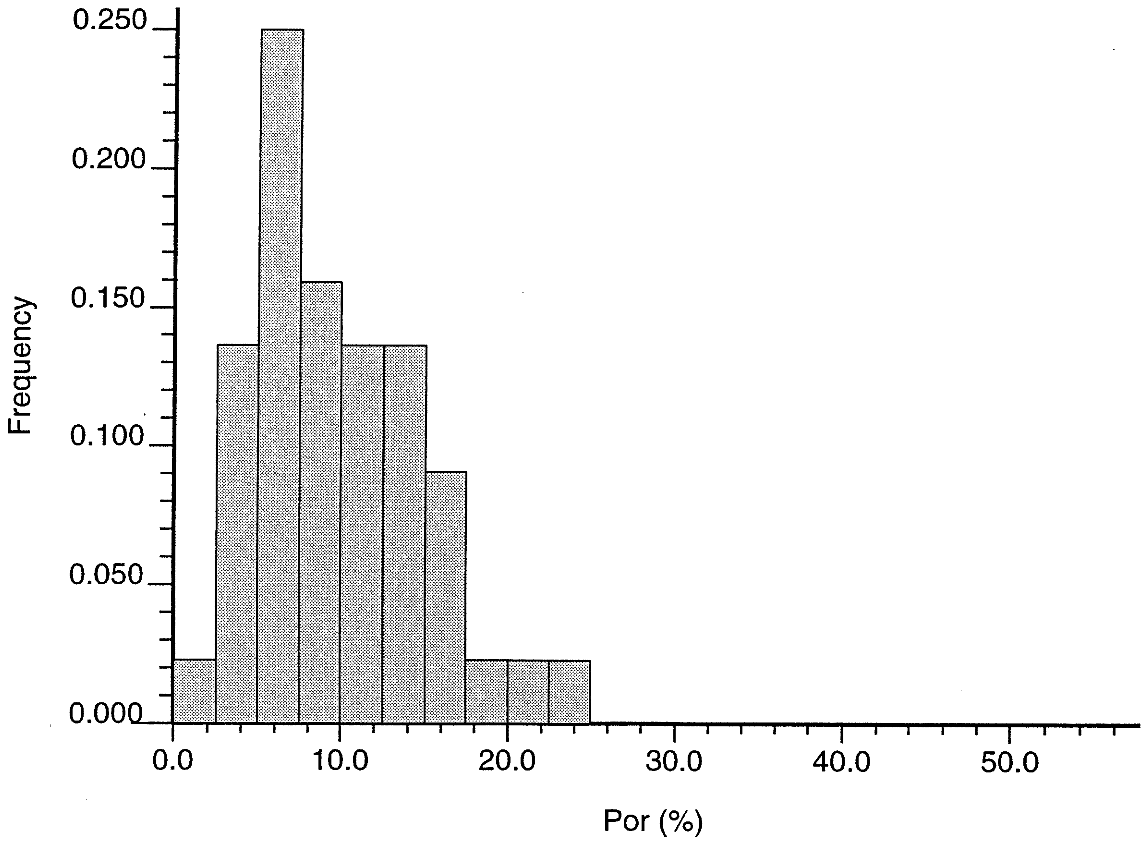
Number of samples	18	Unit
Geometric average:	0.22	mD
Aritmetric average (Mean):	2.41	mD
Harmonic average:	0.03	mD



5.2.2 GANK#1, Porosity

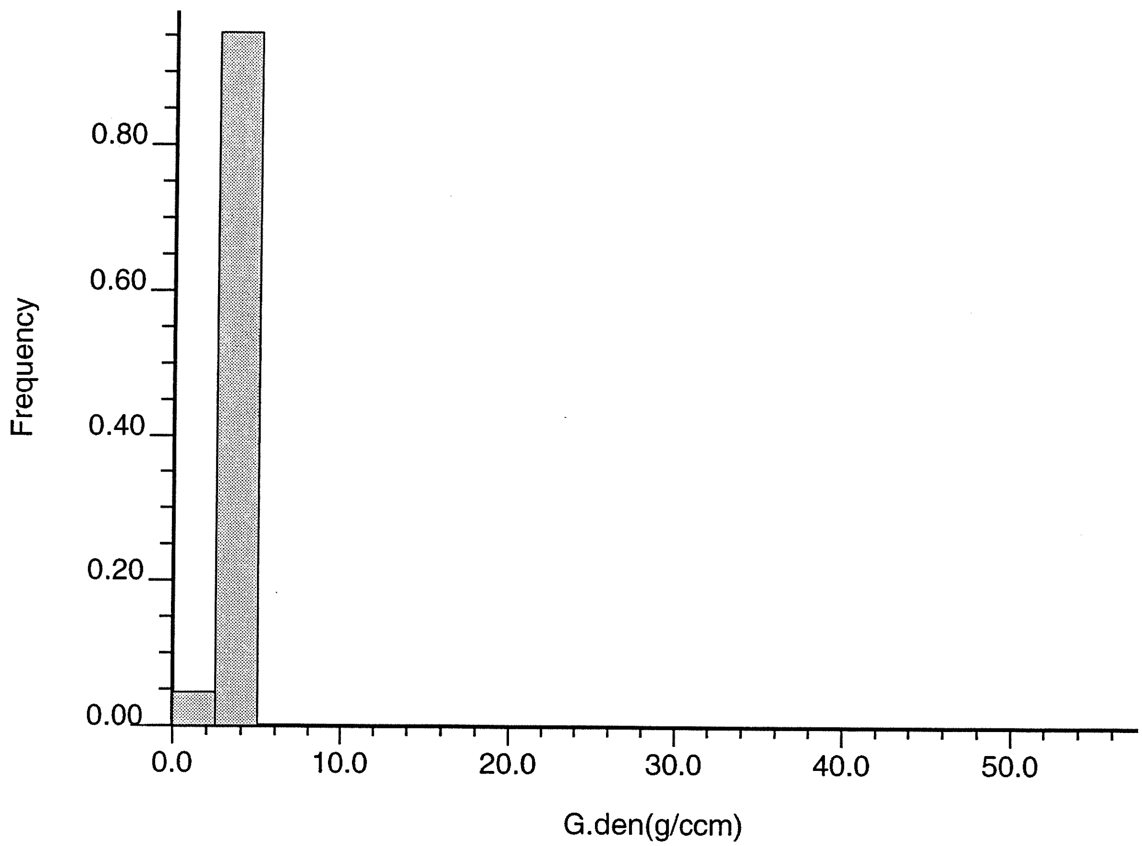
Porosity:

Number of samples	18	44	Unit
Mean porosity:	9.90	9.86	%
Variance on porosity:	35.57	24.65	$\%^2$



5.2.3 GANK#1, Grain density

Number of samples	18	44	Unit
Mean grain density:	2.71	2.66	g/ccm
Variance on mean gr. den.:	0.01	0.01	g^2/ccm^2

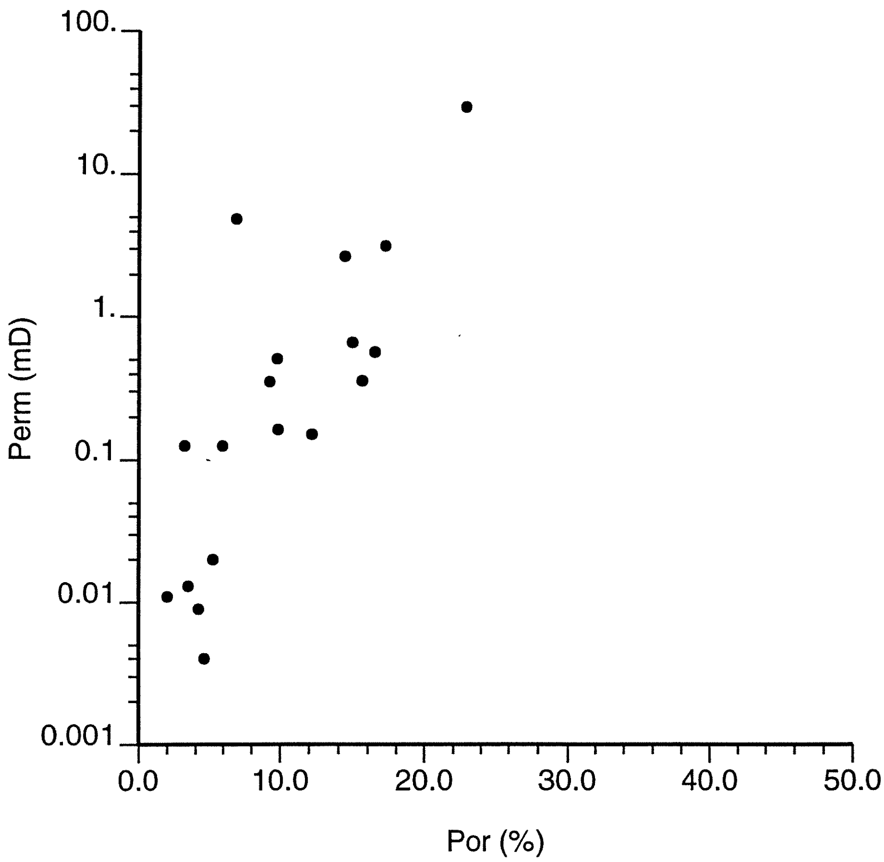


5.2.4 GANK#1, Porosity vs. gas permeability

Calculated from linear regression of permeability on porosity:
Model: Log10(Permeability) = Intercept + Slope * Porosity + Residual

Degrees of freedom:	16	
Coefficient of determination:	0.638	
Standard error on the regression:	0.651	log(mD)
Estimated intercept:	-2.054	log(mD)
Estimated standard error of intercept :	0.304	log (mD)
Estimated slope:	0.14075	log(mD)/%
Estimated standard error of slope:	0.02649	log(mD)/%

Please note that the regression statistics pertain to log permeability values.
The coefficient of determination gives the fraction of the total variation squared which is explained by the mode. The standard error on the regression gives the mean 1 sigma error on the log permeability estimates.



6. Appendix, data tabulation

6.1 Laboratory analysis, GANK#1

6.1.1 General information on the analysis:

Company:	GEUS	Location:	Greenland
Depth interval:	200.08 - 337.28	Box no. :	57 - 101
Depths are measured from:	KB	Analysts:	MKJ,GG,HJL,MJ,GA
Depths are in:	METRES	Date:	11. june 1997
Well:	GANK#1		

REMARKS :
If "boblepermflow" are written as 0.0ml/300sec if less than 0.1ml/100s. I.e. 0 mD
Data not measured: "-"

The Geological Survey of Denmark and Greenland is fully responsible for the analytical results in the present report. The survey, however, bears no responsibility for decisions and interpretations based on the data presented.

6.1.2 Abbreviations for lithological descriptions.

Rock type	carb	Carbonate
	cly	Claystone
	cl	Clay
	slt	Siltstone
	sst	Sandstone
	sd	Sand
	cngl	Conglomerate
	htrl	Heterolith
Grain size	vf-	Very fine grained
	f-	Fine grained ex. fsst = fine grained sst
	m-	Medium grained
	c-	Coarse grained
	vc-	Very coarse grained
	unsrt	Unsorted
Colour	blk	Black
	br	Brown
	gn	Green
	gy	Grey
	ol	Olive
	rd	Red
	wh	White
	vl-	Very light
	l-	Light, ex. lgy = light grey
	ml-	Medium light
	m-	Medium
	md-	Medium dark
	d-	Dark
	-sh	-ish, ex. brsh = brownish
	var	Varioloured
Structures	bed	Bedding
	bio	Bioturbation
	bur	Burrow(-s)
	cla	Clast(-s)
	crs	Crossbedding
	cvn	Calcite vein(-s)
	concr	Concretion
	domn	Domains
	fos	Fossil (-s)
	frg	Fragment(-s)
	lam	Lamina/lamination
Struct. (cont.)	pynd	Pyrite nodule(-s)
	shl	Shell fragment(-s)
	slmp	Slumped
	sly clv	Slaty cleavage
	sol sm	Solution seam(-s)
	strp	Stripe
	sty	Stylolite seam(-s)
	vn	Vein
Miscellaneous	ab	Abundant
	arg	Argillaceous
	art	Artificial
	bit	Bitumineous
	calc	Calcareous
	ccem	Calcite cemented
	cem	Cemented
	dom	Dominantly
	hrd	Hard
	hom	Homogeneous
	ids	Indistinct
	mot	Mottled
	prt	Partly
	slg	Slightly
	sme	Some
	sort	Sorting
	str	Strongly
	sp	Sparse
	thn	Thin
	thk	Thick
	tot	Total
	w	With
Fractures	FRC	Fracture
	FT FRC	Fatal fracture
	SG FRC	Significant fracture
	F FRC	Fine fracture
	H FRC	Hairline
Minerals	cal	Calcite
	carb	Carbonate
	kaol	Kaolinite
	mica	Mica flakes
	qtz	Quartz/silica
	py	Pyrite
	sid	Siderite

6.1.3 Data

Sample no.	Depth m	Plug type	Gas perm mD	Porosity %	Dens. g/ccm	Comment
301	200.88	Hor	-	8.08	2.548	mud, dgy
302	202.66	Hor	0.669	14.95	2.709	msst, lgy, mny cly cla
303	203.34	Hor	0.151	12.21	2.796	msst, lgy, mny cly cla
304	205.61	Hor	-	6.47	2.566	mud, dgy, w slg sly clv
305	208.10	Hor	-	14.59	2.689	msst, lgy, w 20% cl, FT FRC
306	209.20	Hor	-	10.70	2.586	mud, dgy, w sly clv, FR FRC
307	211.73	Hor	-	13.47	2.632	mud, dgy, w sly clv, FT FRC
308	218.36	Hor	-	12.28	2.720	mud, dgy, FT FRC
309	221.16	Hor	-	13.66	2.650	mud, dgy, w 20% msd, FT FRC
310	221.19	Hor	-	20.61	2.739	mud, dgy, w 30% msd & cds, FT FRC
311	221.98	Hor	0.513	9.77	2.683	mud, mgy, w 50% msd
312	223.41	Hor	-	5.25	2.692	msst, lgy
313	224.44	Hor	-	4.24	2.690	mud, mgy, w mny fsst cla
314	225.02	Hor	0.572	16.48	2.721	msst, mlgy, w 40% cl
315	227.90	Hor	-	11.51	2.634	mud, dgy, FT
316	228.42	Hor	0.351	9.23	2.928	mud, mlgy, FRC
317	233.83	Hor	-	9.10	2.617	mud, dgy, FT
318	238.21	Hor	-	5.42	2.578	mud, dgy, w 15% fsd & msd, FT FRC
319	242.11	Hor	-	7.83	2.610	mud, dgy, w 15% fsd & msd, w slg sly clv, FT FRC
320	242.30	Hor	-	5.74	2.586	mud, dgy, FT FRC
321	234.13	Hor	-	5.63	2.617	mud, dgy fds
322	243.68	Hor	-	5.78	2.612	mud, dgy, FT FRC
323	246.64	Hor	-	4.62	2.654	mud, mlgy
324	254.34	Hor	-	11.75	2.624	mud, dgy, w 10% fsd, w prt sly clv, FT FRC
325	255.49	Hor	0.162	9.88	2.815	csst, lgy
326	256.29	Hor	3.16	17.26	2.795	msst, lgy, FRC
327	257.96	Hor	-	2.71	2.475	mud, dgy, FT FRC
328	267.51	Hor	-	5.36	2.554	mud, dgy, w sly clv, FT FRC
329	267.92	Hor	-	3.51	2.528	mud, mgy, FRC
330	267.19	Hor	0.126	3.24	2.550	mud, mgy
331	269.56	Hor	-	3.28	2.492	mud, dgy, w 5% fds, w sly clv, FT FRC
332	270.02	Hor	-	2.00	2.701	msst, lgy
333	271.58	Hor	-	6.78	2.614	mud, dgy, w 10% msd, SG FRC
334	272.19	Hor	4.83	6.82	2.673	htrl, slt/mud, lgy/dgy, thn lam
335	273.85	Hor	-	6.65	2.690	mud, mgy, w 40% msd, FT FRC
336	274.91	Hor	-	12.79	2.631	mud, dgy, w 20% msd & cds, FT FRC
337	276.89	Hor	-	19.07	2.707	htrl, msst/mud, mgy/dgy, FT FRC
338	276.38	Hor	-	12.12	2.626	mud, dgy, w sly clv
339	278.01	Hor	2.68	14.39	2.775	htrl, msst & fsst/mud, mgy/dgy, FRC
340	279.41	Hor	0.356	15.60	2.787	htrl, msst & fsst/mud, mgy/dgy, FRC
341	280.65	Hor	0.126	5.91	2.659	mud, mgy, thn & thk lam, FRC
342	282.17	Hor	-	9.22	2.614	mud, dgy, FT FRC
343	321.38	Hor	-	15.06	2.584	mud, dgy, FT FRC
344	331.15	Hor	29.7	22.89	2.693	csst, mgy, w 20% cl, SG FRC