GEUS

Report file no.
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WESSEL-1

Conventional core analysis well: Wessel-1

Høier, C. & Andersen, P.R.

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DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 1997/138

Conventional Core Analysis

For Amerada Hess A/S

Well: Wessel - 1

GEUS Core Laboratory

Christian Høier and Palle Rubæk Andersen

Confidential report

Copy No.

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GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

GEUS

Contents

1. Introduction

By request of AMERADA HESS A/S, GEUS Core Laboratory has carried out conventional core analysis on the exploration well Wessel-1.

The analytical programme was specified by Mr. Mads Sørensen and included the following services:

- Spectral core gamma log
- Preservation of core and plug samples
- Conventional plug analysis
- Core photography
- Lithological description of plugs

GEUS Core Laboratory received core 1 from Wessel-1 on October 30, 1997. A preliminary spectral core gamma log and data report have been forwarded to AMERADA HESS A/S during November and December 1997.

2. Sampling and analytical procedure

The laboratory received core #1 from Wessel -1 taken in the interval 3037 - 3047 meter measured depth. The 10 cm diameter core was cut into sections of approximately 1 meter which were contained in aluminium sleeves. A list of core boxes is given in table 2.1.

2.1 Spectral core gamma log

A spectral gamma log of the cores was recorded using a scanning speed of 1 cm per minute. The cores were retained in the aluminium sleeves. All data were later adjusted for an average activity from the sleeve and background.

Incomplete filling of the aluminium sleeves can lead to erroneously low gamma activity at the junction between adjacent boxes. This effect has not been corrected on the core gamma log. However the extent of boxes are indicated as bars on the gamma log display to allow for evaluation.

2.2 Plugging

After the gamma scanning the sleeve was removed from the core and the following tasks were performed:

- 1 vertical plug was drilled at every meter of core (0 cm below top).
- 3 horizontal plugs were drilled at every meter of core (10, 40, 70 cm below top).
- 2 horizontal plugs were preserved at every second meter of core (55, 60 cm below top).
- 20 cm full core was preserved at every 3 meters (80 cm below top).

All the plugs were 1.5" diameter plugs and they were drilled using air as coolant. Dean-Stark was measured on every second horizontal plug. The full cores were cut using air as coolant. Figure 2.1 schematically shows the plugging program. A total of 48 plugs were drilled.

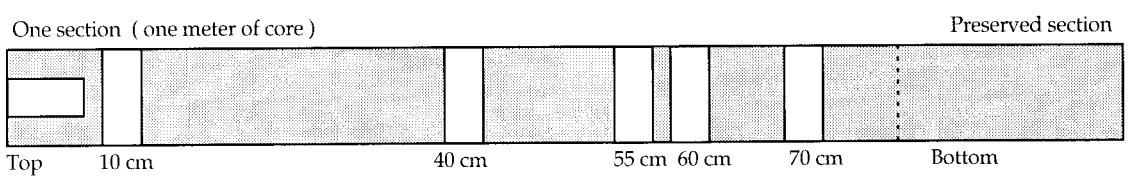


Figure 2.1: Plugging program illustrated on 1 meter of core. The grey areas represent the core and the white areas represent the plugs.

2.3 Preservation

A total of 3 full core sections were preserved by confinement in containers sealed by heat-shrinkable plastic hose. Simulated formation brine was added in the containers to keep the samples wet. A list of the chemical composition is given in table 2.3 and a lists of preserved core sections are given in table 2.1. A total of 16 1.5" plugs were preserved in a similar way. A lists of preserved 1.5" plugs are given in table 2.2. The preserved core sections and plugs are stored at GEUS.

2.4 Slabbing and core photography

After plugging the cores were slabbed and photographed in white light as well as UV light. The photographs are attached to this report. During slabbing a slice with a thickness of 1 cm was cut, mounted on metal trays and later stored with the core material at GEUS.

2.5 Conventional core analysis

The plugs were cleaned in Soxhlet extractors and then dried at 110°C. Conventional core analysis including He-porosity, grain density and gas permeability was performed. The permeability was measured using a sleeve pressure of 400 psi.

2.6 Lithological description

The plugs were lithologically described by a geologist, and the descriptions are included with the core data tabulations.

2.7 Tables for Wessel-1

Table 2.1 Wessel-1. List of core boxes and preserved intervals.

Core no. 1: 3037.50 - 3046.37 m.

Box	Depth [m]	Preserved interval
1	3037.50 - 3038.50	
2	3038.50 - 3039.50	3039.30 - 3039.50
3	3039.50 - 3040.50	
4	3040.50 -3041.50	
5	3041.50 -3042.50	3042.27 -3042.50
6	3042.50 -3043.50	
7	3043.50 -3044.50	3044.22 -3044.50
8	3044.50 -3045.60	
9	3045.60 -3046.37	

Table 2.2 Wessel-1. List of preserved 1.5 inch plugs.

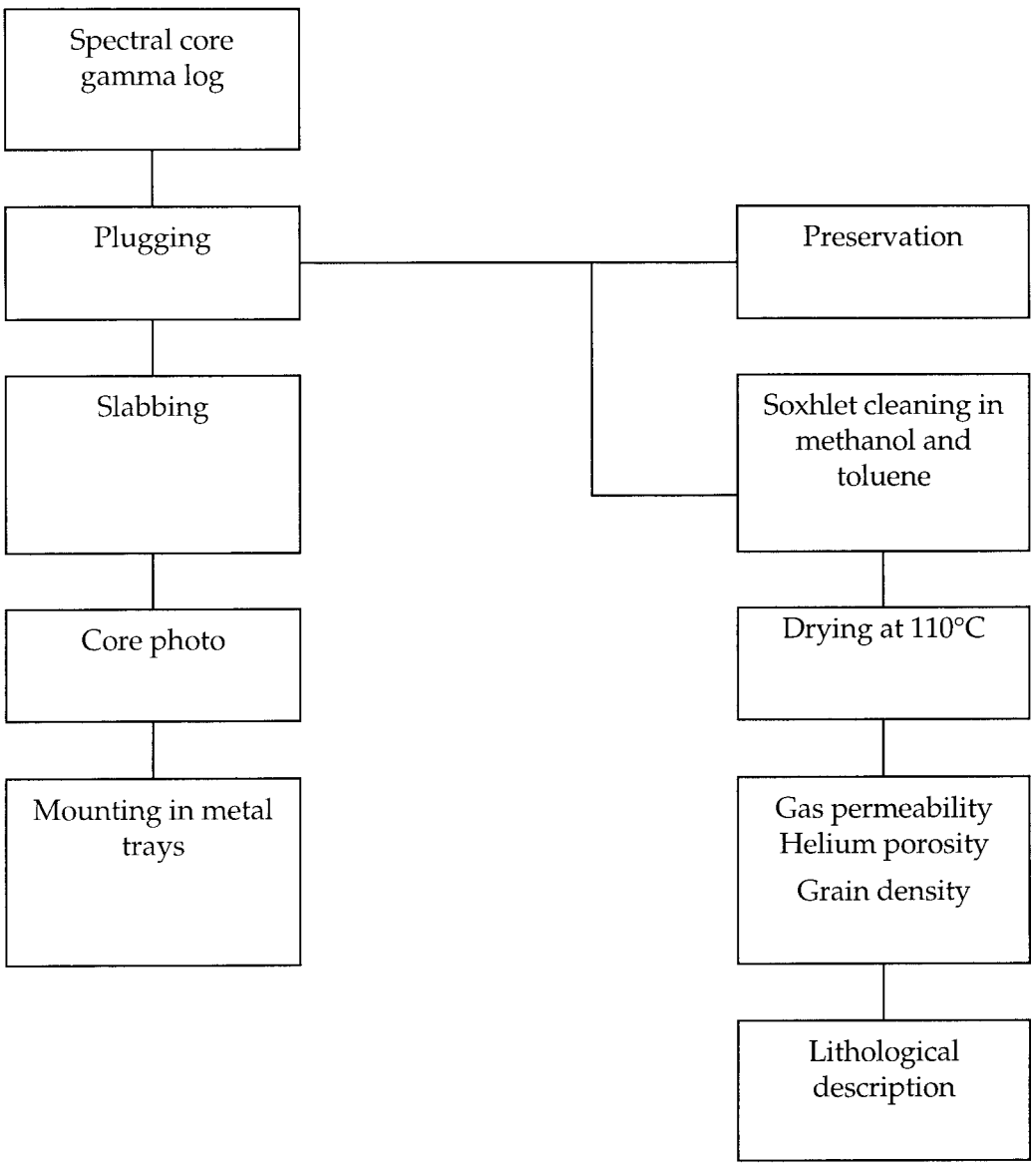
Plug	Core	Box	Depth
501	1	1	3038.05
502		1	3038.10
503		2	3039.05
504		2	3039.10
505		3	3040.05
506		3	3040.10
507		4	3041.10
508		4	3041.15

Plug	Core	Box	Depth
509	1	5	3042.05
510		5	3042.10
511		6	3043.05
512		6	3043.10
513		7	3044.05
514		7	3044.10
515		8	3045.05
516		8	3045.10

Table 2.3 Chemical composition of the simulated Wessel -1 formation brine.

Component	Concentration [mg/l]
Cl^-	32500
Na^+	17400
K^+	1000
Ca^{2+}	1040
Mg^{2+}	170
TDS	52110

3. Flow chart of the analytical procedure



4. Analytical methods

The following is a short description of the methods used by the GEUS Core 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, with the gamma activity being 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 reported in counts per minute (cpm). The following empirical relationship between cpm and GAPI has been established.

cpm = 18.2*GAPI

The relationship should be used as a guideline only. Radiation from decay of potassium and the uranium and thorium decay series are recorded in separate energy windows. Concentrations are calculated using synthetical 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 size of 1.5" diameter and 2.5" 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 110°C.

4.3 Gas permeability

The plug is mounted in a Hassler core holder, and a confining pressure of 400 psi is 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 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 reproducibility (precision) of the total gamma activity analysis is calculated from counting statistics. The following list shows the dependency of reproducibility on count rate at the 2 standard deviation level.

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)
Reproducibility			
Normal to high range	0.06	0.57	1.08
Low range (LLD)	0.02	0.21	0.31
Accuracy	0.06	0.13	0.31

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 of conventional core analysis

The results are presented in the following data listing and in frequency plots of:

- Gas permeability
- Porosity
- Grain density
- A core log plotting Depth vs.
  Gas permeability , Porosity , Grain density, Water saturation, Oil saturation and Gas saturation.
- A spectral gamma log plotting Depth vs.
  Thorium , Uranium , Potassium , Total gamma activity.
- Core photography

5.1 Lithological descriptions of plugs from Wessel-1

Plug no.	Lithological descriptions
1	unsrt, msst/csst, lgy,ids bed
2	unsrt, msst/csst, lgy,ids bed, w shl
3	unsrt, fsst/msst, lgy, bed, bio, ccem
4	unsrt, fsst/msst, lgy, ids bed
5	unsrt, fsst/msst, lgy, bed, ccem
6	unsrt, fsst/msst, lgy, ids bed, ccem
7	unsrt, fsst/msst/csst, lgy, ids bed
8	unsrt, fsst/msst/csst, lgy, w cla, ccem
9	unsrt, fsst/msst/csst, lgy, w cla, ccem
10	unsrt, fsst/msst/csst, lgy, w cla, carb cem
11	unsrt, fsst/msst, lgy, ids bed, ccem
12	unsrt, fsst/msst/csst, lgy, bio, ccem
13	unsrt, fsst/msst/csst, lgy, ids bed, bio, FT FRC
14	unsrt, fsst/msst, lgy, ids bed
15	unsrt, fsst/msst, lgy, bed, bio
16	unsrt, fsst/msst, lgy, bed
17	msst, lgy, ids bed
18	msst, lgy, hom
19	csst, lgy, ids bed
20	csst, lgy, ids bed, sme ccem
21	csst, lgy, ids bed, sme ccem
22	unsrt, msst/csst, lgy, ids bed
23	unsrt, msst/csst, lgy, hom, sme ccem
24	fsst, lgy, ids bed
25	fsst, lgy, ids bed, w cla
26	fsst, lgy, w cla
27	unsrt, msst/csst, lgy, ids bed, FT FRC
28	fsst, lgy, ids bed, slg ccem
29	fsst, lgy, ids bed, slg ccem
30	fsst, lgy, ids bed, w shl
31	fsst, lgy, bio, ccem
32	htrl, slt/cly, lgy, bed, bio, calc

ABBREVITATION 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
	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

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND

GEUS CORE LABORATORY

CORE ANALYSIS TABULATION

Final report

Compiled by Christian Høier

WELL : Wessel - 1

CORE : 1

Printed : 19-DEC-97

GENERAL INFORMATION ON THE ANALYSIS

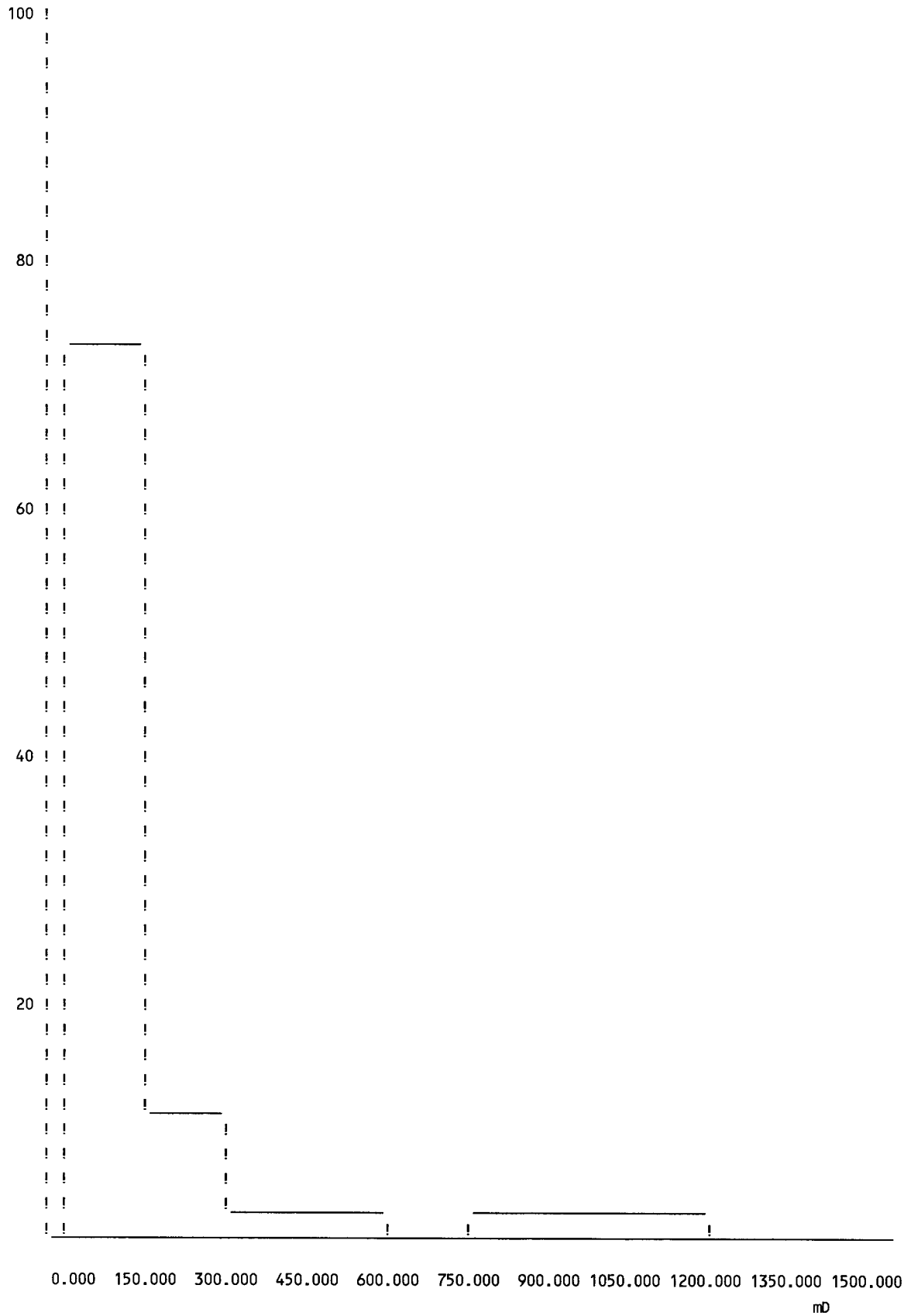
COMPANY	: Amerada Hes	LOCATION	: Danish Northn Sea
DEPTH INTERVAL	: 3037.50 - 3046.37	CORE NO.'S	: 1
DEPTHS ARE MEASURED FROM KB		ANALYSTS	: HJL,GG,MJ
DEPTHS ARE IN METRES		DATE	: 161297
PROGRAM POPE V.5.8		FILE	: WESSEL1

REMARKS :

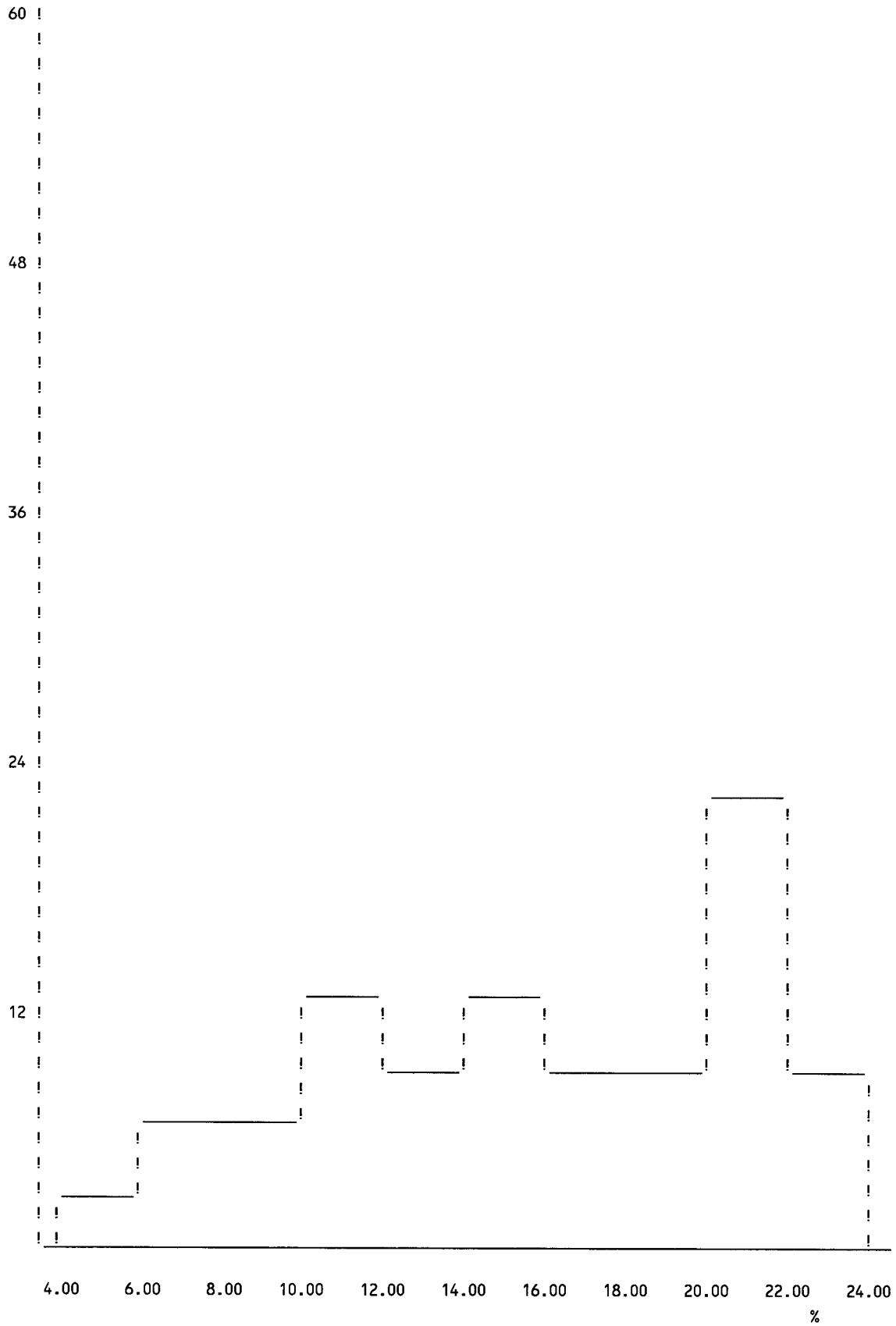
SAMPLE NO.	DEPTH METER	PLUG TYPE	GAS PERM mD	POROSITY %	GRAIN DENS. G/CCM	WATER SATUR. %	OIL SATUR. %	GAS SATUR. %	COMMENT
1	3037.50	VERT	3.13	20.55	2.681				
2	3037.60	HOR	2.58	19.54	2.688				
3	3037.90	HOR	0.335	11.97	2.688	78	8	13	
4	3038.20	HOR	1.08	18.59	2.697				
5	3038.50	VERT	0.063	10.23	2.712				
6	3038.60	HOR	0.095	8.72	2.723	71	20	9	
7	3038.90	HOR	0.700	15.47	2.720				
8	3039.20	HOR	0.084	8.89	2.725	71	19	10	
9	3039.50	VERT	0.078	7.33	2.752				
10	3039.60	HOR	0.004	5.92	2.749				
11	3039.90	HOR	0.074	7.88	2.729	78	15	6	
12	3040.15	HOR	0.827	14.20	2.717				
13	3040.90	HOR		16.67	2.718				
14	3041.00	VERT		15.71	2.681				
15	3041.20	HOR	0.454	11.58	2.693	77	12	11	
16	3041.50	VERT	27.8	21.30	2.661				
17	3041.60	HOR	171	22.41	2.657				
18	3041.85	HOR	88.2	20.94	2.666	65	26	9	
19	3042.20	HOR	267	20.02	2.664				
20	3042.53	VERT	2.05	13.72	2.683				
21	3042.60	HOR	0.608	10.90	2.688	78	12	10	
22	3042.90	HOR	180	17.13	2.670				

SAMPLE NO.	DEPTH METER	PLUG TYPE	GAS PERM mD	POROSITY %	GRAIN DENS. G/CCM	WATER SATUR. %	OIL SATUR. %	GAS SATUR. %	COMMENT
23	3043.20	HOR	96.6	15.07	2.670	68	24	8	
24	3043.50	VERT	395	20.81	2.659				
25	3043.60	HOR	898	20.93	2.660				
26	3043.90	HOR	997	22.62	2.663	50	33	17	
27	3044.20	HOR	1060	22.36	2.662				
28	3044.50	VERT	30.7	19.05	2.669				
29	3044.60	HOR	96.6	16.95	2.675	72	16	12	
30	3044.90	HOR	567	20.66	2.664				
31	3045.15	HOR	4.61	12.70	2.696	81	10	9	
32	3045.80	HOR	4.67	13.30	2.781				

% OF SAMPLES DISTRIBUTION OF GAS PERMEABILITY
N = 30



% OF SAMPLES DISTRIBUTION OF POROSITY
N = 32



% OF SAMPLES

DISTRIBUTION OF GRAIN DENSITY
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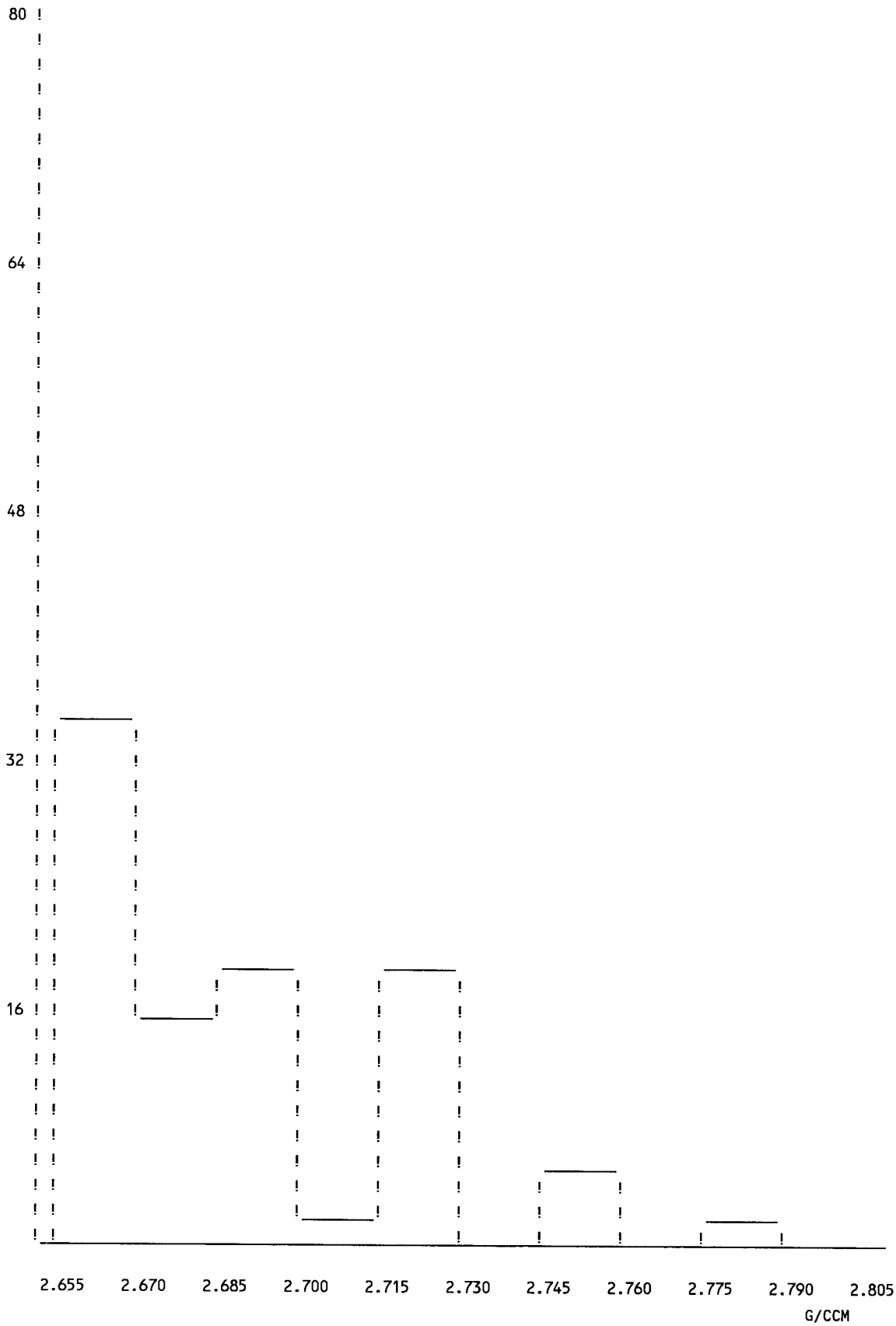
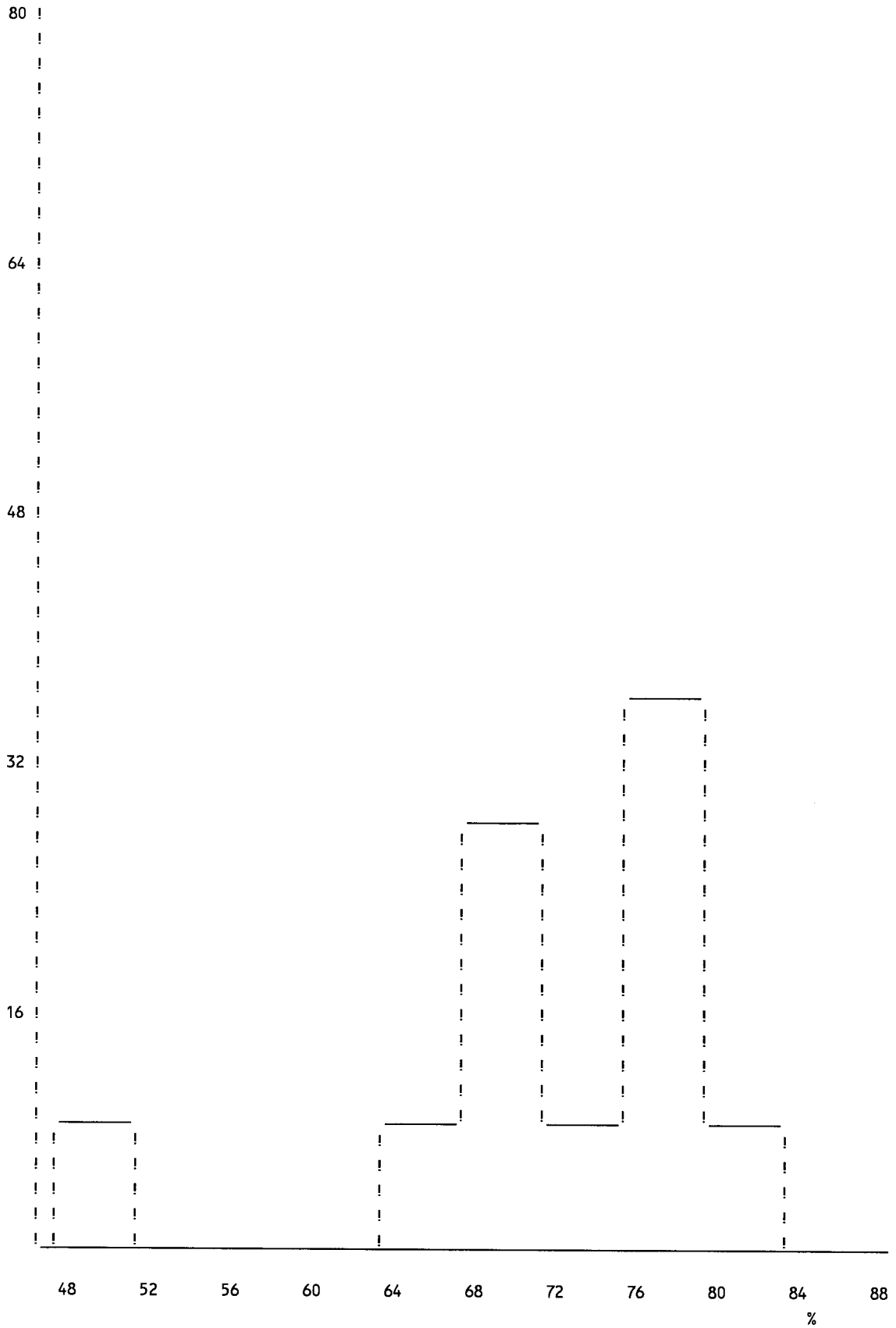


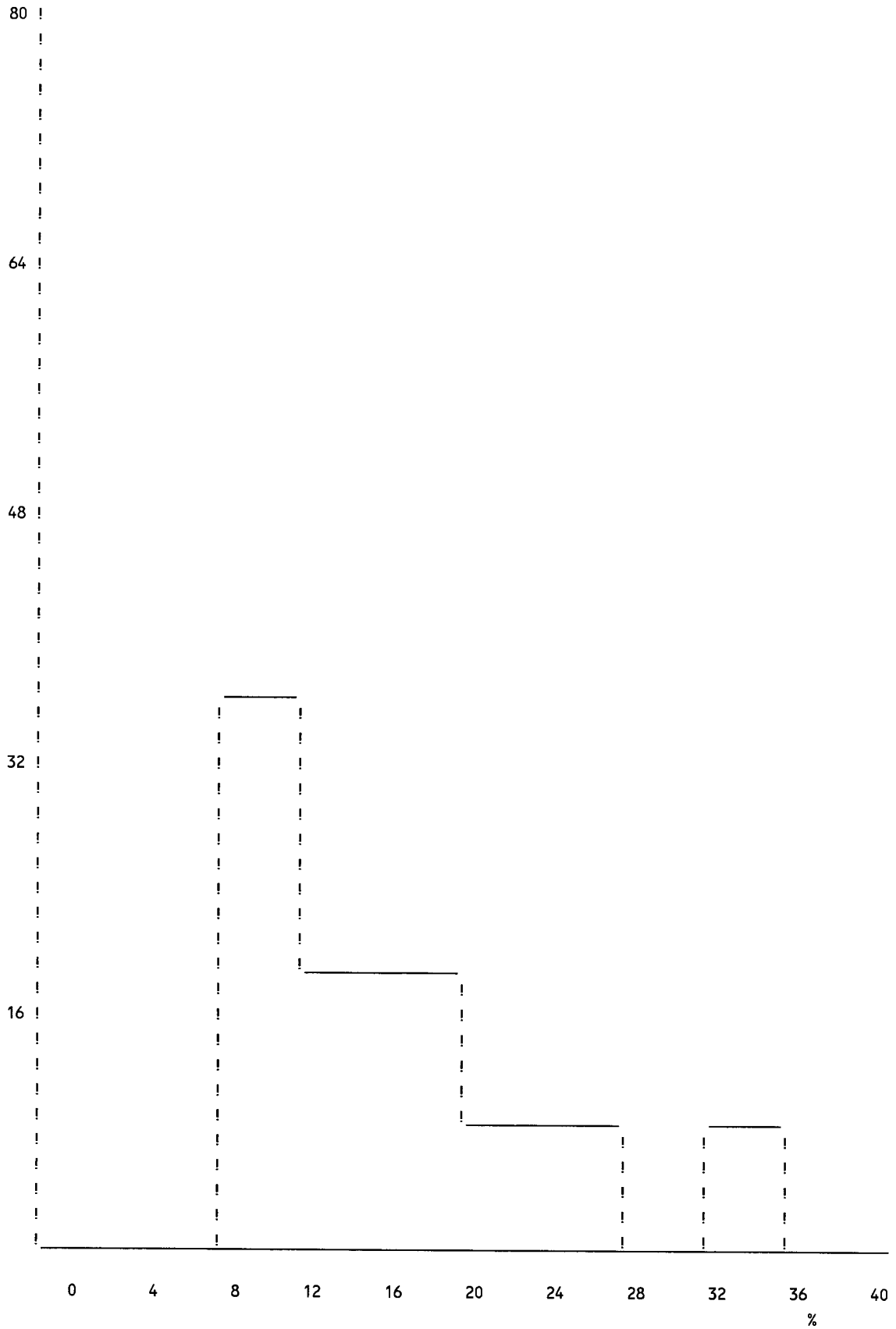
% OF SAMPLES

DISTRIBUTION OF WATER SATURATION
N = 11

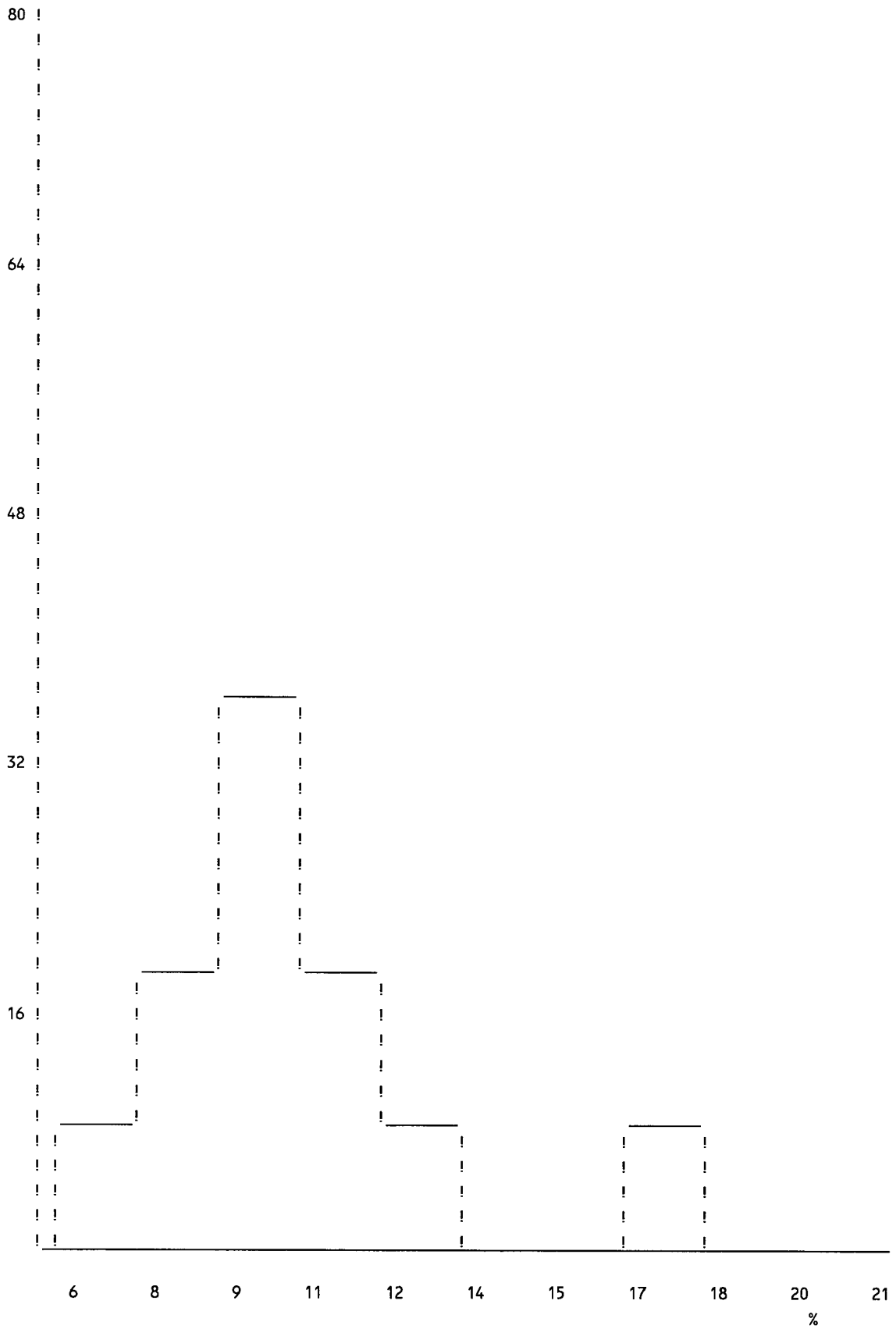


% OF SAMPLES

DISTRIBUTION OF OIL SATURATION
N = 11



% OF SAMPLES DISTRIBUTION OF GAS SATURATION
N = 11



STATISTICAL INFORMATION ON THE POROSITY - GAS PERMEABILITY RELATIONSHIP
CALCULATED ONLY FROM SAMPLES WITH NON-ZERO PERMEABILITY.

NUMBER OF SAMPLES : 30

SINGLE-SAMPLE STATISTICS:

POROSITY:

MEAN POROSITY	:	15.73	%
VARIANCE ON POROSITY	:	26.95	%**2

PERMEABILITY:

GEOMETRIC AVERAGE	:	6.07	mD
ARITHMETRIC AVERAGE	:	163.21	mD
HARMONIC AVERAGE	:	0.10	mD

STATISTICS CALCULATED FROM LINEAR REGRESSION OF PERMEABILITY ON POROSITY:

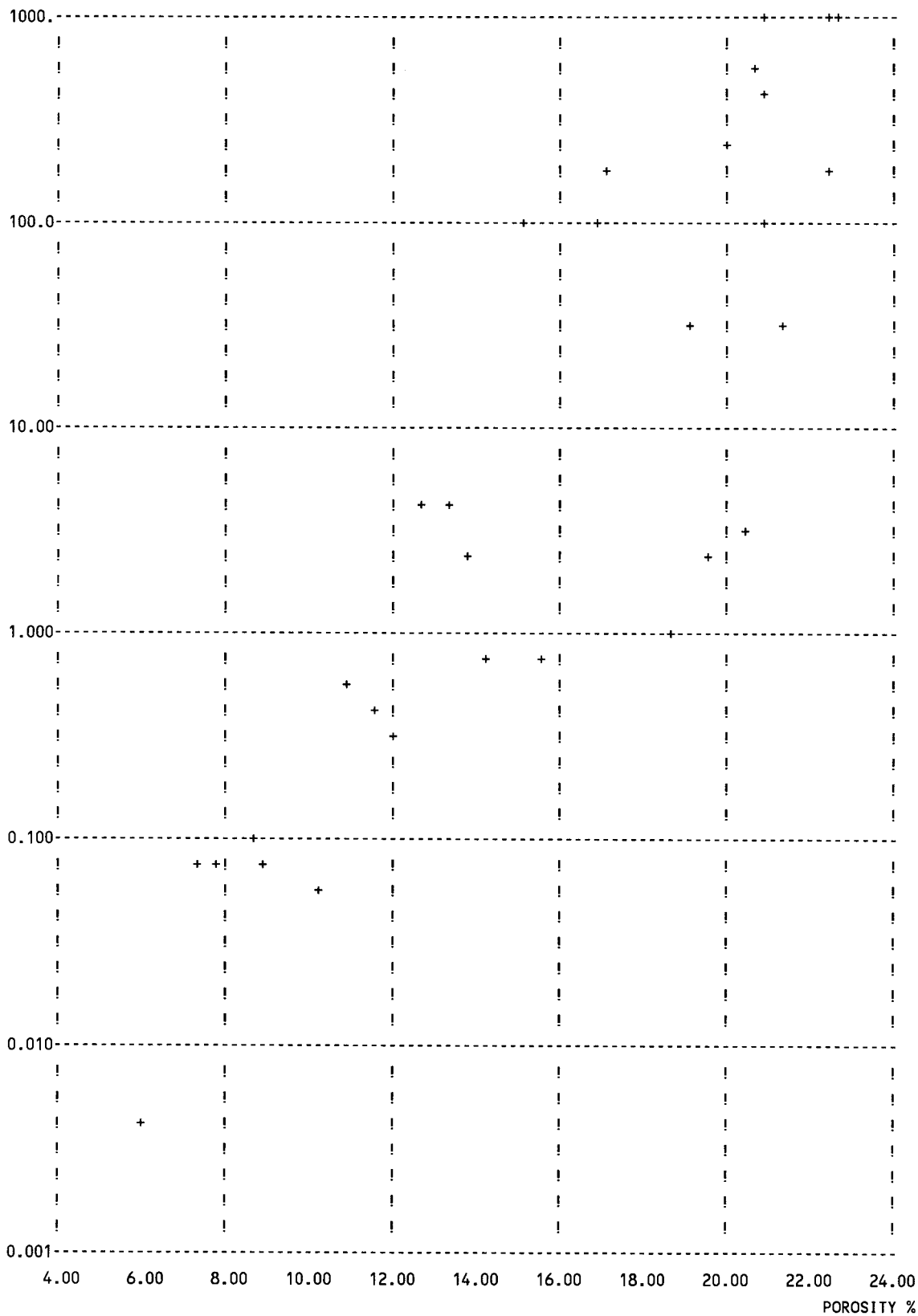
MODEL: LOG10(PERMEABILITY) = INTERCEPT + SLOPE*POROSITY + RESIDUAL

DEGREES OF FREEDOM	:	28	
COEFFICIENT OF DETERMINATION	:	0.768	
STANDARD ERROR ON THE REGRESSION	:	0.752	log(mD)
ESTIMATED INTERCEPT	:	-3.290	log(mD)
ESTIMATED STANDARD ERROR ON INTERCEPT	:	0.445	log(mD)
ESTIMATED SLOPE	:	0.25905	log(mD)/%
ESTIMATED STANDARD ERROR ON SLOPE	:	0.02692	log(mD)/%

PLEASE REMARK THAT THE REGRESSION STATISTICS PERTAIN TO LOG PERMEABILITY VALUES.
THE COEFFICIENT OF DETERMINATION GIVES THE FRACTION AF THE TOTAL VARIATION SQUARED
WHICH IS EXPLAINED BY THE MODEL.
THE STANDARD ERROR ON THE REGRESSION GIVES THE MEAN 1 SIGMA ERROR ON THE LOG
PERMEABILITY ESTIMATES.

GAS PERMEABILITY
mD (Log)

CORE : 1



Well: Wessel-1
Core: 1

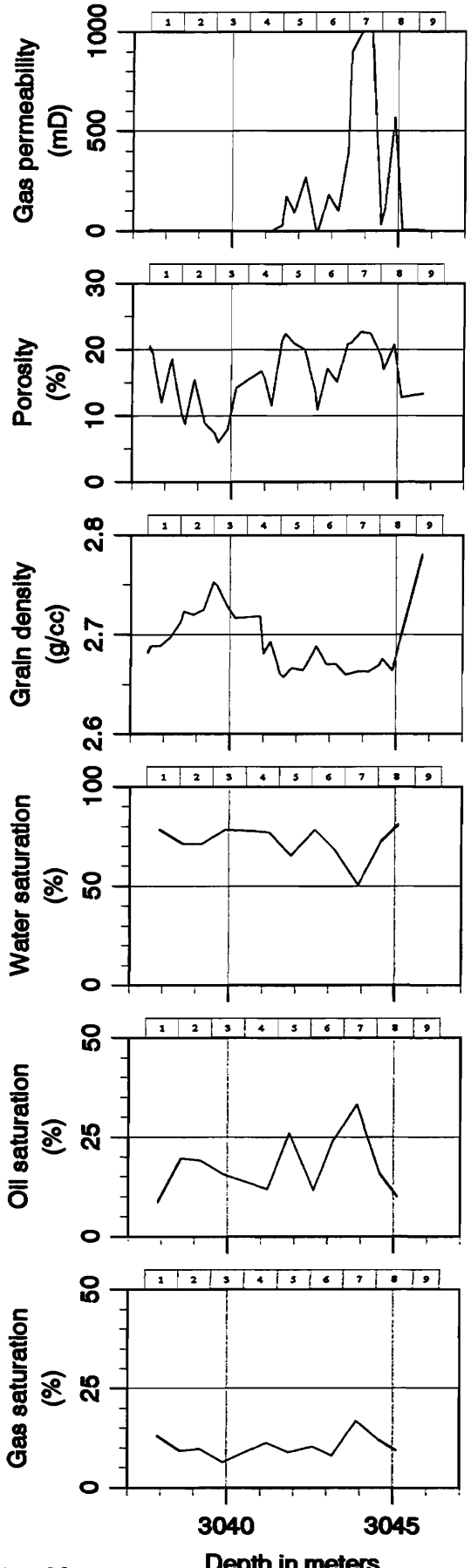
Core log

Depth vs.
- Gas perm.
- Porosity
- Grain dens.
- Water sat.
- Oil sat.
- Gas sat.

Scale 1:200

Legend

Core 1



GEUS Core Analysis Laboratory, 6-JAN-98

Well: Wessel-1
Core: 1

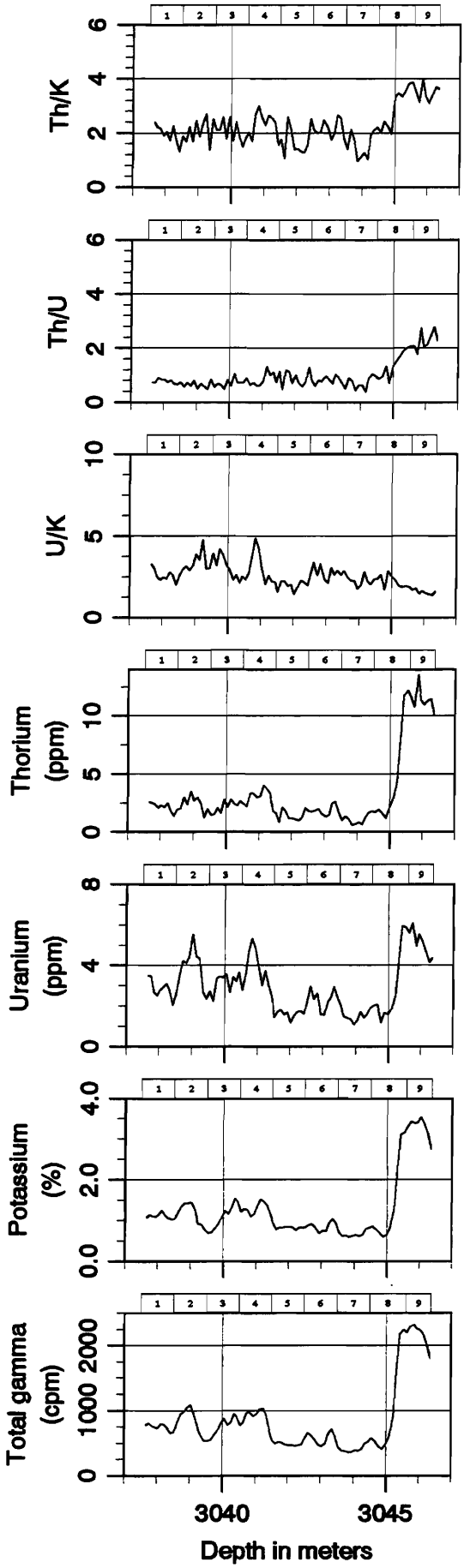
Spectral core gamma log

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

Scale 1:200

Legend

Core 1



GEUS Core Analysis Laboratory, 6-JAN-98

AMERADA HESS WESSEL - 1

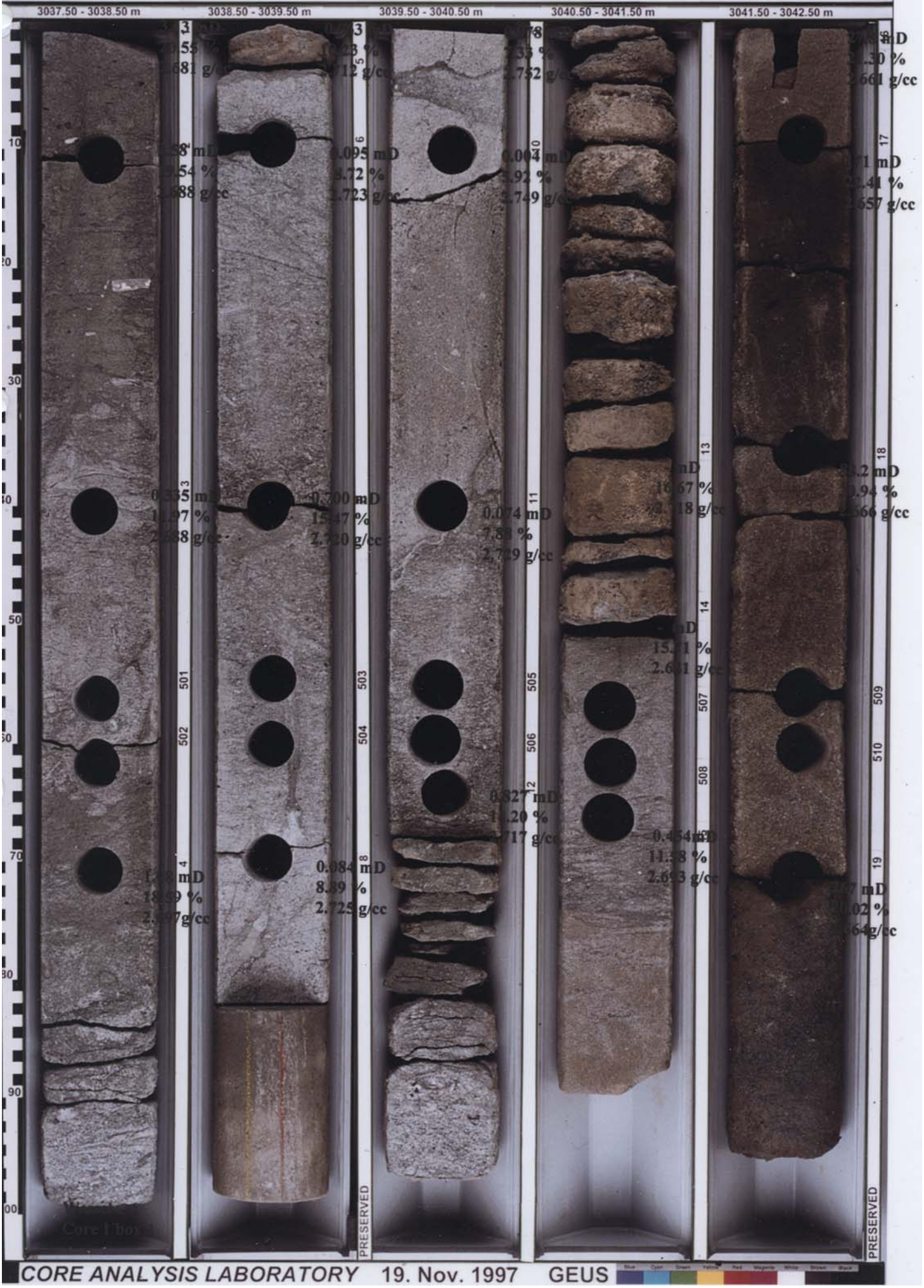
CORE 1

BOX 1	BOX 2	BOX 3	BOX 4	BOX 5
3037.50 - 3038.50 m	3038.50 - 3039.50 m	3039.50 - 3040.50 m	3040.50 - 3041.50 m	3041.50 - 3042.50 m

CORE ANALYSIS LABORATORY 19. Nov. 1997 GEUS

AMERADA HESS — WESSEL - 1

CORE 1



3.13 mD 20.55 % 2.681 g/cc	0.063 mD 10.23 % 2.712 g/cc	0.078 mD 7.33 % 2.752 g/cc		27.8 mD 21.30 % 2.661 g/cc
2.58 mD 19.54 % 2.688 g/cc	0.095 mD 8.72 % 2.723 g/cc	0.004 mD 5.92 % 2.749 g/cc		171 mD 22.41 % 2.657 g/cc
0.335 mD 11.97 % 2.688 g/cc	0.700 mD 15.47 % 2.720 g/cc	0.074 mD 7.88 % 2.729 g/cc	- mD 16.67 % 2.718 g/cc	88.2 mD 20.94 % 2.666 g/cc
			- mD 15.71 % 2.681 g/cc	
1.08 mD 18.59 % 2.697g/cc	0.084 mD 8.89 % 2.725 g/cc	0.827 mD 14.20 % 2.717 g/cc	0.454mD 11.58 % 2.693 g/cc	267 mD 20.02 % 2.664g/cc

Wessel - 1
Core 1 box 1

AMERADA HESS WESSEL - 1

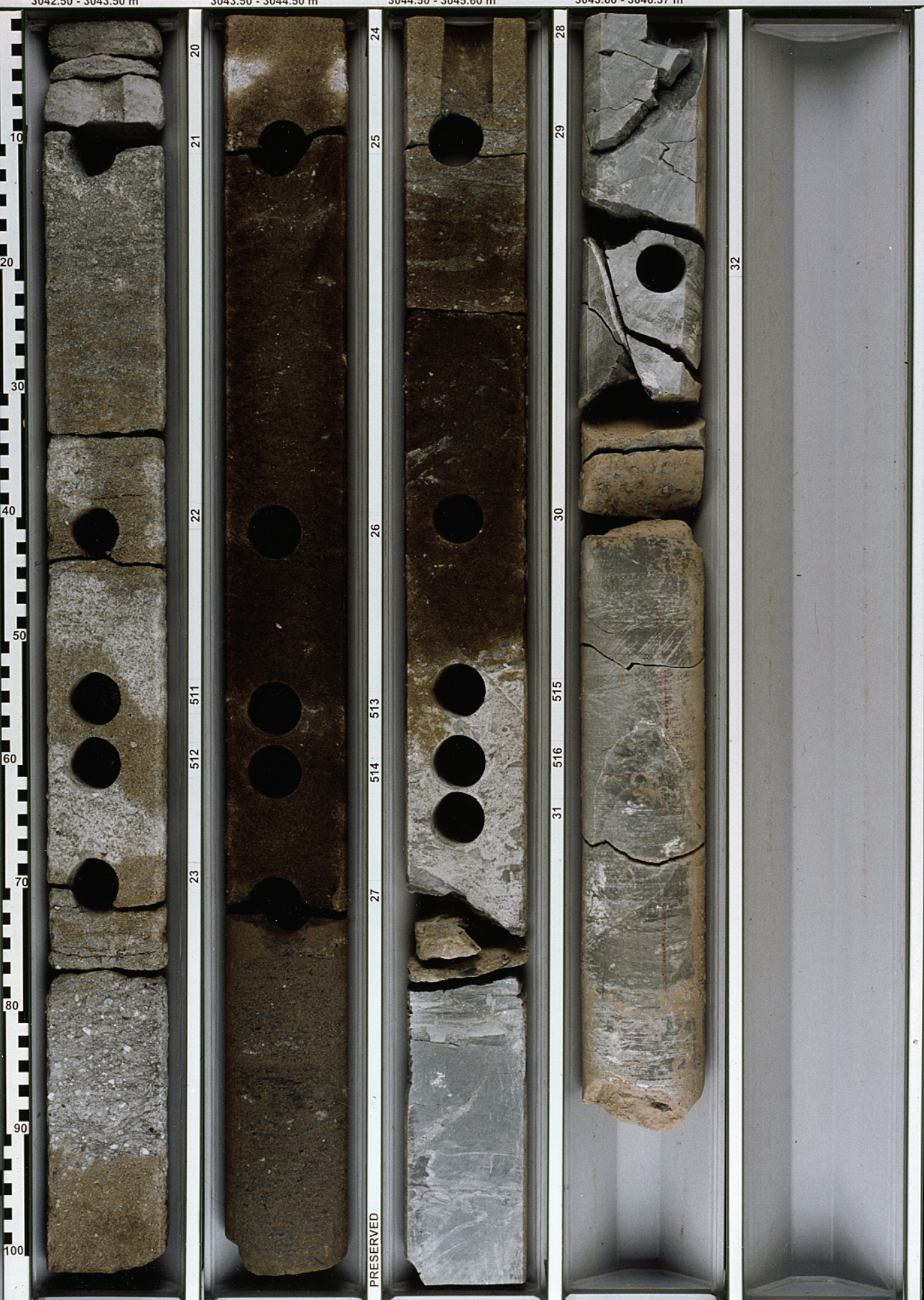
CORE 1

BOX 6 3042.50 - 3043.50 m

BOX 7 3043.50 - 3044.50 m

BOX 8 3044.50 - 3045.60 m

BOX 9 3045.60 - 3046.37 m



CORE ANALYSIS LABORATORY 19. Nov. 1997 GEUS

AMERADA HESS

WESSEL - 1

CORE 1

BOX 6 | BOX 7 | BOX 8 | BOX 9

3042.50 - 3043.50 m | 3043.50 - 3044.50 m | 3044.50 - 3045.60 m | 3045.60 - 3046.37 m

2.05 mD

395 mD

30.7 mD

10.90 %

2.688 g/cc

20.93 %

2.660 g/cc

15.95 %

2.675 g/cc

67 mD

15.36 %

2.781 g/cc

180 mD

17.13 %

2.670 g/cc

4.61 mD

12.70 %

2.596 g/cc

96.6 mD

15.07 %

PRESERVED

CORE ANALYSIS LABORATORY 19. Nov. 1997 GEUS

2.05 mD 13.72 % 2.683 g/cc	395 mD 20.81 % 2.659 g/cc	30.7 mD 19.05 % 2.669 g/cc	
0.608 mD 10.90 % 2.688 g/cc	898 mD 20.93 % 2.660 g/cc	96.6 mD 16.95 % 2.675 g/cc	
			4.67 mD 13.30 % 2.781 g/cc
180 mD 17.13 % 2.670 g/cc	997 mD 22.62 % 2.663 g/cc	567 mD 20.66 % 2.664 g/cc	
		4.61 mD 12.70 % 2.696 g/cc	
96.6 mD 15.07 % 2.670 g/cc	1060 mD 22.36 % 2.662 g/cc		

Wessel - 1
Core 1 box 6