

Denne rapport
tilhører



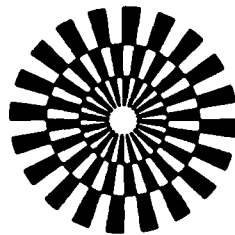
L&U DOK.SENTER

L.NR. 20084430035

KODE Well 31/2-13 or 15

Returneres etter bruk

A/S NORSKE SHELL
SPECIAL CORE ANALYSIS
WELL: 31/2-13
DATE: OCTOBER 1984



GECO
GEOPHYSICAL COMPANY
OF NORWAY A/S

SH01

P5.12.04-01

31/2-13



A/S NORSKE SHELL
SPECIAL CORE ANALYSIS
WELL: 31/2-13
DATE: OCTOBER 1984



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COMMENTS

- GENERAL: Special core analyses have been completed on 10 samples from well 31/2-13 at the depths agreed upon by A/S Norske Shell. The samples were all unconsolidated, cylindrical plugs of 1 inch diameter.
- PREPARATION: All plugs were drilled from frozen core material according to the sample list. All samples seemed to friable to withstand the cleaning process used for consolidated samples. The plug samples were therefore installed in triaxial cells. A light confining pressure of 5 bar was set when the plugs were thawing. The plugs were cleaned by cold solvent flushing and later dried by a lenient air flow. The solvents used were first methanol, then toluene and finally methanol
- MEASUREMENTS: Net overburden pressure was set in laboratory without any Geertsma-factor correction. All samples were installed in a triaxial holder for measurement of air permeability and helium porosity at various confining pressures. The "atmospheric" pressure was set to 15 bar to avoid leakage along the sleeve and the sample plug. The confining pressure levels were as follows: 15 bar, 100 bar, 150 bar and 200 bar. Both tabular and graphic compilations have been enclosed in this report.



POROSITY AND GRAIN DENSITY

After installed in the triaxial cell, each sample was injected with a known volume of helium at the various confining pressures. Pore volume was thus determined. After dismantling each sample was measured for grain volume using a Boyle's law porosimeter. Knowing, in addition, the weight of the sample, porosity and grain density were calculated.

AIR PERMEABILITY

Air permeability was measured using nitrogen at four different pressures. These values were the basis for calculating the Klinkenberg corrected permeability. All samples were measured in a triaxial cell at the requested confining pressures.



PLUG SIZE

Sample no.	Depth (m)	Length (cm)	Diameter (cm)
1	1778.08	4.11	2.58
2	1779.68	4.40	2.54
3	1780.50	3.23	2.55
4	1780.76	3.63	2.58
5	1784.40	3.99	2.59
6	1788.07	3.18	2.55
7	1788.38	3.20	2.60
8	1790.60	3.51	2.59
9	1801.14	2.16	2.57
10	1805.10	3.30	2.58



POROSITY AND GRAIN DENSITY

Sample no.	Depth (m)	"Atmospheric" Porosity (%)	Grain Density(g/cm ³)
1	1778.08	35.4	2.66
2	1779.68	37.4	2.65
3	1780.50	33.8	2.63
4	1780.76	36.1	2.63
5	1784.40	35.8	2.66
6	1788.07	38.2	2.64
7	1788.38	36.1	2.63
8	1790.60	37.7	2.64
9	1801.14	38.1	2.61
10	1805.10	33.7	2.62



KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 1

Depth: 1778.08 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{e1} (mD)
15	0.898	2368	2111
	0.791	2320	
	0.663	2287	
	0.501	2256	
100	0.890	2254	1905
	0.804	2223	
	0.658	2157	
	0.501	2104	
150	0.903	2159	1809
	0.800	2112	
	0.666	2055	
	0.505	2007	
200	0.891	2005	1743
	0.795	1976	
	0.668	1941	
	0.502	1890	

KLINKENBERG CORRECTED AIR PERMEABILITY



Sample no : 1

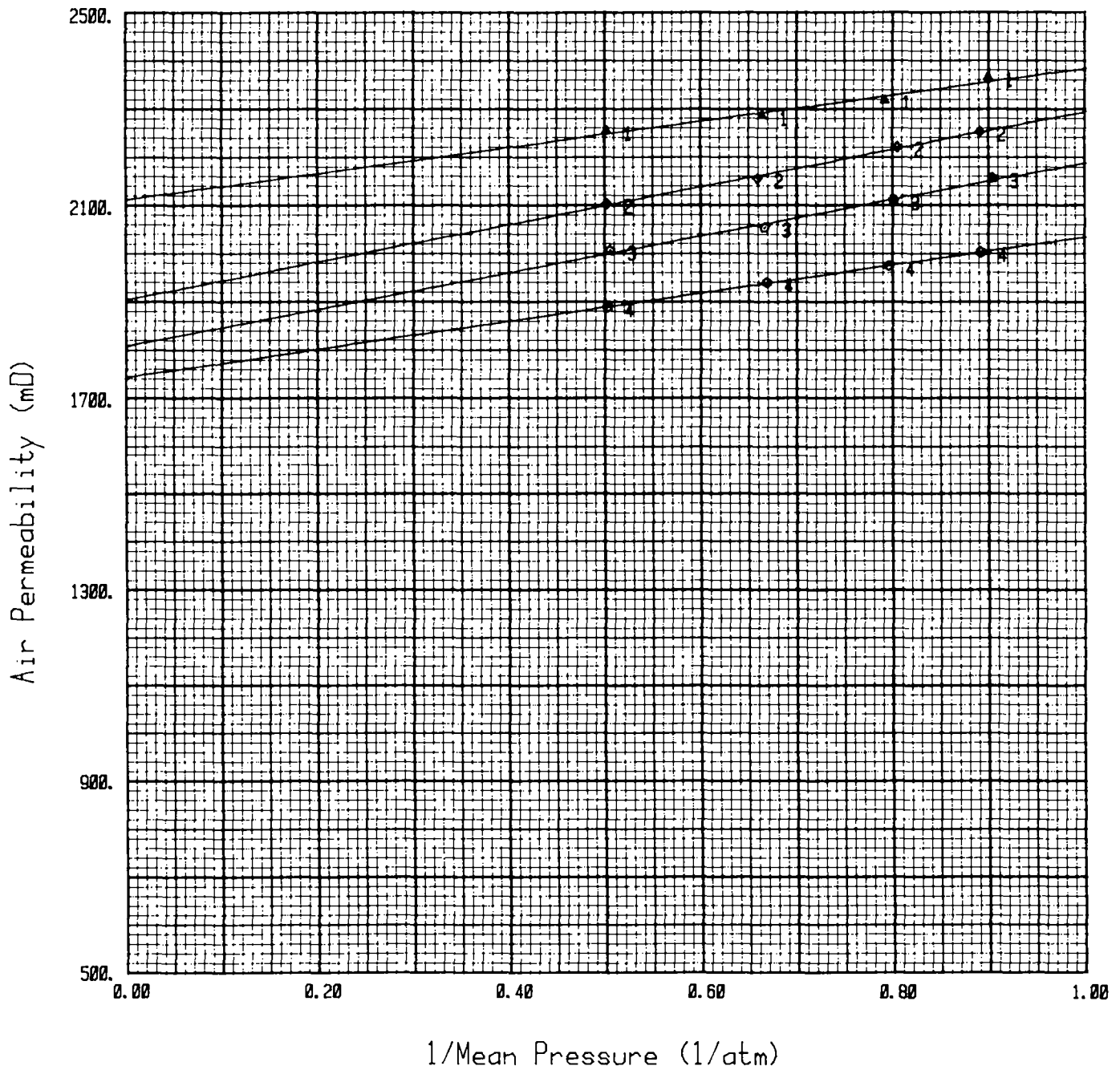
Depth (m): 1778.08

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 2111 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 1905 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 1809 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 1743 mD





KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 2

Depth: 1779.68 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{el} (mD)
15	0.901	15210	14043
	0.796	15035	
	0.665	14937	
	0.501	14674	
100	0.922	9777	8870
	0.805	9640	
	0.665	9547	
	0.503	9352	
150	0.902	7846	7229
	0.799	7733	
	0.668	7694	
	0.502	7561	
200	0.906	6651	5917
	0.796	6548	
	0.665	6477	
	0.500	6313	

KLINKENBERG CORRECTED AIR PERMEABILITY



Sample no : 2

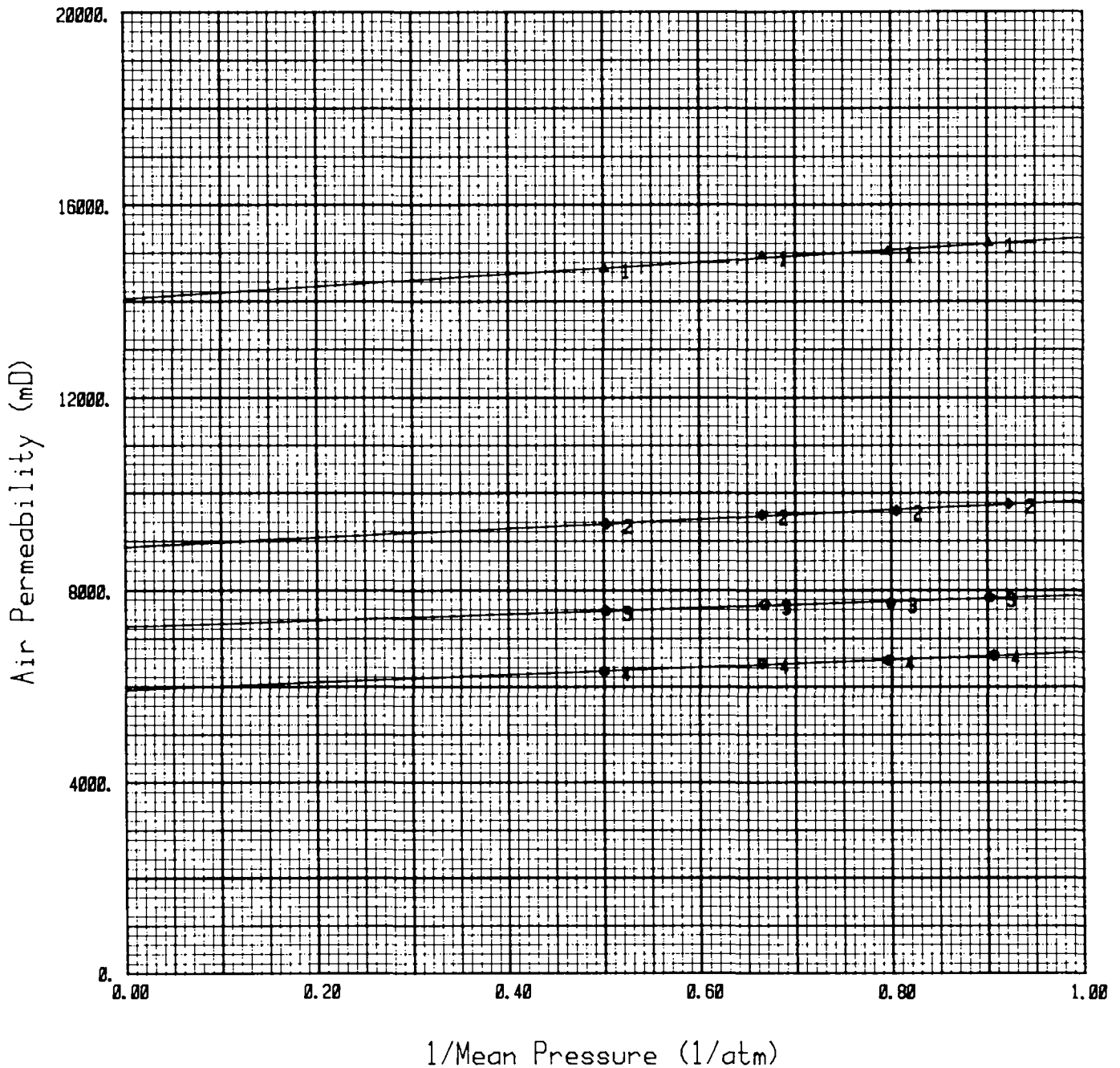
Depth (m): 1779.68

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 14043 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 8870 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 7229 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 5917 mD





KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 3

Depth: 1780.50 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{el} (mD)
15	0.904	7660	6167
	0.802	7511	
	0.669	7302	
	0.501	6989	
100	0.899	5302	4400
	0.805	5220	
	0.665	5098	
	0.497	4891	
150	0.906	4358	3575
	0.793	4254	
	0.668	4183	
	0.500	3996	
200	0.911	3460	2841
	0.798	3387	
	0.660	3314	
	0.498	3172	

KLINKENBERG CORRECTED AIR PERMEABILITY



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Sample no : 3

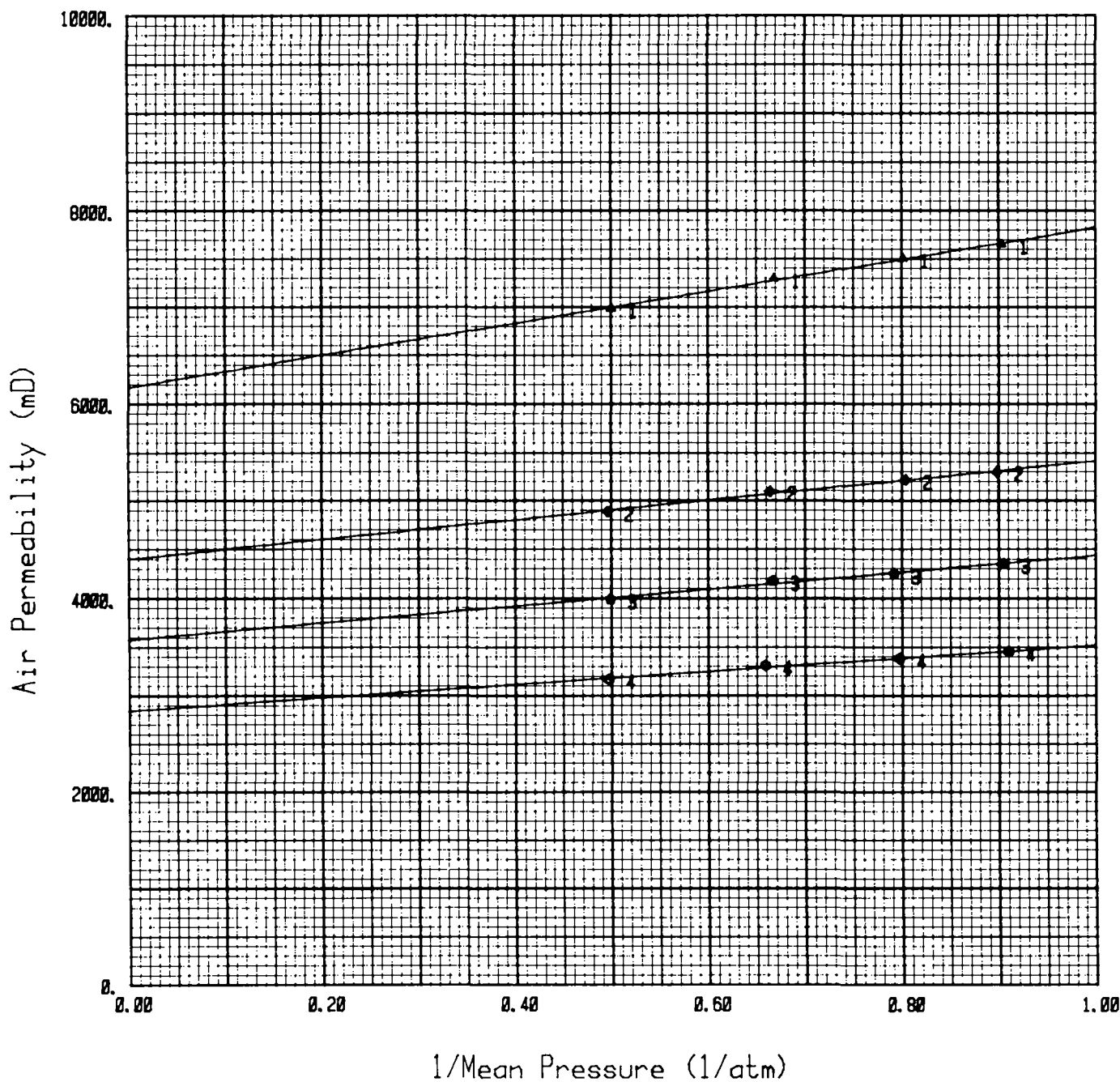
Depth (m): 1780.50

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 6167 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 4400 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 3575 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 2841 mD





KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 4

Depth: 1780.76 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{e1} (mD)
15	0.900	11265	9610
	0.795	11081	
	0.667	10905	
	0.504	10516	
100	0.909	7944	6583
	0.805	7809	
	0.573	7615	
	0.504	7333	
150	0.906	6423	5596
	0.792	6310	
	0.655	6218	
	0.501	6043	
200	0.906	5630	4840
	0.798	5535	
	0.673	5460	
	0.500	5266	

KLINKENBERG CORRECTED AIR PERMEABILITY



Sample no : 4

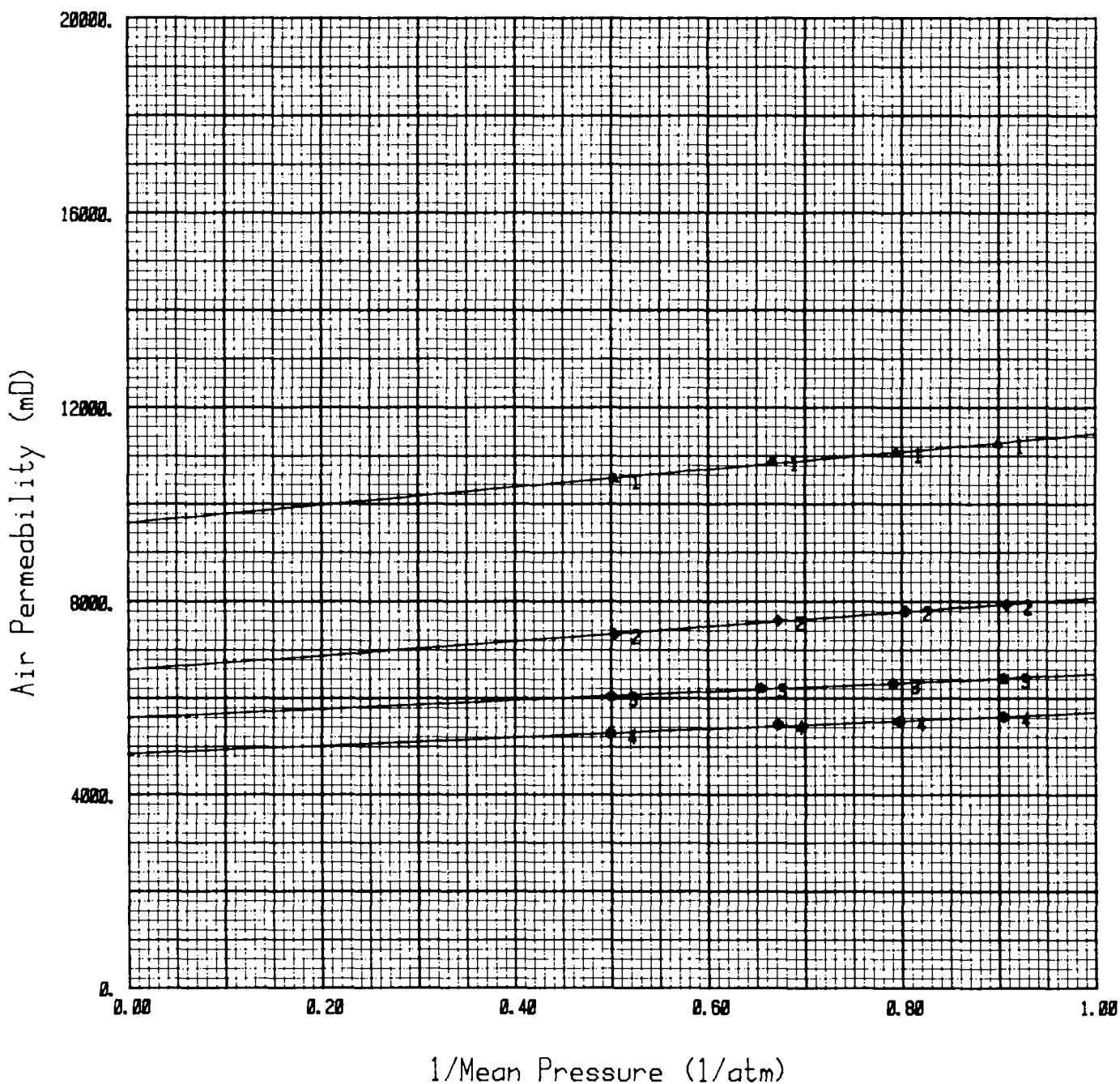
Depth (m): 1780.76

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 9610 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 6583 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 5596 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 4840 mD





KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 5

Depth: 1784.40 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{el} (mD)
15	0.903	11219	9758
	0.796	11123	
	0.662	10863	
	0.500	10571	
100	0.902	7013	5979
	0.801	6924	
	0.665	6784	
	0.502	6546	
150	0.903	5794	5021
	0.806	5712	
	0.656	5600	
	0.496	5440	
200	0.901	4928	4250
	0.800	4863	
	0.666	4793	
	0.496	4612	

KLINKENBERG CORRECTED AIR PERMEABILITY



Sample no : 5

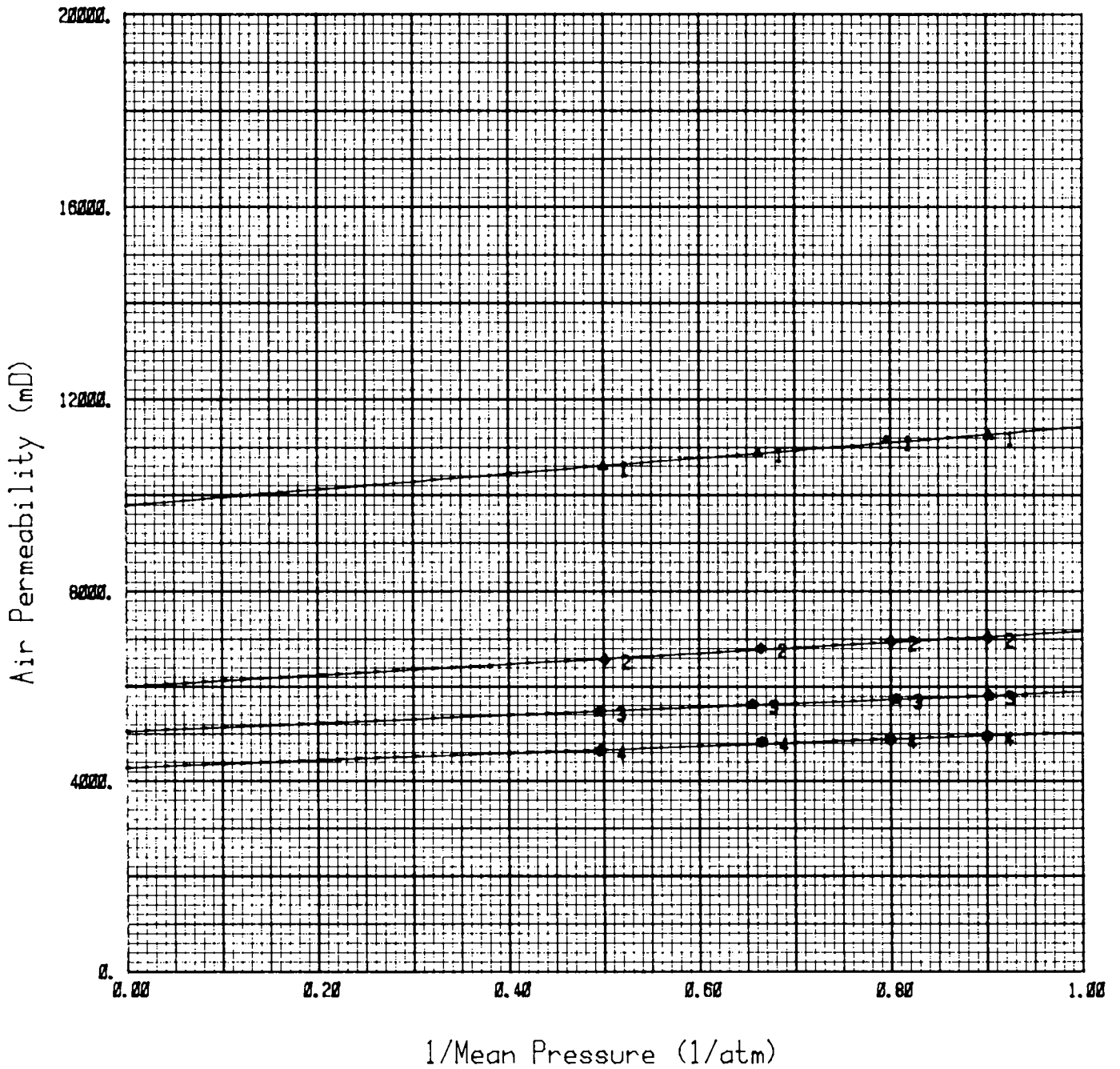
Depth (m): 1784.40

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 9758 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 5979 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 5021 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 4250 mD





KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 6

Depth: 1788.07 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{el} (mD)
15	0.900	7194	6346
	0.796	7093	
	0.666	6992	
	0.499	6810	
100	0.912	3952	3461
	0.796	3870	
	0.662	3818	
	0.500	3727	
150	0.912	2946	2666
	0.793	2917	
	0.669	2879	
	0.501	2819	
200	0.913	2242	2027
	0.801	2217	
	0.664	2196	
	0.497	2140	

KLINKENBERG CORRECTED AIR PERMEABILITY



Sample no : 6

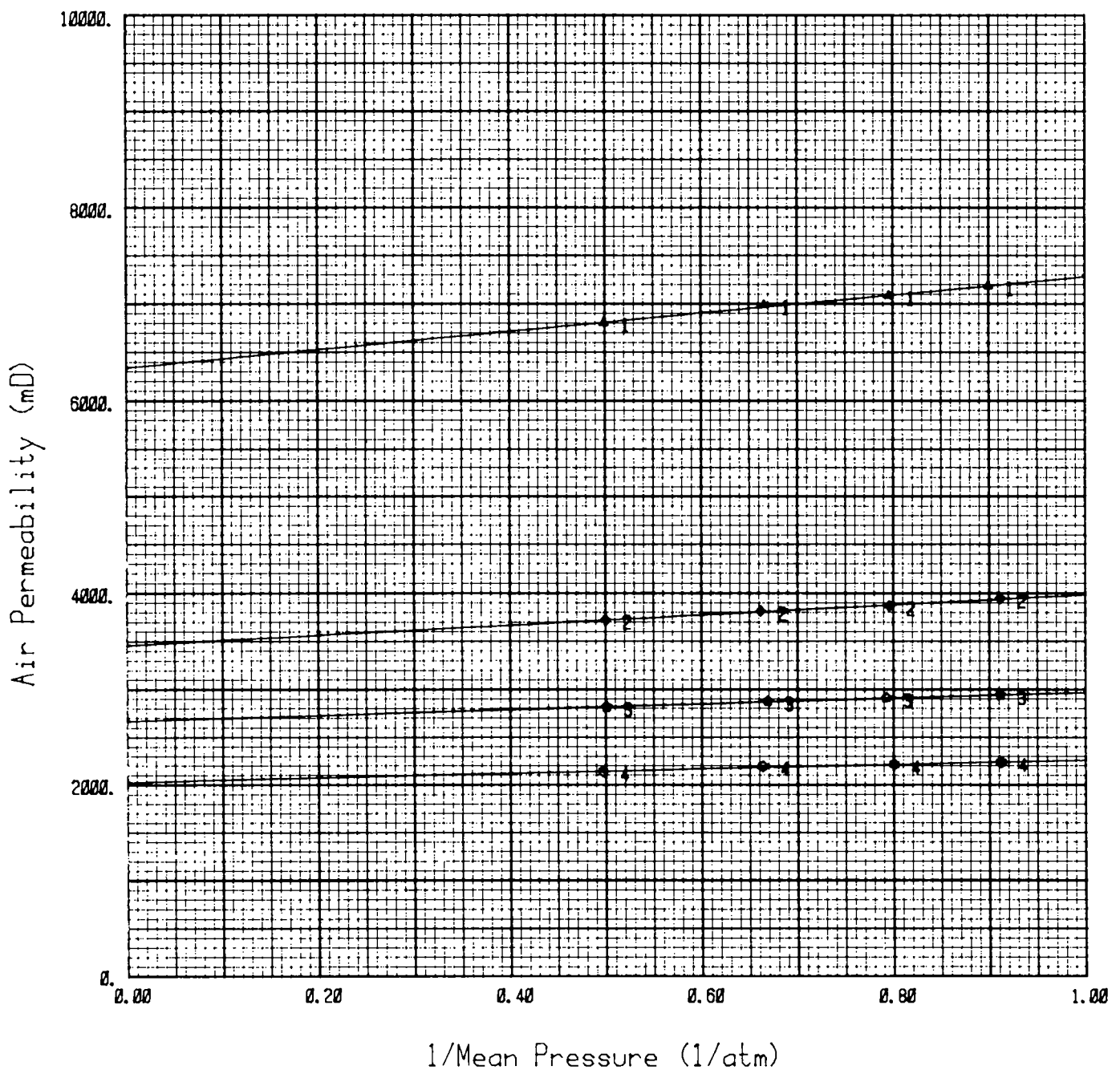
Depth (m): 1788.07

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 6346 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 3461 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 2666 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 2027 mD





KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 7

Depth: 1788.38 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{e1} · (mD)
15	0.903	7940	6664
	0.797	7836	
	0.672	7654	
	0.502	7368	
100	0.903	5211	4323
	0.796	5124	
	0.672	5019	
	0.503	4810	
150	0.892	4313	3551
	0.805	4259	
	0.674	4155	
	0.502	3976	
200	0.901	3459	2862
	0.798	3382	
	0.669	3311	
	0.500	3190	

KLINKENBERG CORRECTED AIR PERMEABILITY



Sample no : 7

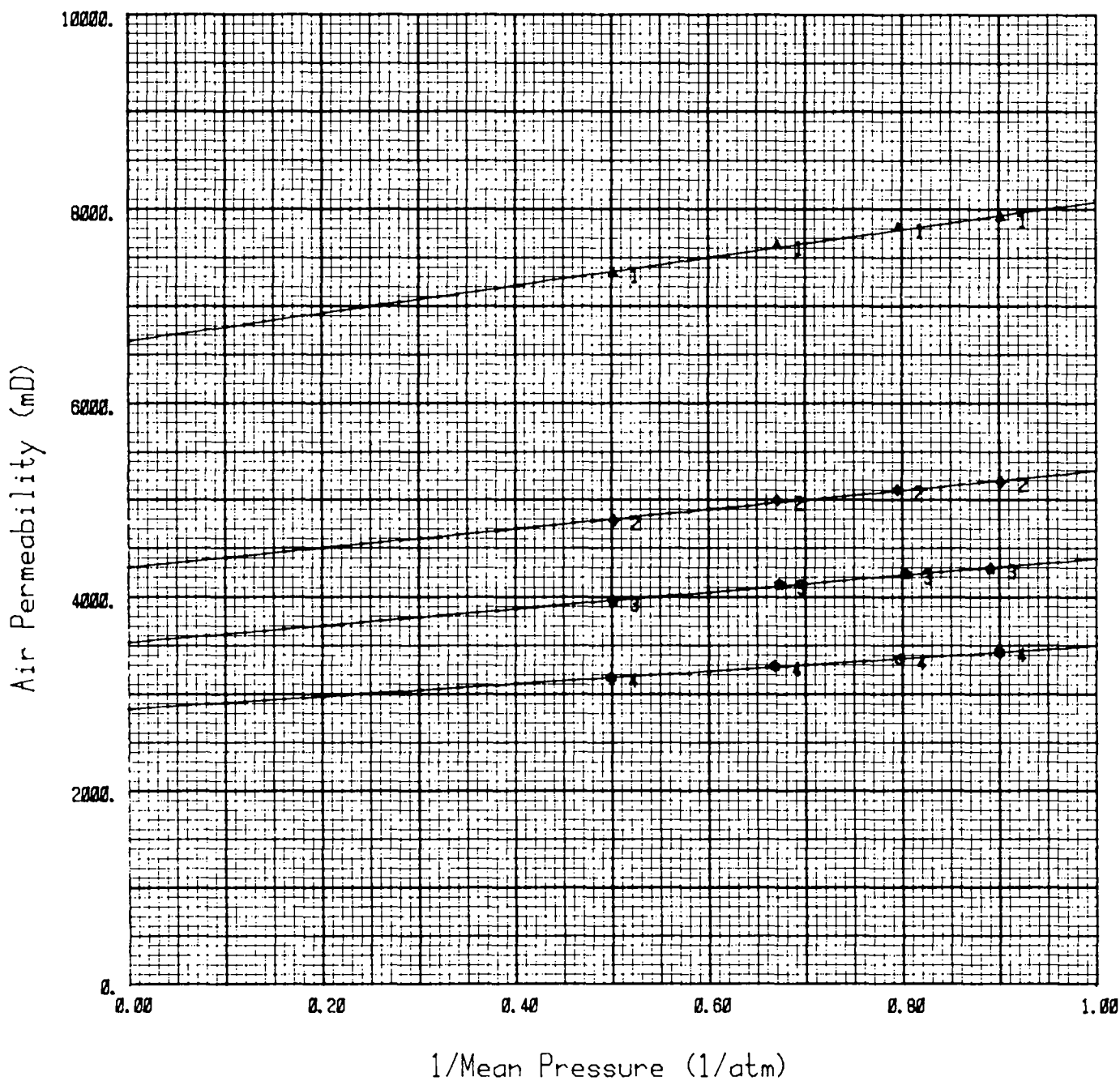
Depth (m): 1788.38

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 6664 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 4323 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 3551 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 2862 mD





KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 8

Depth: 1790.60 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{e1} (mD)
15	0.898	8424	7598
	0.794	8329	
	0.664	8241	
	0.503	8050	
100	0.903	5614	4918
	0.802	5546	
	0.667	5429	
	0.500	5307	
150	0.900	4688	4059
	0.795	4633	
	0.672	4552	
	0.504	4408	
200	0.902	3769	3365
	0.790	3725	
	0.670	3688	
	0.498	3582	

KLINKENBERG CORRECTED AIR PERMEABILITY



Sample no : 8

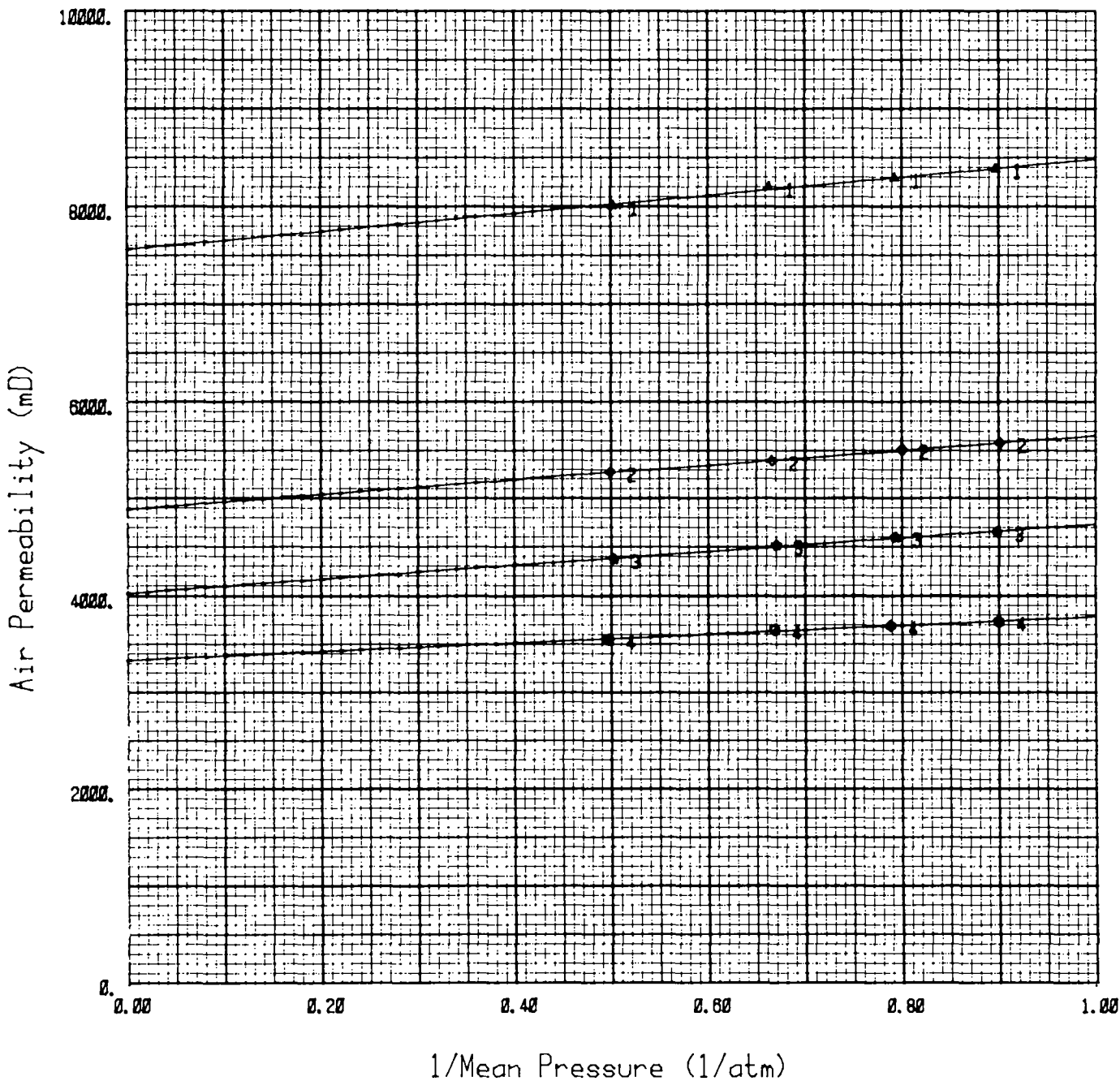
Depth (m): 1790.60

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 7598 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 4918 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 4059 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 3365 mD





KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 9

Depth: 1801.14 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{e1} (mD)
15	0.901	8257	7028
	0.796	8142	
	0.663	7952	
	0.500	7710	
100	0.903	4490	3809
	0.791	4402	
	0.665	4344	
	0.499	4174	
150	0.903	3267	2842
	0.802	3224	
	0.663	3174	
	0.496	3070	
200	0.909	2560	2246
	0.795	2521	
	0.666	2489	
	0.495	2413	

KLINKENBERG CORRECTED AIR PERMEABILITY



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Sample no : 9

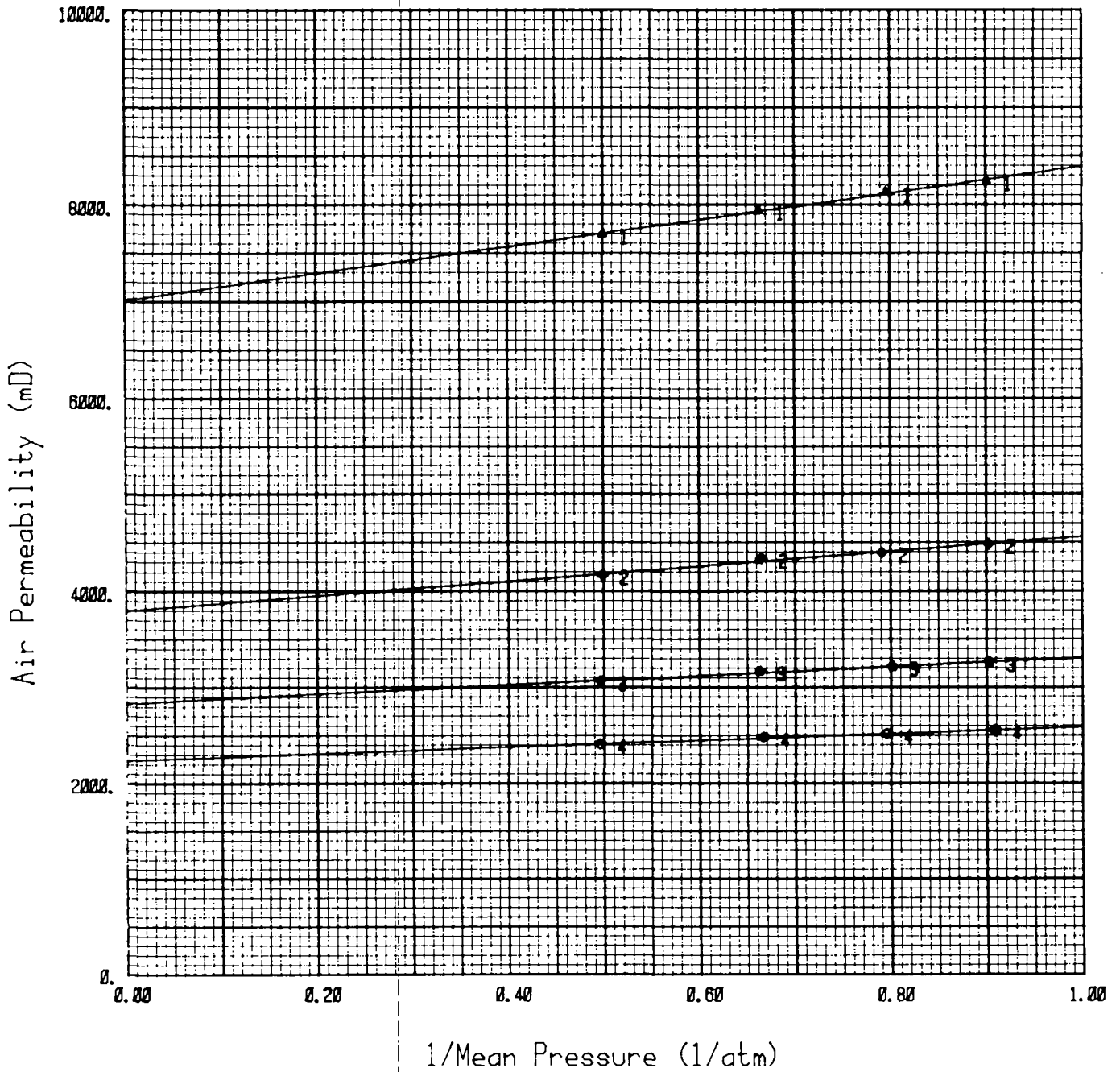
Depth (m): 1801.14

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 7028 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 3809 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 2842 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 2246 mD





KLINKENBERG CORRECTED AIR PERMEABILITY
MEASURED UNDER CONFINING PRESSURE

Sample no. 10

Depth: 1805.10 m

Confining pressure (bar)	(Mean Pressure) ⁻¹ (atm.abs.) ⁻¹	Air permeability k _a (mD)	Klinkenberg corr. permeability k _{el} (mD)
15	0.862	515	467
	0.770	511	
	0.647	505	
	0.489	494	
100	0.866	362	324
	0.767	359	
	0.648	353	
	0.485	345	
150	0.872	318	282
	0.768	315	
	0.640	310	
	0.487	302	
200	0.868	278	244
	0.770	276	
	0.644	270	
	0.487	263	

KLINKENBERG CORRECTED AIR PERMEABILITY



Sample no : 10

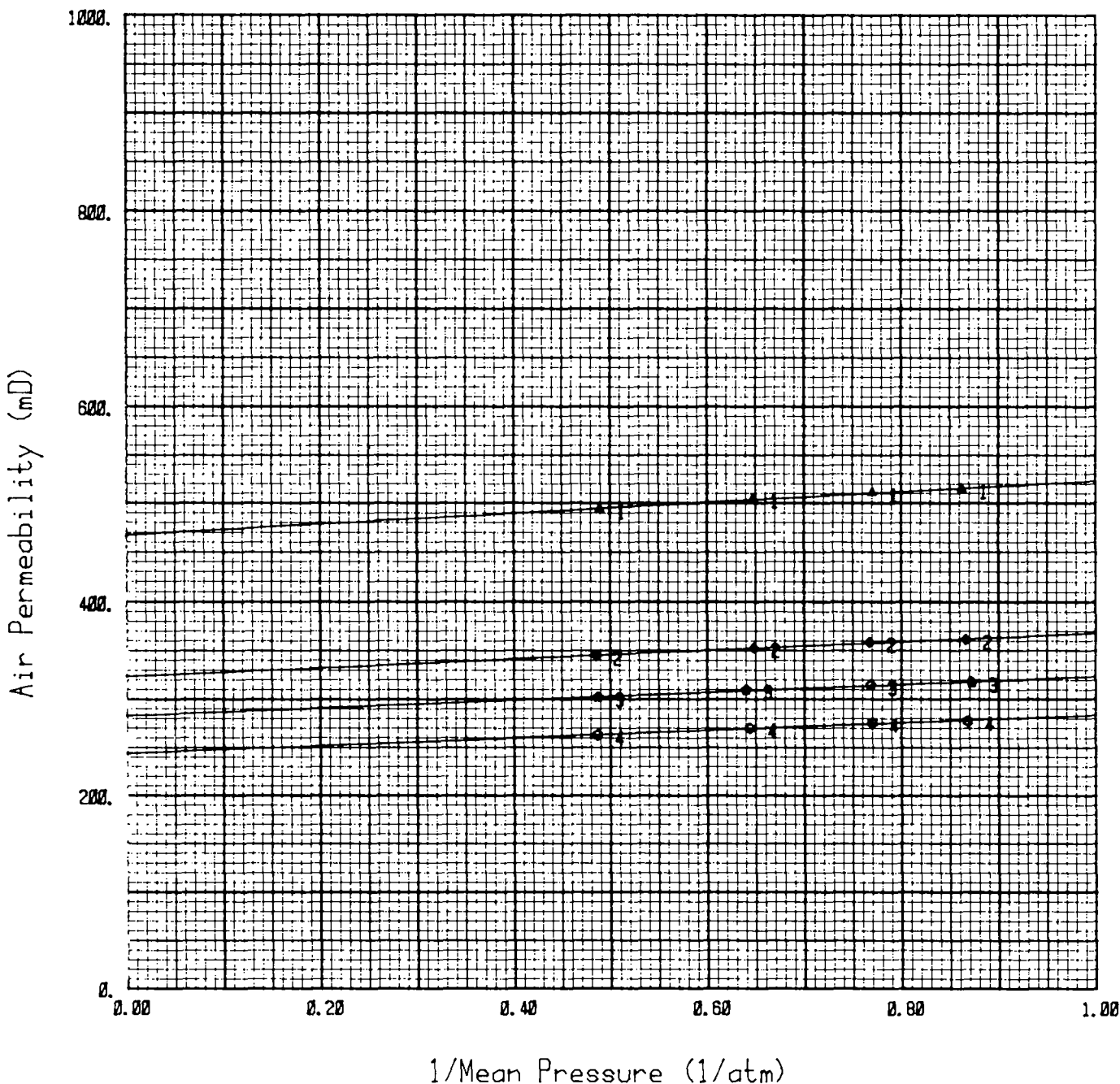
Depth (m): 1805.10

Curve no 1 : Conf. press.: 15 bar
Klink. perm.: 467 mD

Curve no 2 : Conf. press.: 100 bar
Klink. perm.: 324 mD

Curve no 3 : Conf. press.: 150 bar
Klink. perm.: 282 mD

Curve no 4 : Conf. press.: 200 bar
Klink. perm.: 244 mD





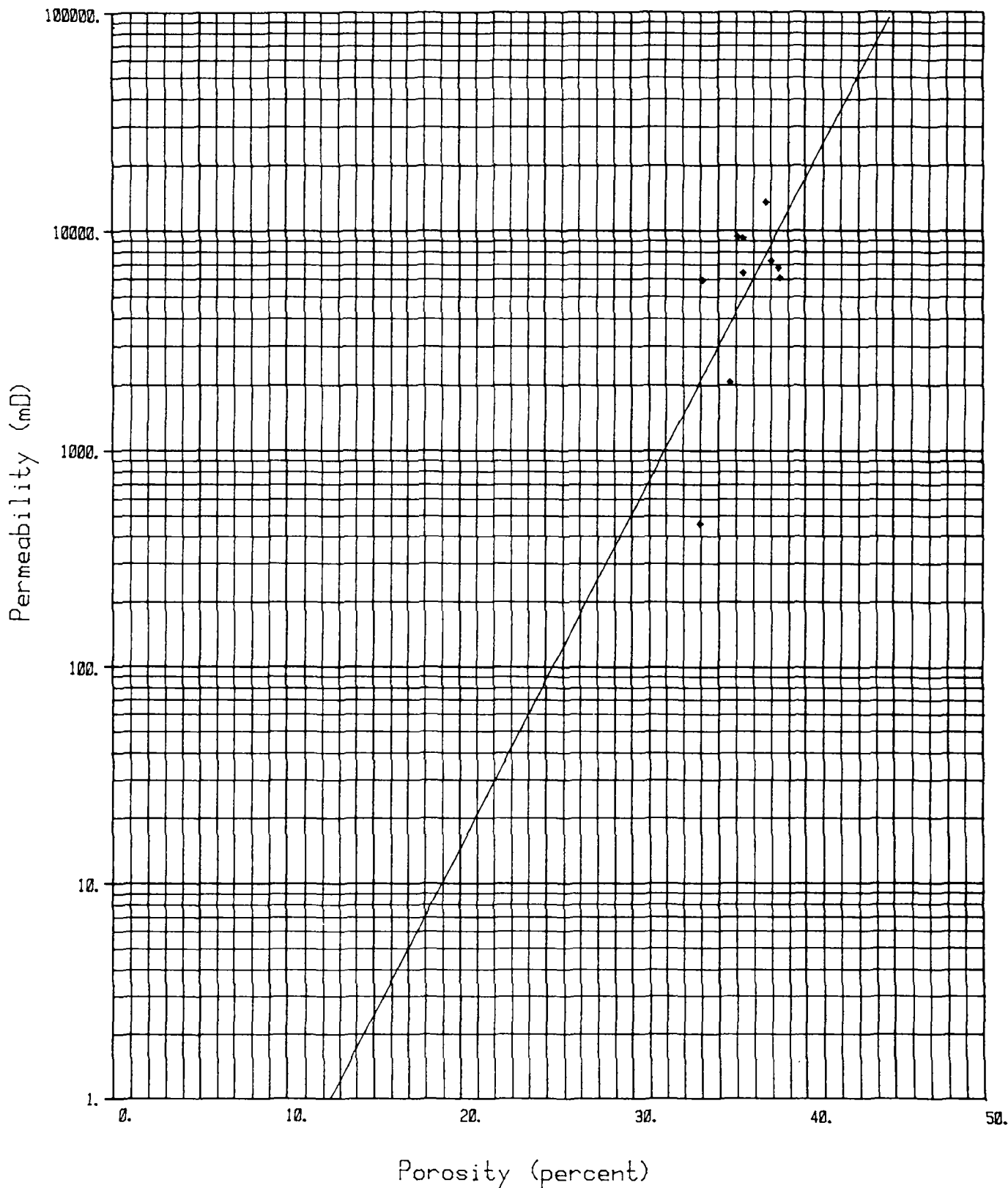
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KLINKENBERG PERMEABILITY VS. POROSITY

Company : A/S NORSKE SHELL

Well : 31/2-13

$$\log k = 0.157 * \phi - 1.97$$





CONFINING PRESSURE MEASUREMENTS

Sample no.: 1

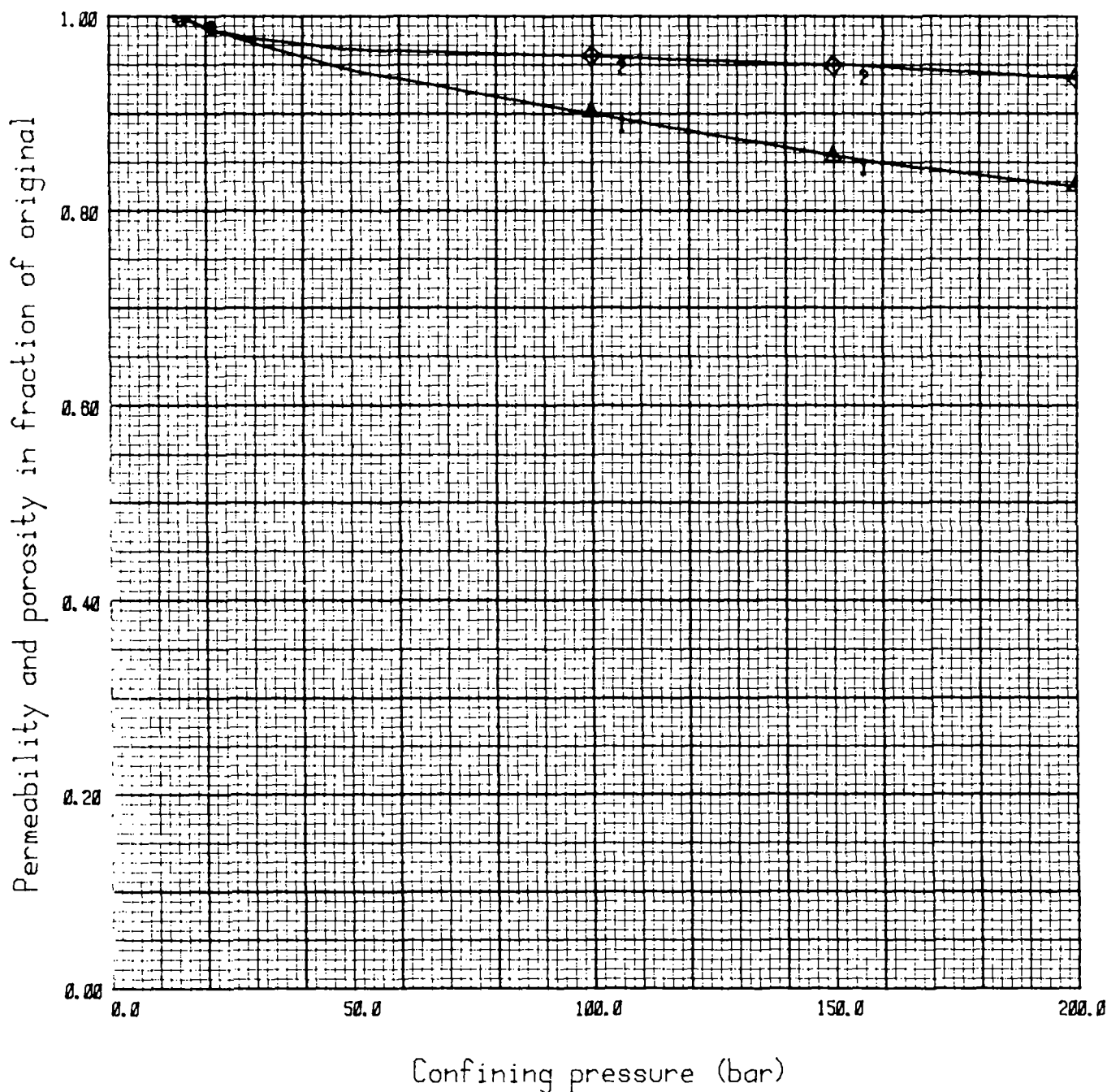
Depth (m): 1778.08

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	35.4	34.0	33.6	33.2
Porosity reduction: (frac. of original)	1.000	0.960	0.950	0.937
Pore volume (cm ³):	7.21	6.77	6.66	6.53
Pore volume reduction:	0.000	0.061	0.076	0.094
Air permeability (mD) :	2111	1905	1809	1743
Permeability reduction: (frac. of original)	1.000	0.902	0.857	0.826

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 1 Orig. permeability (curve 1): 2111 mD
Depth : 1778.08 m Orig. porosity (curve 2): 35.4 %





CONFINING PRESSURE MEASUREMENTS

Sample no.: 2

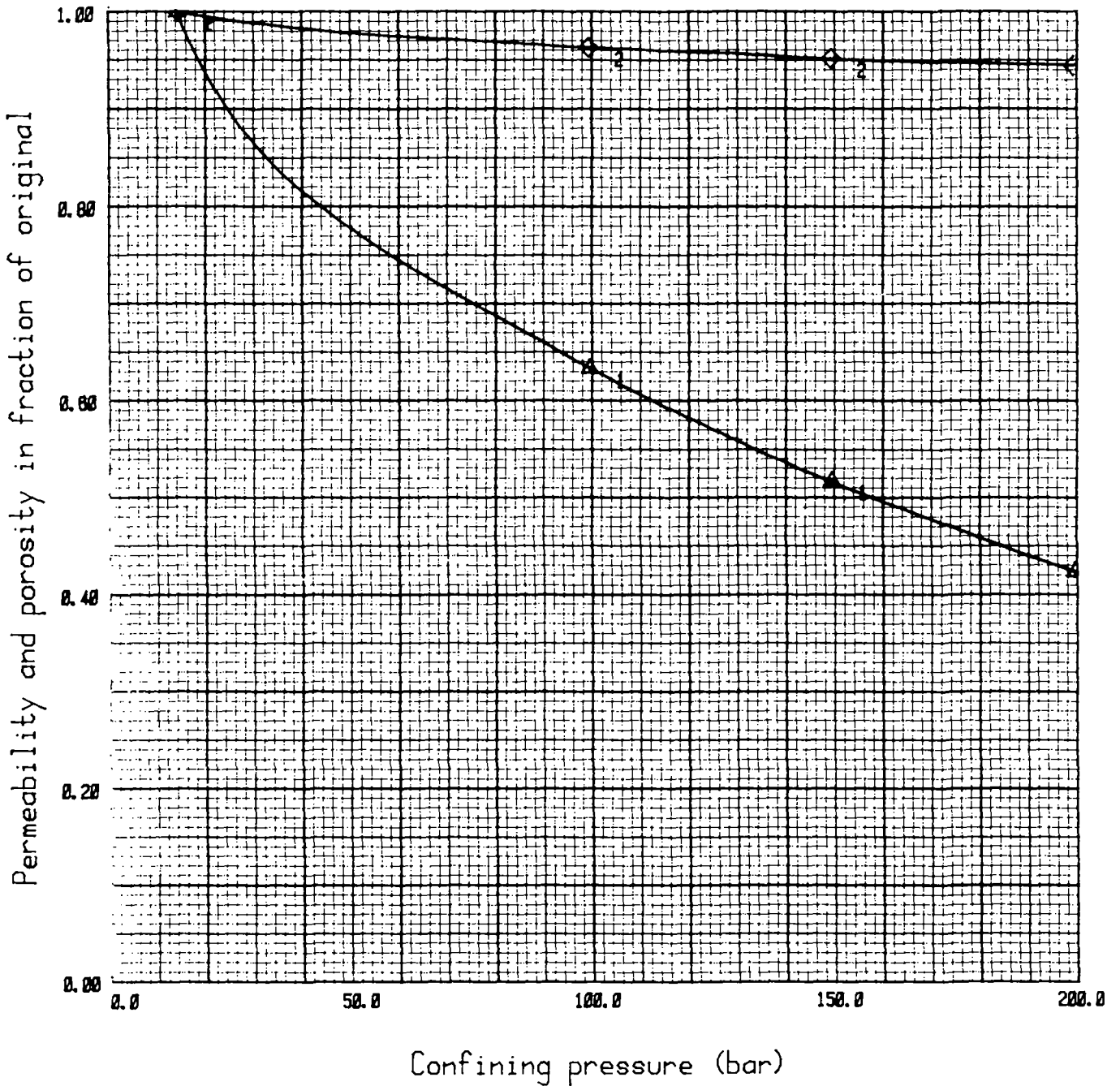
Depth (m): 1779.68

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	37.4	35.9	35.5	35.2
Porosity reduction: (frac. of original)	1.000	0.962	0.950	0.942
Pore volume (cm ³):	8.21	7.72	7.58	7.47
Pore volume reduction:	0.000	0.060	0.077	0.090
Air permeability (mD) :	14043	8870	7229	5917
Permeability reduction: (frac. of original)	1.000	0.632	0.515	0.421

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 2 Orig. permeability (curve 1): 14043 mD
Depth : 1779.68 m Orig. porosity (curve 2): 37.4 %





CONFINING PRESSURE MEASUREMENTS

Sample no.: 3

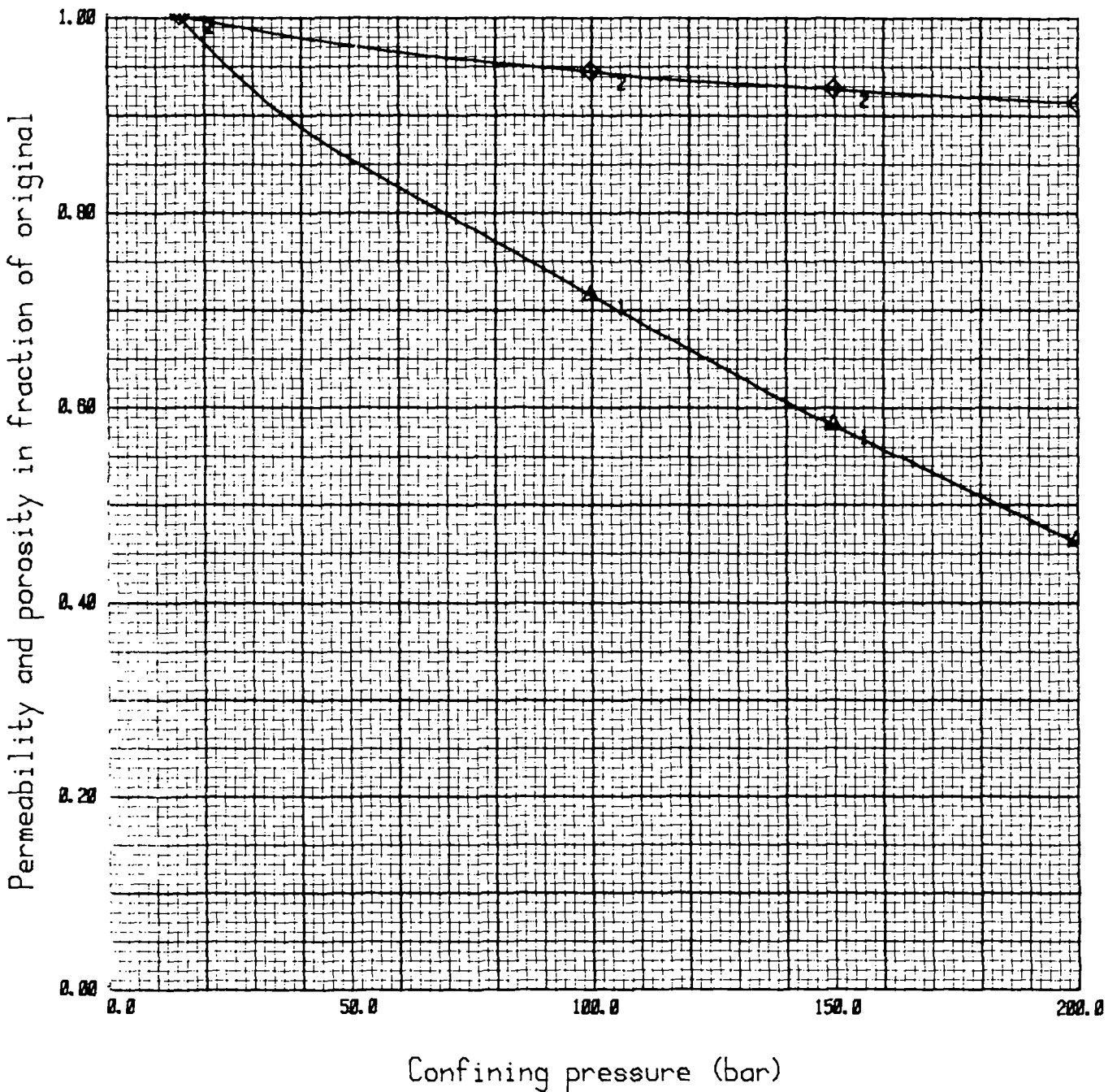
Depth (m): 1780.50

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	33.8	31.9	31.3	30.8
Porosity reduction: (frac. of original)	1.000	0.943	0.926	0.911
Pore volume (cm ³):	5.38	4.94	4.80	4.70
Pore volume reduction:	0.000	0.084	0.108	0.128
Air permeability (mD) :	6167	4400	3575	2841
Permeability reduction: (frac. of original)	1.000	0.713	0.580	0.461

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 3 Orig. permeability (curve 1): 6167 mD
Depth : 1780.50 m Orig. porosity (curve 2): 33.8 %





CONFINING PRESSURE MEASUREMENTS

Sample no.: 4

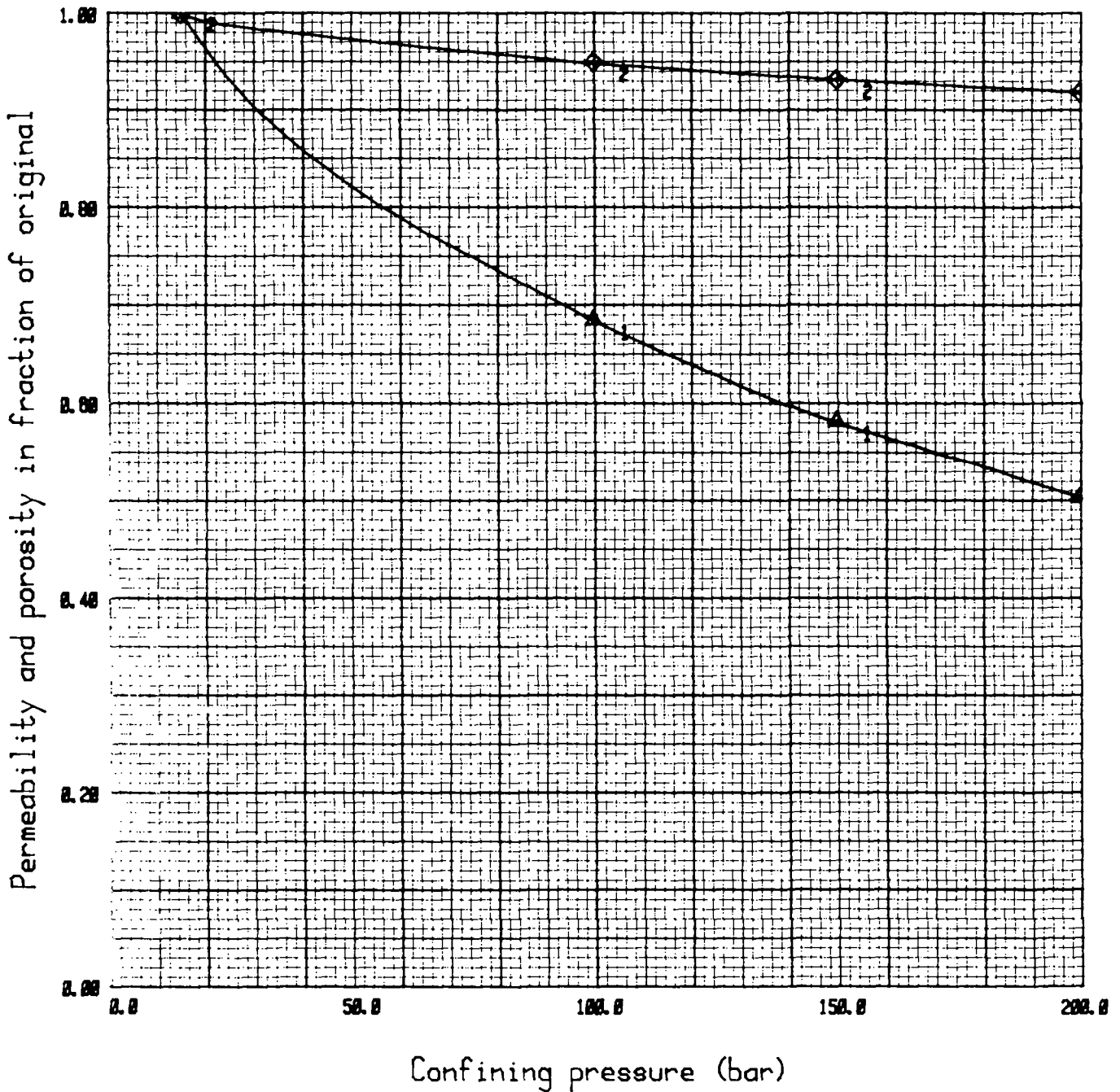
Depth (m): 1780.76

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	36.1	34.3	33.7	33.2
Porosity reduction: (frac. of original)	1.000	0.950	0.932	0.919
Pore volume (cm ³):	6.65	6.15	5.98	5.85
Pore volume reduction:	0.000	0.076	0.101	0.121
Air permeability (mD):	9610	6583	5596	4840
Permeability reduction: (frac. of original)	1.000	0.685	0.582	0.504

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 4 Orig. permeability (curve 1): 9610 mD
Depth : 1780.76 m Orig. porosity (curve 2): 36.1 %





CONFINING PRESSURE MEASUREMENTS

Sample no.: 5

Depth (m): 1784.40

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	35.8	34.0	33.4	33.0
Porosity reduction: (frac. of original)	1.000	0.950	0.935	0.923
Pore volume (cm ³):	7.02	6.48	6.32	6.21
Pore volume reduction:	0.000	0.076	0.099	0.115
Air permeability (mD):	9758	5979	5021	4250
Permeability reduction: (frac. of original)	1.000	0.613	0.515	0.436

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE

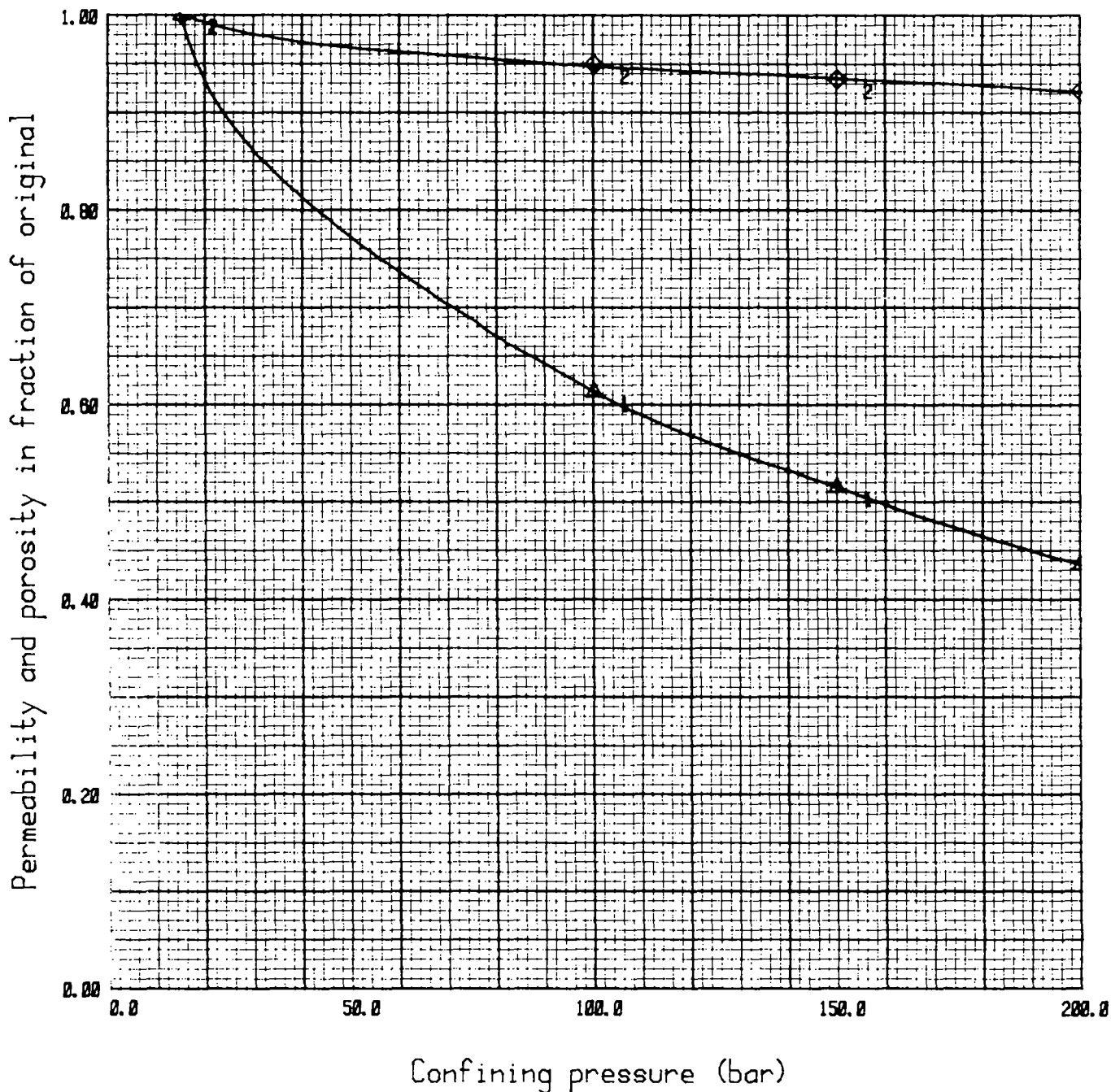


Sample no: 5

Orig. permeability (curve 1): 9758 mD

Depth : 1784.40 m

Orig. porosity (curve 2): 35.8 %





CONFINING PRESSURE MEASUREMENTS

Sample no.: 6

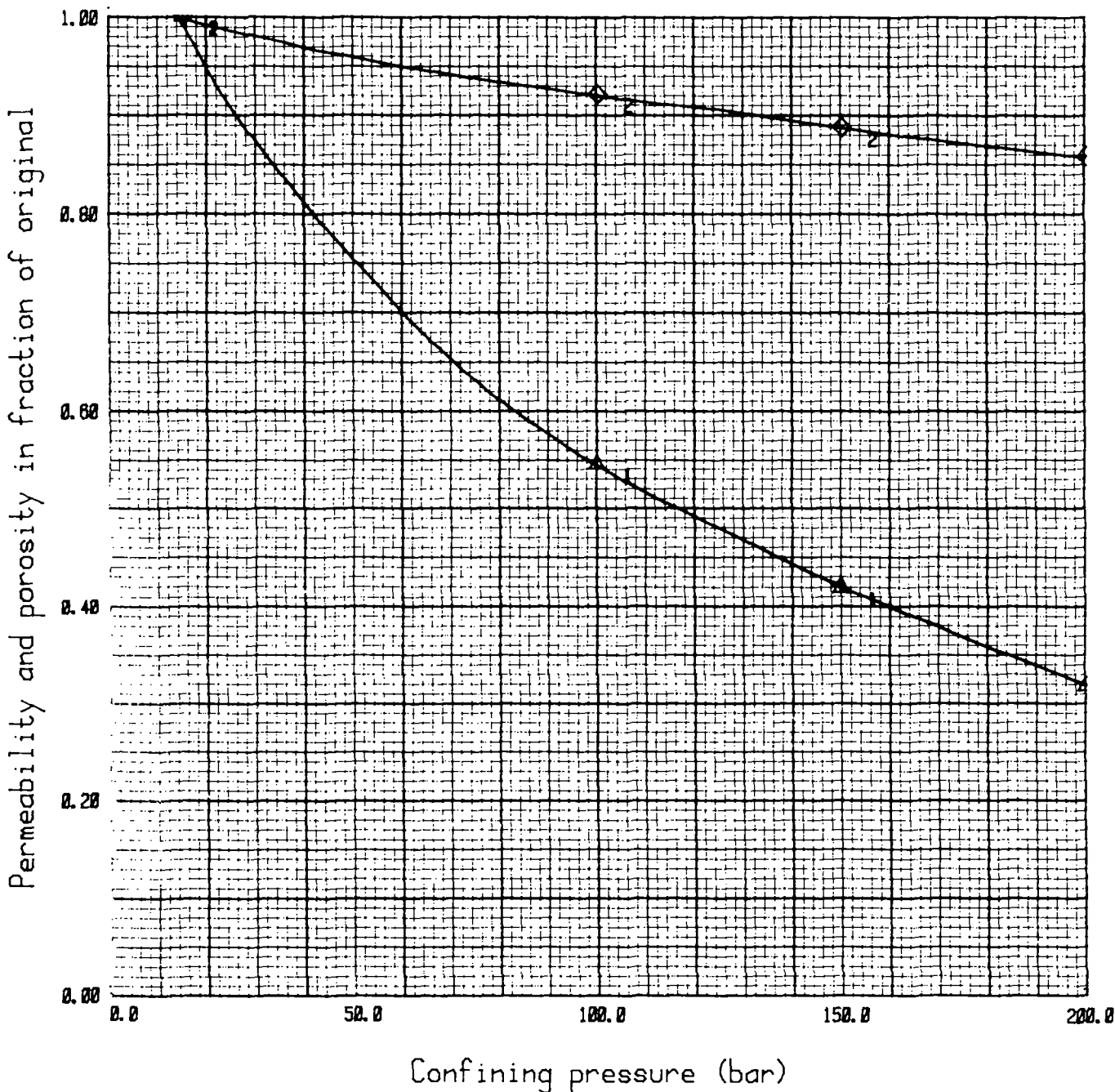
Depth (m): 1788.07

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	38.2	35.3	34.0	32.9
Porosity reduction: (frac. of original)	1.000	0.922	0.889	0.860
Pore volume (cm ³):	5.93	5.21	4.93	4.70
Pore volume reduction:	0.000	0.121	0.168	0.208
Air permeability (mD):	6346	3461	2666	2027
Permeability reduction: (frac. of original)	1.000	0.545	0.420	0.319

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 6 Orig. permeability (curve 1): 6346 mD
Depth : 1788.07 m Orig. porosity (curve 2): 38.2 %





CONFINING PRESSURE MEASUREMENTS

Sample no.: 7

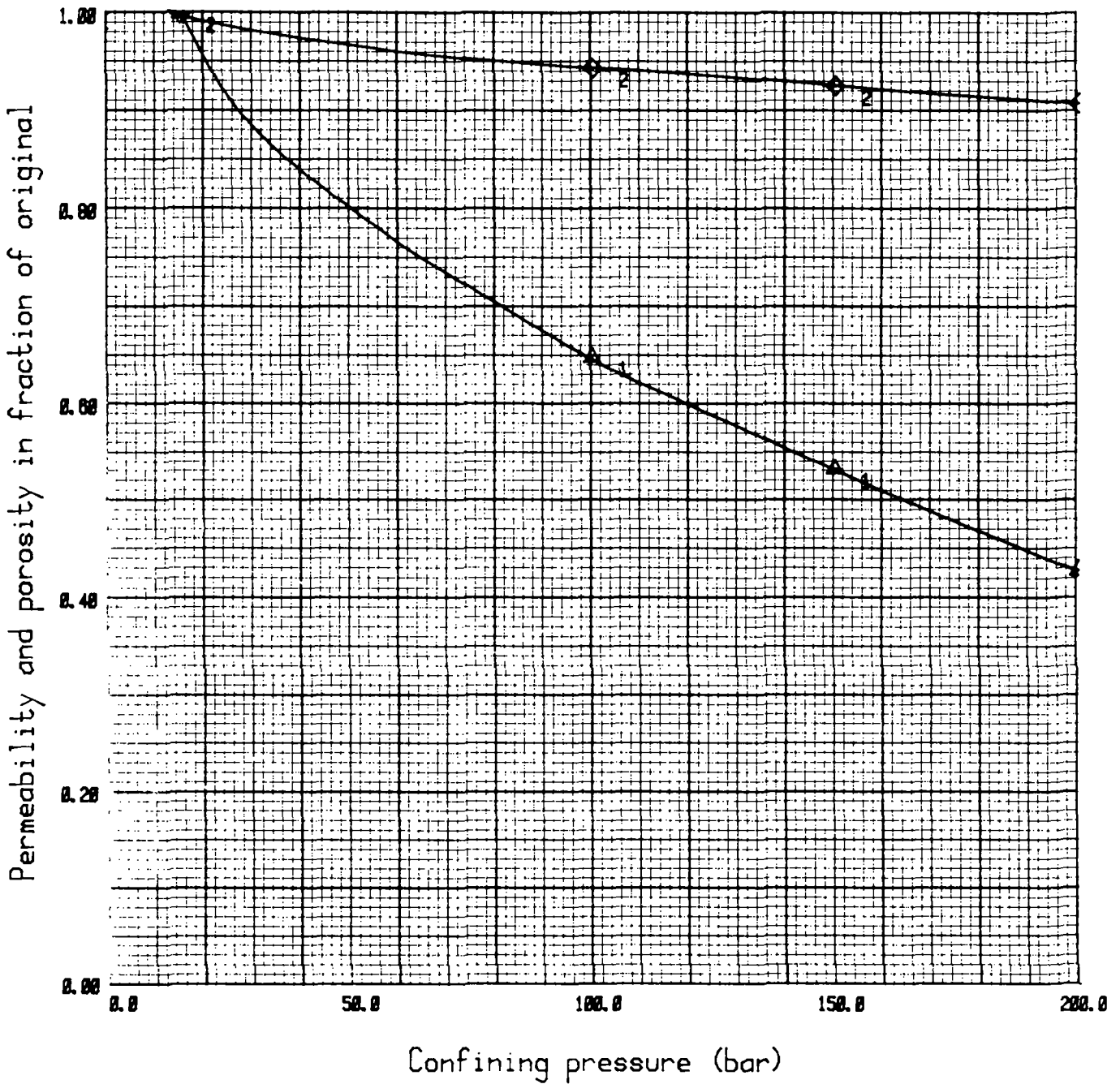
Depth (m): 1788.38

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	36.1	34.1	33.5	32.8
Porosity reduction: (frac. of original)	1.000	0.945	0.927	0.909
Pore volume (cm ³):	5.64	5.18	5.03	4.88
Pore volume reduction:	0.000	0.082	0.109	0.135
Air permeability (mD):	6664	4323	3551	2862
Permeability reduction: (frac. of original)	1.000	0.649	0.533	0.429

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 7 Orig. permeability (curve 1): 6664 mD
Depth : 1788.38 m Orig. porosity (curve 2): 36.1 %





CONFINING PRESSURE MEASUREMENTS

Sample no.: 8

Depth (m): 1790.60

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	37.7	35.9	35.2	34.5
Porosity reduction: (frac. of original)	1.000	0.952	0.933	0.916
Pore volume (cm ³):	6.41	5.93	5.76	5.59
Pore volume reduction:	0.000	0.075	0.103	0.128
Air permeability (mD):	7598	4918	4059	3365
Permeability reduction: (frac. of original)	1.000	0.647	0.534	0.443

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE

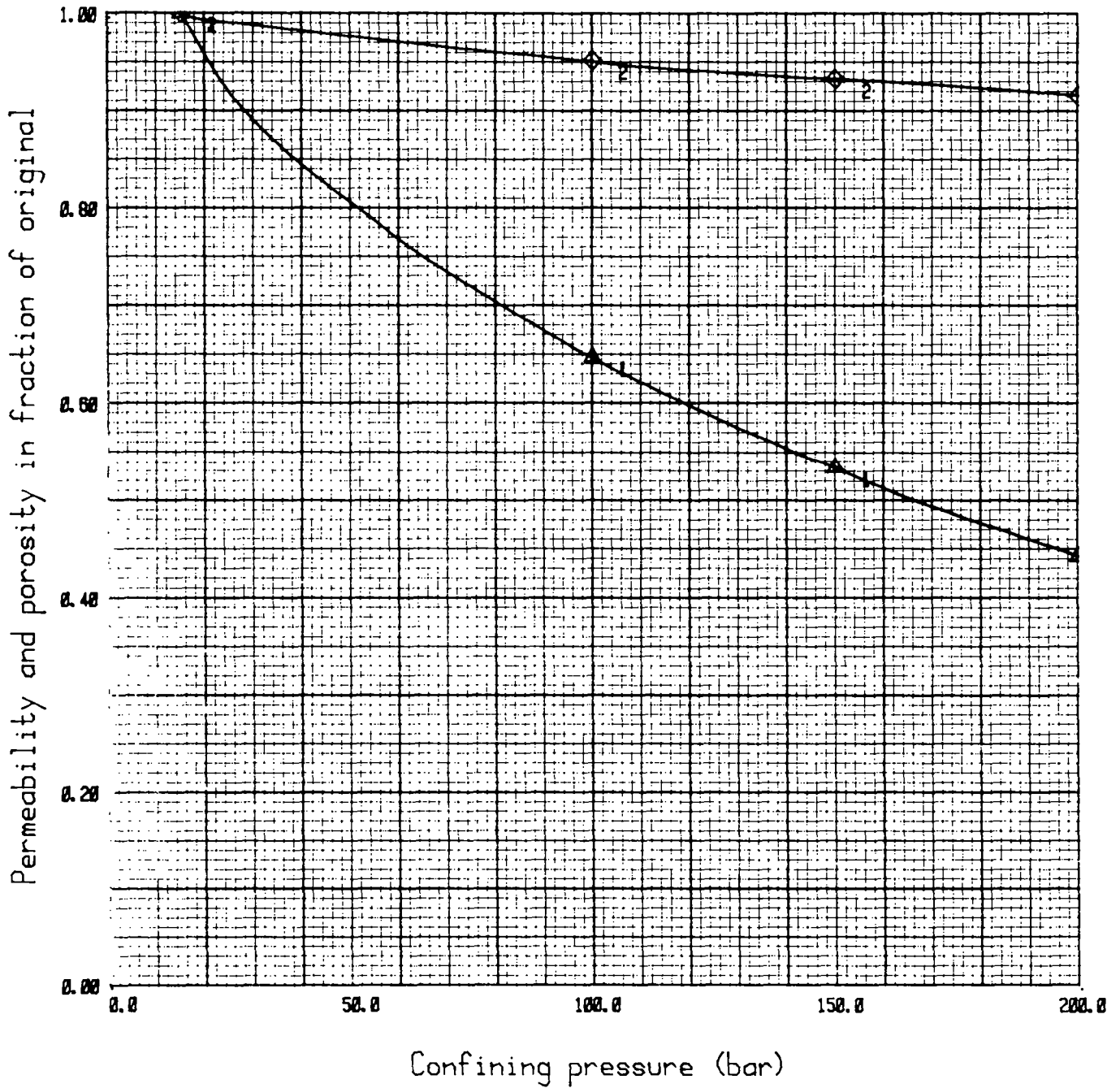


Sample no: 8

Orig. permeability (curve 1): 7598 mD

Depth : 1790.60 m

Orig. porosity (curve 2): 37.7 %





CONFINING PRESSURE MEASUREMENTS

Sample no.: 9

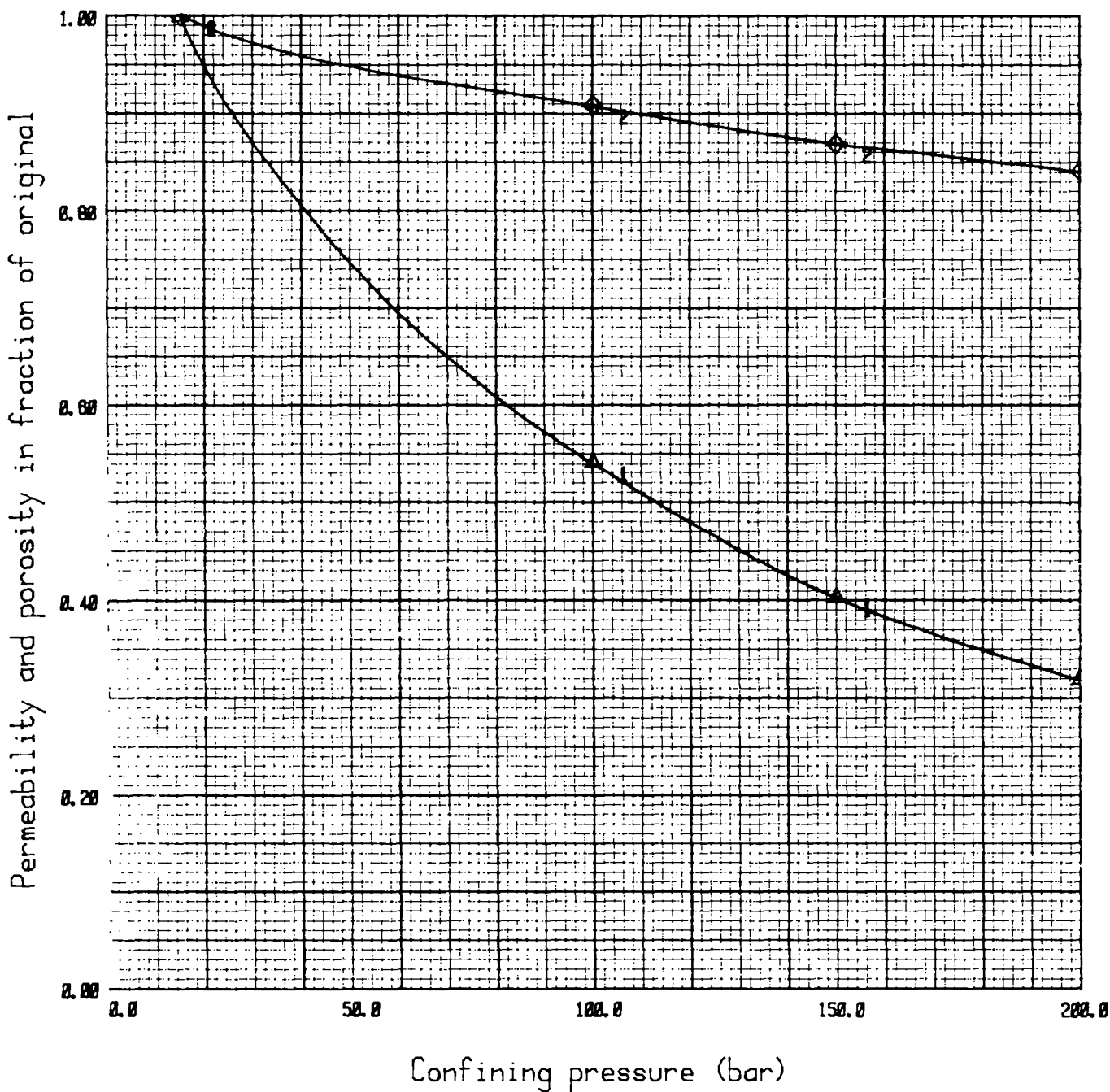
Depth (m): 1801.14

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	38.1	34.7	33.2	32.1
Porosity reduction: (frac. of original)	1.000	0.910	0.870	0.842
Pore volume (cm ³):	3.79	3.26	3.05	2.90
Pore volume reduction:	0.000	0.138	0.194	0.233
Air permeability (mD):	7028	3809	2842	2246
Permeability reduction: (frac. of original)	1.000	0.542	0.404	0.320

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 9 Orig. permeability (curve 1): 7028 mD
Depth : 1801.14 m Orig. porosity (curve 2): 38.1 %





CONFINING PRESSURE MEASUREMENTS

Sample no.: 10

Depth (m): 1805.10

Measurements	"Atmospheric" 15 bar	100 bar	150 bar	200 bar
Porosity (%):	33.7	32.0	31.4	30.9
Porosity reduction: (frac. of original)	1.000	0.951	0.932	0.917
Pore volume (cm ³):	5.31	4.93	4.79	4.67
Pore volume reduction:	0.000	0.072	0.099	0.121
Air permeability (mD):	467	324	282	244
Permeability reduction: (frac. of original)	1.000	0.694	0.604	0.522

PERMEABILITY AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 10 Orig. permeability (curve 1): 467 mD
Depth : 1805.10 m Orig. porosity (curve 2): 33.7 %

