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GEOTECHNICAL INVESTIGATION

KOPANOAR I–44

BEAUFORT SEA, OFFSHORE CANADA

Report To

DOME PETROLEUM LTD.

Calgary, Alberta

FUGRO GULF, INC.

Consulting Geotechnical Engineers and Geologists

EBA Engineering Consultants Ltd.

GEOTECHNICAL INVESTIGATION
KOPANOAR I-44
BEAUFORT SEA, OFFSHORE CANADA
REPORT NO. 80-058-5

* * *

Report

to

DOME PETROLEUM LTD.

Calgary, Alberta

* * *

By

FUGRO GULF, INC.
Houston, Texas

October 1981

FUGRO

Fugro Gulf, Inc./Consulting Engineers and Geologists

5884 Point West Drive, Houston, Texas 77036
Phone (713) 777-2641 Telex 775494

Report No. 80-058-5
October 30, 1981

Dome Petroleum Ltd.
800-6th Avenue S.W.
P.O. Box 200
Calgary, Alberta
Canada T2P ON1

Attention: Mr. M. Gajtani

GEOTECHNICAL INVESTIGATION
KOPANOAR I-44
BEAUFORT SEA, OFFSHORE CANADA

Gentlemen:

Submitted is the final report for our geotechnical investigation at the above location in the Beaufort Sea. This report presents a description of the field and laboratory testing programs and our engineering analyses for pile design.

Dome Petroleum Ltd. authorized this investigation on April 15, 1980. We conducted the study in general accordance with our contract with Canadian Marine Drilling, Ltd. dated June 9, 1980. Our draft field report was sent to you on October 30, 1980.

We received the majority of the laboratory data in preliminary form from EBA Engineering Consultants Ltd. on January 20, 1981. Additional test data were received in telexes dated February 20, 25, and March 24, 1981. Our draft final report was sent to Dome on March 10, 1981 and approved by Mr. M. Gajtani on May 1, 1981.

Final laboratory data were received from EBA on August 12, 1981. These data are included here as Appendices A through G. The ROKE geophysical borehole log was provided by Mr. M. Gajtani on May 1, 1981 for inclusion in the final report. Appendices K and L were received from EBA on October 27, 1981 and are included in this report on request of Mr. M. Gajtani.

We appreciate the opportunity to serve you on this investigation. Please call us if you need further assistance.

Very truly yours,

Ronald H. Pitts, P.E.
Project Engineer

Larry S. Marr P.E.
Deputy Marine
Division Manager

RHP/LSM:ab
Copies Submitted: (10)

EBA Engineering Consultants Ltd.

EARTH-SCIENCES
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1981 10 19

Dome Petroleum Ltd.
9th Floor, 800 - 6 Avenue S.W.
Calgary, Alberta T2P 3G3

Our File: 101-2941

Attention: Mr. M.U. Gajtani
Senior Geotechncial Engineer
Beaufort Sea Construction

Dear Sir:

RE: MERGING OF EBA - FUGRO REPORT: KOPANOAR I-44

EBA sent copies of all laboratory test data to Fugro (Appendices A-G) for the Kopanoar I-44 location on August 6, 1981. On August 20, 1981, Dome further requested that EBA include Appendix K on laboratory testing procedures employed, and Appendix L on evaluation of the laboratory test data. This additional appendix material was forwarded to Fugro on October 19, 1981.

Yours truly,

EBA Engineering Consultants Ltd.

PROFESSIONAL ENGINEER P.M. ROMERIL ALBERTA

P.M. Romeril, P. Eng.
Project Engineer

PROFESSIONAL ENGINEER W.D. ROGGENSACK ALBERTA

W.D. Roggensack, Ph.D., P. Eng.
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THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA
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APPENDICES

SUMMARY

Fugro Gulf, Inc. conducted a geotechnical investigation to determine soil and foundation conditions and pile capacities at Kopanoar I-44 in the Beaufort Sea, offshore Canada. We investigated soil conditions by (1) drilling one borehole (B-2) to a depth of 400 feet (122m), (2) performing tests on samples recovered from B-2 to determine pertinent physical properties of the foundation soils, (3) making in situ cone penetrometer (CPT) soundings in a second borehole (B-3) to a depth of 174.5 feet (53.2m) and (4) making in situ vane tests and CPT soundings to 11 feet (3.3m) from a seabed unit (C-Floor 9). The measured water depth at this site was 179 feet (54.6m).

EBA Engineering Consultants Ltd. made laboratory tests on the soil samples; test results are included in Appendices A through G. ROKE Ltd. conducted geophysical logging of the borehole, results are presented in Appendix J. Fugro's engineering analyses for this location included (1) computing ultimate pile capacity using the CPT Method for a 30-inch driven pipe pile, (2) determining ultimate unit axial capacity using both API and Lambda Methods for driven pipe piles, and (3) computing ultimate axial load capacity of a 30-inch conductor grouted into a 36-inch predrilled hole. In computing the grouted conductor capacity, we used an adhesion factor equal to 0.5 for the slightly overconsolidated soils at this site.

INTRODUCTION

Project Description

Dome Petroleum Ltd. is performing studies in the Beaufort Sea, offshore Canada to determine soil and foundation conditions. Fugro Gulf, Inc. conducted a geotechnical investigation for Dome to determine foundation conditions and pile design parameters at a proposed offshore structure site called Kopanoar I-44.

Purposes and Scope of Study

The purposes of the study were to obtain information on soil and foundation conditions at Kopanoar I-44 and to compute ultimate pile capacity for driven pipe piles. In addition, we computed ultimate axial capacity for a conductor grouted into a predrilled hole. Fugro accomplished these objectives in the following phases:

1. Fugro drilled a borehole (B-2) to a depth of 400 feet (122m) to determine soil stratigraphy and to obtain soil samples. Using the remotely operated C-Floor 9 seabed unit, we also obtained in situ soil strength data to a depth of 11 feet (3.3m).
2. We made in situ cone penetrometer (CPT) soundings in an adjacent borehole (B-3) to a depth of 174.5 feet (53.2m).
3. EBA Engineering Consultants Ltd. performed laboratory tests on soil samples recovered from B-2 to define pertinent engineering properties.

4. ROKE Ltd. conducted geophysical logging of B-2 to help define stratigraphy.

5. Fugro conducted engineering analyses of the CPT soundings, field information, and laboratory test data to develop the required pile design recommendations.

Subsequent sections of this report contain brief descriptions of the field investigation, laboratory testing program, and general soil conditions at the site. Axial pile design results are presented for a driven pipe pile and a conductor grouted into a predrilled hole.

FIELD INVESTIGATION

Fugro investigated soil conditions from the M/V CANMAR SUPPLIER V provided by Canadian Marine Drilling Ltd. (CANMAR). We drilled two boreholes, designated B-2 and B-3, to depths of 400 feet (122m) and 174.5 feet (53.2m) below the seafloor, respectively. Fugro also used a seabed supported, in situ testing unit (C-Floor 9) at this site. Geographical coordinates provided by Offshore Navigation, Inc. are:

Borehole Number	Activity	Latitude, North	Longitude, West
B-2	Sample Boring	70°23'44"	135°14'29"
B-3	WISON (CPT) Soundings	70°23'44"	135°14'26"
C-Floor 9	In situ Vane and CPT	70°23'44"	135°14'27"

The water depth was 179 feet (54.6m) measured at 2130 hours on August 7 and 9, 1980 and at 1420 hours on August 8, 1980. A map illustrating the investigation location is presented on Plate 1. Plates 2 and 3 show the log of B-2, B-3, and the C-Floor 9 results.

The boreholes were drilled using CANMAR's Failing 1500 drill rig and conventional rotary drilling techniques. Samples were taken in B-2 with a downhole wire line operated sliding hammer; frozen soils were sampled with a wire line (Reese) core barrel. In B-3, Fugro conducted cone penetrometer (CPT) soundings using our WISON equipment; a temperature sensitive cone was used in some tests to measure in situ soil temperatures. The WISON normally uses the weight of the drill string as a reaction force to push the cone into the soil. Appropriate drilling subs made up the drill string to enable using the CPT tool. A drill string anchor (packer) was used in some cases to increase the reaction force allowing additional penetration into harder or more dense soils. Fugro also used the C-Floor 9 in situ testing unit to obtain accurate, shallow, in situ vane and cone penetrometer information. Our field report to Dome dated August 12, 1980 presents a detailed discussion of the drilling, sampling, and in situ testing techniques and equipment used. ROKE Ltd. conducted geophysical logging of the borehole, results are presented in Appendix J.

Descriptions of the soils encountered in B-2 and B-3, and by the C-Floor 9 are given on the left portion of the boring logs on Plates 2 and 3, along with a graphical symbol for the various types of soil, sample and CPT numbers and depths, and blow count information. Plate 4 shows a key to soil classification and symbols used on the boring log. Plate 5 is a brief chronological summary of field activities.

FIELD AND LABORATORY TESTS

Field Tests

The field testing program was designed to evaluate the pertinent physical properties of the foundation soils encountered at this location. Shear strengths of cohesive soils were obtained using miniature vane and Torvane devices. Unit weight and water content tests were performed on most samples. Temperatures of samples were measured by inserting a thermistor probe into the soil samples. Also, in situ temperatures were measured using the temperature sensitive cone. In situ and sample temperatures are shown in Plate 6. Selected samples were photographed by EBA; photographs are not included in this report.

Laboratory Tests

Laboratory tests were made for soil identification and classification and to provide detailed information on shear strength and compressibility characteristics of soils. The laboratory testing program was developed jointly by Fugro, EBA, and Dome. EBA conducted the laboratory tests in Edmonton, Alberta.

Most soil test results are presented graphically on the boring logs on Plates 2 and 3. Plate 7 is a plasticity chart showing liquid limits and plasticity indices. Complete laboratory test results are presented in Appendices C through F. Laboratory test procedures and evaluation of laboratory test data are presented in Appendices K and L, respectively.

GENERAL SOIL CONDITIONS

Stratigraphy

The following major soil strata were encountered at this location:

Stratum	Depth, Ft. From	To	Soil Description
I	0 -	25	Very Soft Dark Olive Gray Clay
II	25 -	40	Medium Dense Dark Olive Gray Silty Fine Sand
III	40 -	47.5	Firm Dark Olive Gray Silty Clay
IV	47.5 -	57	Dense Light Gray Fine Sand
V	57 -	63.5	Stiff Dark Olive Gray Silty Clay
VI	63.5 -	83	Laminated Loose Olive Gray Clayey Silt and Sandy Silt
VII	83 -	109	Stiff Dark Gray Silty Clay
VIII	109 -	135	Laminated Medium Dense Dark Gray Sandy Silt and Silty Fine Sand
IX	135 -	151.5	Very Stiff Dark Gray Silty Clay
X	151.5 -	229	Laminated Very Stiff Very Dark Gray Silty Clay and Medium Dense Clayey Silt and Silty Fine Sand
XI	229 -	280	Frozen Very Dark Gray to Dark Olive Gray Sandy Silt and Silt
XII	280 -	313	Frozen Dark Olive Gray Sandy Silt
XIII	313 -	388	Frozen Interbedded Dark Olive Gray Silt, Sandy Silt, and Clayey Silt
XIV	388 -	400+	Frozen Dark Olive Gray Sandy Silt

The boring log shows minor textural and color variations and inclusions of other soil types within each stratum.

Axial pile design analyses presented in this report are based on the soil stratigraphy and conditions disclosed by B-2 and B-3. We have not considered possible stratigraphy changes, faulting, or other regional differences that could influence foundation design.

Soil Properties

The clay soils encountered in the top 25 feet (7.6m) are probably of recent marine origin. The clay has moderately high plasticity, moisture contents generally higher than the liquid limit, typical of soft marine clays, and a sensitivity ranging from 2.0 to 6.0. The submerged unit weight for Stratum I ranges from 28 to 53 pcf (0.45 to 0.85 Mg/m^3). The interpreted undrained shear strength is 0.08 tsf (7.7 kPa) to 15 feet (4.6m), and ranges from 0.08 to 0.12 tsf (7.7 to 11.5 kPa) below 15 feet (4.6m).

The remaining soils to 400 feet (122m) generally grade from fine sand to silt and silty clay. CPT soundings clearly show the soils in Strata VI, VIII, and X are finely laminated. Such a laminated structure of these strata and the interbedding of Stratum XIII indicate depositional characteristics typical of deltaic, fluvial, or lacustrine environments, probably originating from glacial processes. The silty sands, fine sands, and silts of Strata II, IV, VI, VIII, and X have variable in situ densities, ranging from loose to dense as measured by the WISON CPT system. The average moisture content below 25 feet (7.6m) was 25 percent.

Numerous inclusions of silt, sand, clay, and silty clay seams, pockets, and partings occur throughout the soil profile. Organic material is found in a majority of the samples. Soil color varies between dark olive gray and very dark and dark-gray. In general, the soil is slightly overconsolidated with overconsolidation ratios (OCR) ranging from 0.5 to 2.2, as determined from consolidation tests. EBA described the frozen soils in general accordance with a standard issued by the National Research Council (Canada) Technical Manual (Plate 4a). EBA described the soils below 229 feet (69.8m) as frozen, well bonded with no visible ice (Nbn). Ice crystals were visible (Vx) at several depths.

Soil Design Parameters

We developed a curve of interpreted shear strength variation with depth for cohesive soil layers based on an evaluation of the field and laboratory test results and the CPT soundings. This shear strength profile is indicated by the heavy solid line in the shear strength graph on the boring log. This shear strength profile is also shown on the soil properties graph on Plates 8 and 9 together with average submerged unit weights between the indicated depth intervals.

For the granular materials encountered at this site, design strength parameters were selected on the basis of in situ cone penetrometer data, triaxial compression test results, grain size distribution, and the presence of other soil types within the stratum. The design strength parameters and submerged unit weights for these granular materials are also summarized on Plates 8 and 9.

AXIAL PILE DESIGN ANALYSES AND RECOMMENDATIONS

Axial Load Capacity

Fugro used the static method of analysis to predict the ultimate compressive axial load capacities of piles. We computed axial pile capacity using a procedure based on cone penetrometer test results (CPT Method), the API Criteria [1] (Para. 2.6.4b.2), and the Lambda Method [2]. A detailed description of the methods used to calculate unit skin friction and unit end bearing is presented in Appendix H.

Cone penetrometer test (CPT) results are presented in Appendix I in the form of cone resistance and sleeve friction measurements. Since cone soundings are in situ tests, they implicitly reflect in situ properties such as density, strength, grain crushability, and stress conditions. The CPT Method uses these in situ soundings directly for pile capacity computations. Curves of unit skin friction and unit end bearing were developed using the CPT data for driven piles; these curves are shown on Plate 8.

Plate 9 presents the soil stratigraphy, interpreted strength parameters, and submerged unit weights of the different soil strata used for the pile capacity computations by API and Lambda Methods. In developing the design shear strength profile for the cohesive soils at this site, we interpreted the assembled soil test results plotted on the boring log and produced a curve through the data considered to best represent the actual shear strength of the soil. Using the API and Lambda Methods and selected strength parameters, curves of unit skin friction

(1) American Petroleum Institute (1980), Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms, API RP 2A, 11th Edition.
(2) Vijayvergiya, V. N. and Focht, J. A., Jr. (1972), "A New Way to Predict Capacity of Piles in Clay," Proceedings, Fourth Offshore Technology Conference, Houston, Vol. 2, pp. 865-874.

and unit end bearing were developed for driven piles. These curves are also shown on Plate 9.

Pile Capacity Curves

CPT Method. Ultimate pile capacity curves for a 30-inch driven pipe pile are presented on Plate 10. The CPT Method predicts the following ultimate loads:

Depth Below Seafloor		Ultimate Pile Capacity, Tons, (Kilonewtons)	
Feet	Meters	Tension	Compression
174.5	(53.2m)	101 (899)	157 (1397)

The computed skin frictional capacity of the soil plug formed inside the pile was less than the computed end bearing in several soil strata. As a result, unit end bearing was limited to the soil plug frictional resistance as indicated on the right graph of Plate 8. Increased end bearing can be achieved by replacing the soil plug by a grout plug.

API and Lambda Methods. Ultimate pile capacity curves for driven pipe piles are presented on Plate 11. At the present time, driven pipe pile diameters have not been specified by Dome. As a result, pile capacity curves combining both skin friction and end bearing components were not prepared for this report. Cumulative skin frictional capacity curves have been prepared using the unit skin friction values from Plate 9 and a surface area of the pile, A_s, equal to 1.0 ft^2 ($0.09m^2$).

When pile diameters are known, prediction of ultimate axial pile capacity, combining both skin friction and end bearing, can be made as follows:

1. Determine pile surface area, A_s, of the given pile,

(2) Multiply A_s times the value at the given depth from Plate 11,

(3) Determine pile end area, A_p, of the given pile,

(4) Multiply A_p times the unit end bearing value, q_p, at the given depth from the right hand graph on Plate 9, and

(5) Add (2) and (4).

Grouted Conductor Axial Load Capacity

At the request of Dome, Fugro determined ultimate axial load capacity for a 30-inch O.D. conductor grouted into a 36-inch pre-drilled hole. Plate 12 shows the results of the conductor axial load capacity analyses. The axial capacity was determined using the soil strength design parameters presented in Plate 9 and a computational procedure presented by Kraft[3] and recommended by Dome. This method is similiar to the API Method except that clay unit skin friction is determined at the soil-grout interface by reducing the clay cohesion by an empirical adhesion factor, α.

We computed ultimate axial load capacities with adhesion factors of 0.5 and 1.0 to compare pile capacities in overconsolidated and normally consolidated soils respectively. At present, the available data does not warrant using an adhesion factor equal to 1.0. We therefore recommend using an adhesion value of 0.5 for soils at this location until additional information is available in the future to evaluate the consolidation characteristics. End bearing was not computed for these grouted conductors.

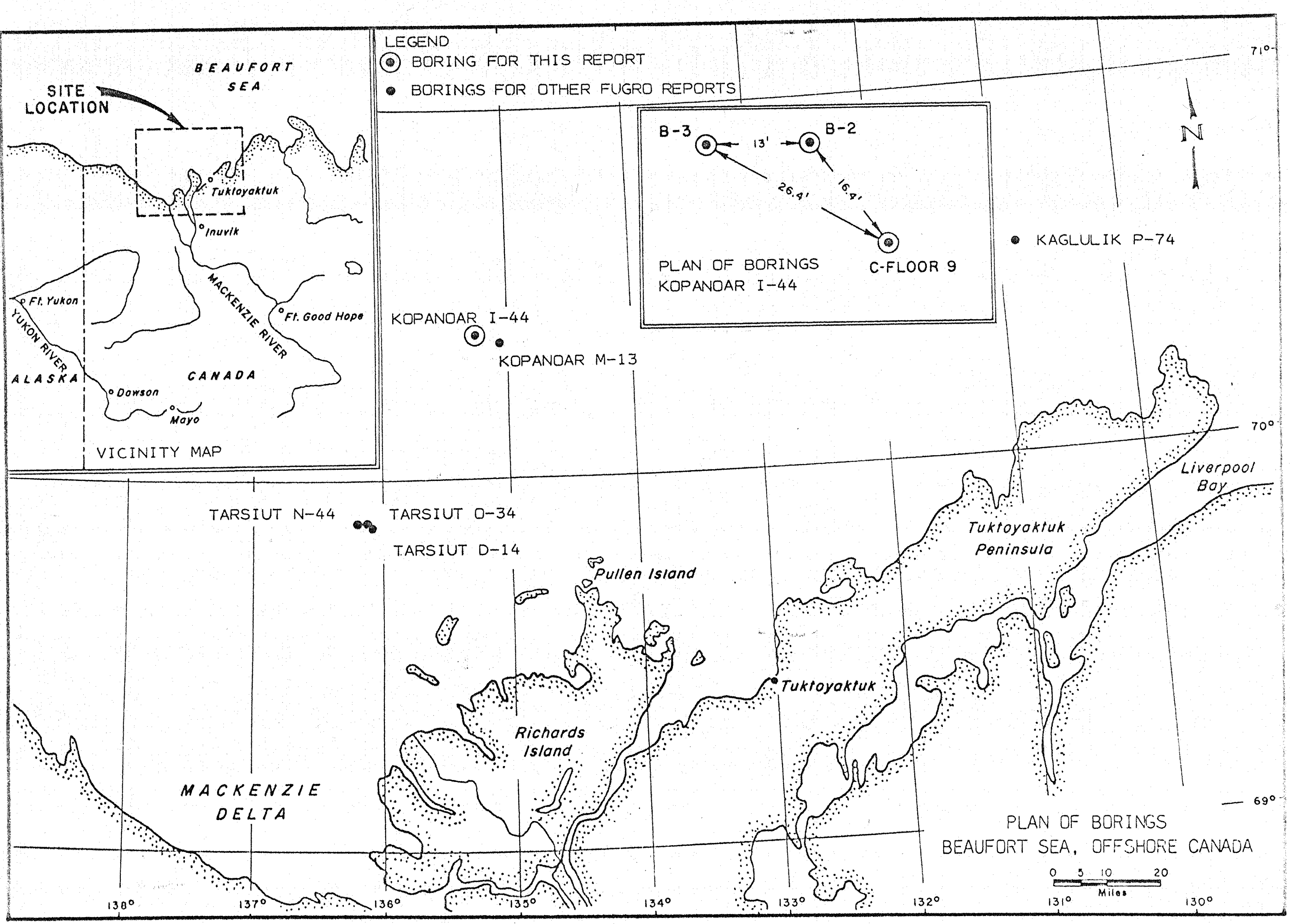
(3) Kraft, L. M. and Lyons, C. G. (1974), "State-of-the-Art: Ultimate Axial Capacity of Grouted Piles." Proceedings, Sixth Annual Offshore Technology Conference, Houston, 1974, Vol. 2, pp. 485-503.

Factors of Safety

We computed ultimate pile capacity curves as requested by Dome. Factors of safety used to compute design (allowable) pile capacity should be selected considering several factors including (1) storm frequency; (2) wave, current, and ice forces; (3) economic importance of the structure; (4) methods used in determining subsurface conditions and predetermining pile capacities; (5) grouting techniques; and (6) sensitivity of the structure to vertical movement. Factors of safety appropriate for driven pile capacities determined from CPT data are 1.5 for design and storm loads and 2.0 for operating loads.

ILLUSTRATIONS

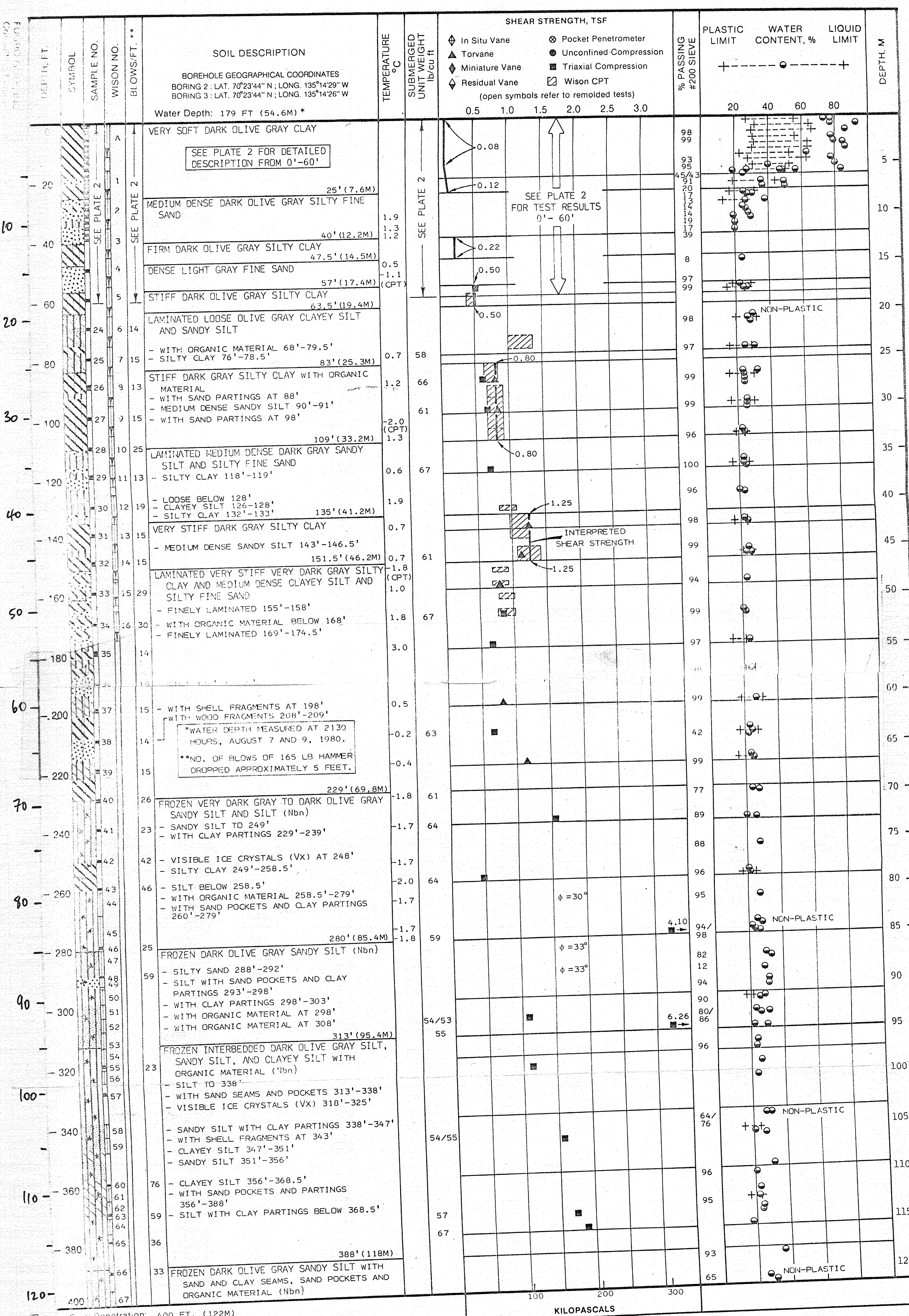
Job No. 80-058



PLAN OF BORINGS
BEAUFORT SEA, OFFSHORE CANADA

FUGRO GULF, INC.
Consulting Engineers and Geologists

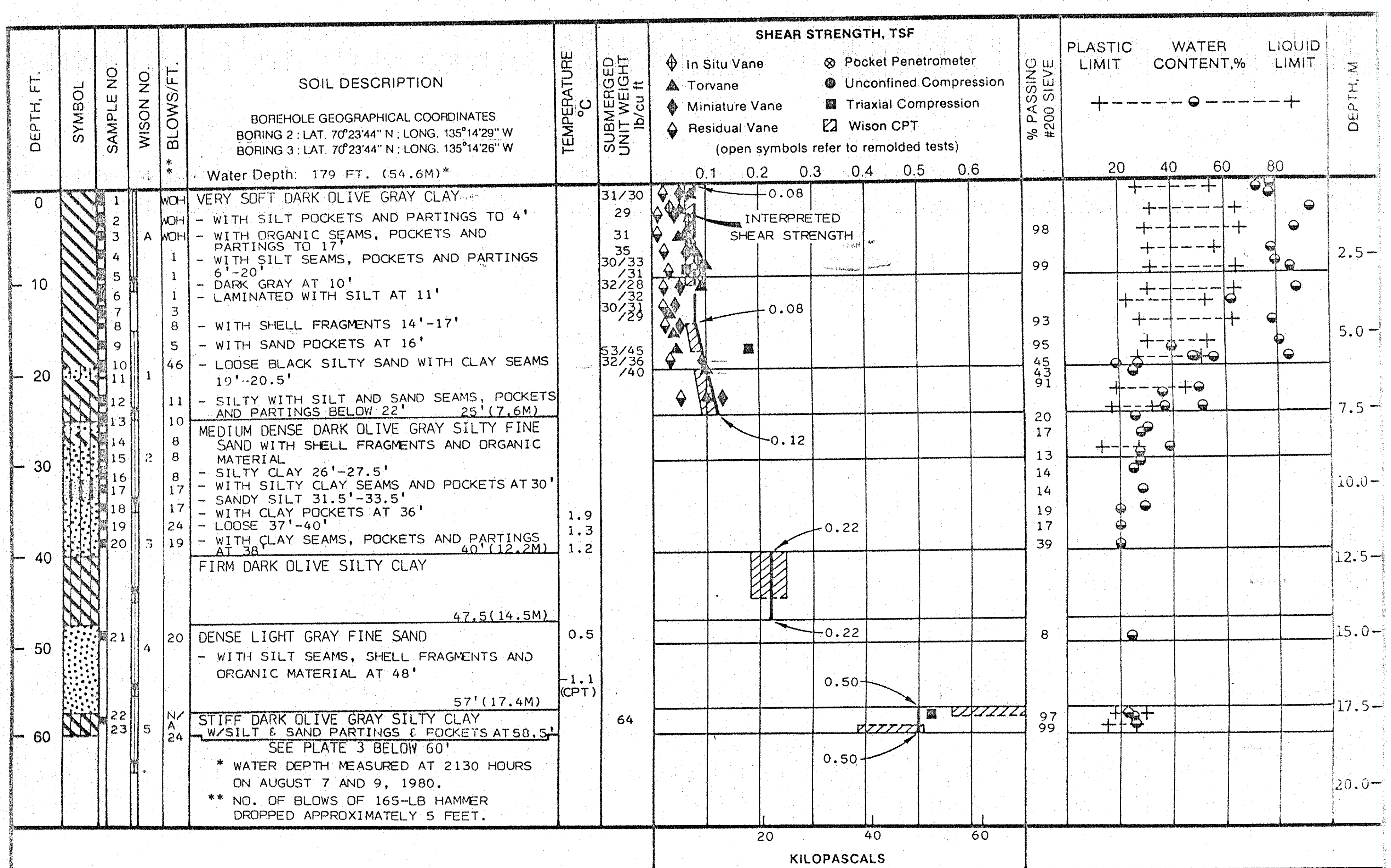
PLATE 1



LOG OF BORING AND TEST RESULTS

BORINGS 2 AND 3, KOPANOAR I-44

BEAUFORT SEA, OFFSHORE CANADA

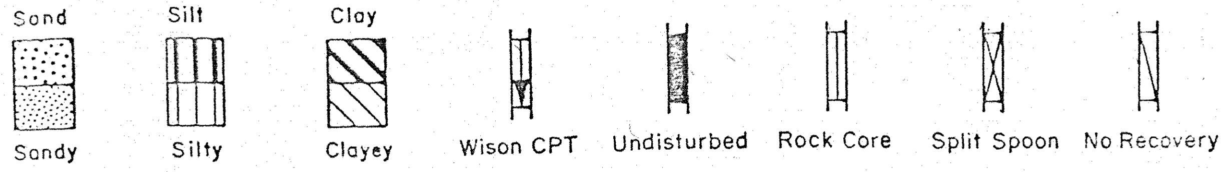


LOG OF BORING AND TEST RESULTS
0-60 FT.

BORINGS 2 AND 3, KOPANOAR I-44
BEAUFORT SEA, OFFSHORE CANADA

KEY TO SOIL CLASSIFICATION AND SYMBOLS

SOIL TYPE (Shown in Symbol Column) — SAMPLE TYPE (Shown in Samples Column)



Predominant type shown heavy

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (Major Portion Retained on No. 200 Sieve)

Includes (1) clean gravels & sand described as fine, medium or coarse, depending on distribution of grain sizes & (2) silty or clayey gravels & sands (3) fine grained low plasticity soils (PI < 10) such as sandy silts. Condition is rated according to relative density, as determined by lab tests or estimated from resistance to sampler penetration.

Descriptive Term	Relative Density
Loose	0 to 40 %
Medium Dense	40 to 70 %
Dense	70 to 90 %
Very Dense	90 to 100 %

FINE GRAINED SOILS (Major Portion Passing No. 200 Sieve)

Includes (1) inorganic & organic silts & clays, (2) sandy, gravelly or silty clays, & (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests for soils with PI ≥ 10

Descriptive Term	Cohesive Shear Strength Tons/Sq. Ft.
Very Soft	Less Than 0.125
Soft	0.125 to 0.25
Firm	0.25 to 0.50
Stiff	0.50 to 1.00
Very Stiff	1.00 to 2.00
Hard	2.00 and Higher

NOTE: *SLICKENSIDED AND FISSURED CLAY MAY HAVE LOWER UNCONFINED COMPRESSIVE STRENGTHS THAN SHOWN ABOVE, BECAUSE OF PLANES OF WEAKNESS OR SHRINKAGE CRACKS; CONSISTENCY RATINGS OF SUCH SOILS ARE BASED ON HAND PENETROMETER READINGS*

TERMS CHARACTERIZING SOIL STRUCTURE

Parting: paper thin in size

Seam: 1/8"–3" thick

Layer: greater than 3"

Fissured: containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical

Sensitive: pertaining to cohesive soils that are subject to appreciable loss of strength when remolded

Interbedded: composed of alternate layers of different soil types

Laminated: composed of thin layers of varying color and texture

Calcareous: containing appreciable quanities of calcium carbonate

Well Graded: having wide range in grain sizes and substantial amounts of all intermediate particle sizes

Poorly Graded: predominately of one grain size, or having a range of sizes with some intermediate size missing

Flocculated: pertaining to cohesive soils that exhibit a loose knit or flakey structure

Slickensided: having inclined planes of weakness that are slick and glossy in appearance

DEGREE OF SLICKENSIDED DEVELOPMENT

Slightly Slickensided: slickensides present at intervals of 1'-2'; soil does not easily break along these planes

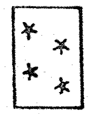
Moderately Slickensided: slickensides spaced at intervals of 1'-2'; soil breaks easily along these planes

Extremely Slickensided: continuous and interconnected slickensides spaced at intervals of 4"–12"; soil breaks along the slickensides into pieces 3"–6" in size

Intensely Slickensided: slickensides spaced at intervals of less than 4", continuous in all directions; soil breaks down along planes into nodules 1/4"–2" in size

KEY TO SOIL CLASSIFICATION AND SYMBOLS FOR FROZEN SOILS

SYMBOL TYPE
(Shown in Symbol Column)



FROZEN SOIL
(Overlays Soil Symbol)

ICE DESCRIPTION (After NRC TM No. 79) *

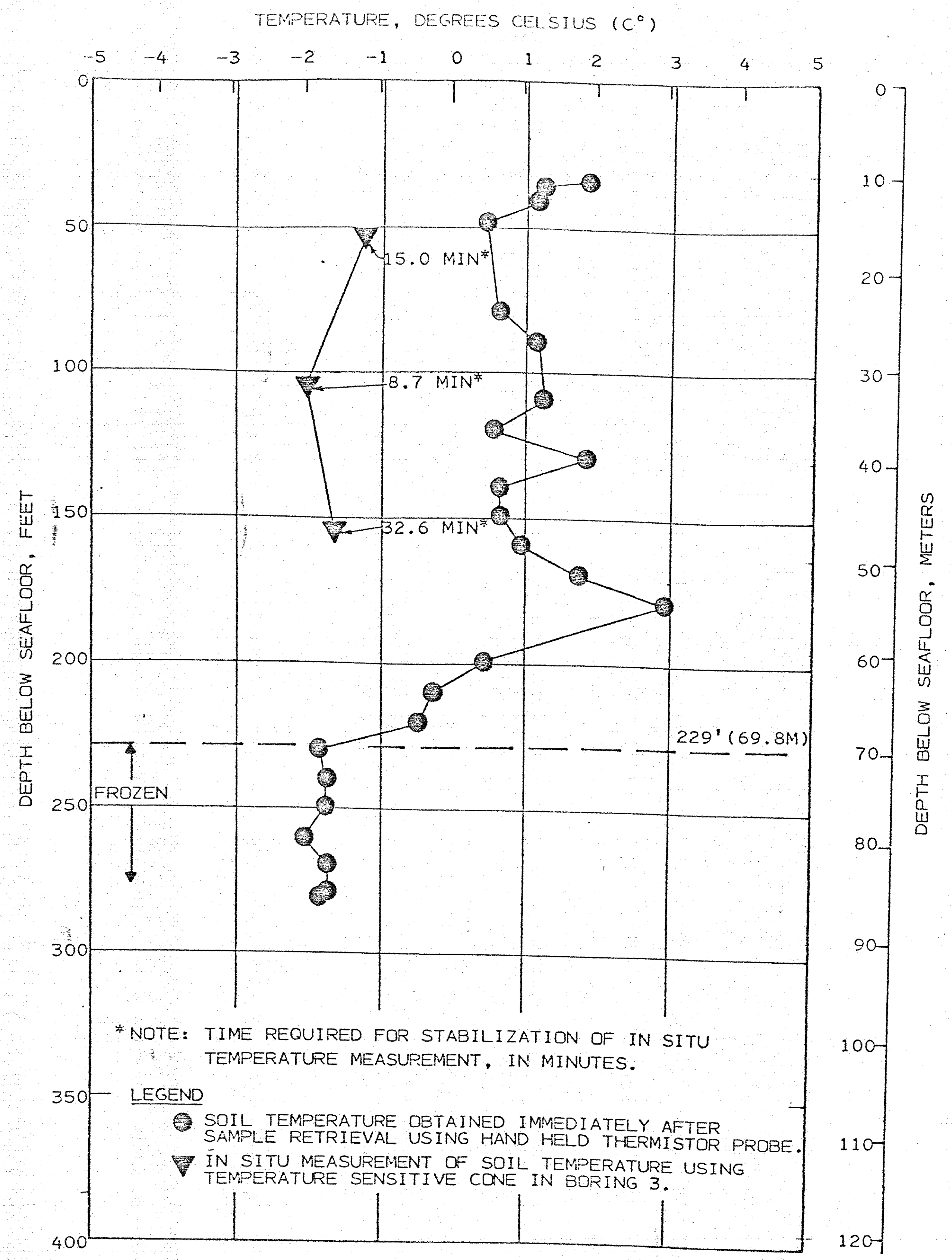
GROUP	ABBREVIATION	DESCRIPTION
NON VISIBLE ICE	Nf	Poorly Bonded
	Nbn	Well Bonded
	Nbe	Excess Ice
VISIBLE ICE LESS THAN 1 INCH THICK	Vx	Individual Ice Crystals or Inclusions
	Vc	Ice Coatings or Particles
	Vr	Random or Irregularly Oriented Ice Formations
	Vs	Stratified or Distinctly Oriented Ice Formations
VISIBLE ICE GREATER THAN 1 INCH THICK	ICE+	(Soil Type) Ice with Soil Inclusions
	ICE	Ice without Soil Inclusions

* NATIONAL RESEARCH COUNCIL (CANADA) TECHNICAL MANUAL

SUMMARY OF FIELD ACTIVITIES
KOPANOAR I-44
BEAUFORT SEA, OFFSHORE CANADA

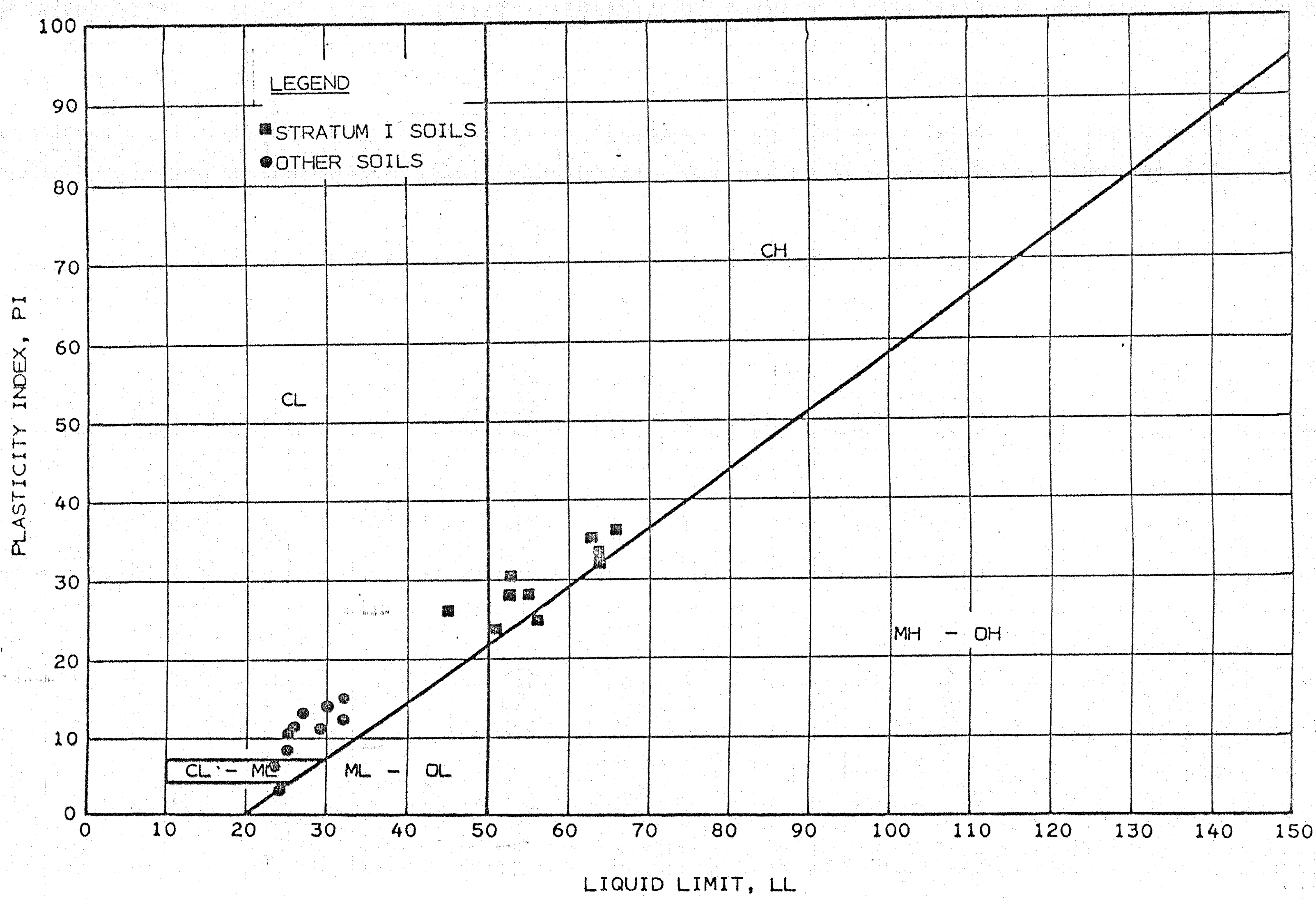
DATE	TIME FROM	TIME TO	DESCRIPTION OF ACTIVITY
8/07/80	09:05	11:50	Travel to Kopanoar I-44.
	11:50	18:50	Wait at location; starboard engine down.
	18:50	21:00	Set anchors.
	21:00	21:30	Prepare to drill. Water depth is 179 ft. at 2130 hrs.
	21:30	23:00	Lower drill pipe. Location of this boring, Boring 2: Lat. 70° 23' 44" N Long. 135° 14' 29" W.
	23:00	24:00	Drill and sample 0 to 8 ft.
8/08/80	00:00	24:00	Drill and sample, 8 to 325 ft. (CPT sounding with C Floor 9 unit 1420-1630. Location of this sounding. Lat. 70° 23' 44" N Long. 135° 14' 27" W.)
8/09/80	00:00	07:00	Drill and sample 325 to 400 ft.
	07:00	09:00	Prepare ROKE logging unit.
	09:00	09:45	Log borehole through drill pipe with ROKE gamma tool.
	09:45	11:00	Pull drill string to 100 ft penetration.
	11:00	15:00	Log borehole with ROKE gamma, resistivity, caliper/density and temperature tools. (Vane tests with C Floor 9 unit 1140-1215.)
	15:00	16:15	Pull drill string.
	16:15	19:30	Repair and test heave compensator.
	19:30	19:40	Winch vessel over to do CPT borehole. Location of CPT boring, Boring 3: Lat. 70° 23' 44" N Long. 135° 14' 26" W
	19:40	21:30	Repair combicable reel. Water depth is 179 ft. at 2130 hrs.
	21:30	23:30	Lower drill pipe.
	23:30	24:00	Drill and Wison test, 0 to 25 ft.
8/10/80	00:00	16:30	Drill and Wison test 25 to 174.5 ft.
	16:30	17:30	Pull drill pipe; rig clutch cannot pull more drill pipe.
	17:30	20:10	Pull anchors.

Job No.

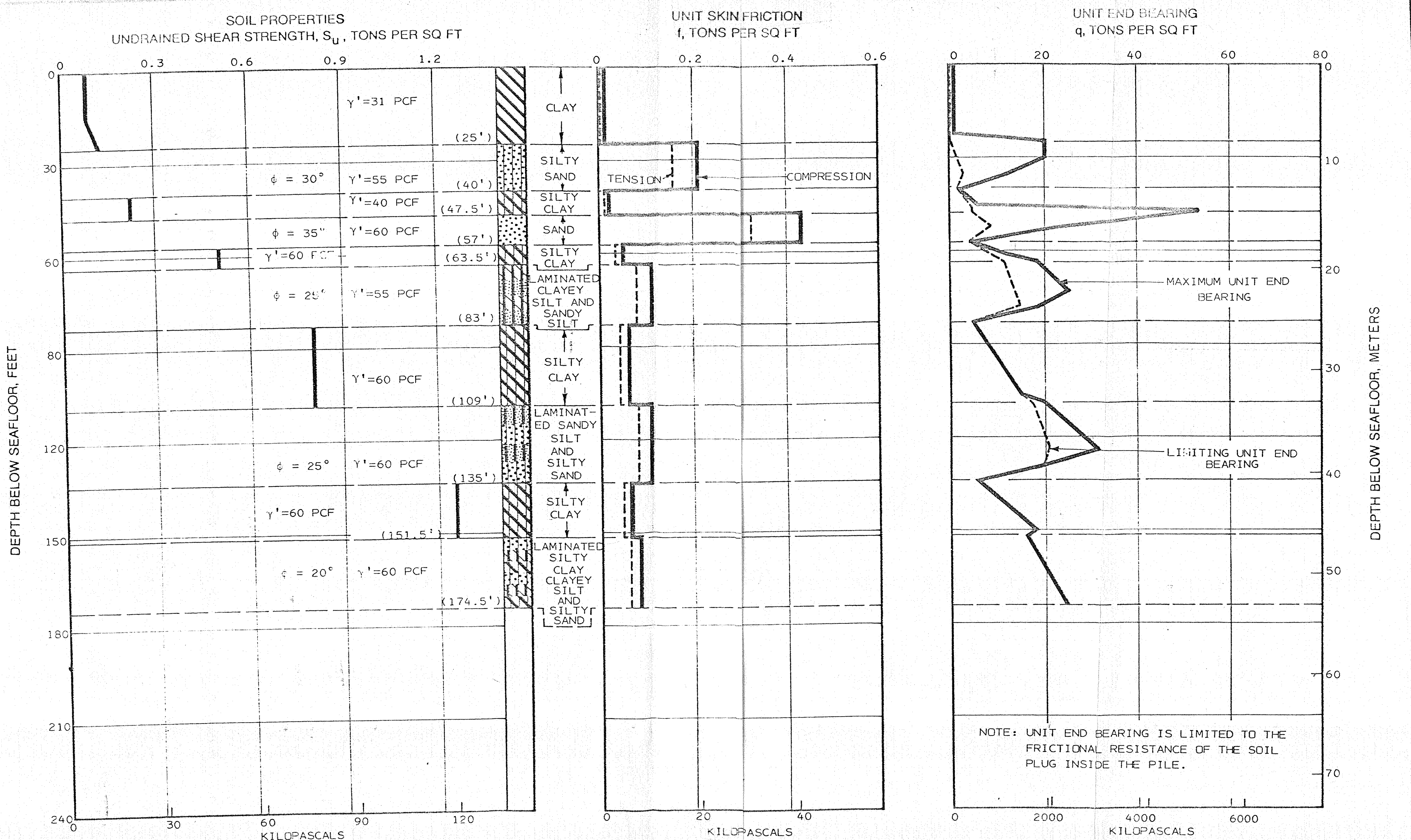


IN SITU AND SAMPLE TEMPERATURES
BORINGS 2 AND 3, KOPANOAR I-44
BEAUFORT SEA, OFFSHORE CANADA

Job No. 80-058-5



PLASTICITY CHART
BORING 2, KOPANOAR I-44
BEAUFORT SEA, OFFSHORE CANADA



SOIL PROPERTIES AND PILE CAPACITY DATA

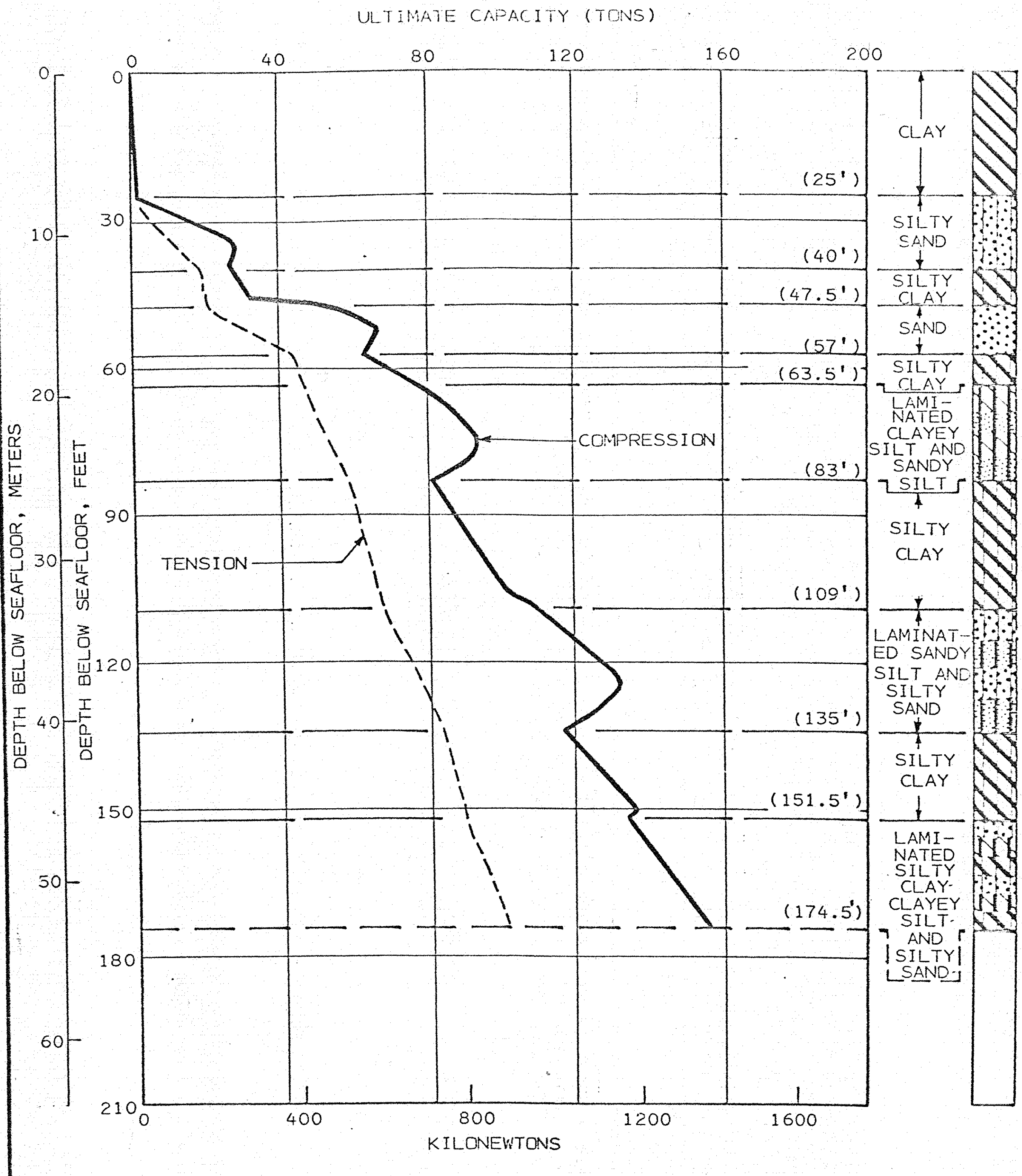
CPT METHOD

BORING 3, KOPANOAR I-44

BEAUFORT SEA, OFFSHORE CANADA

FUGRO GULF, INC
Consulting Engineers and Geologists

PLATE



ULTIMATE PILE CAPACITY CURVES

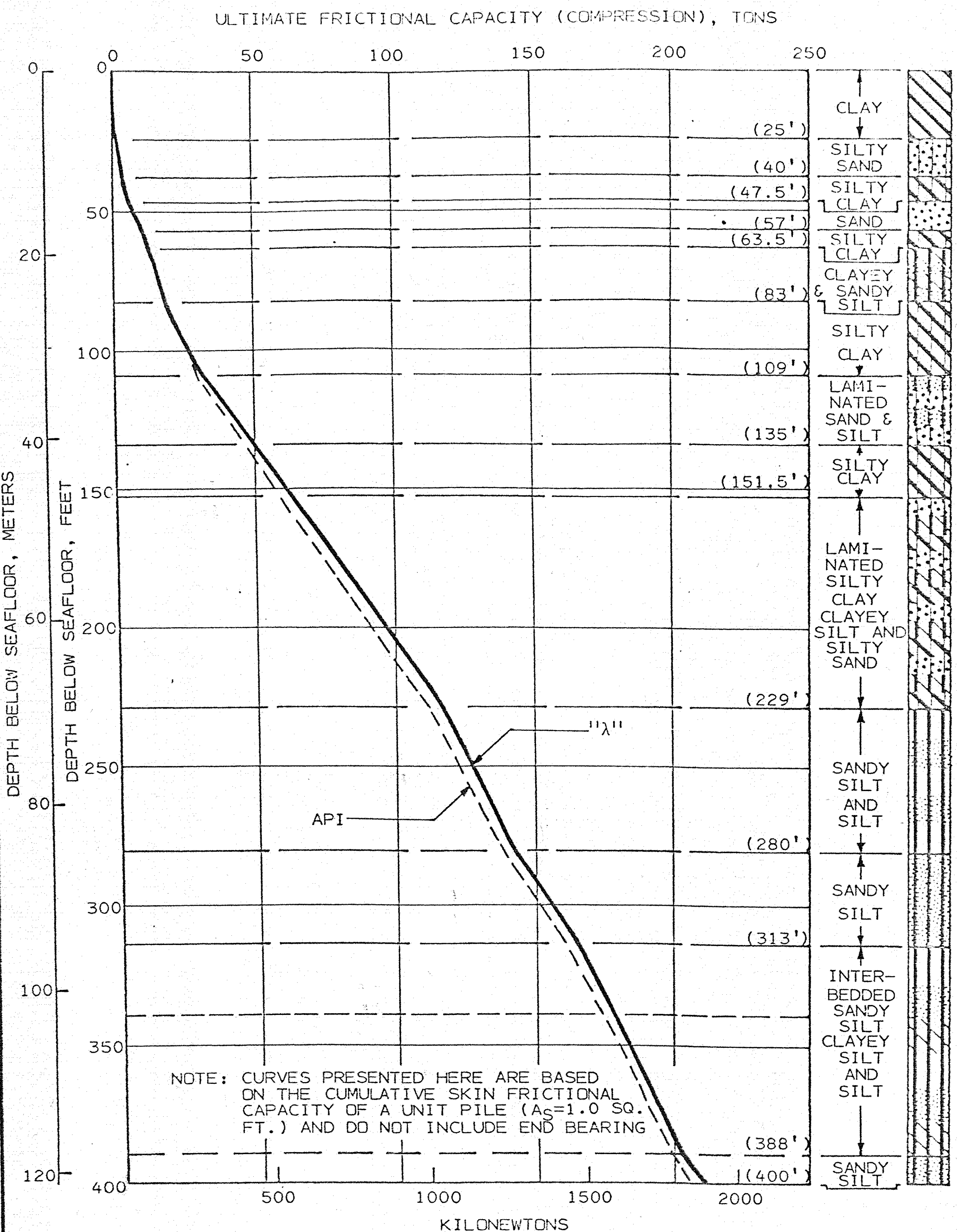
CPT METHOD

30-INCH DRIVEN PIPE PILE

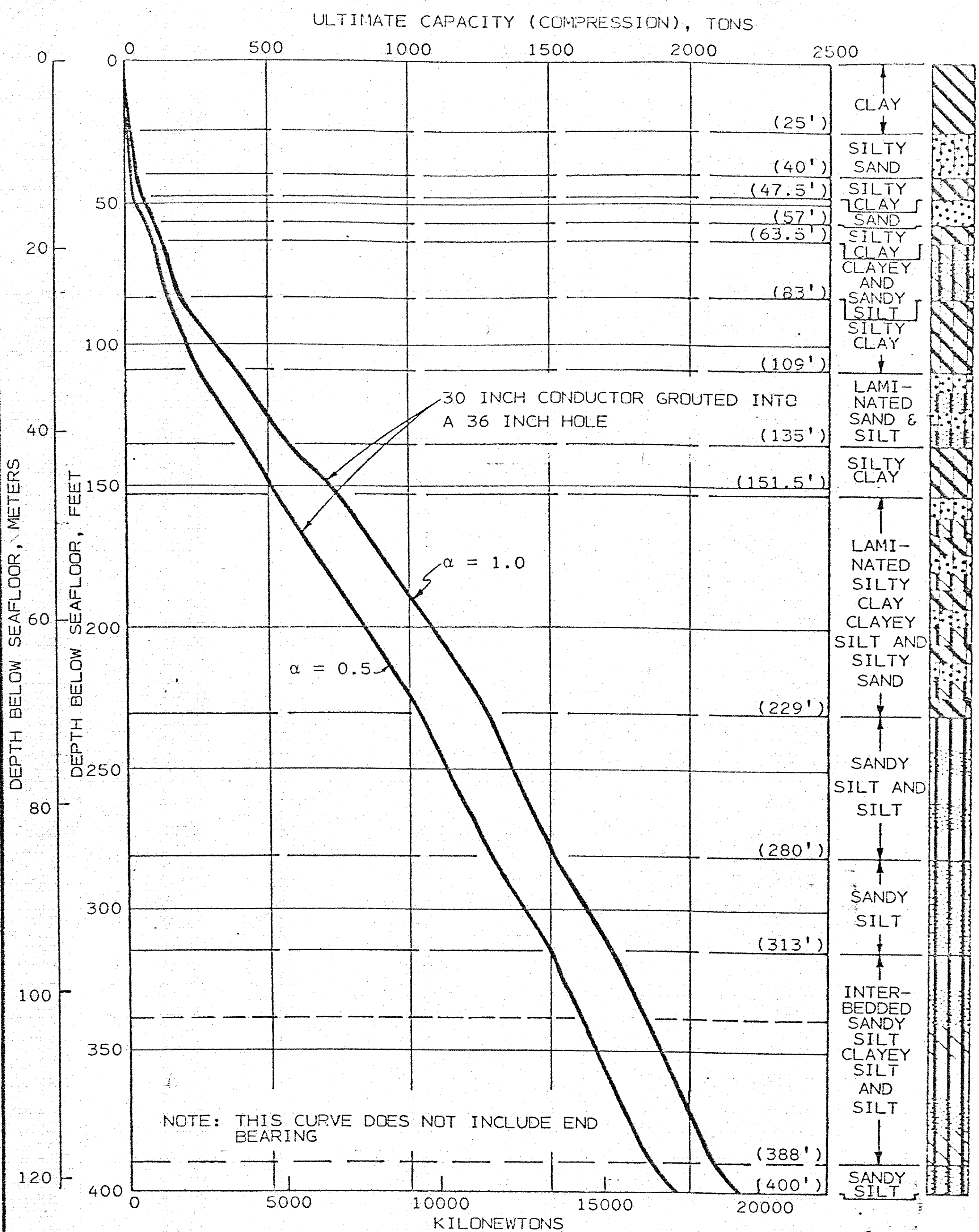
BORING 3, KOPANOAR I-44

BEAUFORT SEA, OFFSHORE CANADA

Job No. 80-035-3

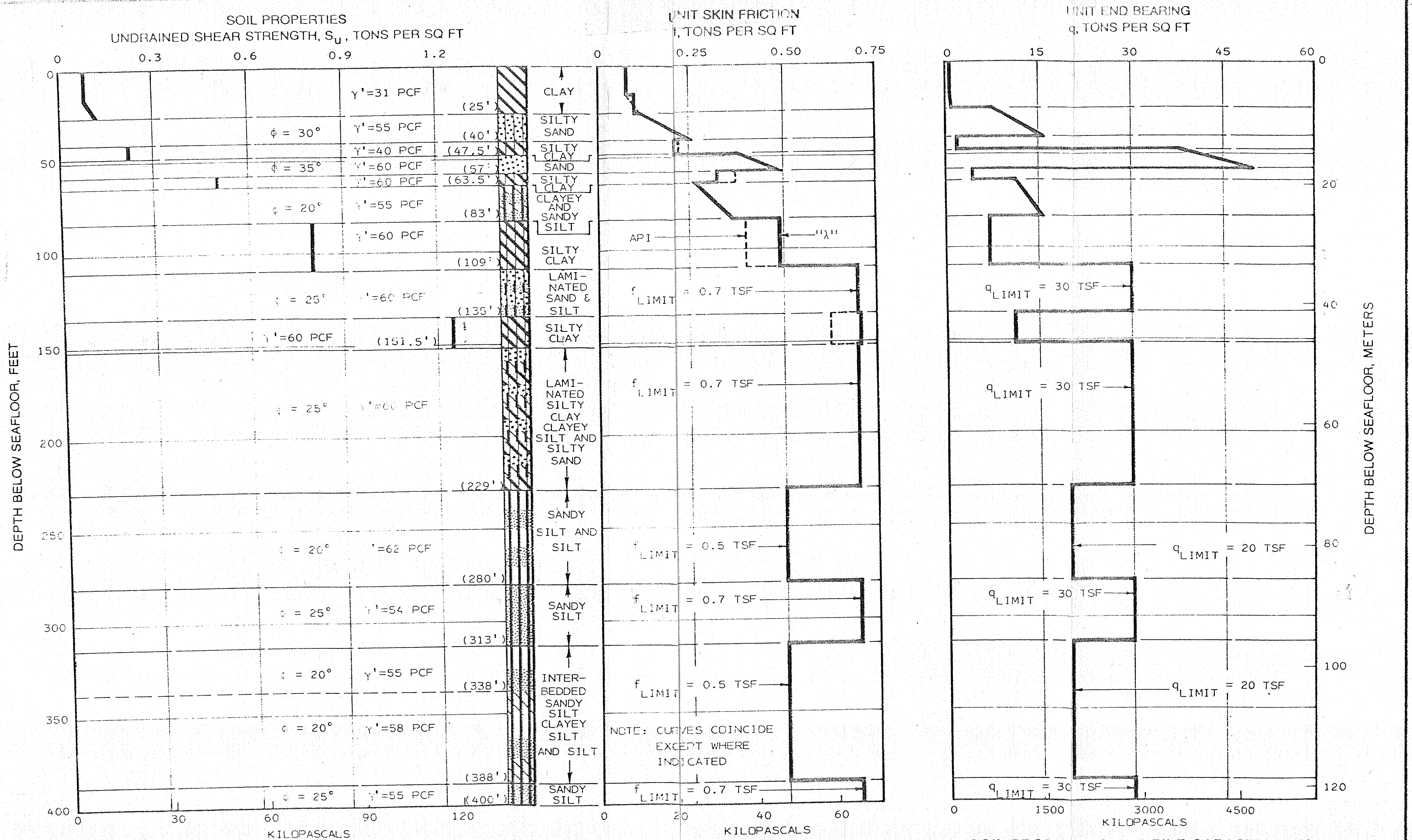


UNIT PILE CAPACITY CURVES (COMPRESSION)
"λ" AND API METHODS
BORINGS 2 AND 3, KOPANOAR I-44
BEAUFORT SEA, OFFSHORE CANADA



GROUTED CONDUCTOR PILE CAPACITY CURVE (COMPRESSION)
BORINGS 2 AND 3, KOPANOAR I-44
BEAUFORT SEA, OFFSHORE CANADA

FUGRO GULF, INC.
Consulting Engineers and Geologists



SOIL PROPERTIES AND PILE CAPACITY DATA

"λ" AND API METHODS

BORINGS 2 AND 3, KOPANOAR I-44

BEAUFORT SEA, OFFSHORE CANADA

PLATE

FUGRO GULF, INC.
Consulting Engineers and Geologists

APPENDIX A

BOREHOLE LOGS (EBA)

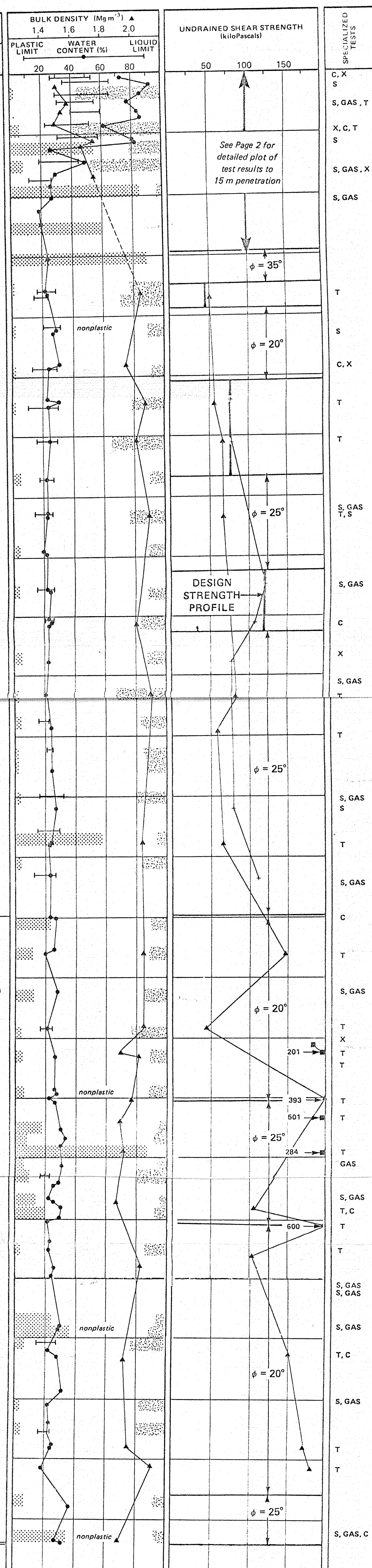
APPENDIX A

BOREHOLE LOGS

Appendix - Illustrations & Tables

LOCATION: KOPANOAR I-44
LAT. 70° 23′ 44″ N, LONG. 135° 14′ 26″ W — WATER DEPTH: 54.6 m

DEPTH BELOW SEABED (metres)	USC	SMPL.	SOIL DESCRIPTION	BLOW COUNT	GROUND ICE
0	CH	DETAIL OMITTED	CLAY AND SILT - trace of organics, very wet, very soft, high plastic, olive grey (5Y 3/2), (10YR 6/1)	WOH/60 cm	NOT FROZEN
			- siltier, trace to some organics in distinct laminae and occasional pockets, olive grey	1/60 cm 2/60 cm	
			- occasional shell fragments		
5			- isolated sand lenses, becoming sandier at 5.8 m (5.93)	6/60 cm	
	SC		SAND - clayey, laminated, wet, loose, brown (2.5Y 5/2), (5Y 3/2) (6.90)	15/60 cm	
	CL		CLAY - some silt, trace of sand, occasional shell fragments (7.70)		
10	SM/SC		SAND - some silt to silty, faintly laminated with clay layers		
			- some silt, trace of clay, shell fragments and organic pockets, laminations of clay and organics, moist, loose, low to nonplastic, olive grey (5Y 3/2), (10YR 6/1)	20/60 cm	
15		B	- trace of silt, roots and shell fragments, faint laminae (17.7)	20/60 cm	
	CL	B W	CLAY AND SILT - trace of sand, clay pockets and clay laminations, moist, stiff, low plastic, olive grey (5Y 4/2), (10YR 6/1)	20/60 cm	
20		B	- trace of sand, laminations of silt, clay, sand, and organics	20/60 cm	
25		B W	- trace of sand, and organics, laminated lenses, stiff, nonplastic, grey (5Y 3/2), (10YR 6/2)	25/60 cm	
		W	- distinct laminations of clay, sand, and organics at 27.2 m	25/60 cm	
30		B W	- sandy, trace of organics, moist, stiff, low plastic, dark grey (5Y 4/1), (10YR 5/2)	25/60 cm	
			- sand laminae at 33.3 m, silty, fine-grained, uniform, 50 mm thick	25/60 cm	
35		W G V W	- few clay laminae and pockets with organic inclusions, damp	25/60 cm	
40		B	- trace to some sand, occasional clay laminae, very stiff	25/60 cm	
	CL-ML	G B	- very thick clay laminae, 20-30 mm thick	25/60 cm	
			- laminated silts and sandy silts		
45		B W	- trace of sand, very thick clay laminae, up to 30 mm thick, very stiff	25/60 cm	
50		B	- trace of sand, laminated, damp, stiff, low plastic to nonplastic, dark grey (5Y 4/1), (10YR 5/2)	25/60 cm	
		G W		25/60 cm	
55	CL	W	- trace of organics, laminated	25/60 cm	
	CL-ML	B B	- trace of sand, and organics, laminated	30/60 cm	
60	CL	B G	- trace to some sand, trace of organics and shell fragments, lamination up to 50 mm thick	25/60 cm	
		B W		25/60 cm	
65	CL-ML	B G	- 100 mm thick sand and silt bed at 63.8 m, trace of wood fragments, very dark grey (5Y 3/1), (10YR 5/1) (70.05 m)	25/60 cm	
70	ML	P.F. B	SILT - some fine sand, trace clay, olive grey (5Y 3/2), (10YR 6/2)	30/60 cm	FROZEN Bonded, Nbn
		B PF	- some sand, faint laminations	30/60 cm	
75		G B	- some sand and clay, faint laminations	30/60 cm	Isolated Vx<3 mm
80		P.F. B	- clayey, trace of sand and organics, faint laminations, stiff		Well bonded, Nbn
		P.F.	- some clay		
85		B B PF	- trace of sand, faint laminations, damp, hard, low plastic, olive grey (5Y 3/2), (10YR 6/2)	25/60 cm	
		B P.F. B	- trace of sand and clay, laminated	25/60 cm	
		B PF	- sand bed, 100 mm thick, some silt, at 89.05 m		
90		B G	- trace of sand, laminated		Bonded, Nbn
		PF	- trace of sand, organics, and clay, laminated		
		G PF	- trace clay		
95		PF	- some sand, laminated		
		PF B	- trace of sand	30/60 cm	Trace Vx
100		PF G PF		25/60 cm	
					Nbn
105		B G B PF	- sandy, trace of clay, laminations even, parallel, and horizontal		Nbn
		PF	- clayey		
110		G PF B	- some clay, trace of sand and organics, sand laminations	25/60 cm	Nbn
		B PF		25/60 cm	
115		PF		25/60 cm	
		B	- trace of clay and sand, organic specks, sand laminations	25/60 cm	Nbn
120		B G PF	- sandy, trace of clay (121.9)		Nbn
			END OF BOREHOLE		
125					
130					



JOB No.: 101 - 2941 DRILLING COMPLETED: 80/08/09 BOREHOLE DEPTH: 121.9 m DRILLING RIG: FA 1500 LOG COMPILED BY: RJG/TRM/LSM	BOREHOLE NUMBER 2 PAGE 1 of 2

LEGEND

GRAIN SIZE: % Sand, % Silt, % Clay

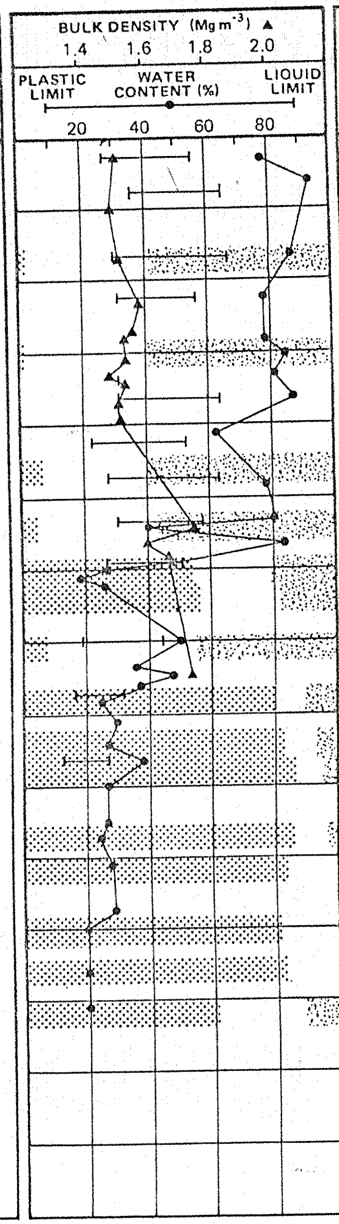
SHEAR STRENGTH: + Torvane; × Min. Vane; ♦ Res. Min. Vane; ● Unconfined Compr.; ▲ UU Triaxial; ■ CU Triaxial

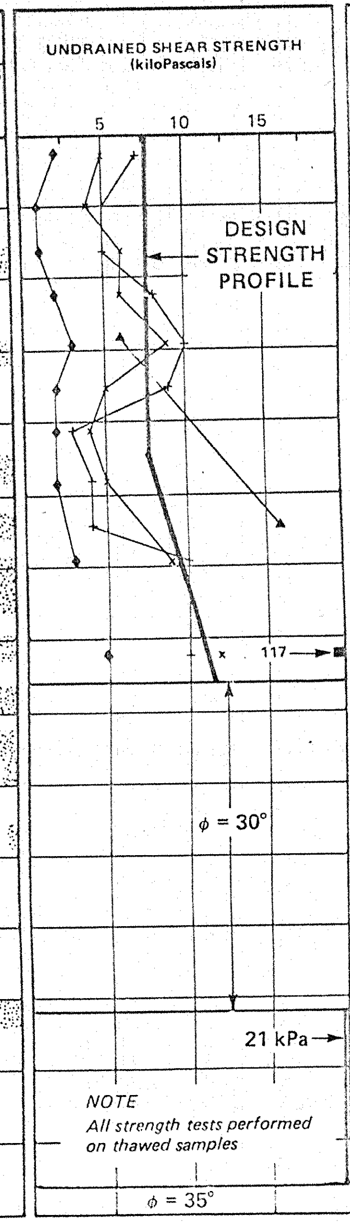
TEST IDENTIFICATION: C - Consolidation; TS - Thaw Strain; DS - Direct Shear; T - Triaxial Shear; S - P.W. Salinity; X - X-Ray Diffr.

FIGURE A-1 BOREHOLE LOG AND LABORATORY TEST RESULTS

LOCATION: KOPANOAR I-44
LAT. 70° 23' 44'' N, LONG. 135° 14' 26'' W — WATER DEPTH: 54.6 m

DEPTH BELOW SEABED (metres)	USC	SMPL.	SOIL DESCRIPTION		GROUND ICE
0	CH	V	CLAY AND SILT - trace of organics, very wet, very soft, - high plastic, olive grey, (5Y 3/2), (10YR 6/1)	WOH/60 cm	NOT FROZEN
1				WOH/60 cm	
		V	- few organic seams and pockets	WOH/60 cm	
2		V	- silty, trace to some organic, distinct organic laminae and pockets	1/60 cm	
		V	- occasional silt laminations	1/60 cm	
3		V		2/60 cm	
4		V	- occasional shell fragments	2/60 cm	
		V	- silt seams and occasional shell fragments	2/60 cm	
5		B	- isolated sand lenses - becoming sandier (5.93)	6/60 cm	
6	SC	V, B	SAND - silty and clayey, fine-grained, uniform, laminated, moist, greyish brown (2.5Y 3/2), (10YR 6/1) (6.90)	10/60 cm 15/60 cm	
7	CL	B	CLAY - silty to some silt, trace of sand, occasional shell fragments, wet, soft, low plastic - numerous sand lenses and pockets (7.70)	15/60 cm	
8	SM/SC	B, B	SAND - some silt to trace of silt, with interbedded clay layers	15/60 cm 15/60 cm	
		B	- silty clay layer 8.6 - 8.8 m		
9		B	- trace of silt and clay, occasional shell	15/60 cm	
		B	- fine-grained sand, homogeneous (2.5Y 5/4) uniform, laminated, moist, olive grey (5Y 3/2), (10YR 6/1)	15/60 cm	
10		B	- some silt, trace of clay, faint horizontal, laminae of clay and organics	20/60 cm	
11		B		20/60 cm	
		B		20/60 cm	
12		B	- silty, some clay, faint horizontal laminae of clay and organics	20/60 cm	
13					
14					
15		B	- trace of silt, occasional root and shell fragments, faint laminations		





SPECIALIZED TESTS	Depth (m, approx.)
C	0
X, S	0.5
GAS, S	1.9
T	2.4
T, C,S	5.2
T	6.9
GAS, S	7.6
X	8.4

JOB No.: 101 - 2941
DRILLING COMPLETED: 80/08/09
BOREHOLE DEPTH: 121.9 m
DRILLING RIG: FA 1500
LOG COMPILED BY: RJG/TRM/LSM

LEGEND

GRAIN SIZE: % Sand, % Silt, % Clay

SHEAR STRENGTH:
+ Torvane
× Min. Vane
◆ Res. Min. Vane
● Unconfined Compr.
▲ UU Triaxial
■ CU Triaxial

TEST IDENTIFICATION:
C - Consolidation
TS - Thaw Strain
DS - Direct Shear
T - Triaxial Shear
S - P.W. Salinity
X - X-Ray Diffr.

BOREHOLE NUMBER 2

BOREHOLE LOG AND LABORATORY TEST RESULTS

TABLE A.1 SUMMARY OF FIELD OPERATIONS FOR 1980 PROGRAM

DATE (1980)	ACTIVITY
July 25 to August 1	TUK BASE: mobilization of the drilling and testing equipment
August 2 to August 9	KOPANOAR I-44: coring, logging and testing
August 9 to August 11	TUK BASE: resupply and maintenance
August 11 to August 15	TARSIUT D-14: coring, logging and testing
August 16	TUK BASE
August 17 to August 25	KAGLULIK P-74: coring, logging and testing
August 26 to August 28	TUK BASE: shipped available samples, resupply and maintenance
August 29 to September 13	BORROW INVESTIGATION: coring at Tarsiut South and Isserk locations
September 14 to September 17	TARSIUT 0-34: coring, logging and testing
September 17 to September 20	TUK BASE: resupply and maintenance
September 20 to September 22	TARSIUT N-44: coring, logging and testing of borehole no.1.
September 23 to October 9	BORROW INVESTIGATION: coring at Isserk, Tarsiut south and Uviluk locations
October 10 to October 12	TARSIUT N-44: coring logging and testing of boreholes no. 2 - 6
October 15	TUK BASE: programmed demobilization. Equipment personel and soil sample transported south.

TABLE A-2 SUMMARY OF FIELD OPERATIONS

BOREHOLE KOPANOAR I-44
BEAUFORT SEA

Date (1980)	Activity
July 25th	- Personnel assemble at Tuk base - Alterations to Supplier V accommodation in preparation for offshore program
July 26th	- EBA personnel arranging field lab deployment on vessel. - Fugro personnel supervising drill rig and Wison installations
July 27th	- EBA - continuing lab set-up - Fugro - locating and ordering equipment
July 28th	- Roke personnel arrive - EBA & Fugro - as above

TABLE A-2 SUMMARY OF FIELD OPERATIONS (cont'd)

BOREHOLE KOPANOAR I-44

Date (1980)	Activity
July 29th	- EBA - as above - Fugro - modification of sea-floor remote vane - Roke - setting up lab
July 30th	- EBA - continued set-up lab - Fugro - completing rig and Wison installation
July 31st	- EBA - final lab preparations - Fugro - calibration of sea-floor remote vane - Taking on drill pipe, drilling mud, water, etc.
August 1st	- Waiting on ship due to anchor malfunction and fractured fuel lines - Delayed arrival on Kopanoar I-44 location

TABLE A-2 SUMMARY OF FIELD OPERATIONS (cont'd)

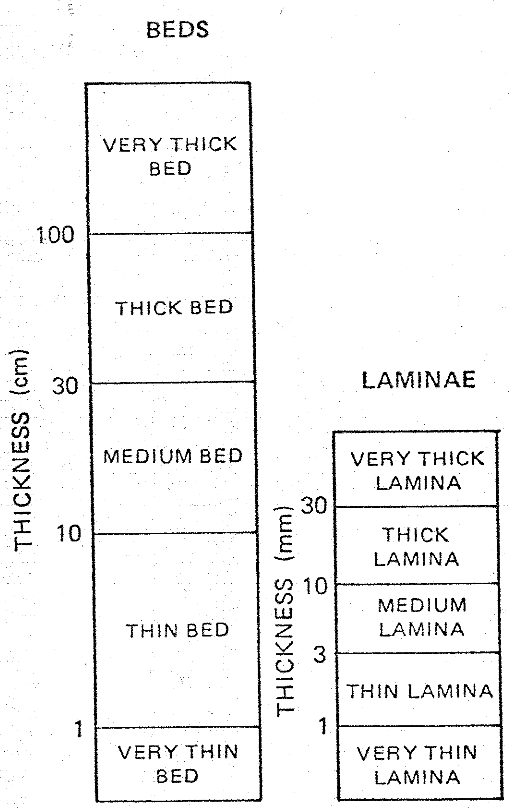
BOREHOLE KOPANOAR I-44

Date (1980)	Activity
August 2nd	- Commenced drilling and Wison testing
August 3rd	- Continued slow progress, problems such as slipping clutch on rig and faulty motion compensator
August 4th	- Very little progress, lost drill string, packer collar and 1.5 m cone - Motion compensator still not performing satisfactorily
August 5th	- Return to Tuk base for drilling supplies - Take onboard government personnel for oceanographic and gas survey

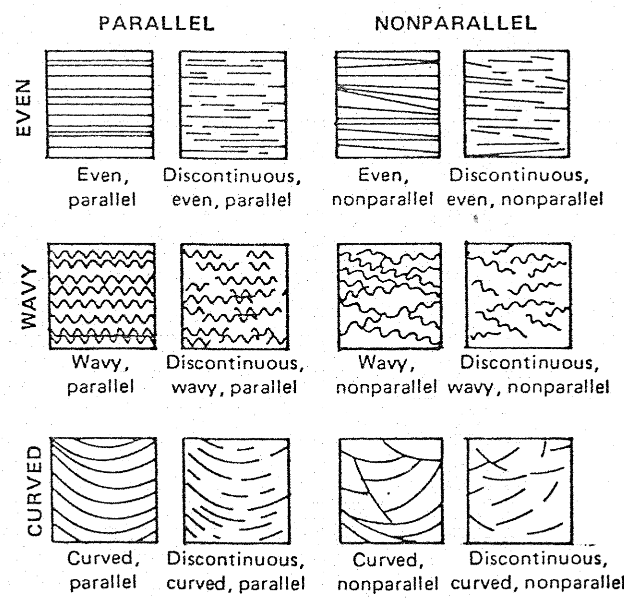
DESCRIPTION OF SEDIMENTARY STRUCTURES

BEDS - SEDIMENTATION UNITS DEPOSITED UNDER ESSENTIALLY CONSTANT PHYSICAL CONDITIONS, SEPARATED BY BEDDING PLANES WHICH ARE RECOGNIZABLE BY TEXTURAL OR COMPOSITIONAL CHANGES RESULTING FROM PERIODS OF NON-DEPOSITION OR EROSION, OR ABRUPT CHANGES IN DEPOSITIONAL CONDITIONS. BEDS MAY BE INTERNALLY HOMOGENEOUS, OR COMPOSED OF SMALLER UNITS-LAMINAE

LAMINAE - THE SMALLEST MEGASCOPIC LAYERS IN A SEDIMENTARY SEQUENCE, REPRESENTING MINOR FLUCTUATIONS IN PHYSICAL CONDITIONS DURING THE DEPOSITION OF BEDS. LAMINAE ARE RELATIVELY UNIFORM IN TEXTURE AND COMPOSITION AND GENERALLY LACK MEGASCOPIC INTERNAL LAYERING.



(Modified after Ingram, 1954 and Campbell, 1967)



(After Campbell, 1967)

DEPTH BELOW SEABED (m)	USC	SAMPLES	SOIL DESCRIPTION	GEOLOGIC DETAILS
	CH	V B	CLAY AND SILT - trace organics, very soft	Generally homogeneous; isolated thin organic laminae, organic specks Generally homogeneous; few thin silt beds, wavy, even, parallel laminae
		V		Generally homogeneous; isolated thin organic laminae and pockets
2		V	- soft	Wavy to even, parallel, thin to medium laminae; organic laminae and pockets Even to wavy, parallel, thin to very thin laminae
		V V	- more silty	Wavy to even, parallel, thin to very thin laminae-isolated; few organic pockets
4		V		Even, parallel, thin to very thin laminae; few organic specks
		V	- occasional shell fragments	Wavy to even, parallel, thin to very thin laminae; organic pockets
		B V B	- isolated sand pockets, lenses - becoming more sandy	Wavy, parallel, very thin laminae Wavy to even, parallel, thin to medium laminae; isolated sand pockets
6	SC		SAND - clayey, loose	Thin to medium-interbedded sand and clay Discontinuous, wavy, parallel, thin laminae
	CL	V	CLAY - some silt, trace sand	Interbedded sand and clay; wavy, parallel, thin to very thin laminae; sand and clay pockets
8	SM/SC	B B B B	SAND AND CLAY - some silt to silty	Distorted medium laminae and pockets of sand and clay Distorted medium to thin laminae and pockets of sand and clay; organic pockets
		B	SAND - some silt, trace clay, loose	Wavy to even, parallel, very thin to thin laminae; silty clay pockets
10		B		Wavy to even, parallel, thin to very thin laminae-faint; thin clay beds and pockets
		B		Thinly interbedded sand and silt; wavy to even, parallel, thin laminae-faint
		B		Wavy to even, parallel, thin laminae-faint, very thin organic laminae
12		B	- silty, some clay	Discontinuous, even to wavy, nonparallel, very thin to medium laminae; clay and organic pockets
14				
		B	- trace silt, roots, and shell fragments	Curved to even, parallel, thin laminae Some homogeneous sand beds
16				
18	CL	B B	CLAY AND SILT - trace sand, stiff	Wavy to curved, nonparallel, very thin to medium laminae; clayey pockets
20				
		B	- more silty	Thinly interbedded clay and silt; Even, parallel, very thin to thin laminae, organic laminae and specks
22				
24	ML	B	SILT - trace clay and sand, stiff	Even to wavy, parallel, thin to medium laminae-faint
26				
		B		Even to wavy, parallel, very thin to thin laminae
28				
30		B		Even to wavy, parallel, very thin to thin laminae-faint in clay beds
	CL		CLAY AND SILT - trace sand	

eba

JOB No.: 101 - 2941
DRILLING COMPLETED: 80/08/09
BOREHOLE DEPTH: 121.9 m
DRILLING RIG: FA 1500
LOG COMPILED BY: RJG/TRM/LSM

BOREHOLE NUMBER 2

PAGE 1 OF 4

FIGURE A-2 LOG OF SEDIMENTARY STRUCTURE
KOPANOAR I-44

DEPTH BELOW SEABED (m)	USC	SAMPLES	SOIL DESCRIPTION	GEOLOGIC DETAILS
	CL	B	CLAY AND SILT - trace sand, stiff	Even to wavy, parallel, very thin to thin laminae-faint in clay beds
32				
		B		Even to wavy, parallel, thin to very thin laminae; isolated thin beds of sand
34	CL			
		B		Wavy to even, parallel, thin to very thin laminae; clay pockets with organics
36				
38				
		B	- higher silt and sand content	Even to wavy, parallel, thin laminae, minor thin laminae of clay
40				
42		B	- few thick laminae of clay	Even to wavy, parallel, very thin to thin laminae-inclined 5°-10°; few thick laminae of clay
44				
		B	- very stiff	Even to wavy, parallel thin laminae-horizontal; few thick laminae of clay
		W		
46				
48				
		V		Even to wavy, parallel, thin laminae; thin clayey bed with "mud ball" structure
	ML		SILT - trace clay and sand, stiff	
50				
52		B		Even, parallel, thin to medium laminae
54	ML			
		B	- trace organics	Even, parallel, thin to very thin laminae; silt pockets
56				
		B		Even to wavy, very thin to thin laminae; few clayey laminae and pockets
58				
60				
		B	- more clayey	

JOB No.: 101-2941
DRILLING COMPLETED: 80/08/09
BOREHOLE DEPTH: 121.9 m
DRILLING RIG: FA 1500
LOG COMPILED BY: RJG/TRM/LSM

BOREHOLE NUMBER 2

FIGURE A-2 LOG OF SEDIMENTARY STRUCTURE (continued)
KOPANOAR I-44

DEPTH BELOW SEABED (m)	USC	SAMPLES	SOIL DESCRIPTION	GEOLOGIC DETAILS
	ML	B	SILT - as above - more clayey below 60.45 m	Interbedded silt and clay-thin beds Even to wavy, parallel, very thin to thin laminae
62				
64		B	- clayey and sandy layers	Interbedded silt, clay and sand-thin beds Even to wavy, parallel, very thin to medium laminae, sand pockets, roots
66		B		Interbedded silt, sand and clay-thin beds Even, parallel, thin laminae-inclined 20°-30°; organic inclusions
68				
70		PF B	- sandy, trace clay	Wavy to even, parallel, very thin to medium laminae-faint
72	ML	B		Even to wavy, parallel, very thin lmainae-faint
74				
76		B	- some clay and sand	Even to wavy, parallel, very thin to medium laminae-faint
78				
	-(CL)-	B	- clayey lenses, trace sand, low plastic	Discontinuous, wavy to even, parallel, very thin laminae; organic inclusions
80		B	- some clay, trace sand	Discontinuous, wavy to even, parallel, very thin to thin laminae; organic inclusions
82				
84		B	- some clay, trace sand	Wavy, parallel, thin to very thin laminae; clay pockets
		B	- trace clay and sand	Wavy nonparallel, thin to very thin laminae-faint; sand pockets
		B		Even, parallel, very thin to thin laminae-inclined 20°
86				
88		B	- some sand, trace clay	Wavy, nonparallel, thin to very thin laminae-faint
		B		Wavy, nonparallel, thin to very thin laminae-faint
		B		Wavy, nonparallel, thin to very thin laminae-faint
90		G	- trace sand and clay	Even to wavy, parallel, thin to very thin laminae; sand pockets

eba

JOB No.: 101 - 2941
DRILLING COMPLETED: 80/08/09
BOREHOLE DEPTH: 121.9 m
DRILLING RIG: FA 1500
LOG COMPILED BY: RJG/TRM/LSM

BOREHOLE NUMBER 2

FIGURE A-2 LOG OF SEDIMENTARY STRUCTURE (continued)
KOPANOAR I-44

LOG OF SEDIMENTARY STRUCTURE

KOPANOAR I-44

DEPTH BELOW SEABED (m)	USC	SAMPLES	SOIL DESCRIPTION	GEOLOGIC DETAILS
		G	SILT - trace sand and clay	Even to wavy, parallel, thin to very thin laminae; sand pockets
92		B	- some clay, trace sand	Even to wavy, parallel, thin to very thin laminae-faint; sand pockets, organic inclusions
94		B		Even to wavy, parallel; very thin to medium laminae-faint
		B	- some sand, trace clay	Even to wavy, parallel, thin to medium laminae; sand pockets, organic laminae
96				
		B		Even, parallel, thin to medium laminae; sand pockets
		B	- some clay, trace sand	Even, parallel, thin to medium laminae; sand pockets
98				
		B		Even to wavy, parallel, thin to very thin laminae; sand pockets
100		G		Even to wavy, parallel, thin to very thin laminae
102				
104		B	- sandy, trace clay - and SAND, some clay	Even to wavy, parallel, thinto medium laminae; sand pockets, few organic inclusions
106	ML	B		Even to wavy, parallel, very thin to medium laminae
108				
		B		Even to wavy, parallel, very thin to medium laminae
110			- some clay, trace sand and organics	
		B		Wavy to even, parallel, thin to medium laminae
112				
		B		Even to wavy, parallel, very thin to medium laminae; isolated, very thin organic laminae
114		B		Even to wavy, parallel, very thin to medium laminae
116				
118				
		B	- trace clay and sand	Even to wavy, parallel, very thin to medium laminae
		B	- sandy, trace clay	Wavy to even, parallel, very thin to thin laminae, sand pockets
122			END OF BOREHOLE	

eba

JOB No.: 101 - 2941
DRILLING COMPLETED: 80/08/09
BOREHOLE DEPTH: 121.9 m
DRILLING RIG: FA 1500
LOG COMPILED BY: RJG/TRM/LSM

BOREHOLE NUMBER 2

FIGURE A-2 LOG OF SEDIMENTARY STRUCTURE (continued)
KOPANOAR I-44

A P P E N D I X B

DIAGNOSTIC PROFILES (EBA)

APPENDIX B

DIAGNOSTIC PROFILES

Appendix - Illustrations & Tables

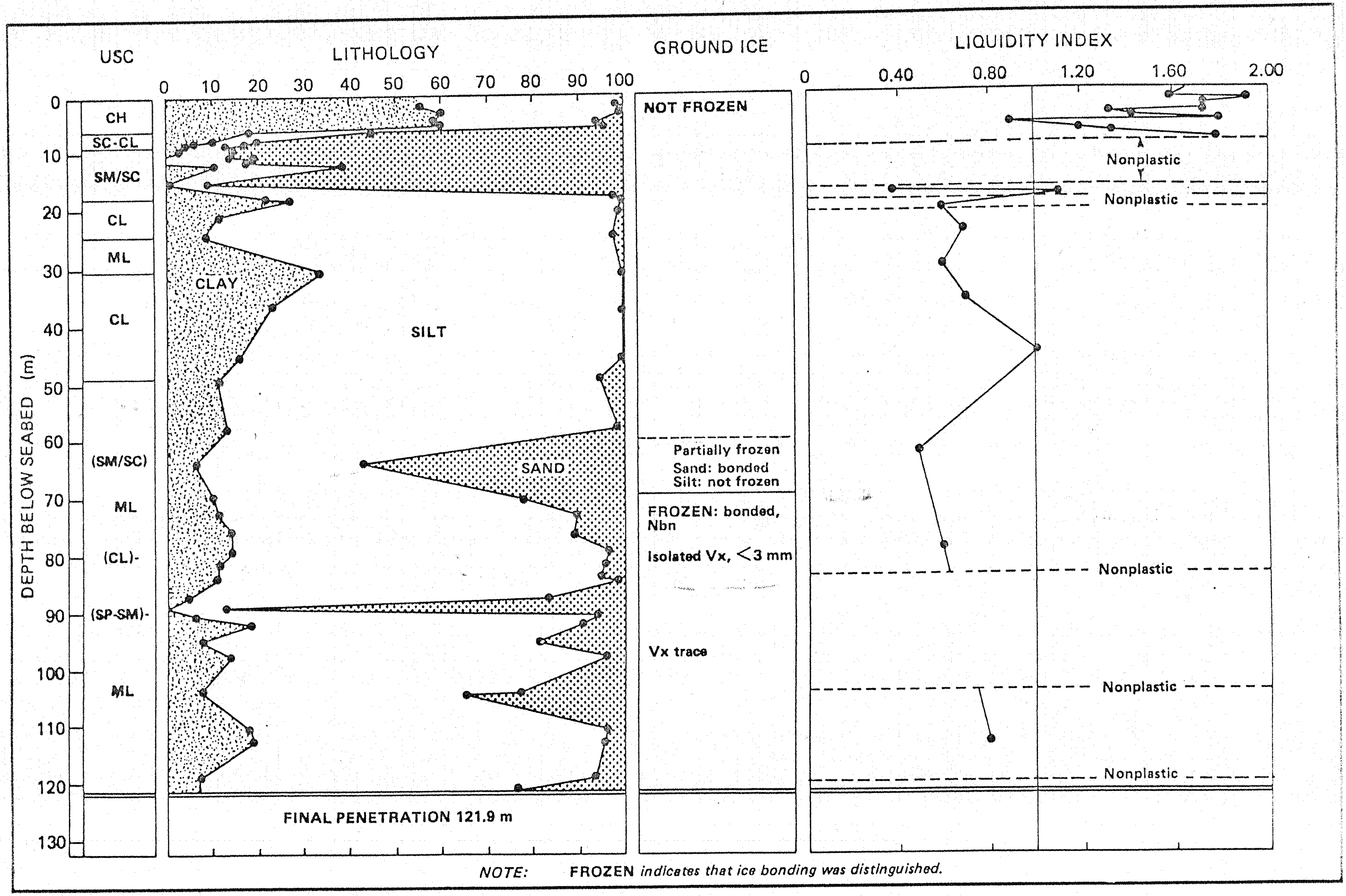
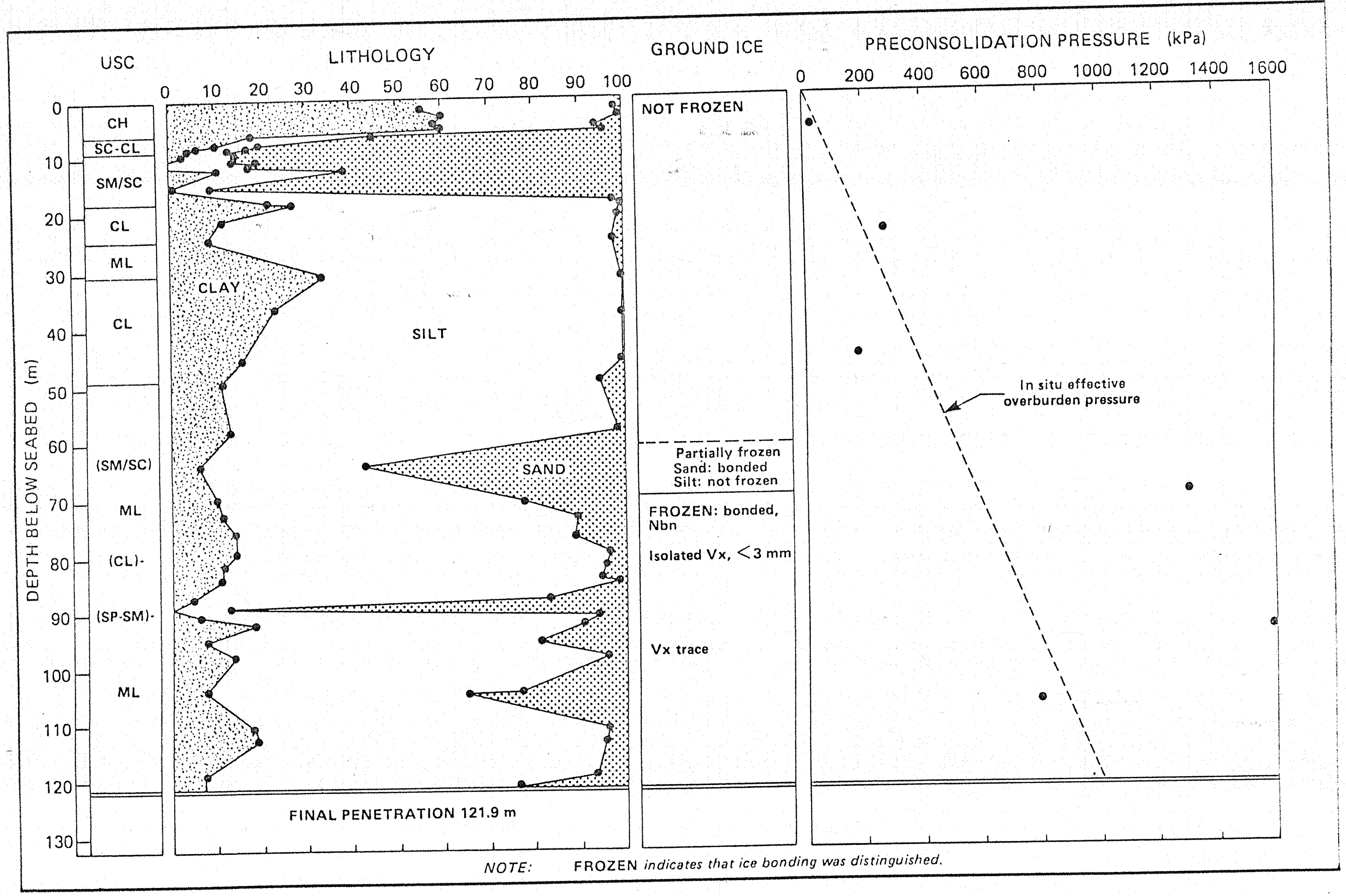


FIGURE B-1 LIQUIDITY INDEX PROFILE, KOPANOAR I-44

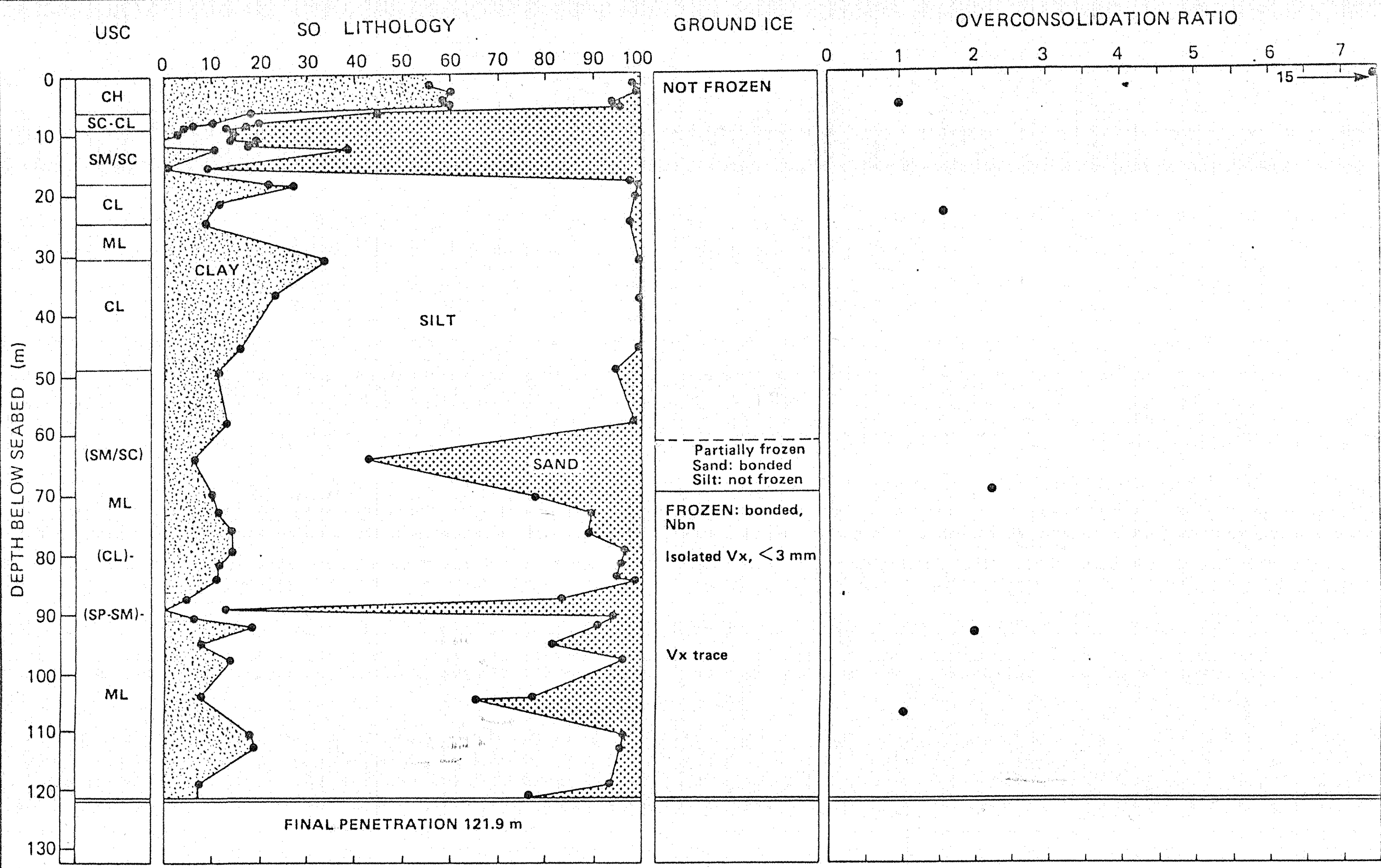
TABLE B-1 SUMMARY OF ATTERBERG LIMIT TESTING, KOPANOAR I-44

SAMPLE NUMBER	DEPTH INTERVAL (m)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	USC	LIQUIDITY INDEX
1C	0.25 - 0.30	73	55	27	28	CH	1.6
2B	0.70 - 0.85	--	64	32	32	CH	---
3A	1.59 - 1.63	87	66	30	36	CH	1.6
4A	2.15 - 2.28	78	56	31	25	MH	1.9
5D	2.87 - 3.00	85	64	32	32	MH	1.7
6D	3.48 - 3.60	87	64	31	33	CH	1.7
7D	4.07 - 4.20	63	53	23	30	CH	1.3
8A	4.65 - 4.80	78	63	28	35	CH	1.4
9A	5.25 - 5.32	81	53	31	28	CH	1.8
10C	5.80 - 5.93	48	51	27	24	CH	0.9
12A	6.90 - 7.00	50	45	19	26	CL	1.2
13B	7.57 - 7.70	37	32	17	15	CL	1.3
15A	8.60 - 8.65	38	27	13	14	CL	1.8
22A	17.70 - 17.85	22	29	18	11	CL	0.4
23B	18.05 - 18.15	26	25	15	10	CL	1.1
24A	20.95 - 21.15	29	nonplastic			ML	
24B	21.15 - 21.25	27	32	20	12	CL	0.6
25B	24.15 - 24.27	25	29	16	13	CL	0.7
26C	27.15 - 27.30	24	30	15	15	CL	0.6
27A	30.10 - 30.25	25	30	16	14	CL	0.6
28A	33.25 - 33.45	22	23	19	4	CL-ML	0.8
29C	36.25 - 36.40	23	26	15	11	CL	0.7
32A	45.20 - 45.35	24	24	21	3	CL-ML	1.0
35C	54.53 - 54.66	--	22	14	8	CL	---
36A	57.55 - 57.70	--	25	21	4	CL-ML	---
37B	60.60 - 60.75	--	31	18	13	CL	---
38A	63.68 - 63.80	23	28	17	11	CL	0.5
39C	66.65 - 66.80	21	23	16	7	CL-ML	0.7
43B	79.15 - 79.25	22	25	17	8	CL	0.6
45C	84.55 - 84.70	28	nonplastic			ML	
51A	92.30 - 92.35	26	21	18	3	ML	2.7
58B	104.20 - 104.35	28	nonplastic			ML	
59B	106.10 - 106.30	21	24	15	9	CL	0.7
63A	112.65 - 112.80	22	23	17	6	CL-ML	0.8
67C	121.55 - 121.75	27	nonplastic			ML	
1A(CPT)	3.15 - 3.30	92	64	33	31	MH	1.9
1B(CPT)	3.30 - 3.45	86	68	29	39	CH	1.5
1C(CPT)	3.45 - 3.60	81	64	14	50	CH	1.3
1F(CPT)	3.90 - 4.00	85	62	28	34	CH	1.7



NOTE: FROZEN *indicates that ice bonding was distinguished.*

FIGURE B-2 PRECONSOLIDATION PRESSURE PROFILE, KOPANOAR I-44



NOTE: FROZEN *indicates that ice bonding was distinguished.*

FIGURE B-3 OVERCONSOLIDATION RATIO PROFILE KOPANOAR I-44

TABLE B-2 SUMMARY OF CONSOLIDATION TEST RESULTS, KOPANOAR I-44

SAMPLE	DEPTH INTERVAL (m)	USC	EFFECTIVE OVERBURDEN PRESSURE (kPa)	ESTIMATED PRECONSOLIDATION PRESSURE (kPa)	OVERCONSOLIDATION RATIO	COMPRESSION INDEX
1B	0.13 - 0.25	CH	1	15	15.0	0.58
10A	5.55 - 5.67	CL	27			
25A	24.00 - 24.15	ML	169	280	1.7	0.21
32C	45.50 - 45.65	ML	363	175	0.5	0.19
40B*	69.90 - 70.05	ML	584	1300	2.2	0.17
52A*	93.65 - 93.90	ML	798	1600	2.0	0.19
59A*	106.30 - 106.70	ML	913	800	0.9	0.15
67B*	121.75 - 121.85	ML	1051	1300	1.2	0.15

NOTE: 1. Samples marked by asterisk were returned frozen from the field. These samples were thawed as a first stage in the testing.

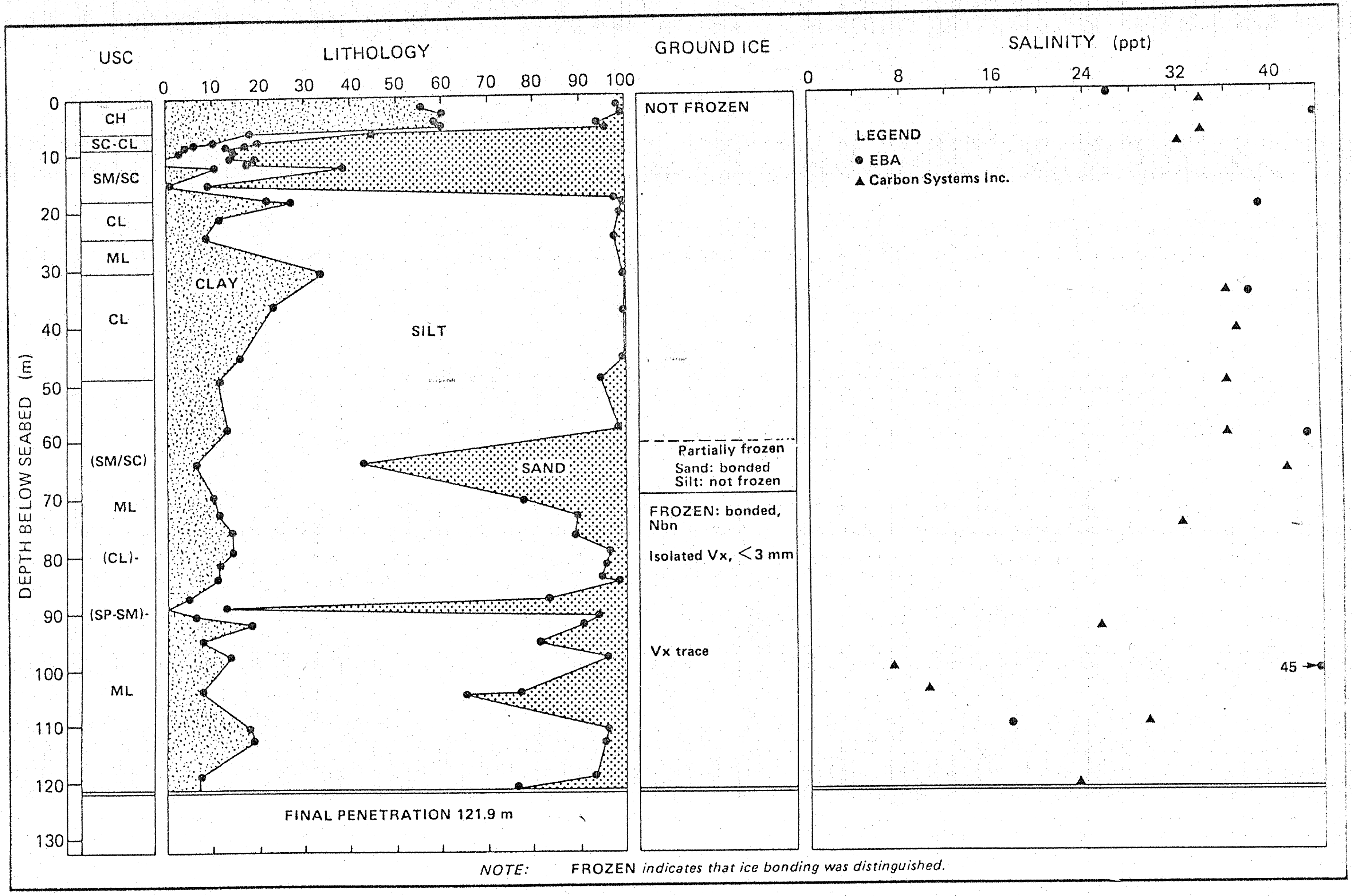


FIGURE B-4 SALINITY PROFILE
KOPANOAR I-44

TABLE B-3 SUMMARY OF SALINITY TEST RESULTS, KOPANOAR I-44

SAMPLE NUMBER	DEPTH INTERVAL (m)	USC	SALINITY (ppt)	ESTIMATED CLAY FRACTION (%)
● 2C	0.85 - 1.0	CH	26	50
▲ 5A	2.50 - 2.62	CH	34	60
● 10B	5.67 - 5.80	CH	44	21
▲ 14A	7.95 - 8.05	SM/SC	34	6
▲ 17B	10.10 - 10.25	SM/SC	32	3
● 24B	21.15 - 21.25	CL	39	11
▲ 29A	36.00 - 36.10	CL	36	23
● 29C	36.25 - 36.40	CL	38	23
▲ 31A	42.25 - 42.35	CL	37	20
▲ 34A	51.55 - 51.60	ML/CL	36	10
▲ 37A	60.45 - 60.60	ML/CL	36	10
● 37B	60.60 - 60.75	ML/CL	43	10
▲ 39D	66.95 - 67.05	ML	41	5
▲ 42A	75.98 - 76.10	ML/CL	32	14
▲ 52C	93.25 - 93.40	ML/CL	25	10
● 57A	100.15 -100.6	ML/CL	45	10
▲ 57B	100.00 -100.15	ML/CL	7	10
▲ 58C	104.00 -104.20	ML	10	7
● 61C	110.15 -110.25	ML/CL	29	18
▲ 67D	121.45 -121.55	ML	23	7

NOTE: 1. Testing performed by EBA (●) and Carbon Systems Inc. (▲).

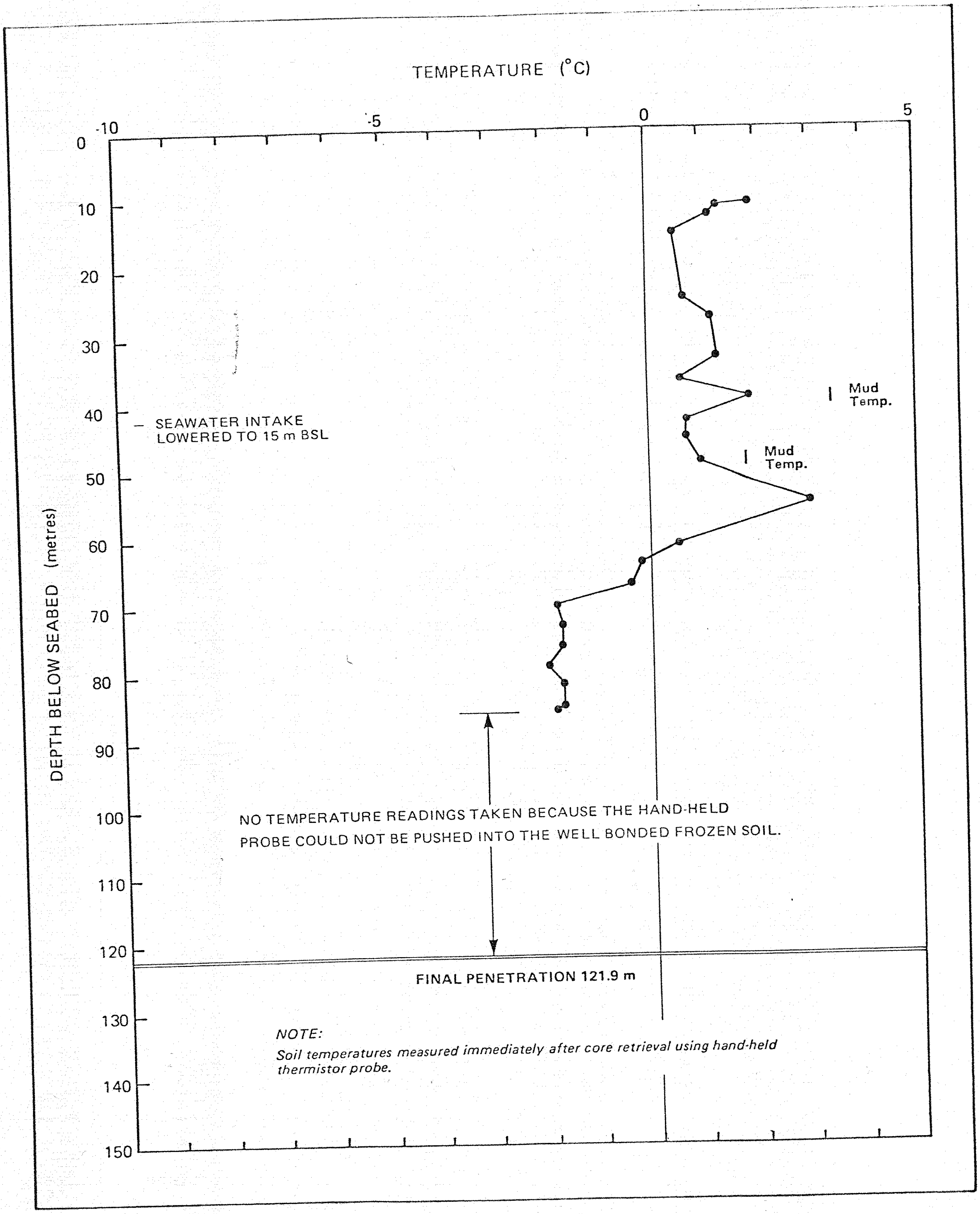


FIGURE B-5 SOIL CORE TEMPERATURE PROFILE, KOPANOAR I-44

TABLE B-4 SUMMARY OF CORE TEMPERATURES, KOPANOAR I-44

DEPTH (m)	TEMPERATURE (°C)
11.0	+1.9
11.6	+1.3
12.2	+1.2
15.2	+0.5
24.4	+0.7
27.4	+1.2
33.5	+1.3
36.6	+0.6
39.6	+1.9
42.7	+0.7
45.7	+0.7
48.8	+1.0
51.8	+1.8
54.9	+3.0
61.0	+0.5
64.0	-0.2
67.0	-0.4
70.1	-1.8
73.2	-1.7
76.2	-1.7
79.2	-2.0
81.7	-1.7
84.7	-1.7
85.3	-1.8

A P P E N D I X C

CLASSIFICATION AND INDEX TEST RESULTS (EBA)

APPENDIX C

CLASSIFICATION AND INDEX TEST RESULTS

Appendix - Illustrations & Tables

SUMMARY OF LABORATORY TESTING RESULTS — PERMAFROST

SAMPLE NO.	SAMPLE TYPE	DEPTH INTERVAL (metres)	MOIST. CONT. (%)	BULK DENS. (Mg/m3)	GROUND ICE DESCRIPTION (%)	ATTERBERG LIMITS LL (%)	PL (%)	PI (%)	GRAIN SIZE DISTRIBUTION CLAY (%)	SILT (%)	SAND (%)	GRAV. (%)	ORGANIC CONTENT (%)	SOIL DESCRIPTION
1A	L	0.00 -0.125			NOT FROZEN									
1B	L	0.125-0.25	78	1.51	NOT FROZEN									
1C	V	0.25- 0.30	73		NOT FROZEN	55	27	28						(CH) CLAY
1D	B	0.30- 0.35	78		NOT FROZEN									
2A	B	0.60- 0.70	93		NOT FROZEN									
2B	L	0.70- 0.85			NOT FROZEN	64	32	32						(CH) CLAY
2C	L	0.85- 1.00		1.49	NOT FROZEN									
2D	V	1.00- 1.15			NOT FROZEN									
3A	V	1.59- 1.63	87		NOT FROZEN	66	30	36	55	43	2	0		(CH) CLAY AND SILT
3B	L	1.63- 1.75		1.52	NOT FROZEN									
4A	V	2.15- 2.28	78		NOT FROZEN	56	31	25						(MH) SILT
4B	L	2.28- 2.40		1.58	NOT FROZEN									
5A	G	2.50- 2.62			NOT FROZEN									
5B	L	2.62- 2.75		1.56	NOT FROZEN									
5C	L	2.75- 2.87	79	1.53	NOT FROZEN									
5D	V	2.87- 3.00	85		NOT FROZEN	64	32	32	60	39	1	0		(MH) SILT
6A	L	3.10- 3.23		1.54	NOT FROZEN									
6B	L	3.23- 3.35		1.48	NOT FROZEN									
6C	L	3.35- 3.48		1.54	NOT FROZEN									
6D	Y	3.48- 3.60	87		NOT FROZEN	64	31	33						(CH) CLAY
7A	L	3.70- 3.82		1.51	NOT FROZEN									
7B	L	3.82- 3.95		1.52	NOT FROZEN									
7C	L	3.95- 4.07		1.49	NOT FROZEN									
7D	V	4.07- 4.20	63		NOT FROZEN	53	23	30						(CH) CLAY
8A	V	4.65- 4.80	78		NOT FROZEN	63	28	35	58	35	7	0		(CH) CLAY AND SILT

PROJECT NUMBER 101-2941 SITE NUMBER KOPANOAR I -44 BOREHOLE No. 2

SUMMARY OF LABORATORY TESTING RESULTS – PERMAFROST

SAMPLE NO.	SAMPLE TYPE	DEPTH INTERVAL (metres)	MOIST. CONT. (%)	BULK DENS. (Mg/m³)	GROUND ICE DESCRIPTION (%)	ATTERBERG LIMITS LL (%)	ATTERBERG LIMITS PL (%)	ATTERBERG LIMITS PI (%)	GRAIN SIZE DISTRIBUTION CLAY (%)	GRAIN SIZE DISTRIBUTION SILT (%)	GRAIN SIZE DISTRIBUTION SAND (%)	GRAIN SIZE DISTRIBUTION GRAV. (%)	ORGANIC CONTENT (%)	SOIL DESCRIPTION
9A	B	5.25- 5.32	81		NOT FROZEN	53	31	28	59	39	5	0		(CH) CLAY AND SILT
9B	L	5.32- 5.45	40	1.75	NOT FROZEN									
10A	L	5.55- 5.67	48	1.60	NOT FROZEN									
10B	L	5.67- 5.80	56	1.67	NOT FROZEN									
10C	V	5.80- 5.93	48		NOT FROZEN	51	27	24						(CH) CLAY
10D	B	5.93- 6.05	27		NOT FROZEN				21	24	55	0		(SC) SAND
10E	B	6.05- 6.10	19		NOT FROZEN									
11A	B	6.10- 6.20	26		NOT FROZEN				18	25	57	0		(SC) SAND
12A	B	6.90- 7.00	50		NOT FROZEN	45	19	26						(CL) CLAY
12B	W	7.00- 7.15			NOT FROZEN				47	44	9	0		CLAY
12C	V	7.15- 7.30	36		NOT FROZEN									
13A	W	7.45- 7.57	51	1.75	NOT FROZEN									
13B	B	7.57- 7.70	37		NOT FROZEN	32	17	15						(CL) CLAY
13C	B	7.70- 7.80	25		NOT FROZEN				10	10	80	0		(SM/SC) SAND
14A	G	7.95- 8.05			NOT FROZEN									
14B	B	8.05- 8.20	30		NOT FROZEN									
14C	B	8.35- 8.45	27		NOT FROZEN				6	11	83	0		(SM/SC) SAND
15A	B	8.60- 8.65	38		NOT FROZEN	27	13	14						(CL) CLAY
15C	B	8.65- 8.80			NOT FROZEN									
15B	B	8.95- 9.10	27		NOT FROZEN				4	9	87	0		(SM/SC) SAND
16A	B	9.30- 9.45			NOT FROZEN									
16B	B	9.45- 9.60	27		NOT FROZEN									
16C	B	9.60- 9.75	25		NOT FROZEN				3	11	86	0		(SM/SC) SAND
17A	B	10.10-10.25	28		NOT FROZEN				-	14	86	0		(SM/SC) SAND
17B	G	10.25-10.35			NOT FROZEN									

PROJECT NUMBER 101-2941 SITE NUMBER KOPANOAR I-44 BOREHOLE No. 2

SUMMARY OF LABORATORY TESTING RESULTS – PERMAFROST

SAMPLE NO.	SAMPLE TYPE	DEPTH INTERVAL (metres)	MOIST. CONT. (%)	BULK DENS. (Mg/m³)	GROUND ICE DESCRIPTION (%)	ATTERBERG LIMITS LL (%)	ATTERBERG LIMITS PL (%)	ATTERBERG LIMITS PI (%)	GRAIN SIZE DISTRIBUTION CLAY (%)	GRAIN SIZE DISTRIBUTION SILT (%)	GRAIN SIZE DISTRIBUTION SAND (%)	GRAIN SIZE DISTRIBUTION GRAV. (%)	ORGANIC CONTENT (%)	SOIL DESCRIPTION
18A	B	10.65-10.75	29		NOT FROZEN									
18B	B	10.75-10.87			NOT FROZEN									
18C	B	10.87-11.00	19		NOT FROZEN				-	19	81	0		SAND
19A	B	11.35-11.50			NOT FROZEN									
19B	B	11.50-11.60	20		NOT FROZEN				-	17	83	0		SAND
20A	B	11.85-11.97			NOT FROZEN									
20B	B	11.97-12.10			NOT FROZEN									
20C	B	12.10-12.20	20		NOT FROZEN				11	28	61	0	3.2	SAND
21A	B	14.90-15.05			NOT FROZEN									
21B	B	15.05-15.20	24		NOT FROZEN				-	8	92	0		SAND
22A	B	17.70-17.85	22		NOT FROZEN	29	18	11	22	75	3	0		(CL) CLAY AND SILT
23A	W	17.95-18.05	24	2.05	NOT FROZEN									
23B	B	18.05-18.15	26		NOT FROZEN	25	15	10	28	71	1	0		(CL) CLAY AND SILT
24A	B	20.95-21.15	29		NOT FROZEN	non-plastic			11	87	2	0		(ML) SILT
24B	B	21.15-21.25	27		NOT FROZEN	32	20	12						(CL) CLAY
24C	B	21.25-21.30	29		NOT FROZEN									
25A	W	24.00-24.15	31	1.95	NOT FROZEN									
25B	B	24.15-24.27	25		NOT FROZEN	29	16	13	8	89	3	0		(CL) CLAY AND SILT
25C	B	24.27-24.40			NOT FROZEN									
26A	B	26.80-26.95	23		NOT FROZEN									
26E	V	26.95-27.00	32		NOT FROZEN									
26B	B	27.00-27.15	24		NOT FROZEN									
26C	W	27.15-27.30	24	2.08	NOT FROZEN	30	15	15	21	78	1	0		(CL) CLAY AND SILT
26D	B	27.30-27.40	24		NOT FROZEN									
27A	B	30.10-30.25	25		NOT FROZEN	30	16	14	34	65	1	0		(CL) CLAY AND SILT

SUMMARY OF LABORATORY TESTING RESULTS – PERMAFROST

SAMPLE NO.	SAMPLE TYPE	DEPTH INTERVAL (metres)	MOIST. CONT. (%)	BULK DENS. (Mg/m³)	GROUND ICE DESCRIPTION (%)	ATTERBERG LIMITS LL (%)	ATTERBERG LIMITS PL (%)	ATTERBERG LIMITS PI (%)	GRAIN SIZE DISTRIBUTION CLAY (%)	GRAIN SIZE DISTRIBUTION SILT (%)	GRAIN SIZE DISTRIBUTION SAND (%)	GRAIN SIZE DISTRIBUTION GRAV. (%)	ORGANIC CONTENT (%)	SOIL DESCRIPTION
27B	W	30.37-30.40	25	2.01	NOT FROZEN									
27C	B	30.40-30.50	25		NOT FROZEN									
28A	B	33.25-33.45	22		NOT FROZEN	23	19	4	12	84	4	0		(CL-ML) CLAY & SILT
28B	B	33.45-33.50	24		NOT FROZEN									
29A	G	36.0-36.10			NOT FROZEN									
29B	W	36.10-36.25			NOT FROZEN									
29C	B	36.25-36.40	23		NOT FROZEN	26	15	11	23	77	0	0		(CL) CLAY & SILT
29D	W	36.40-36.55	22	2.10	NOT FROZEN									
29E	B	36.55-36.60	24		NOT FROZEN									
30A	B	39.30-39.45	20		NOT FROZEN									
30B	B	39.45-39.60	23		NOT FROZEN				10	86	4	0		SILT
31A	G	42.25-42.35			NOT FROZEN									
31B	B	42.35-42.50	22		NOT FROZEN	23	17	6	11	87	2	0		(CL-ML) CLAY & SILT
31C		42.50-42.65			NOT FROZEN									
31D	B	42.65-42.70	24		NOT FROZEN									
32A	B	45.20-45.35	24		NOT FROZEN	24	21	3	16	83	1	0		(CL-ML) SILT & CLAY
32B	V	45.35-45.56			NOT FROZEN									
32C	W	45.50-45.65	26	2.00	NOT FROZEN									
32D	B	45.65-45.70	23		NOT FROZEN									
33A	B	48.55-48.60			NOT FROZEN									
33B	V	48.60-48.70			NOT FROZEN									
33C	B	48.70-48.8	23		NOT FROZEN				11	83	6	0		SILT
34A	G	51.55-51.60			NOT FROZEN									
34B	W	51.60-51.75	21	2.10	NOT FROZEN				30	69	1	0		SILT
34C	B	51.75-51.80	22		NOT FROZEN									

PROJECT NUMBER 101-2941 SITE NUMBER KOPANOAR I-44 BOREHOLE NO. 2

SUMMARY OF LABORATORY TESTING RESULTS – PERMAFROST

SAMPLE NO.	SAMPLE TYPE	DEPTH INTERVAL (metres)	MOIST. CONT. (%)	BULK DENS. (Mg/m³)	GROUND ICE DESCRIPTION (%)	ATTERBERG LIMITS LL (%)	ATTERBERG LIMITS PL (%)	ATTERBERG LIMITS PI (%)	GRAIN SIZE DISTRIBUTION CLAY (%)	GRAIN SIZE DISTRIBUTION SILT (%)	GRAIN SIZE DISTRIBUTION SAND (%)	GRAIN SIZE DISTRIBUTION GRAV. (%)	ORGANIC CONTENT (%)	SOIL DESCRIPTION
35A	B	54.28-54.38	24		NOT FROZEN									
35B	B	54.38-54.53			NOT FROZEN									
35C	W	54.53-54.66			NOT FROZEN	22	14	8	18	79	3	0		(CL) CLAY & SILT
35D	B	54.66-54.86	20		NOT FROZEN									
36A	B	57.55-57.70			NOT FROZEN	25	21	4	14	84	2	0		(CL-ML) CLAY & SILT
36B	B	57.80-57.90	25		NOT FROZEN				13	85	2	0		SILT
37A	G	60.45-60.60			NOT FROZEN									
37B	B	60.60-60.75			NOT FROZEN	31	18	13	20	79	1	0		(CL) CLAY & SILT
37C	B	60.75-60.90			NOT FROZEN									
37D	B	60.90-60.95	27		NOT FROZEN									
38A	W	63.68-63.80	23	2.03	NOT FROZEN	28	17	11						(CL) CLAY
38B	B	63.80-63.90	25		NOT FROZEN				6	36	58	0		SAND
38C	B	63.90-64.00	22		NOT FROZEN									
39A	V	66.55-66.60	23		NOT FROZEN									
39B	B	66.60-66.65	25		NOT FROZEN									
39C	B	66.65-66.80	21		NOT FROZEN	23	16	7	17	82	1	0		(CL-ML) CLAY & SILT
39D	G	66.95-67.05			NOT FROZEN									
40A	B	69.85-69.90			FROZEN									
40B	PF	69.90-70.05	23	2.01	-Bonded, Nbn "									
40C	B	70.05-70.10	28		"				10	67	23	0		SILT
41A	B	72.75-72.90	26		"				11	78	11	0		SILT
41B	PF	72.90-73.10	20	2.05	"									
42A	G	75.98-76.10			FROZEN -Isolated Vx									
42B	B	76.1-76.20	28		"				14	74	12	0		SILT
43A	PF	79.05-79.15	21	2.05	FROZEN -well bonded									

SUMMARY OF LABORATORY TESTING RESULTS – PERMAFROST

SAMPLE NO.	SAMPLE TYPE	DEPTH INTERVAL (metres)	MOIST. CONT. (%)	BULK DENS. (Mg/m³)	GROUND ICE DESCRIPTION (%)	ATTERBERG LIMITS LL (%)	ATTERBERG LIMITS PL (%)	ATTERBERG LIMITS PI (%)	GRAIN SIZE DISTRIBUTION CLAY (%)	GRAIN SIZE DISTRIBUTION SILT (%)	GRAIN SIZE DISTRIBUTION SAND (%)	GRAIN SIZE DISTRIBUTION GRAV. (%)	ORGANIC CONTENT (%)	SOIL DESCRIPTION
43B	B	79.15-79.25	22		FROZEN -well bonded	25	17	8	24	72	4	0		(CL) CLAY & SILT
44A	B	81.00-81.12			-Nbn "									
44		81.12-81.25			"									
44B	PF	81.25-81.40	29	1.88	"									SILT
44C	B	81.40-81.55	27		"				11	84	5	0		
44D	PF	81.55-81.70	22	2.01	"									
45A	B	83.80-83.90			"									SILT
45B	B	84.20-84.45	26		"				11	83	6	0		
45C	B	84.55-84.70	28		"	non plastic			10	88	2	0	3.2	(ML) SILT
46C	B	84.95-85.10	22		"									
46B	PF	85.10-85.25	24	1.97	"									
46A	C	85.25-85.30	27		"									SILT
47B	B	87.47-87.60	30		"				4	78	18	0		
47A	PF	87.60-87.80	31	1.87	"									SILT
48A	B	88.25-88.40	33		"				6	86	8	0		
49D	B	88.70-88.90			"									
49C		88.90-89.05			"									SAND
49B	B	89.05-89.15	29		"				-	12	88	0		
49A	PF	89.15-89.30	28	1.90	"									
50D		90.25-90.45			FROZEN -bonded, Nbn									SILT
50C	B	90.45-90.60	31		"				6	88	6	0		
50B	G	90.60-90.70			"									
50A	B	90.70-90.85	31		"									SILT
51C	B	91.85-92.00	29		"				19	71	10	0		
51D	B	92.00-92.15			"									

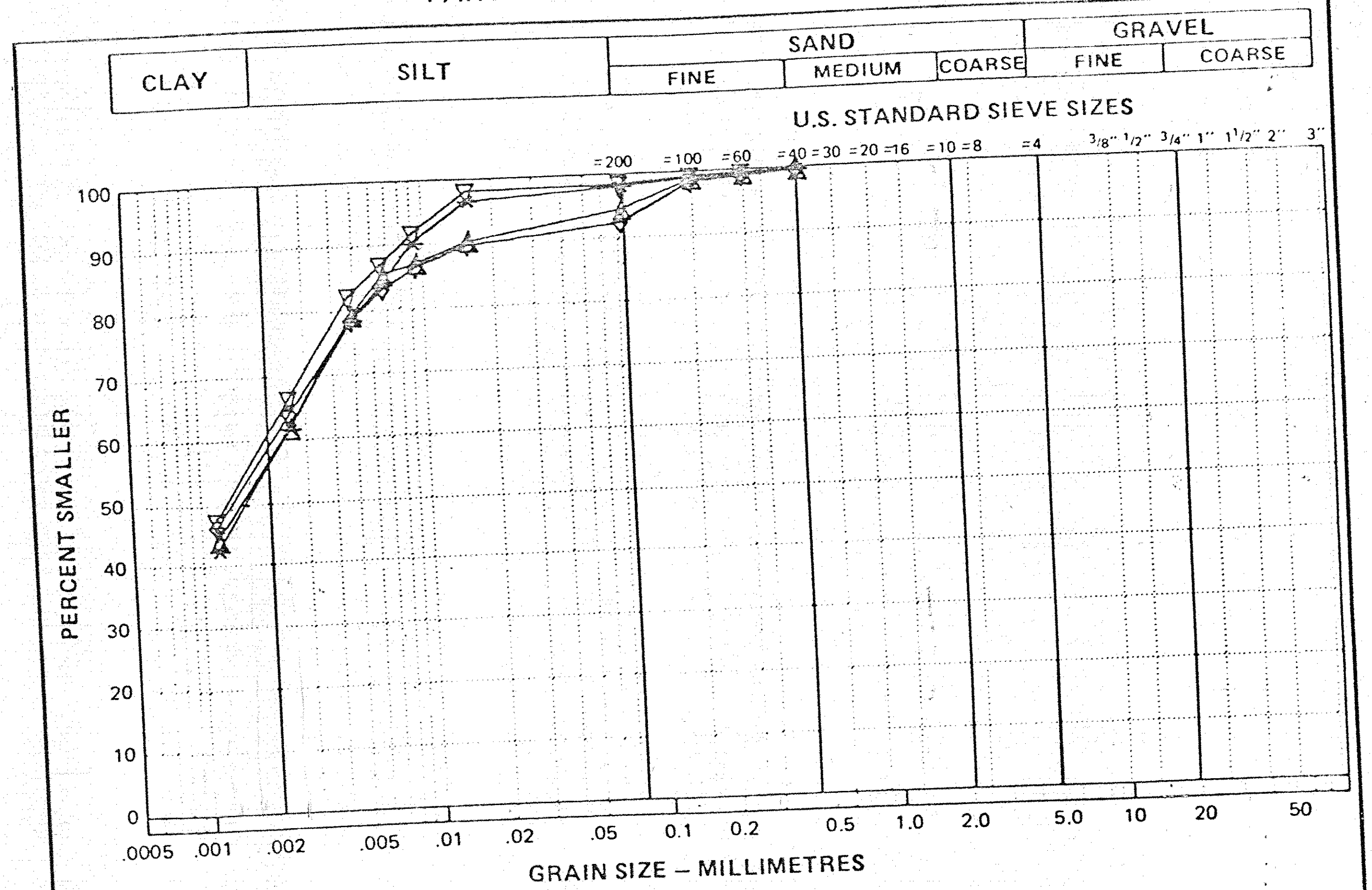
SUMMARY OF LABORATORY TESTING RESULTS – PERMAFROST

SAMPLE		DEPTH INTERVAL	MOIST. CONT.	BULK DENS.	GROUND ICE DESCRIPTION	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION				ORGANIC CONTENT	SOIL DESCRIPTION
NO.	TYPE					LL	PL	PI	CLAY	SILT	SAND	GRAV.		
		(metres)	(%)	(Mg/m3)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	
51B	PF	92.15-92.3			FROZEN -bonded, Nbn									
51A	B	92.3-92.35	26		"	21	18	3						(ML) SILT
52C	G	93.25-93.40	23		"									
52B	B	93.40-93.65	26		"									
52A	PF	93.65-93.90	31	1.87	"				5	81	14	0		SILT
53C	B	94.90-95.00	30		"				7	73	20	0		SILT
53B	PF	95.00-95.20			"									
53A	PF	95.20-95.40	22	1.90	"									
54C	B	96.55-96.60			"									
54B	PF	96.60-96.90			"									
54A	B	96.90-96.95	24		"									
55C		97.15-97.30			FROZEN -trace Vx									
55B	PF	97.30-97.50			FROZEN -bonded, Nbn									
55A	B	97.50-97.55	23		"				14	82	4	0		SILT
56B	PF	98.85-99.05	22	2.02	"									
56A	B	99.05-99.10	26		"									
57B	G	100.00-100.15	24		"									
57A	PF	100.15-100.60			"									
58D	B	103.80-104.00	30		"				7	69	24	0		SILT
58C	G	104.00-104.20			"									
58B	B	104.20-104.35	28		"	nonplastic			8	56	36	0		(ML) SILT & SAND
58A	PF	104.35-104.55			"									
59C	B	105.90-106.10			"									
59B	B	106.10-106.30	21		"	24	15	9	25	71	4	0		(CL) CLAY & SILT
59A	PF	106.30-106.70	28	1.91	"									

SUMMARY OF LABORATORY TESTING RESULTS — PERMAFROST

SAMPLE		DEPTH INTERVAL	MOIST. CONT.	BULK DENS.	GROUND ICE DESCRIPTION	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION				ORGANIC CONTENT	SOIL DESCRIPTION
						LL	PL	PI	CLAY	SILT	SAND	GRAV.		
NO.	TYPE	(metres)	(%)	(Mg/m3)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	
60A	B	109.3-109.4	31		FROZEN -bonded, Nbn									
61D		110.05-110.15			"									
61C	G	110.15-110.25			"									
61B	PF	110.25-110.5			"									
61A	B	110.5-110.65	21		"				18	78	4	0		SILT
62A	B	112.05-112.15	23		"									
63A	B	112.65-112.80	22		"	23	17	6	19	76	5	0		(CL-ML) CLAY & SILT
64C	B	113.80-113.90	25		"									
64B	PF	113.90-114.10	24	1.94	"				Not Possible					
64A	PF	114.10-114.30			"									
65A	PF	115.60-115.80	18	2.10	"									
66A	B	118.65-118.85	36		"				7	86	7	0		SILT
67F	B	121.25-121.35			"									
67E	PF	121.35-121.45			"									
67D	G	121.45-121.55			"									
67C	B	121.55-121.75	27		"	nonplastic			7	58	35	0		(ML) SILT
67B	PF	121.75-121.85	28	1.89	"									
67A	B	121.85-121.90	31		"									

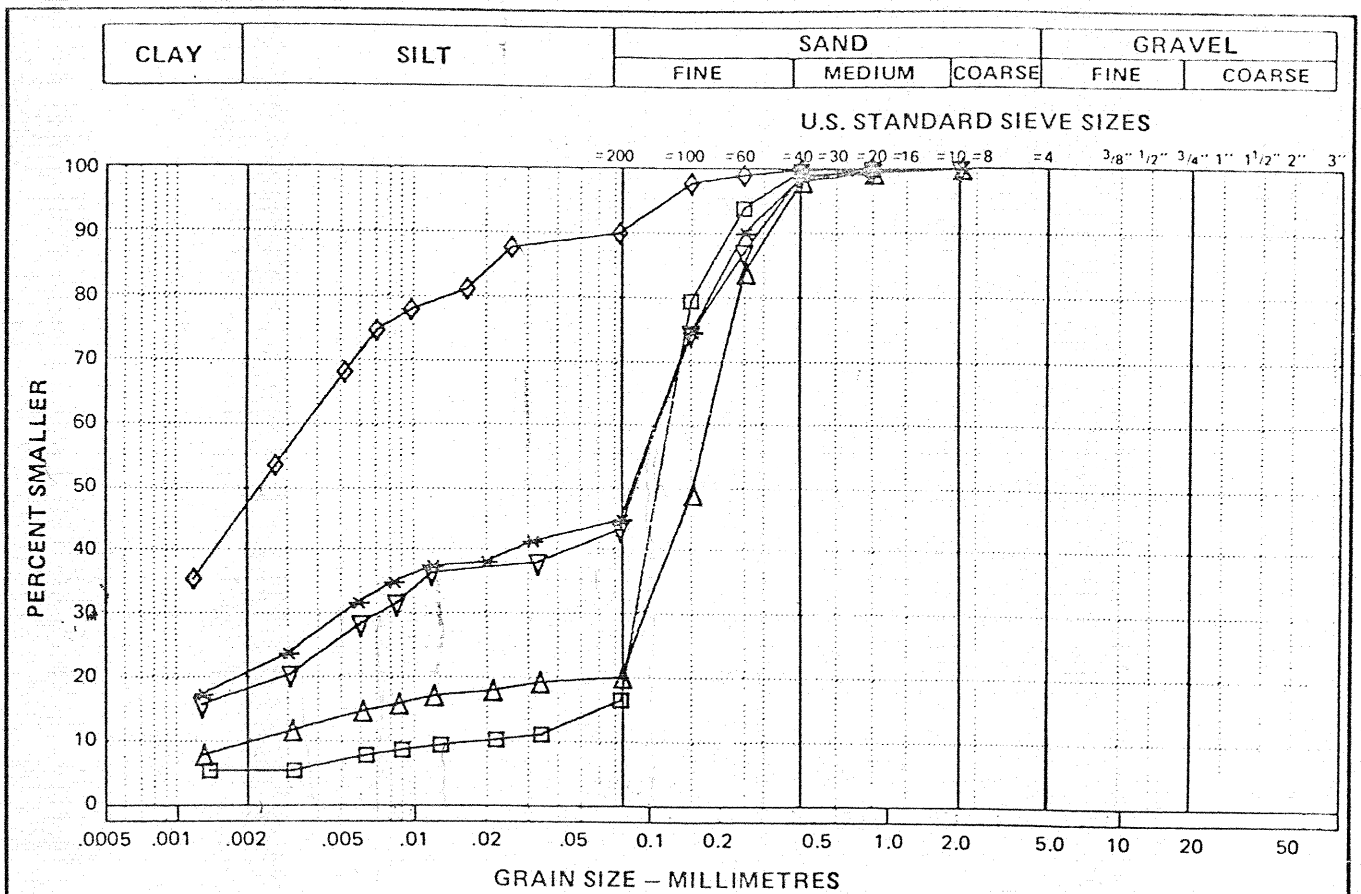
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—×—	KOP-I44	1.59- 1.63	55	43	2	Ø	–	–	CH
—▽—	KOP-I44	2.87- 3.ØØ	6Ø	39	1	Ø	–	–	MH
—◇—	KOP-I44	4.65- 4.85	58	35	7	Ø	–	–	CH
—△—	KOP-I44	5.25- 5.32	56	39	5	Ø	–	–	CH

JOB NO. 1Ø1-2941 DATE 8Ø-12-19

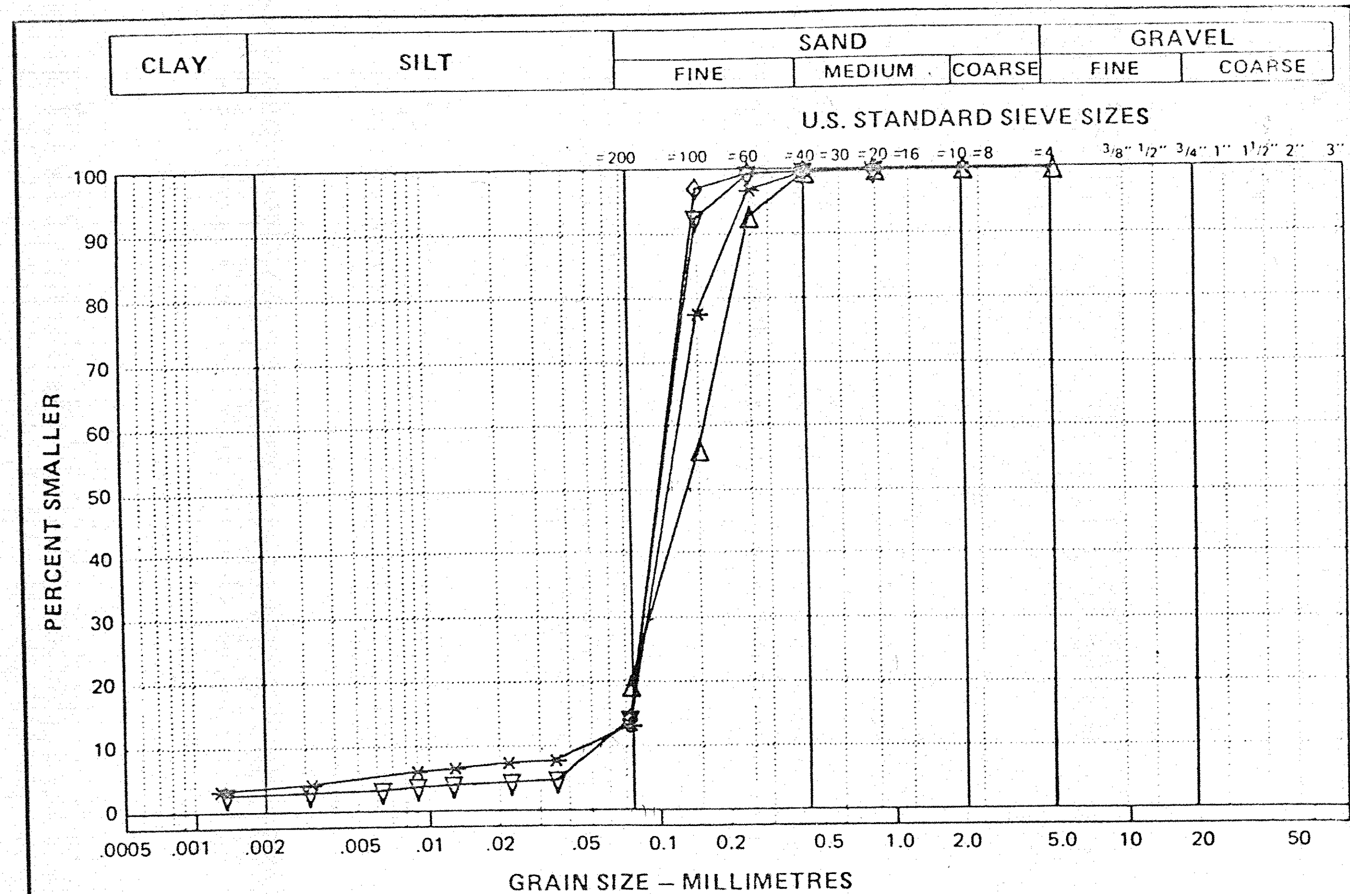
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—*—	KOP-I44	5.93– 6.05	21	24	55	Ø	–	–	SC
—▽—	KOP-I44	6.10– 6.20	18	25	57	Ø	–	–	SC
—◇—	KOP-I44	7.00– 7.15	47	43	10	Ø	–	–	
—△—	KOP-I44	7.70– 7.80	10	10	80	Ø	–	–	SM/SC
—□—	KOP-I44	8.35– 8.45	6	11	84	Ø	–	–	SM/SC

JOB NO. 101-2941 DATE 81- 4-13

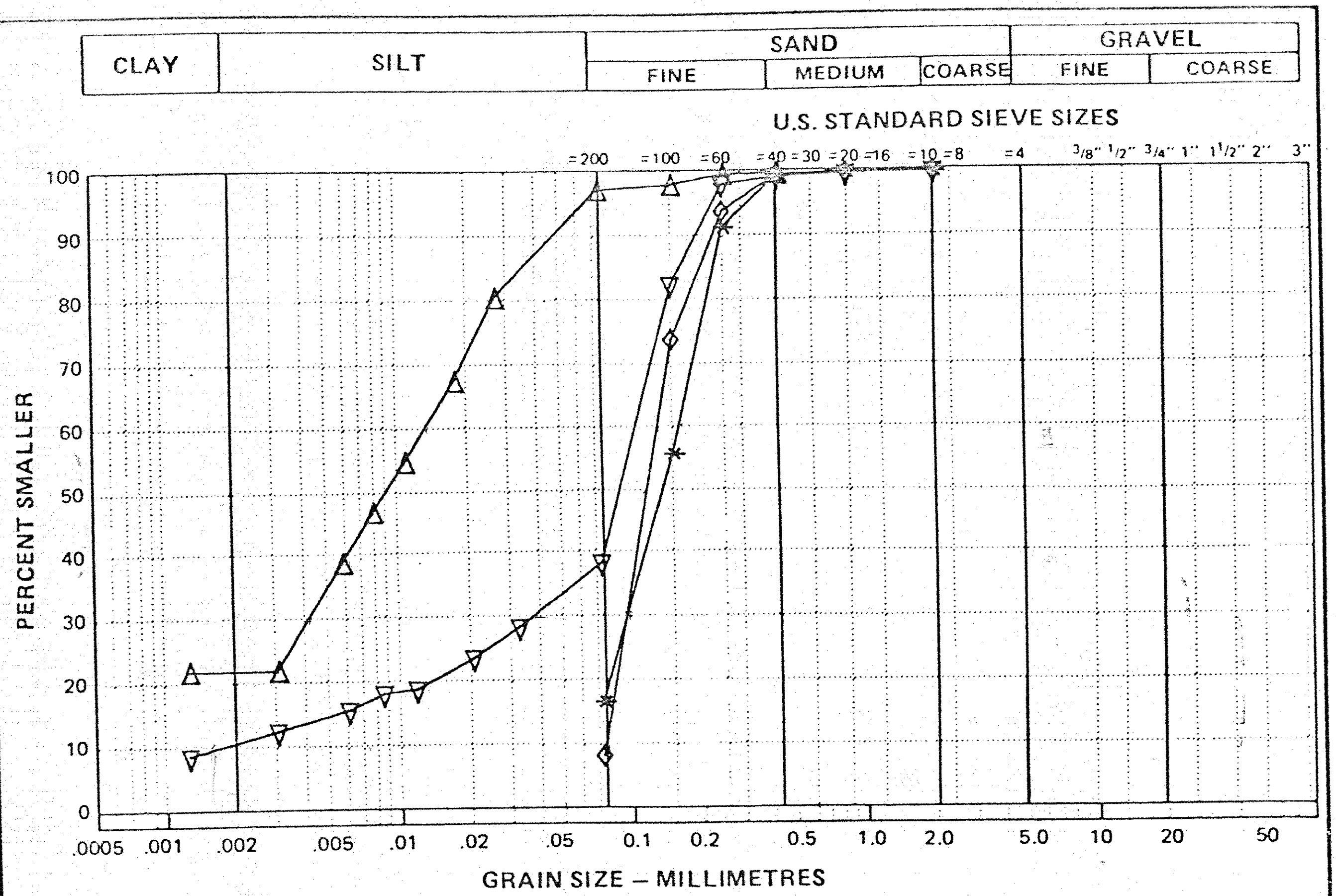
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—×—	KOP-I44	8.95– 9.10	4	9	87	0	2.7	1.4	SM/SC
—▽—	KOP-I44	9.60– 9.75	3	11	86	0	2.1	1.2	SM/SC
—◇—	KOP-I44	10.10– 10.25	–	14	86	0	–	–	SM/SC
—△—	KOP-I44	10.87– 11.00	–	19	81	0	–	–	SM/SC

JOB NO. 101–2941 **DATE** 80–12–19

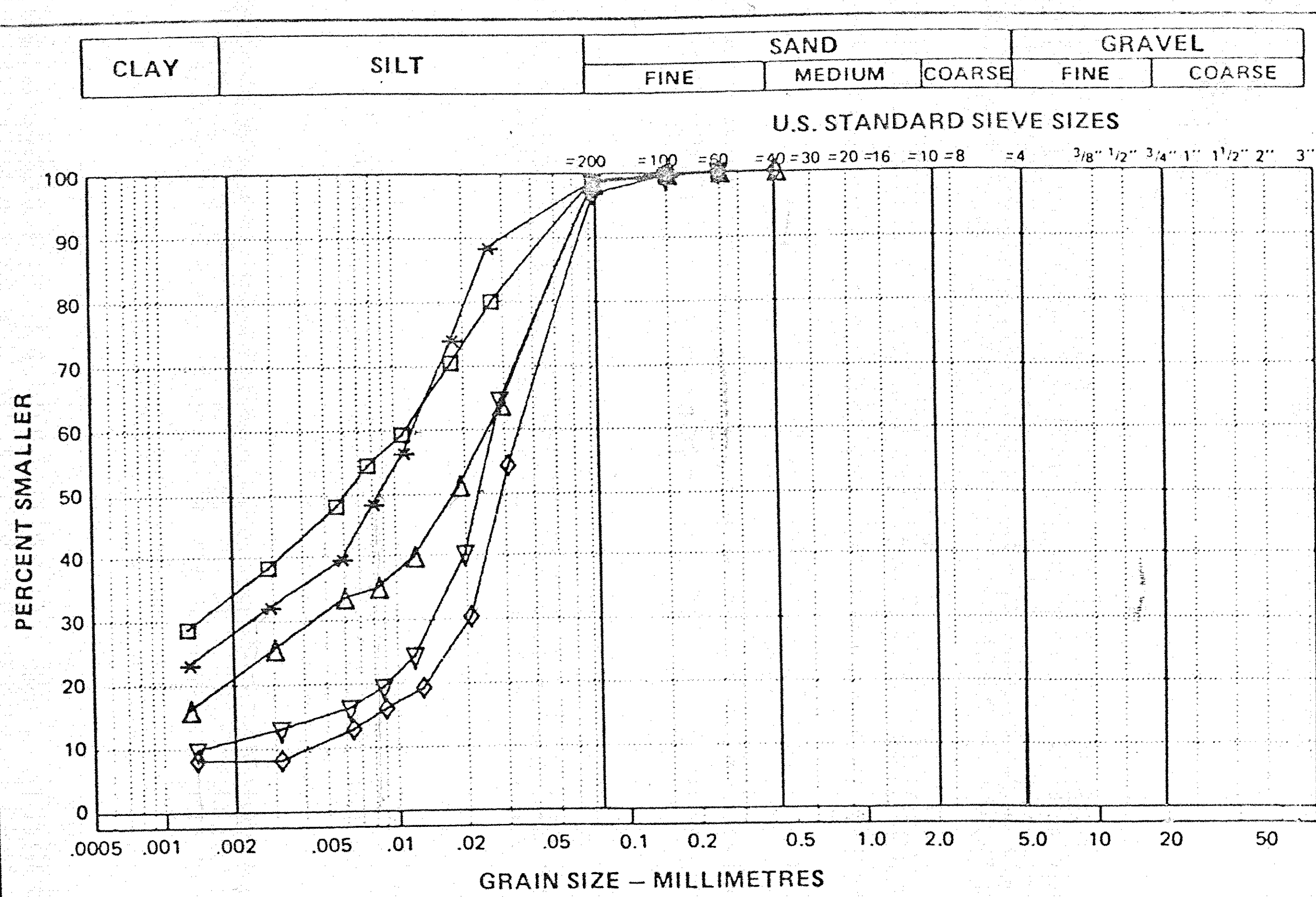
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—×—	KOP-I44	11.5Ø- 11.6Ø	–	17	83	Ø	–	–	SM/SC
—▽—	KOP-I44	12.1Ø- 12.2Ø	11	28	61	Ø	–	–	SM/SC
—◇—	KOP-I44	15.Ø5- 15.2Ø	–	8	92	Ø	1.7	.9	
—△—	KOP-I44	17.7Ø- 17.85	22	75	3	Ø	–	–	CL

JOB NO. 1Ø1-2941 DATE 8Ø-12-19

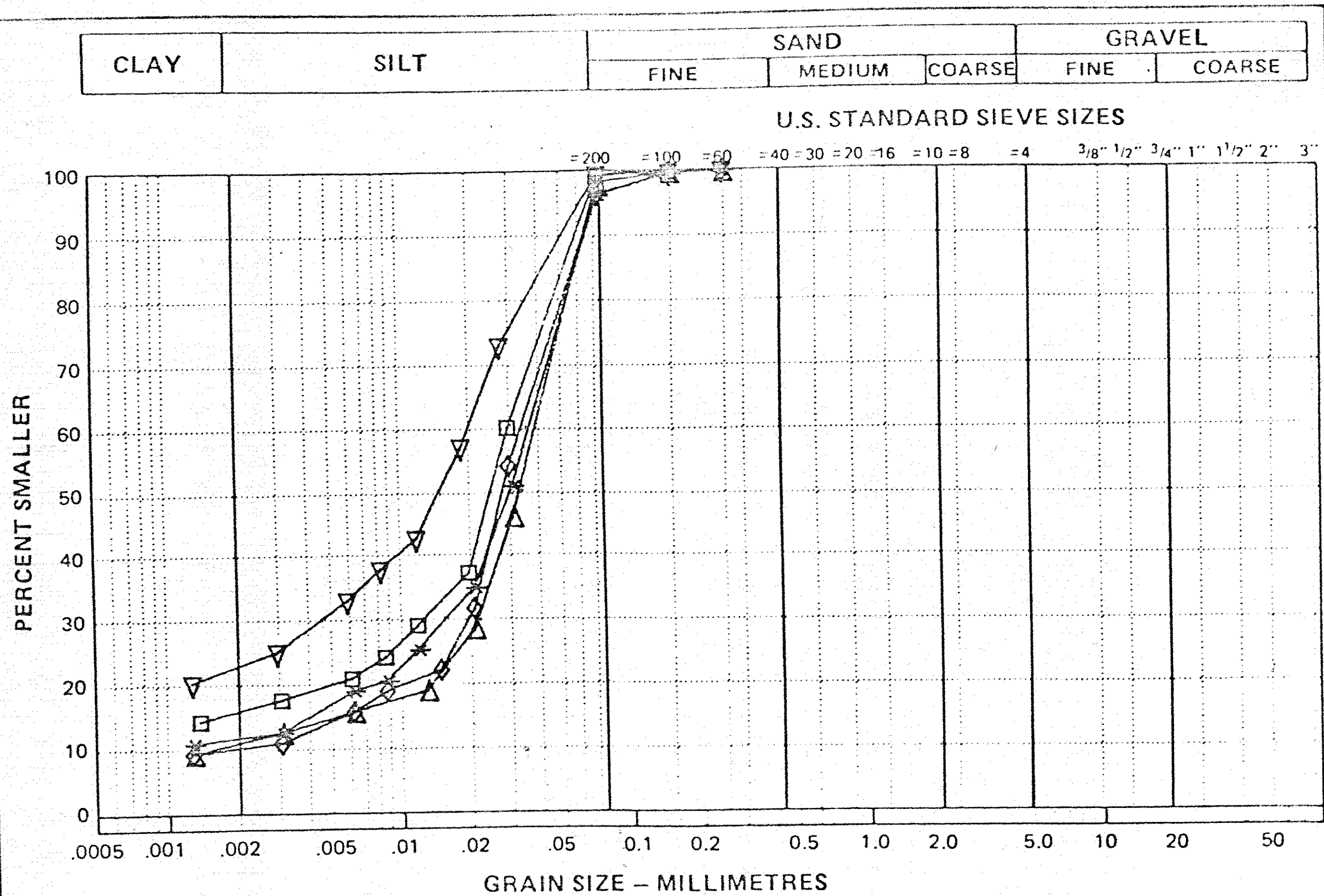
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—×—	KOP-I44	18.05- 18.15	28	71	1	Ø	–	–	CL
—▽—	KOP-I44	20.95- 21.15	11	87	2	Ø	–	–	ML
—◇—	KOP-I44	24.15- 24.27	8	89	3	Ø	–	–	CL
—△—	KOP-I44	27.15- 27.30	21	77	2	Ø	–	–	CL
—□—	KOP-I44	30.10- 30.25	34	65	1	Ø	–	–	CL

JOB NO. 1Ø1-2941 DATE 81- 4-13

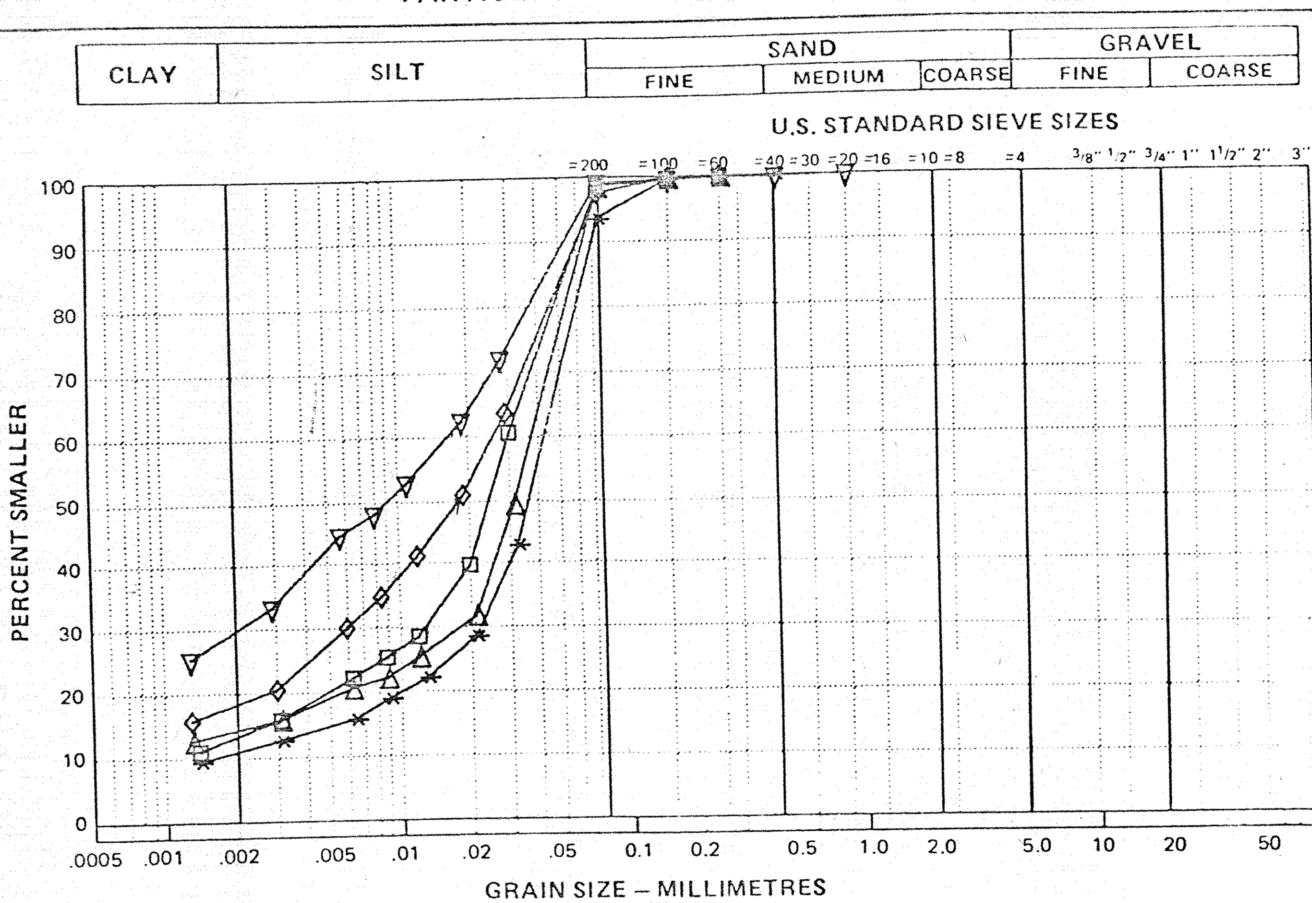
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—×—	KOP-I44	33.25- 33.45	12	84	4	Ø	–	–	CL-ML
—▽—	KOP-I44	36.25- 36.40	23	76	Ø	Ø	–	–	CL
—◇—	KOP-I44	39.45- 39.60	10	86	4	Ø	–	–	
—△—	KOP-I44	42.35- 42.50	11	87	2	Ø	–	–	CL-ML
—□—	KOP-I44	45.20- 45.35	16	83	1	Ø	–	–	CL-ML

JOB NO. 1Ø1-2941 DATE 81- 4-13

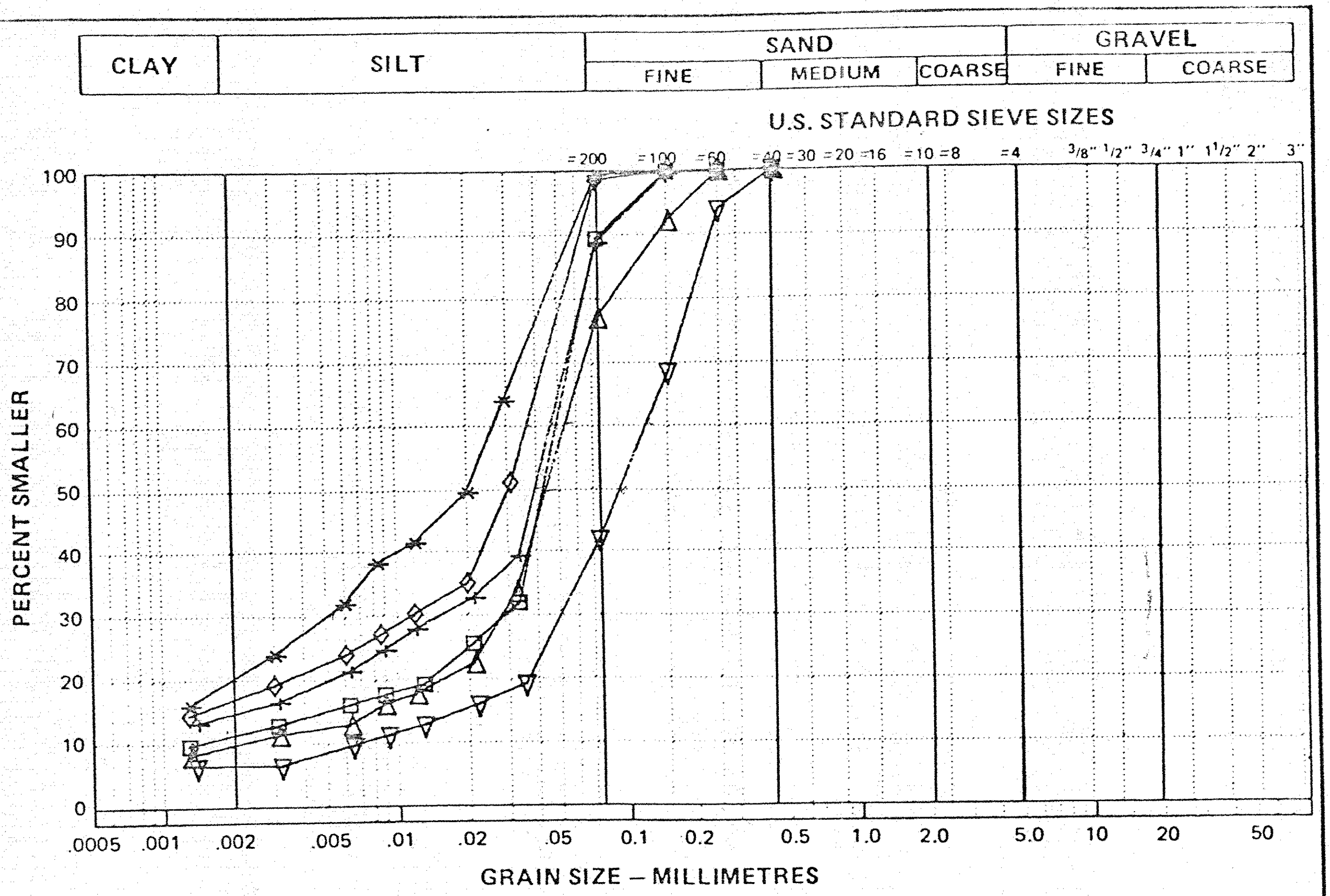
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—×—	KOP-I44	48.70- 48.80	11	83	6	0	–	–	
—▽—	KOP-I44	51.60- 51.75	30	69	1	0	–	–	
—◇—	KOP-I44	54.53- 54.66	18	79	2	0	–	–	CL
—△—	KOP-I44	57.55- 57.70	14	84	1	0	–	–	CL-ML
—□—	KOP-I44	57.80- 57.90	13	85	1	0	–	–	

JOB NO. 101-2941 DATE 81- 4-13

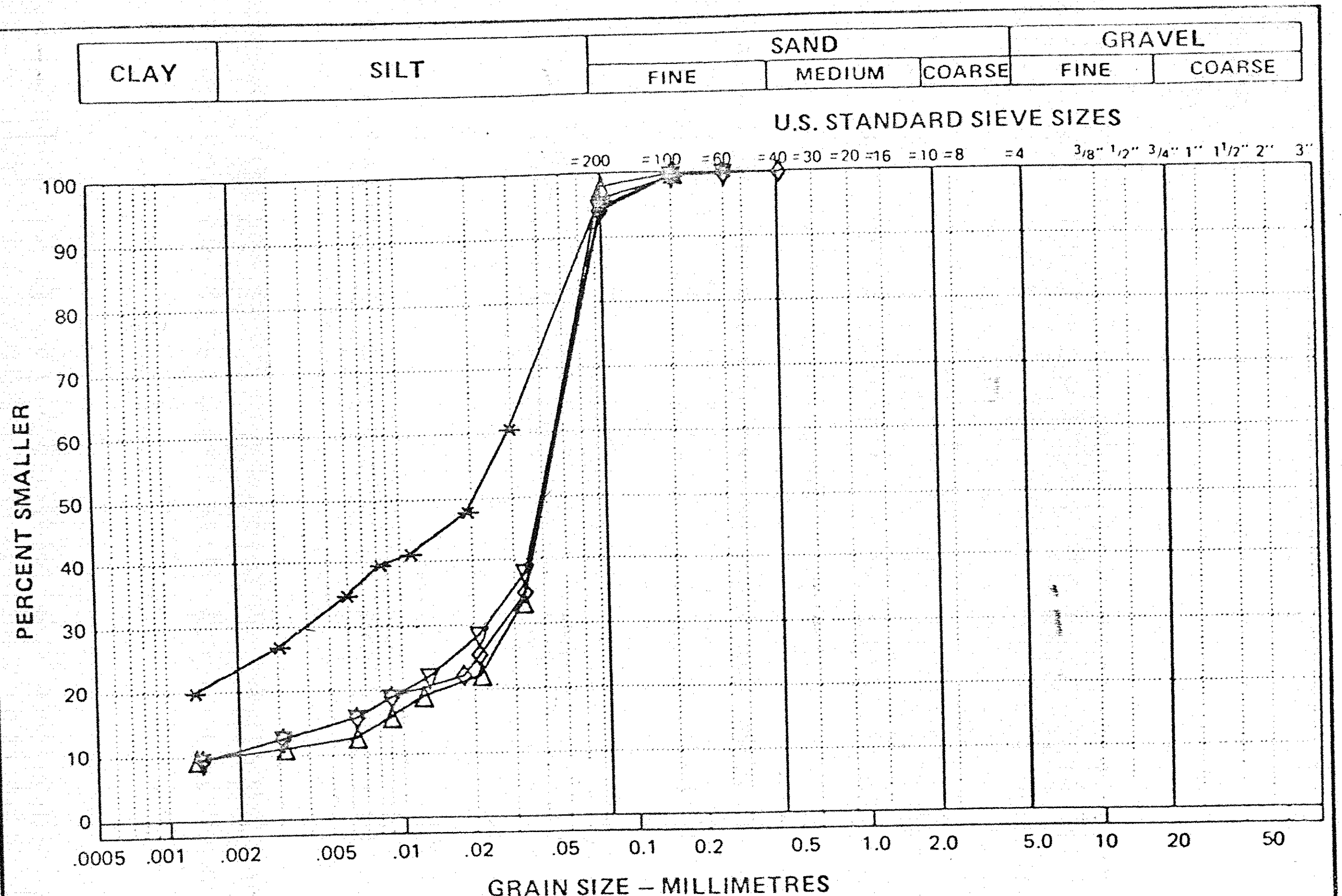
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—x—	KOP-I44	60.60– 60.75	20	79	1	0	–	–	CL
—▽—	KOP-I44	63.80– 63.90	6	35	58	0	–	–	
—◇—	KOP-I44	66.65– 66.80	17	82	2	0	–	–	CL–ML
—△—	KOP-I44	70.05– 70.10	10	67	23	0	–	–	
—□—	KOP-I44	72.75– 72.90	11	78	11	0	–	–	
—+—	KOP-I44	76.10– 76.20	15	74	12	0	–	–	

JOB NO. 101–2941 **DATE** 81– 4–13

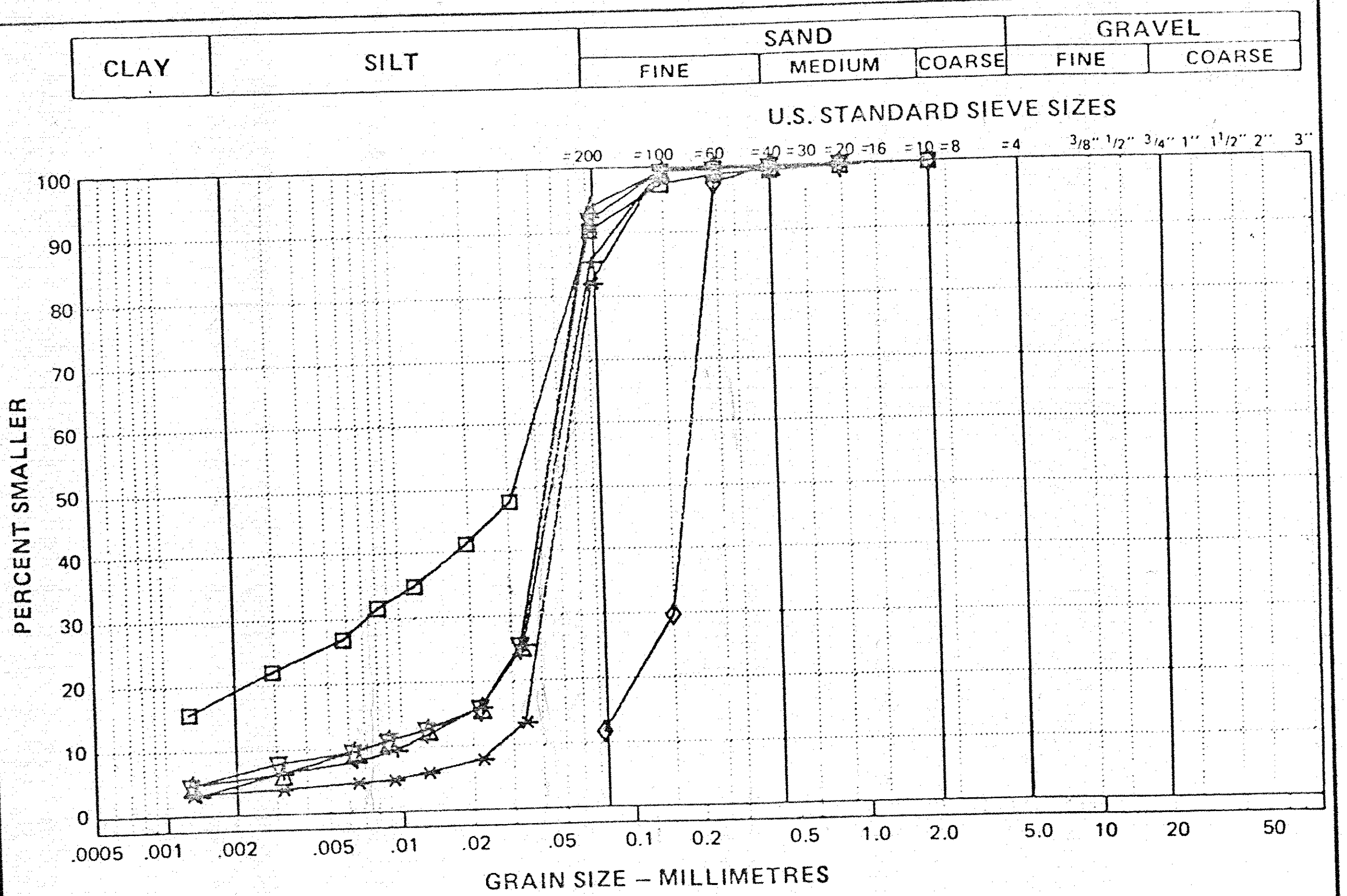
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—*—	KOP-I44	79.15- 79.25	24	72	4	Ø	–	–	CL
—▽—	KOP-I44	81.40- 81.55	11	84	5	Ø	–	–	
—◇—	KOP-I44	84.20- 84.45	11	83	6	Ø	–	–	
—△—	KOP-I44	84.55- 84.70	10	88	2	Ø	–	–	ML

JOB NO. 101-2941 DATE 80-12-19

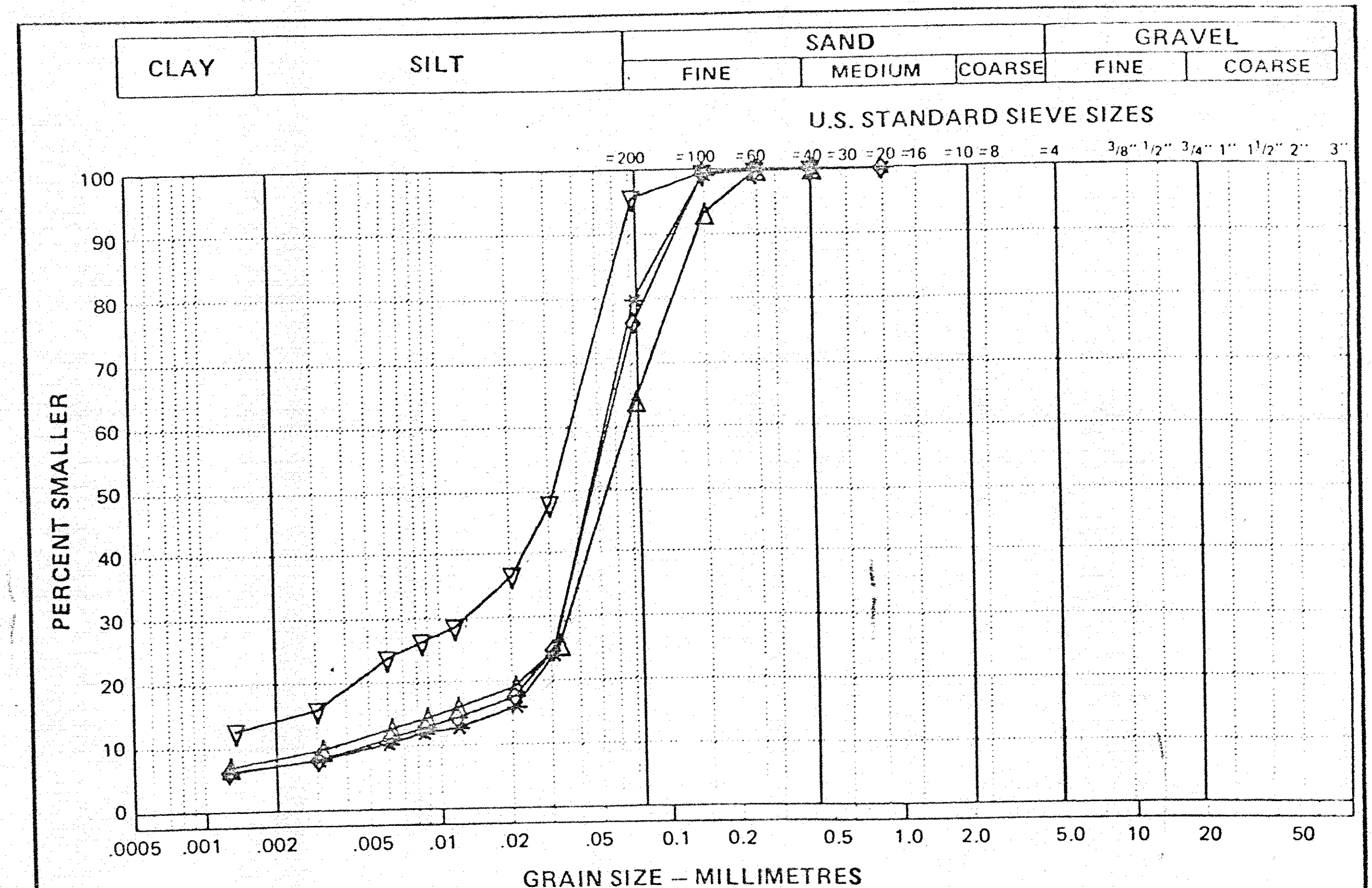
PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—×—	KOP-I44	87.47- 87.60	4	78	18	Ø	–	–	
—▽—	KOP-I44	88.25- 88.40	6	86	8	Ø	–	–	
—◇—	KOP-I44	89.05- 89.15	–	12	88	Ø	–	–	
—△—	KOP-I44	90.45- 90.60	6	88	6	Ø	–	–	
—□—	KOP-I44	91.85- 92.00	19	71	10	Ø	–	–	
—+—	KOP-I44	93.65- 93.90	5	81	14	Ø	–	–	

JOB NO. 101-2941 DATE 81- 4-14

PARTICLE - SIZE ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY (%)	SILT (%)	SAND (%)	GRAVEL (%)	Cu	Cc	U.S.C.
—×—	KOP-I44	94.90– 95.00	7	73	20	0	–	–	
—▽—	KOP-I44	97.50– 97.55	14	82	4	0	–	–	
—◇—	KOP-I44	103.80–104.00	7	69	24	0	–	–	
—△—	KOP-I44	104.20–104.35	8	56	36	0	–	–	ML

JOB NO. 101–2941 DATE 80–12–19

APPENDIX D

SHEAR STRENGTH TEST RESULTS (EBA)

APPENDIX D

SHEAR STRENGTH TEST RESULTS

Appendix - Illustrations & Tables

TABLE D-1 SUMMARY OF LABORATORY VANE SHEAR TEST RESULTS, KOPANOAR I-44

SAMPLE NUMBER	DEPTH INTERVAL (m)	WATER CONTENT (%)	MINIATURE VANE PEAK (kPa)	MINIATURE VANE RESIDUAL (kPa)	SENSITIVITY
1C	0.25 - 0.30	73	5	2	2.5
2D	1.00 - 1.15	-	4	1	4.0
3A	1.50 - 1.63	87	6	1	6.0
4A	2.15 - 2.28	78	6	2	3.0
5D	2.87 - 3.00	85	9	3	3.0
6D	3.48 - 3.60	87	5	2	2.5
7D	4.07 - 4.20	63	4	2	2.0
8A	4.65 - 4.80	78	5	2	2.5
10C	5.80 - 5.93	48	9	3	3.0
12C	7.15 - 7.30	36	12	5	2.4
1D(CPT)	3.60 - 3.75	-	7	3	2.3
1E(CPT)	3.75 - 3.90	89	2	1	2.0

NOTE: 1. Tests performed in field laboratory.

TABLE D-2 SUMMARY OF TORVANE TEST RESULTS, KOPANOAR I-44

SAMPLE NUMBER	DEPTH INTERVAL (m)	WATER CONTENT (%)	TORVANE (kPa)
1C	0.25 - 0.3	73	7
2D	1.00 - 1.15	-	5
3A	1.50 - 1.63	87	5
4A	2.15 - 2.28	78	8
5D	2.87 - 3.00	85	10
6D	3.48 - 3.60	87	9
7D	4.07 - 4.20	63	3
8A	4.65 - 4.80	78	4
9B	5.32 - 5.45	40	4
10C	5.80 - 5.93	48	10
12C	7.15 - 7.30	36	10
26E	26.95 - 27.00	32	77
27B	30.25 - 30.37	25	79
31A	42.25 - 42.35	-	120
32B	45.35 - 45.5	-	108
33B	48.60 - 48.7	-	77
37D	60.90 - 60.95	27	79
39A	66.55 - 66.60	23	110

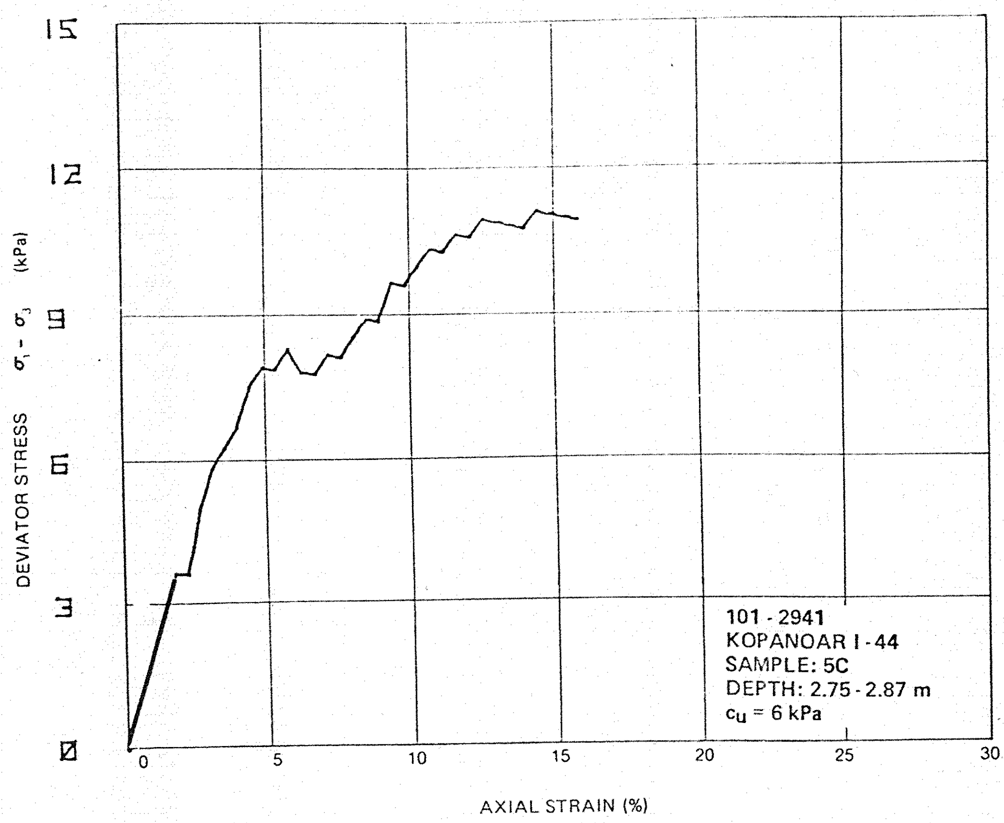
NOTE: 1. Test performed in field laboratory.

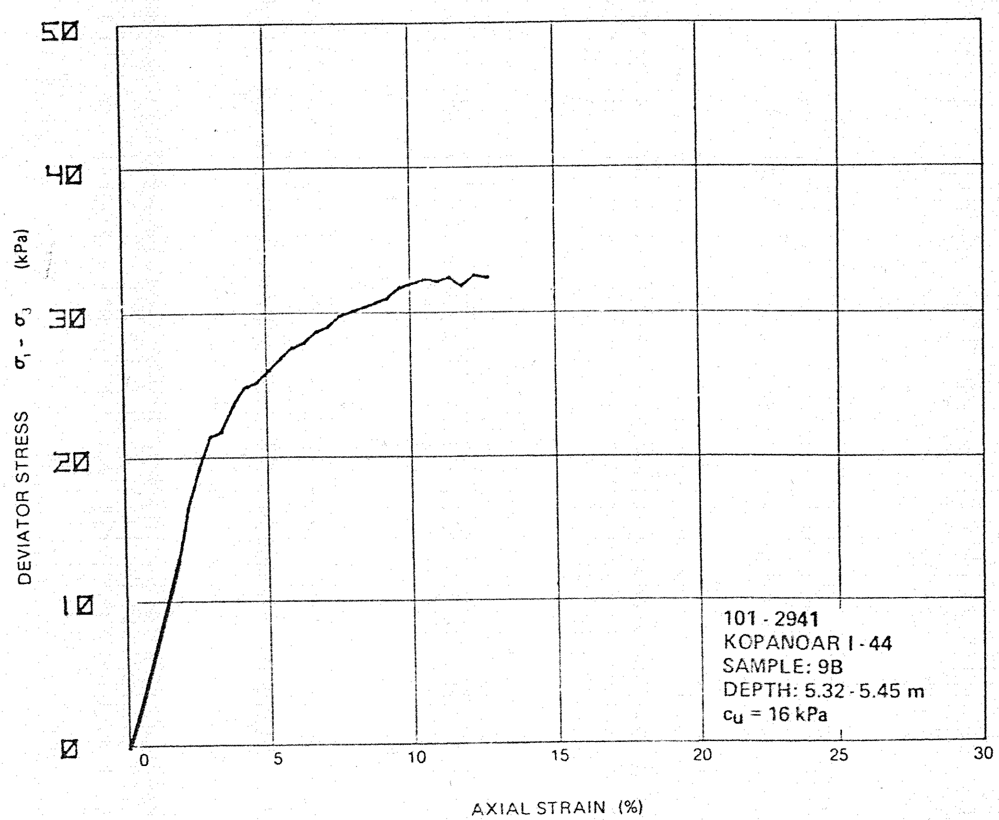
TABLE D-3 SUMMARY OF RESULTS FROM UNCONSOLIDATED-UNDRAINED TRIAXIAL TESTS, KOPANOAR I-44

SAMPLE NUMBER	DEPTH INTERVAL (m)	USC	MOISTURE CONTENT (%)	INITIAL BULK DENSITY (Mg/m^3)	CONFINING PRESSURE (kPa)	AXIAL STRAIN AT FAILURE (%)	UNDRAINED SHEAR STRENGTH (JACKETED TRIAXIAL) (kPa)	REMARKS
2B	0.70-0.85	CH						Disturbed
5C	2.75-2.87	CH	79	1.50	360	15	6	
9B	5.32-5.45	CH	40	1.88	385	12	17	
12B	7.30-7.45	CL						Disturbed
23A	17.45-18.05	CL	24	2.05	405	15	50	
26C	27.15-27.30	ML	24	2.08	625	15	58	
27B	30.37-30.40	CL	25	2.01	660	15	65	
29D	36.40-36.55	CL	22	2.10	730	15	67	
34B	51.60-51.75	ML	21	2.10	910	15	81	
35C	54.53-54.66	ML	21	2.09	940	15	64	
38A	63.68-63.80	ML	23	2.03	1045	15	63	
41B*	72.90-73.10	ML	20	2.05	1155	15	149	
43A*	79.05-79.15	ML	21	2.05	1225	15	45	
46B*	85.10-85.25	ML	24	1.97	1295	14	393	
52A*	93.65-93.90	ML	28	1.89	1395	15	104	
53A*	95.20-95.40	ML	27	1.90	1415	15	600	
+56B*	98.85-99.05	ML	22	2.02	1407	15	106	Low Value
59A*	106.30-106.70	ML	28	1.89	1540	15	150	
64B*	113.90-114.10	ML	24	1.94	1630	15	165	
65A*	115.60-115.80	ML	18	2.10	1650	15	180	
1A(CPT)	3.15- 3.30	MH	92	1.52	250	15	8	
1B(CPT)	3.30- 3.45	CH	86	1.53	350	15	8	
1C(CPT)	3.45- 3.60	CH	81	1.52	450	15	11	

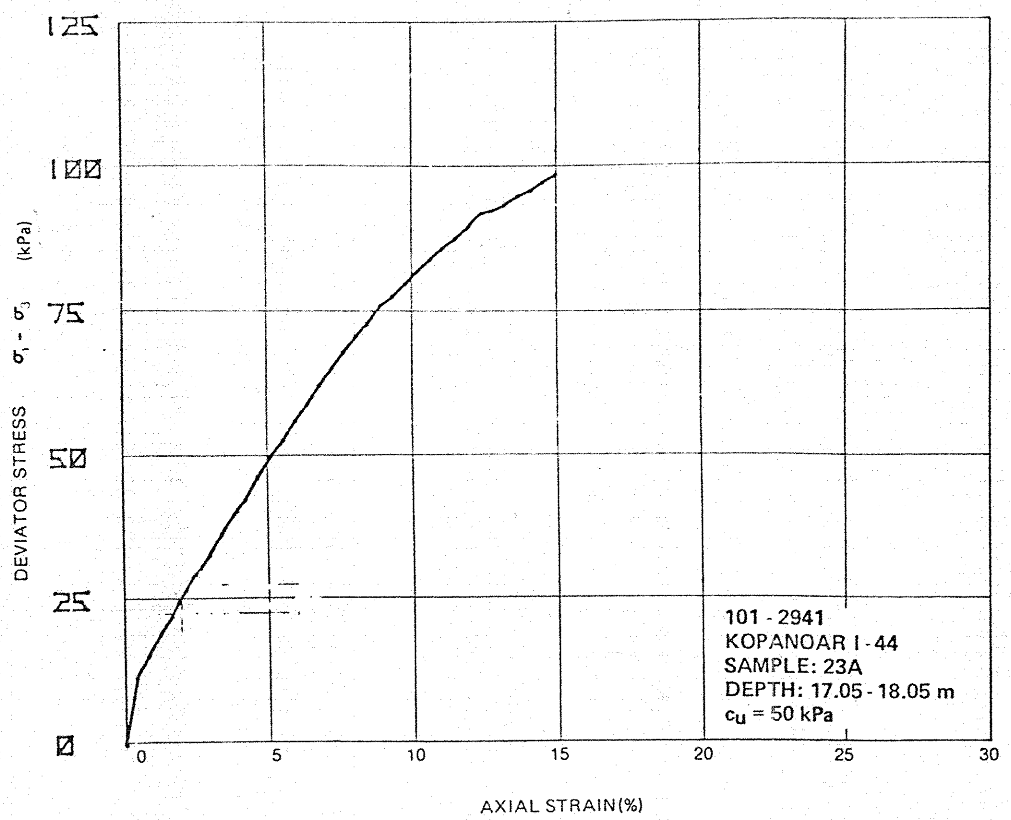
Note:
1. 15% axial strain assumed as failure unless peak stress obtained earlier.
2. Asterisk indicates sample in frozen state prior to testing. Initial bulk density reported is therefore frozen bulk density.
3. Test with pore pressure measurement (+) were done at slower rates.

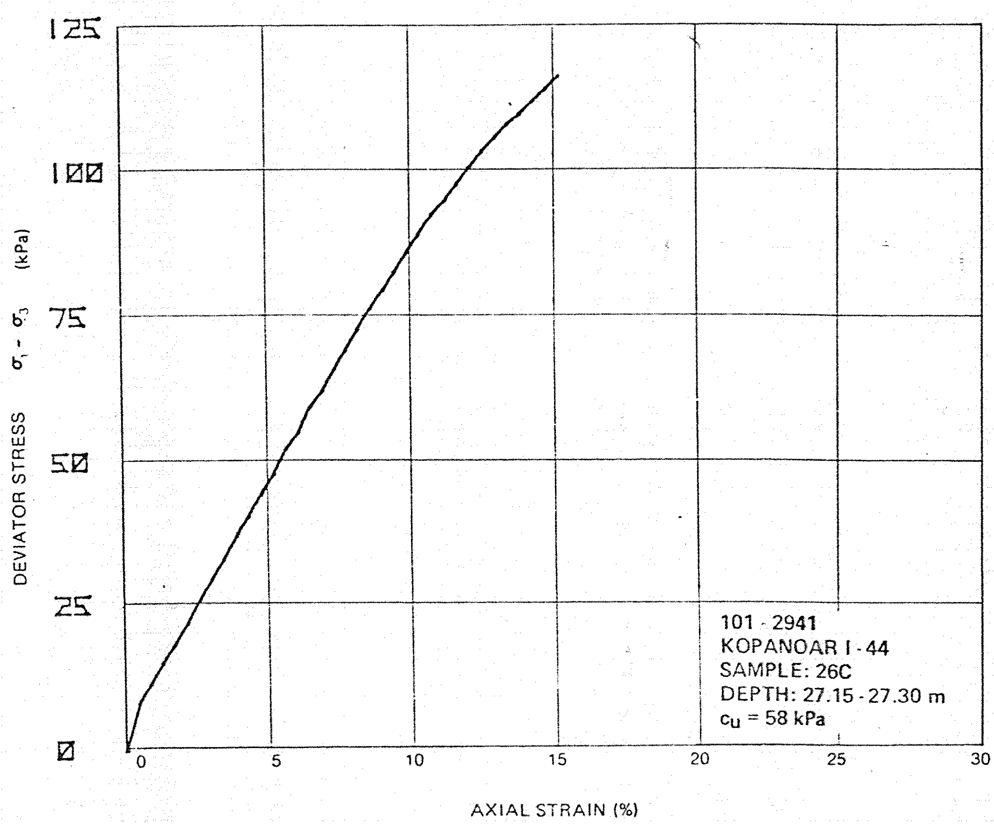
UNCONSOLIDATED – UNDRAINED TRIAXIAL TESTS





UNCONSOLIDATED – UNDRAINED TRIAXIAL TESTS





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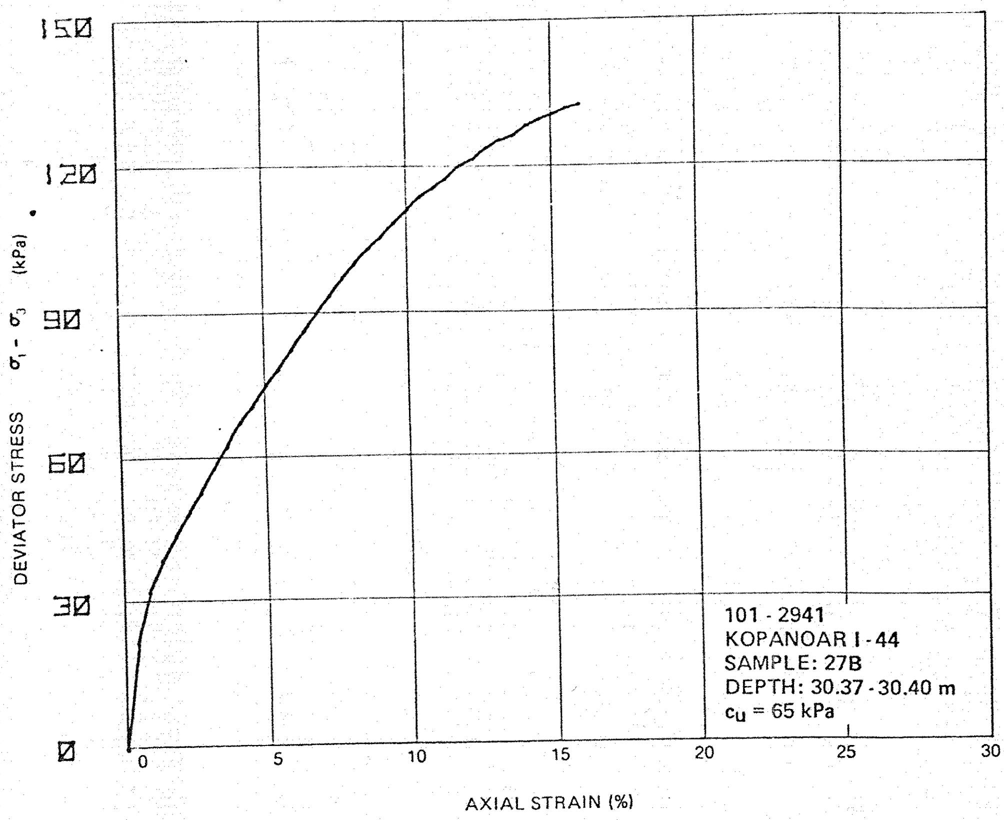

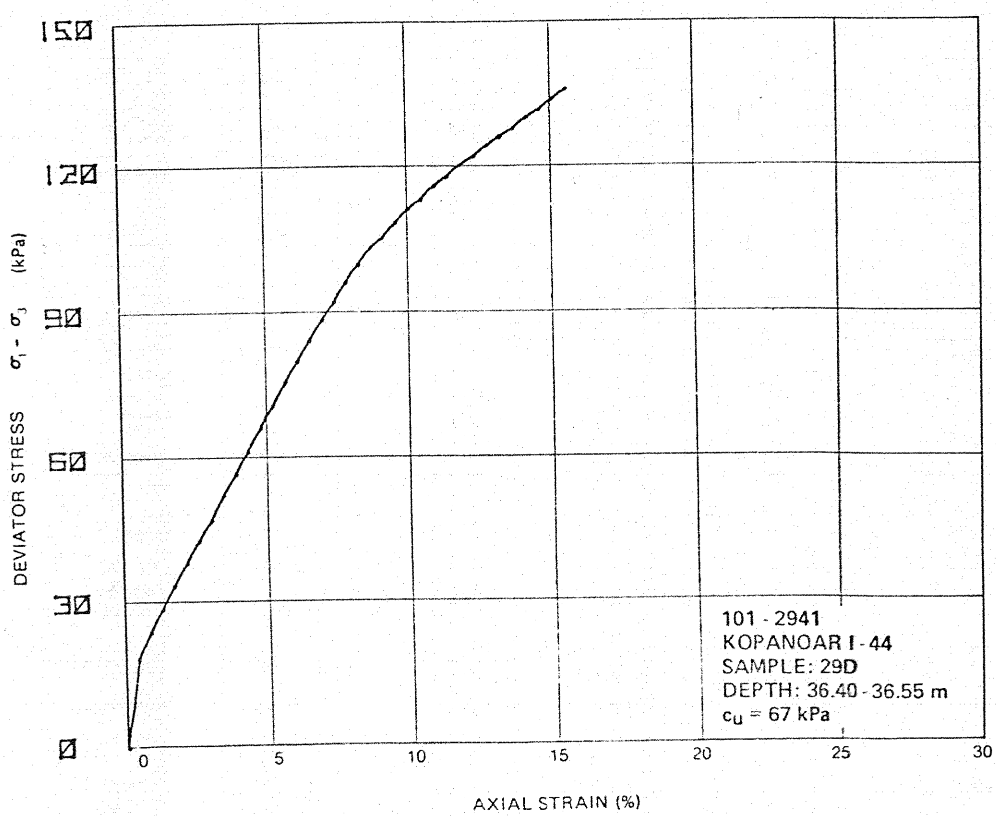

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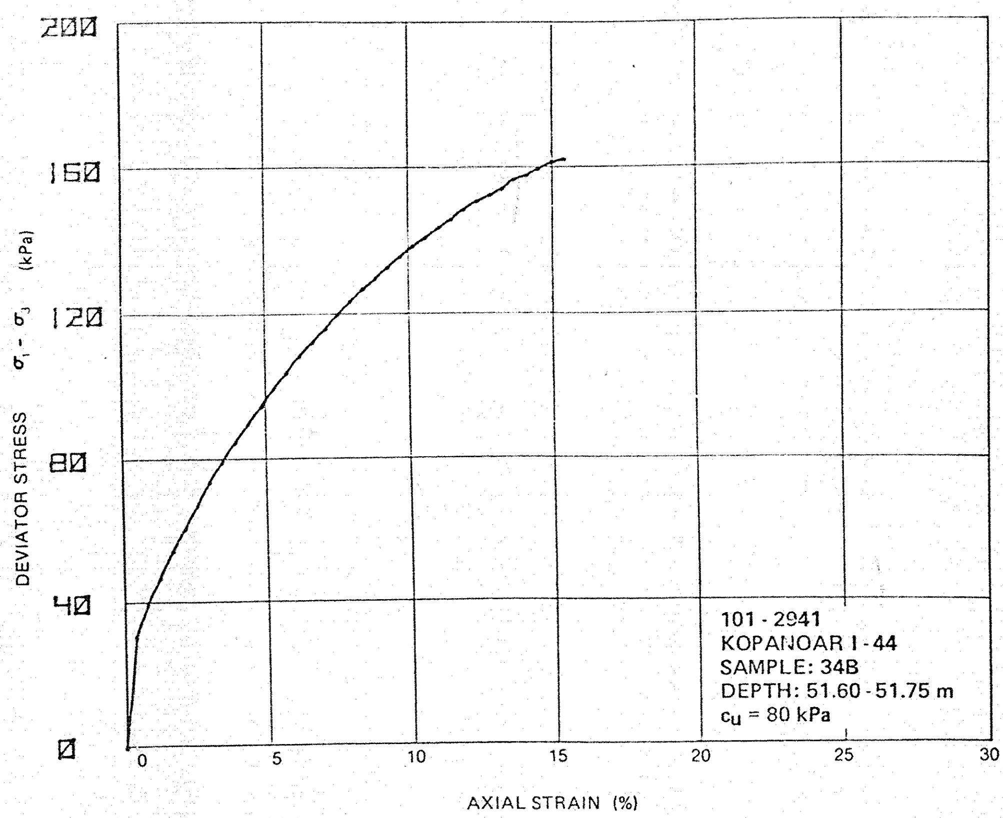

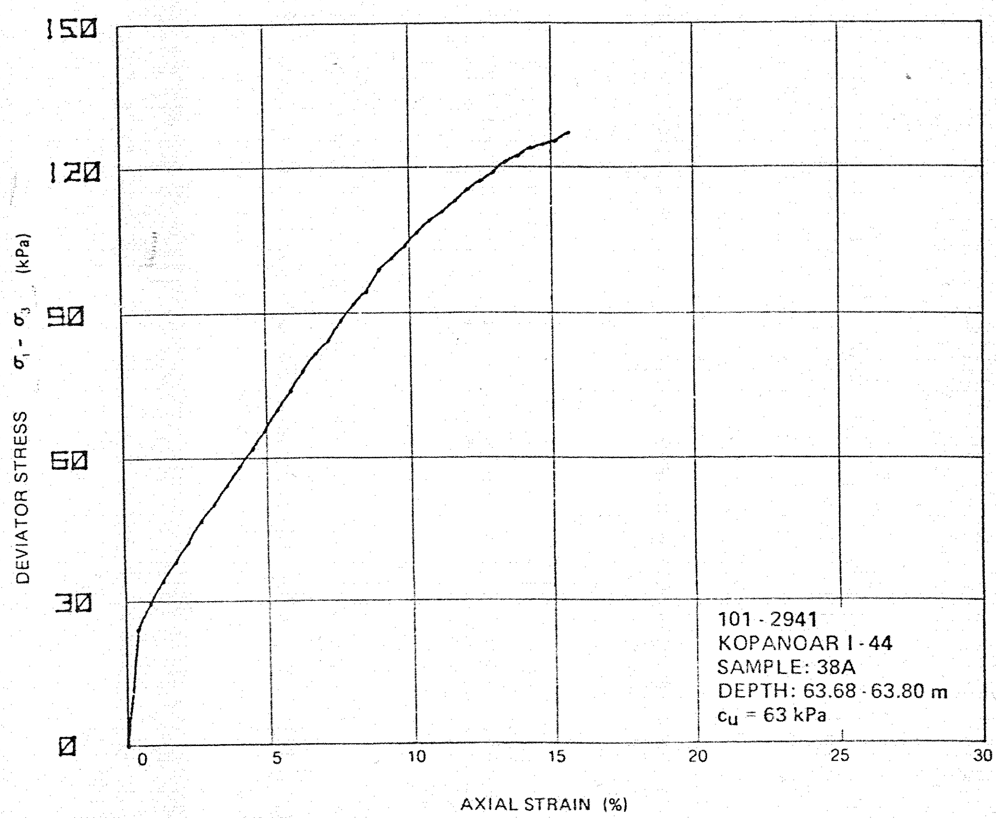

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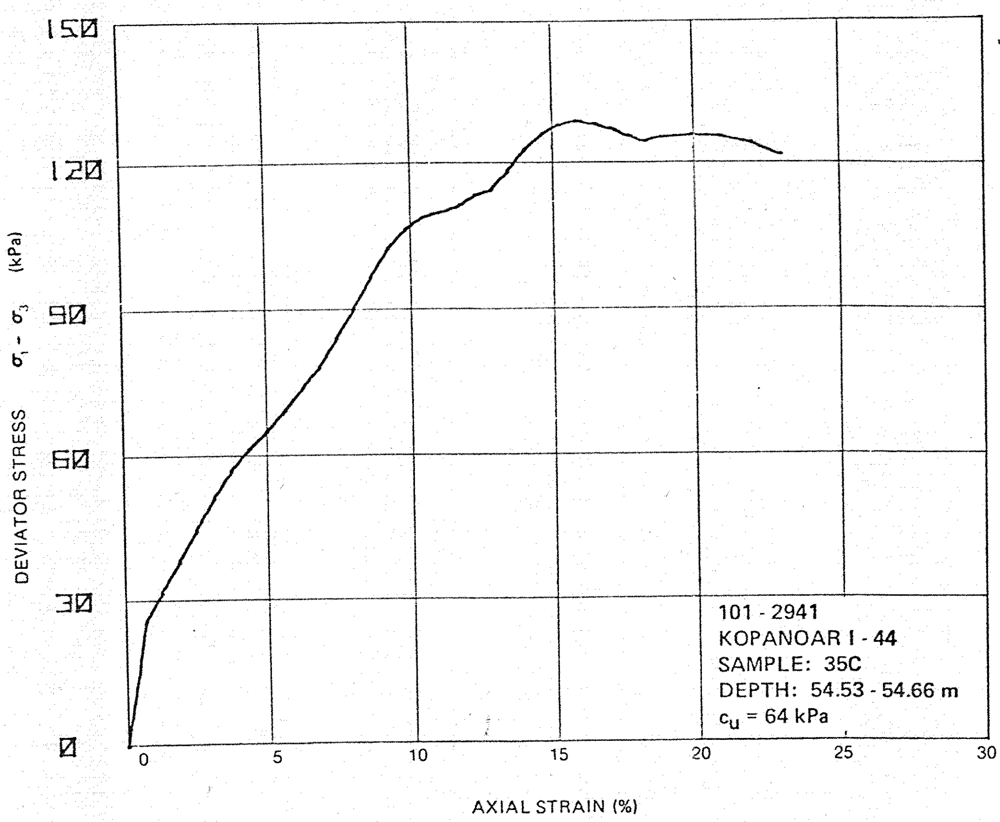

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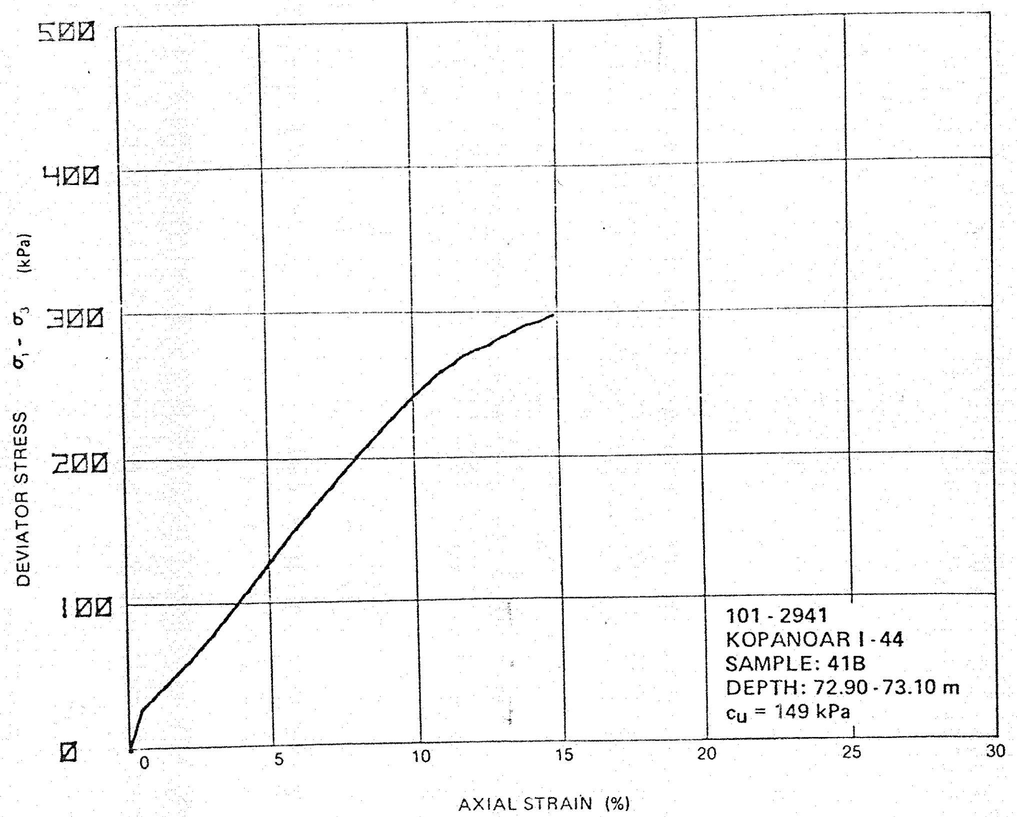

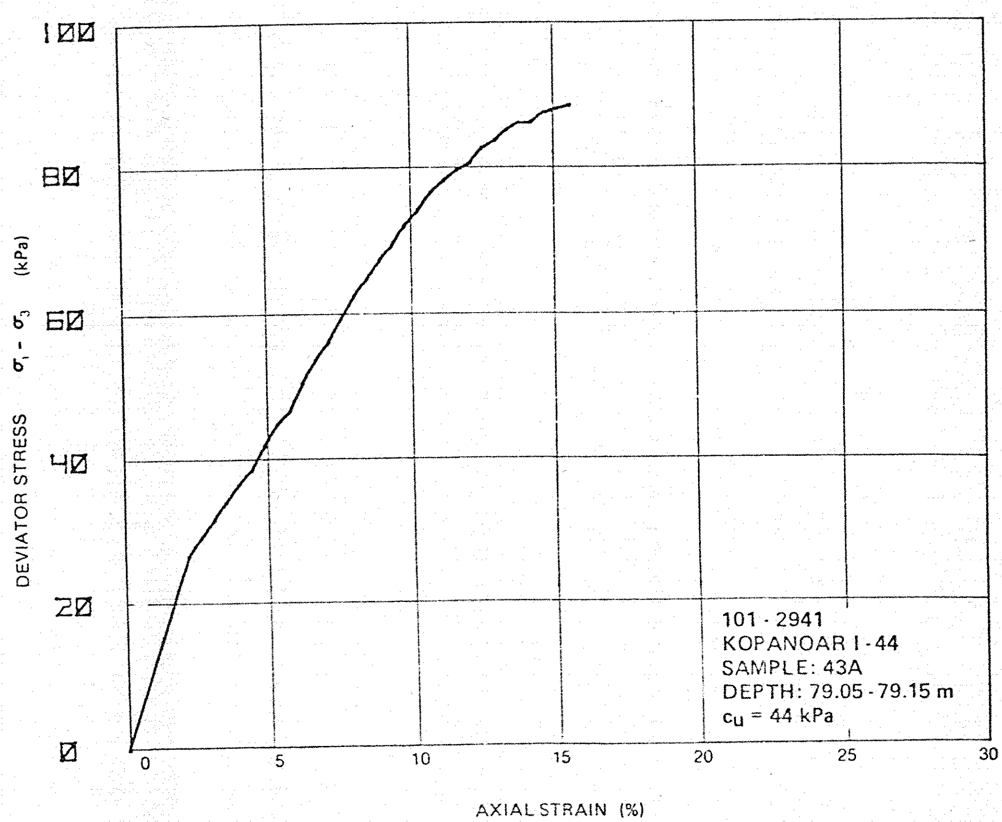

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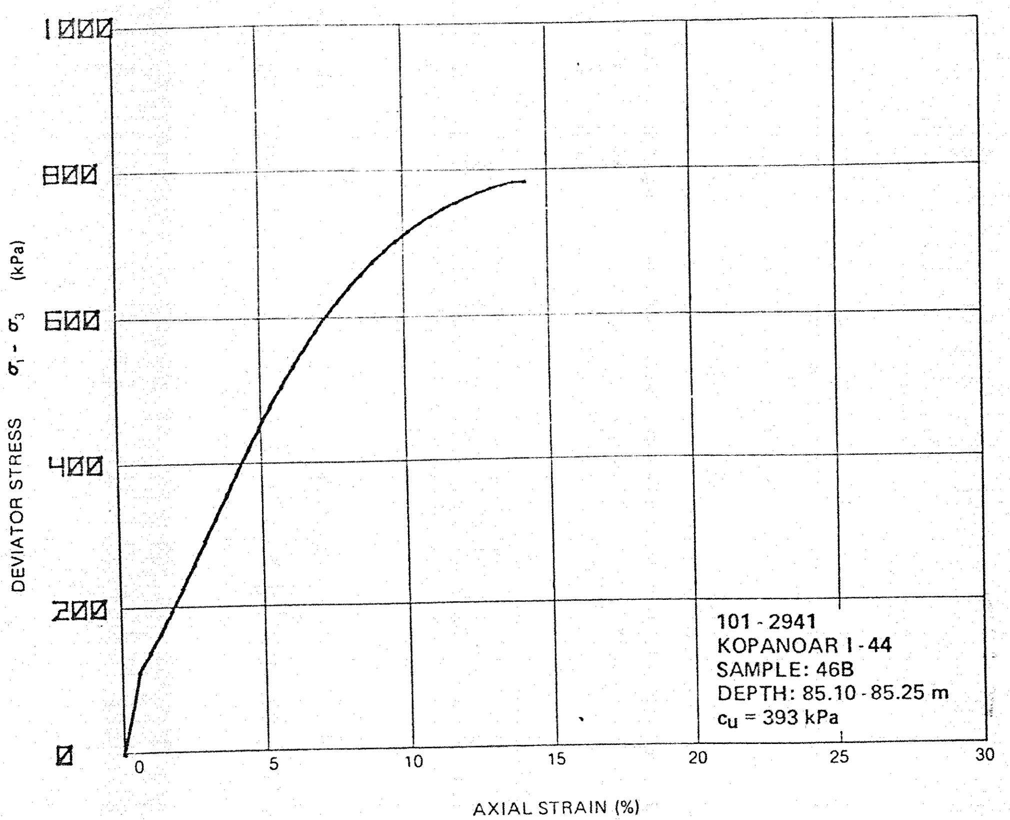
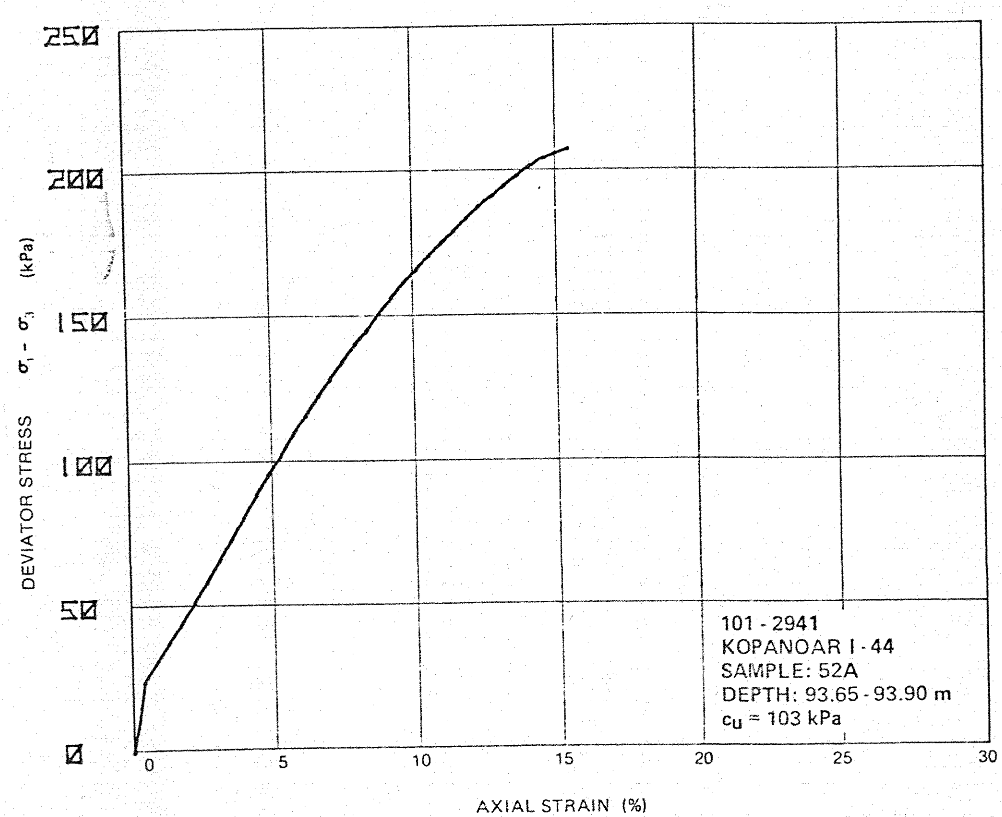
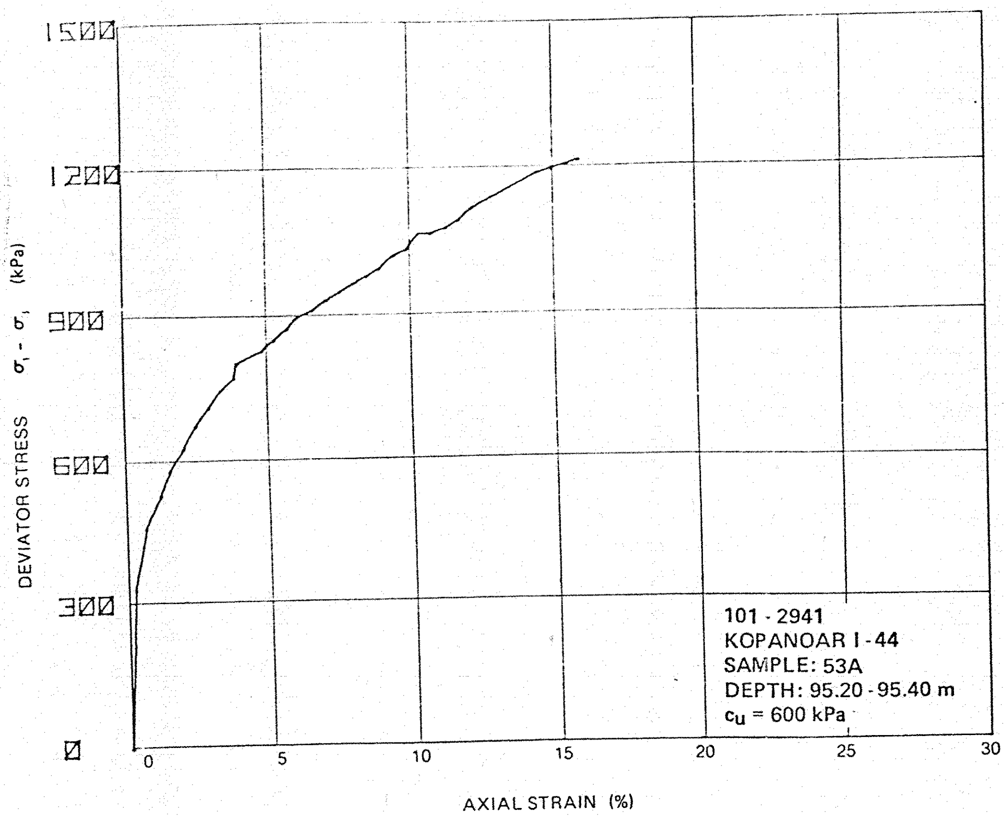
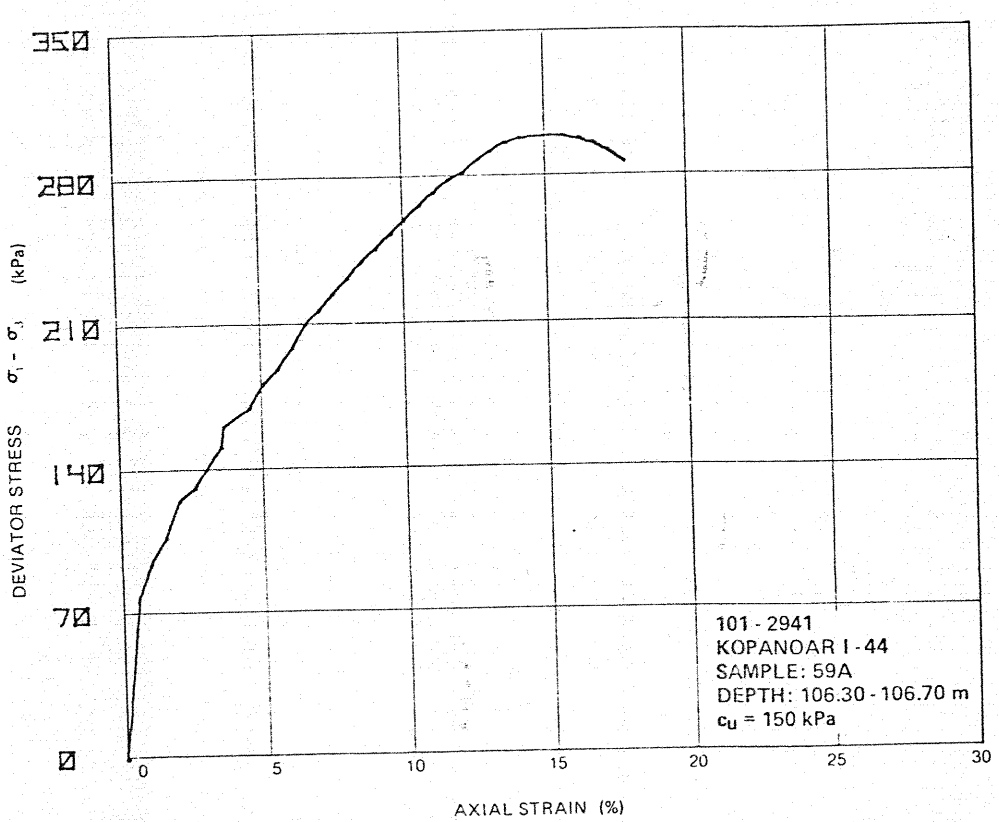


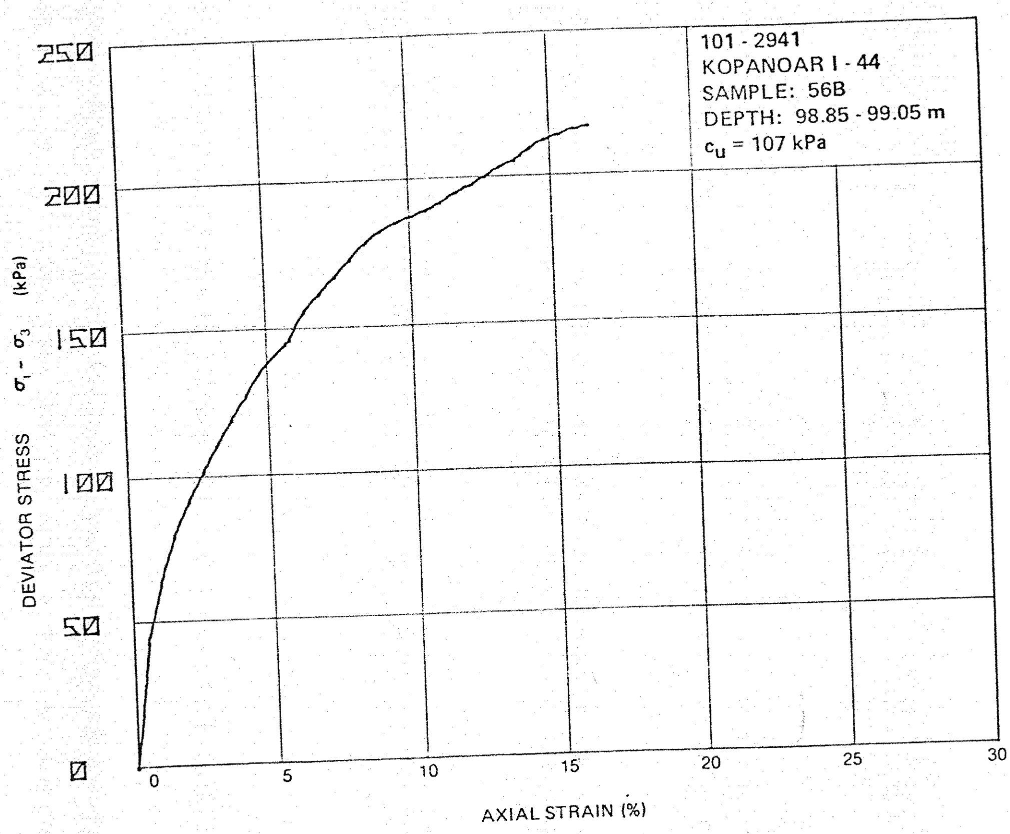


UNCONSOLIDATED – UNDRAINED TRIAXIAL TESTS

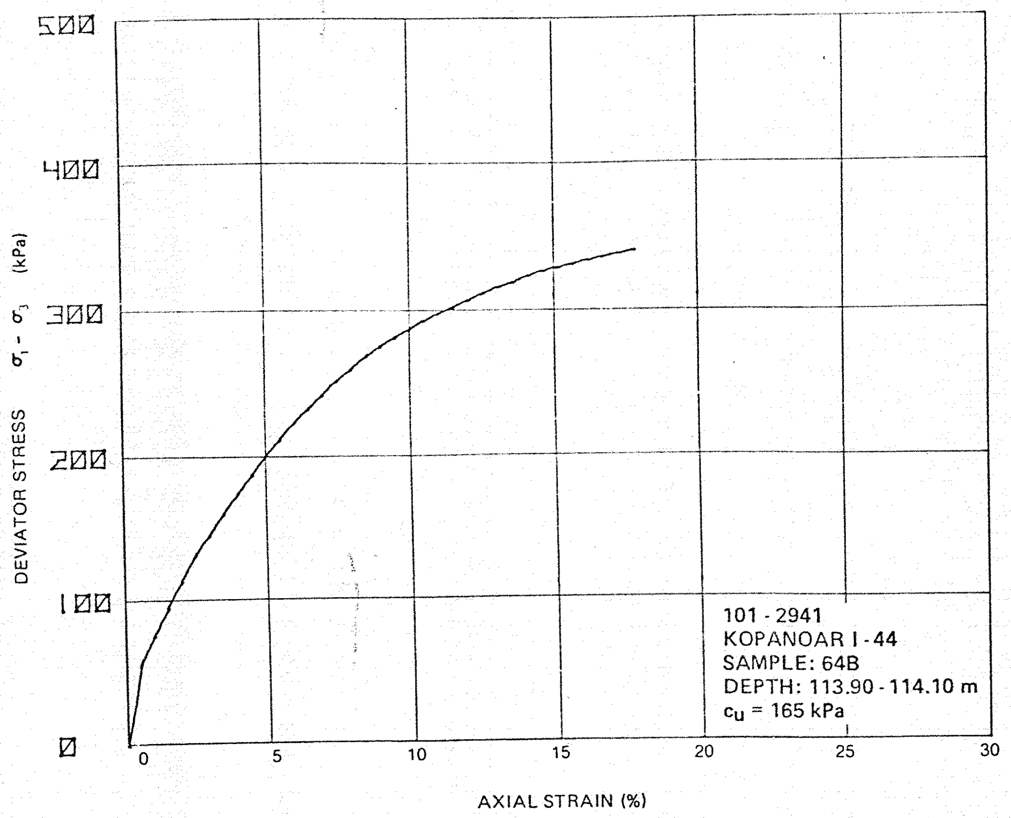




UNCONSOLIDATED – UNDRAINED TRIAXIAL TESTS



UNCONSOLIDATED – UNDRAINED TRIAXIAL TESTS



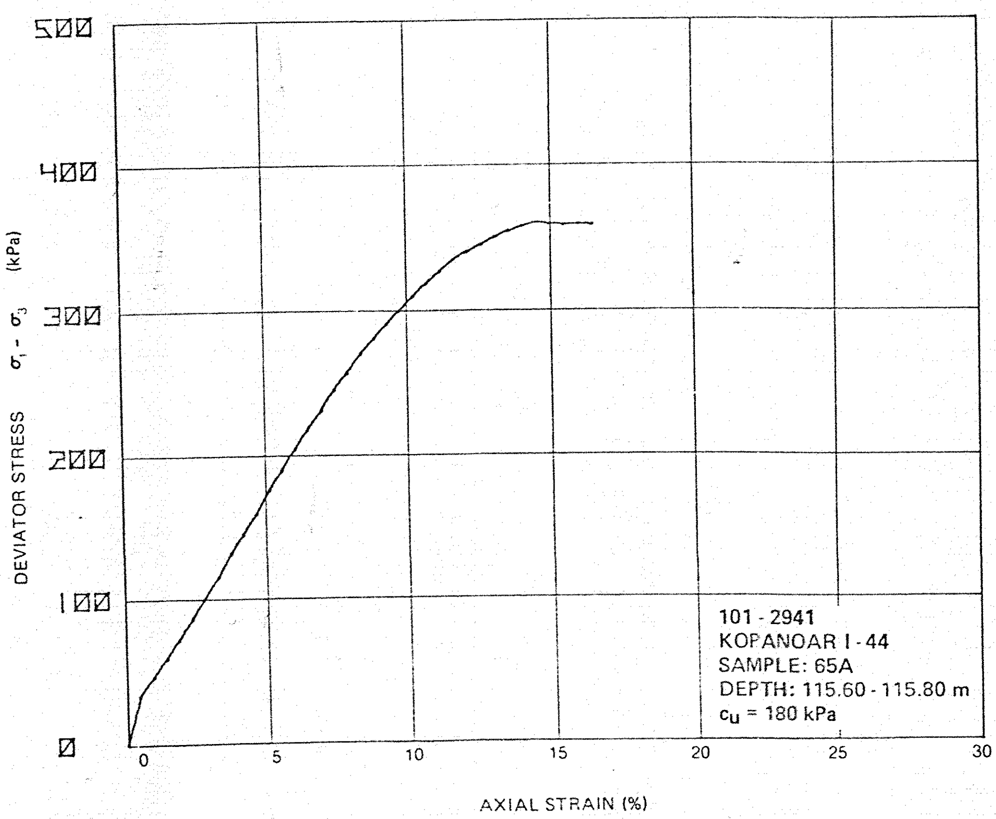


TABLE D-4 CONSOLIDATED - DRAINED TRIAXIAL TEST RESULTS, KOPANOAR I-44

TEST NUMBER	DEPTH INTERVAL	USC	SAMPLE		EFFECTIVE CONFINING PRESSURE	BACK PRESSURE	STRAIN RATE	MOISTURE CONTENT		FROZEN BULK DENSITY	CONDITIONS AT FAILURE				EFFECTIVE COHESION INTERCEPT	EFFECTIVE FRICTION ANGLE
			HEIGHT	DIAMETER				INITIAL	FINAL		$\frac{\sigma'_1+\sigma'_3}{2}$	$\frac{\sigma'_1-\sigma'_3}{2}$	AXIAL STRAIN	$\frac{\Delta V}{V}$		
	(m)		(mm)	(mm)	(kPa)	(kPa)	(%/min)	(%)	(%)	(Mg/m^3)	(kPa)	(kPa)	(%)	(%)	(kPa)	(degrees)
1	9.30-15.15	SM/SC	69	37	80	690	0.07	19	22	1.99	235	155	4	-1.0		
2			74	36	150	552	0.07	18	23	1.97	415	265	3	-0.8		
3			70	36	220	552	0.07	18	21	2.08	567	347	5	-0.2	14	36
4			72	37	80	69	0.07	24	25	2.00	207	127	6	-0.4		
5			71	37	150	345	0.07	18	23	2.00	374	224	6	0.0		
6			72	36	220	69	0.07	23	22	2.08	542	322	7	0.0		

NOTES:
1. Consolidated-drained triaxial tests performed on sand reconstituted from bag samples (16A, 16B, 18A, 18B, 19B, 21A).
2. The effective cohesion intercept and effective friction angle were determined as the average of the six triaxial tests performed.

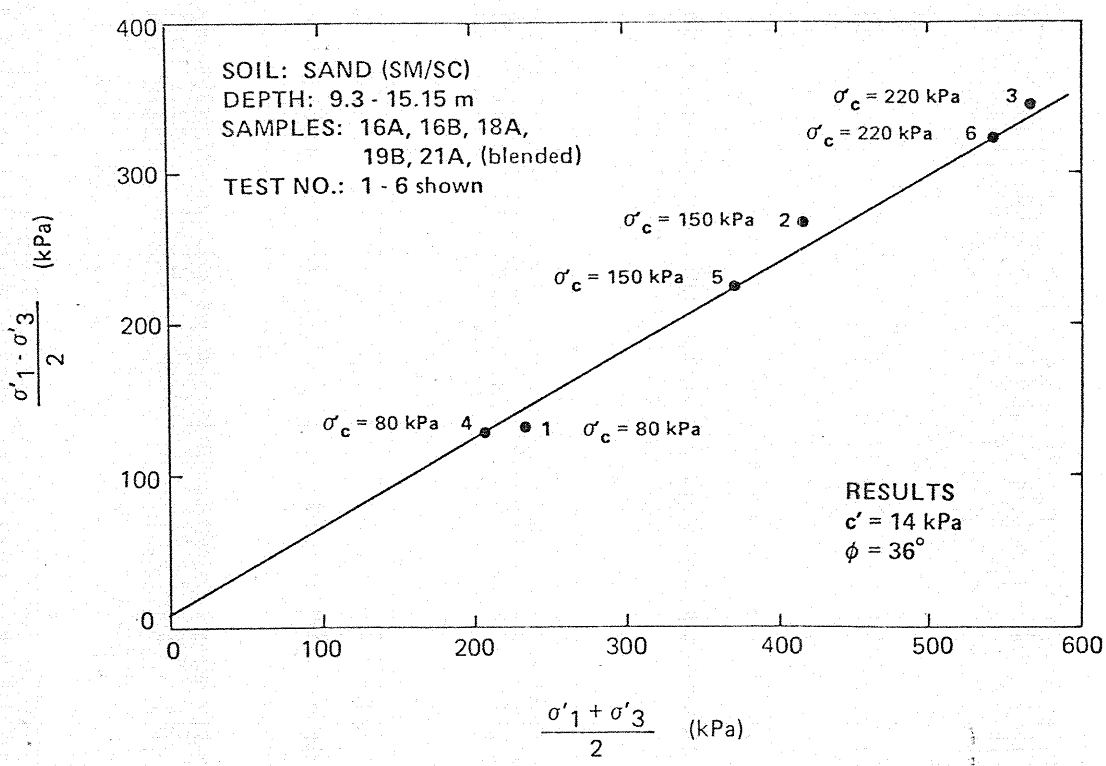
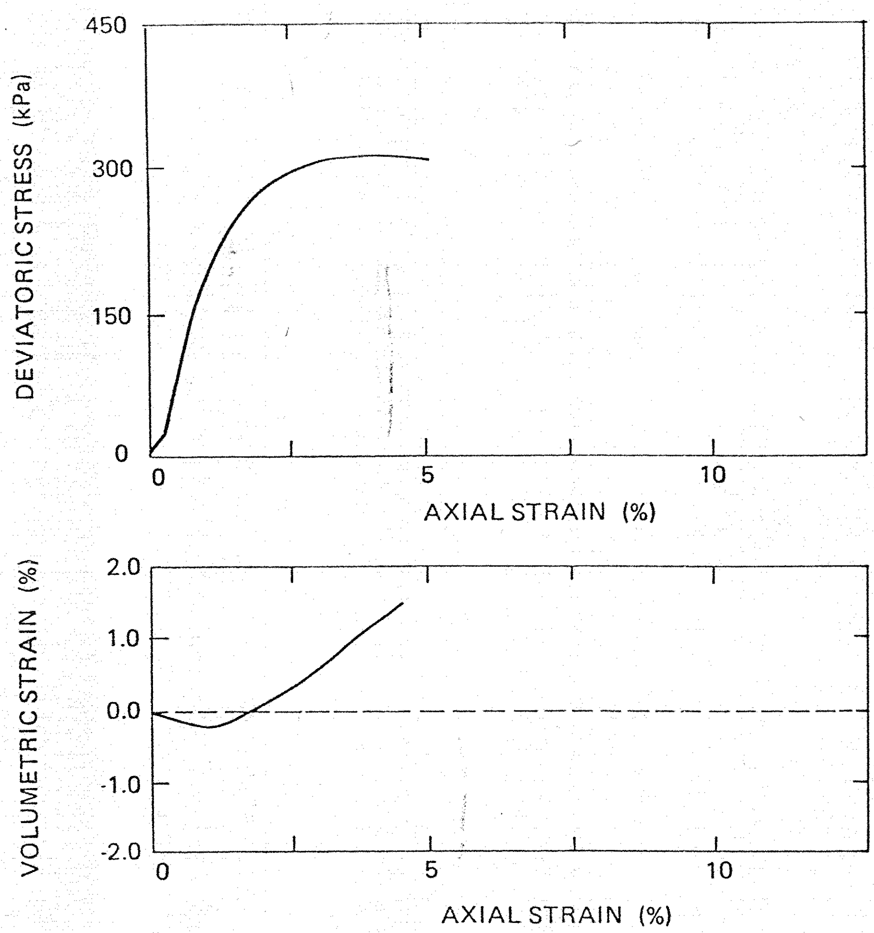


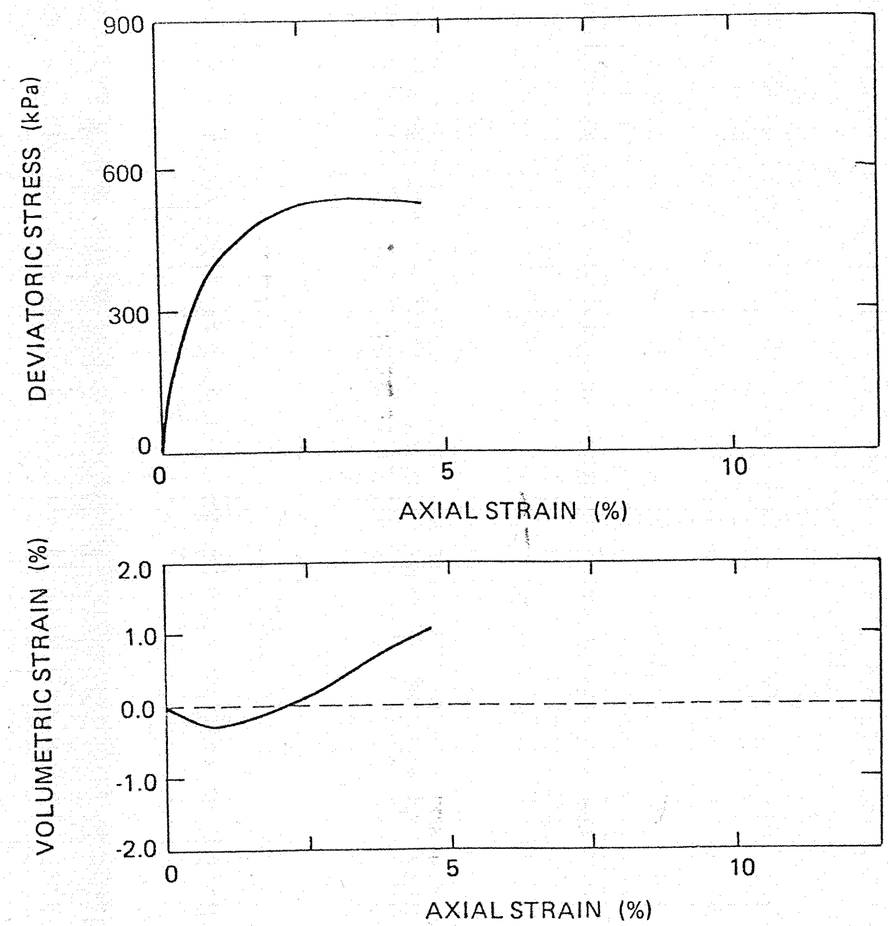
FIGURE D-1 SHEAR STRENGTH ENVELOPE FOR CONSOLIDATED - DRAINED TRIAXIAL TEST, KOPANOAR I - 44

CONSOLIDATED-DRAINED TRIAXIAL TEST



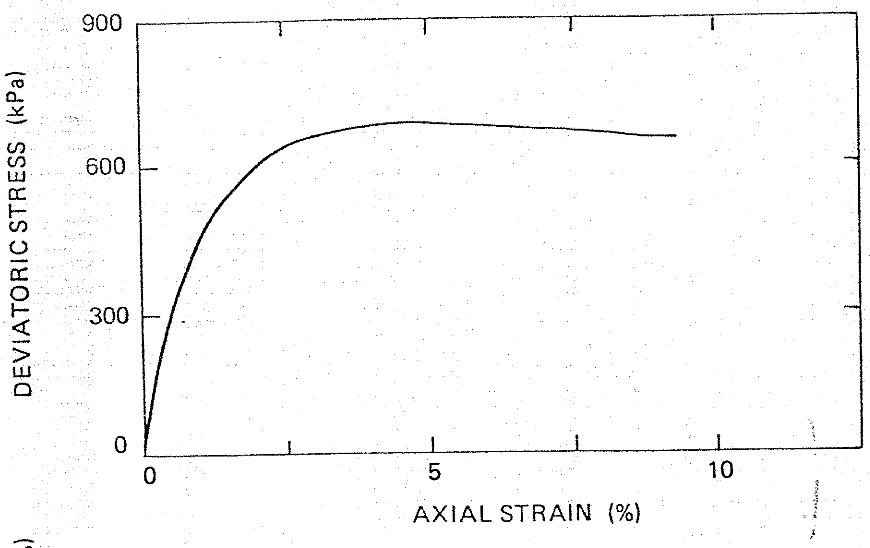
KOPANOAR I - 44
DEPTH: 9.3 - 15.15 m
SOIL: SAND (SM/SC)
TEST NO.: **1**
$e_i = 0.60$ $\sigma'_c = 80$ kPa

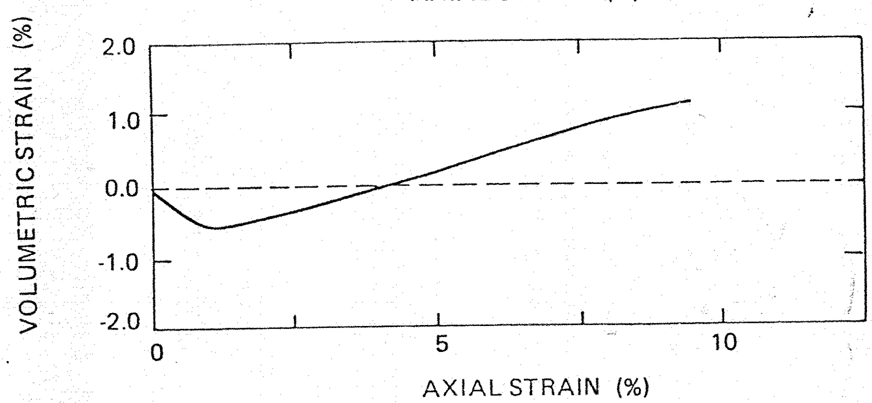
CONSOLIDATED-DRAINED TRIAXIAL TEST



KOPANOAR I - 44
DEPTH: 9.3 - 15.15
SOIL: SAND (SM/SC)
TEST NO.: 2
e_i = 0.60 σ'_c = 150 kPa

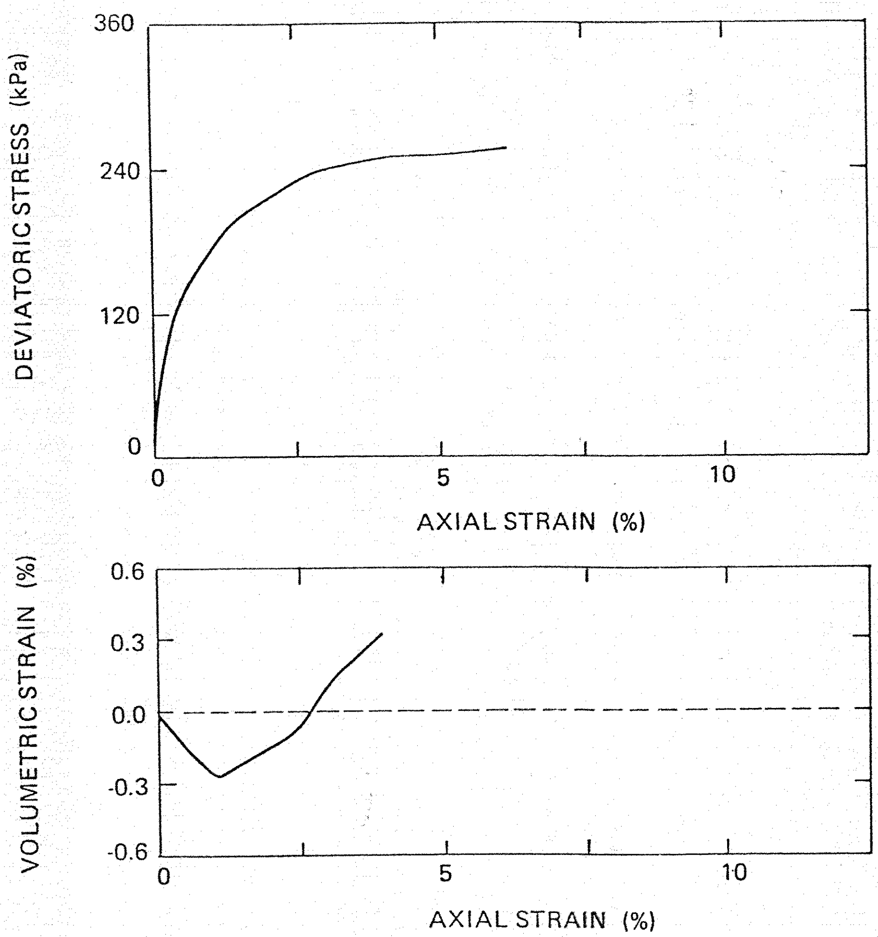
CONSOLIDATED-DRAINED TRIAXIAL TEST





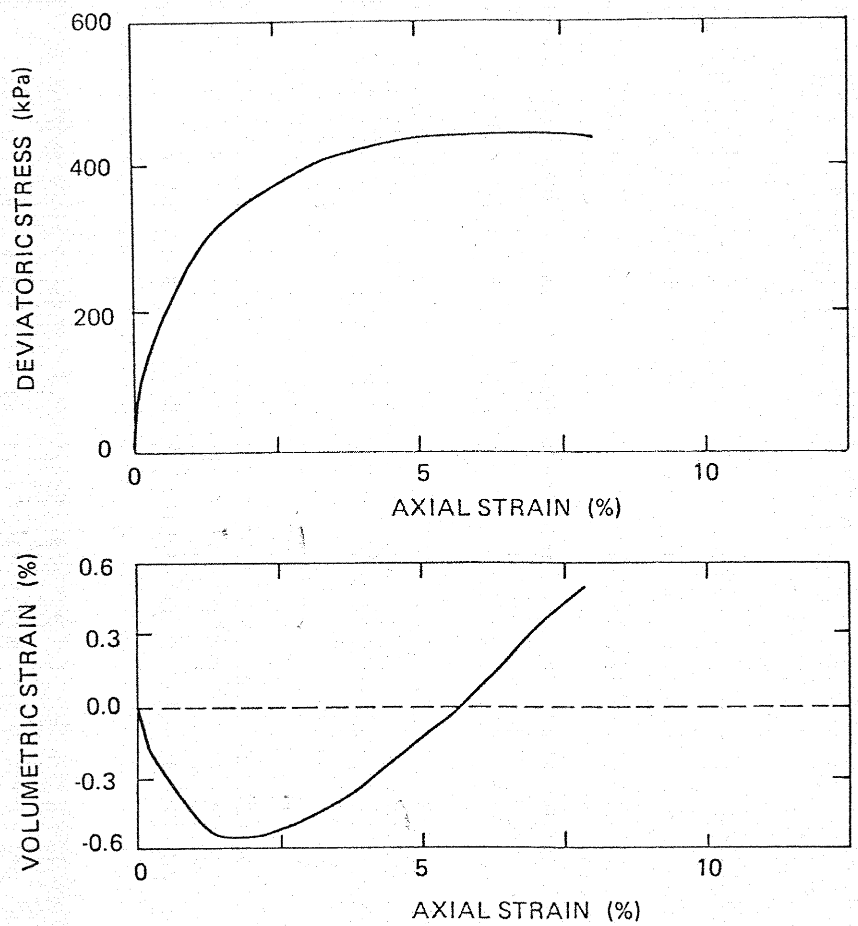
KOPANOAR I - 44
DEPTH: 9.3 - 15.15
SOIL: SAND (SM/SC)
TEST NO.: 3
$e_i = 0.52$ $\sigma'_c = 220$ kPa

CONSOLIDATED-DRAINED TRIAXIAL TEST



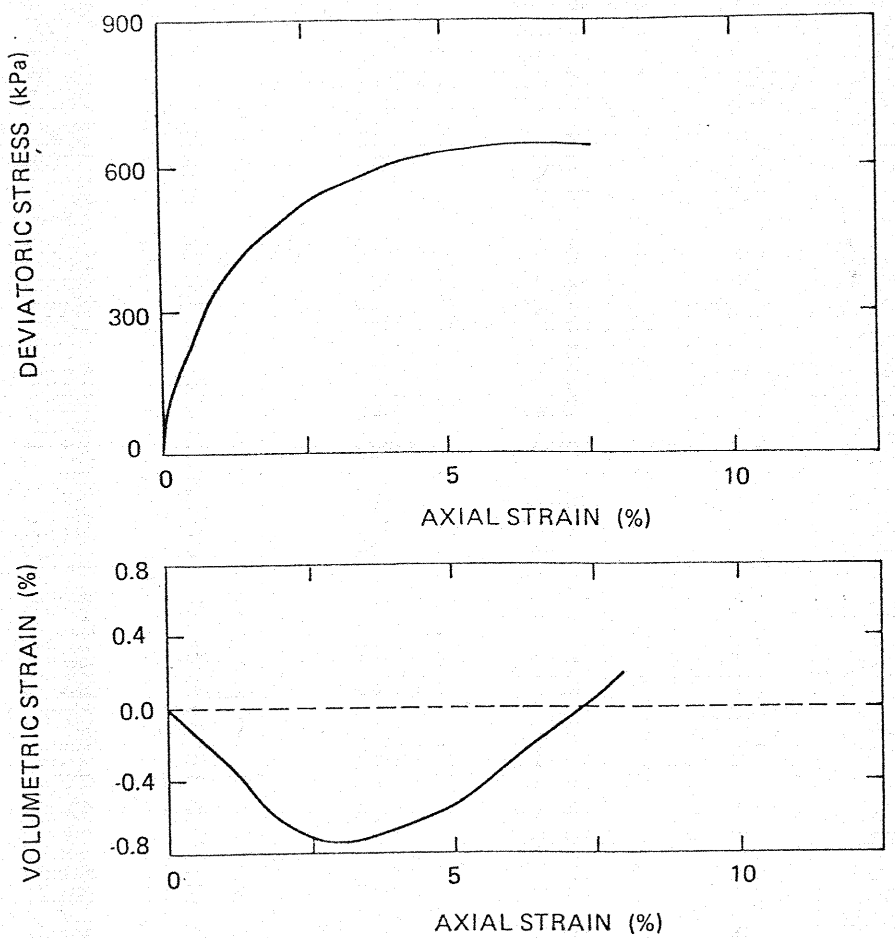
KOPANOAR I - 44
DEPTH: 9.3 - 15.15
SOIL: SAND (SM/SC)
TEST NO.: 4
$e_i = 0.67$ $\sigma'_c = 80$ kPa

CONSOLIDATED-DRAINED TRIAXIAL TEST



KOPANOAR I - 44
DEPTH: 9.3 - 15.15
SOIL: SAND (SM/SC)
TEST NO.: 5
e_i = 0.57 σ'_c = 150 kPa

CONSOLIDATED-DRAINED TRIAXIAL TEST



KOPANOAR I - 44
DEPTH: 9.3 - 15.15 m
SOIL: SAND (SM/SC)
TEST NO.: 6
$e_i = 0.62$ $\sigma'_c = 220$ kPa

TABLE D-5 SUMMARY OF LIMITING DENSITIES FOR SILTY SAND, KOPANOAR I-44

SAMPLES BLENDED	DEPTH (m)	OPTIMUM MOISTURE CONTENT (%)	MINIMUM DRY DENSITY (Mg/m^3)	MAXIMUM DRY DENSITY (Mg/m^3)
16A, 16B, 18A	9.30-10.75	20	1.26	1.67
16A, 16B, 18A, 18B, 19B, 21A	9.30-15.15	20	1.31	1.68

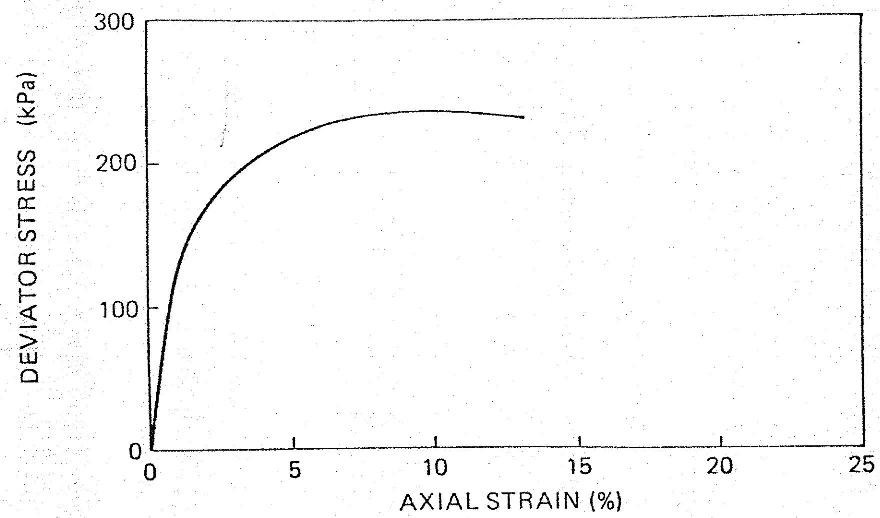
NOTE: 1. This soil was used to reconstitute samples for consolidated-drained triaxial testing.

TABLE D-6 CONSOLIDATED - UNDRAINED TRIAXIAL TEST RESULTS, KOPANOAR I-44

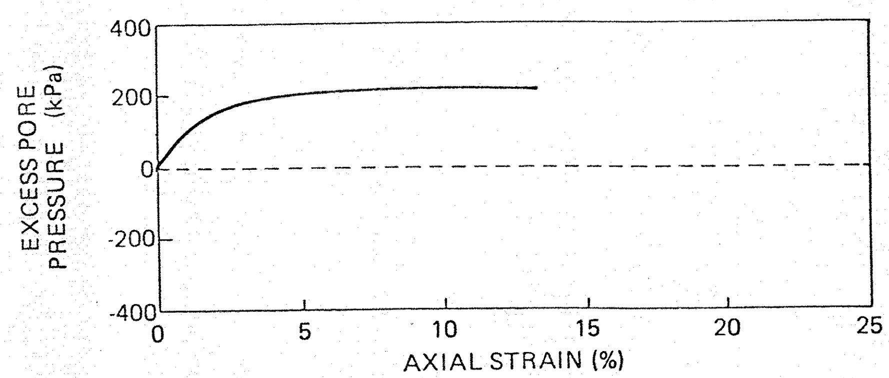
SAMPLE NUMBER	DEPTH INTERVAL	USC	SAMPLE		EFFECTIVE CONFINING PRESSURE	BACK PRESSURE	STRAIN RATE	MOISTURE CONTENT		FROZEN BULK DENSITY	CONDITIONS AT FAILURE				EFFECTIVE COHESION INTERCEPT	EFFECTIVE FRICTION ANGLE
			HEIGHT	DIAMETER				INITIAL	FINAL		$\frac{\sigma_1' + \sigma_3'}{2}$	$\frac{\sigma_1' - \sigma_3'}{2}$	AXIAL STRAIN	A_f		
	(m)		(mm)	(mm)	(kPa)	(kPa)	(%/min)	(%)	(%)	(Mg/m^3)	(kPa)	(kPa)	(%)	(%)	(kPa)	(degrees)
13A	7.45 - 7.57	CL	99	50	393	138	.01	51	28	1.75	292	117	11	.94		
44B	81.3 - 81.4	ML	100	50	147	138	.27	29	24	1.88	303	182	5	.07	26	30
44D	81.6 - 81.7	ML	100	50	346	138	.17	22	19	2.01	341	201	8	.51		
47A	87.6 - 87.8	ML	100	50	246	138	.25	31	26	1.87	479	284	8	.09	21	33
49A	89.2 - 89.3	ML	99	50	548	138	.25	28	26	1.90	881	501	11	.17		

NOTE:
1. Failure taken as maximum obliquity obtained.
2. All samples were originally frozen. Specimens were thawed in cell prior to testing.
3. Sample 13A was not frozen.

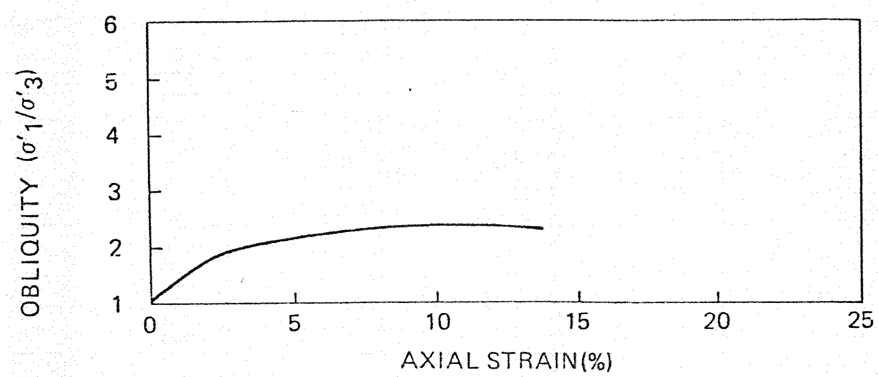
CONSOLIDATED - UNDRAINED TRIAXIAL TEST



COMPRESSIVE STRESS vs AXIAL STRAIN



EXCESS PORE PRESSURE vs AXIAL STRAIN



OBLIQUITY vs AXIAL STRAIN

KOPANOAR I-44
SAMPLE: 13A
DEPTH: 7.5-7.6 m
e_i = 1.39 σ'_c = 393 kPa

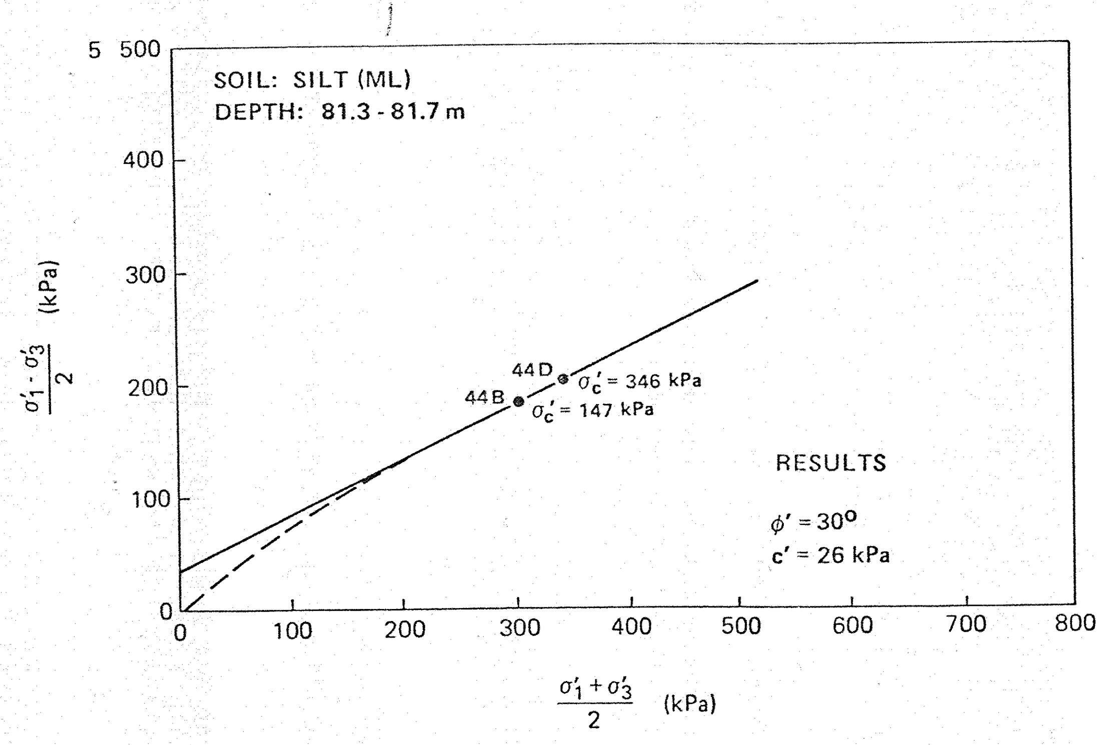
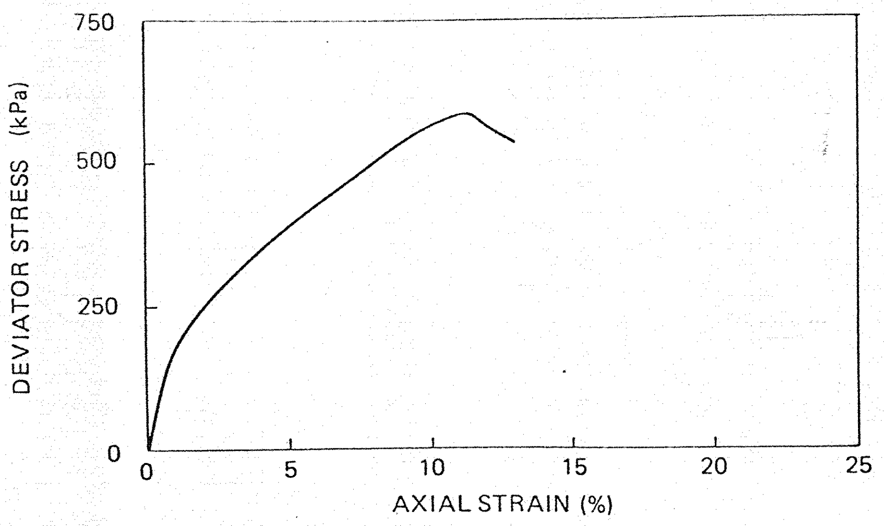
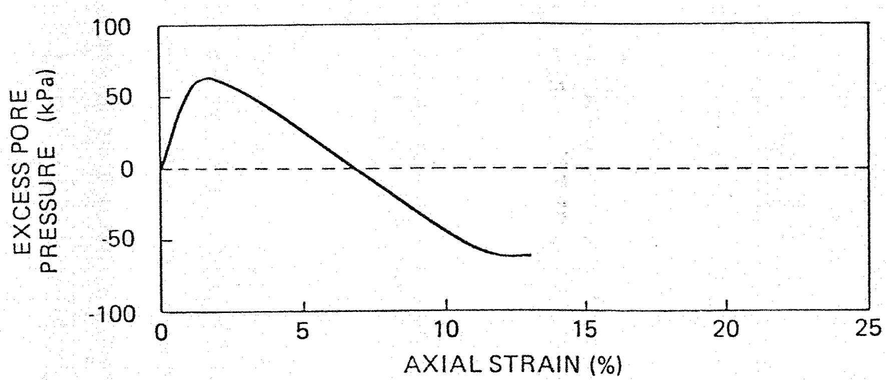


FIGURE D-2 SHEAR STRENGTH ENVELOPE FOR CONSOLIDATED - UNDRAINED TRIAXIAL TEST, KOPANOAR I - 44

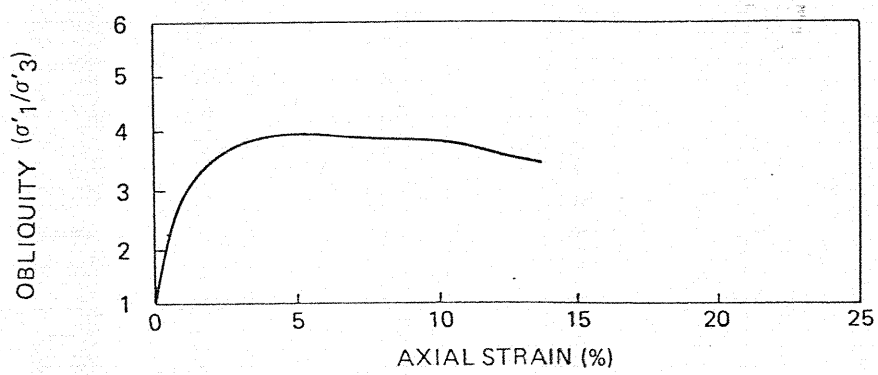
CONSOLIDATED - UNDRAINED TRIAXIAL TEST



COMPRESSIVE STRESS vs AXIAL STRAIN



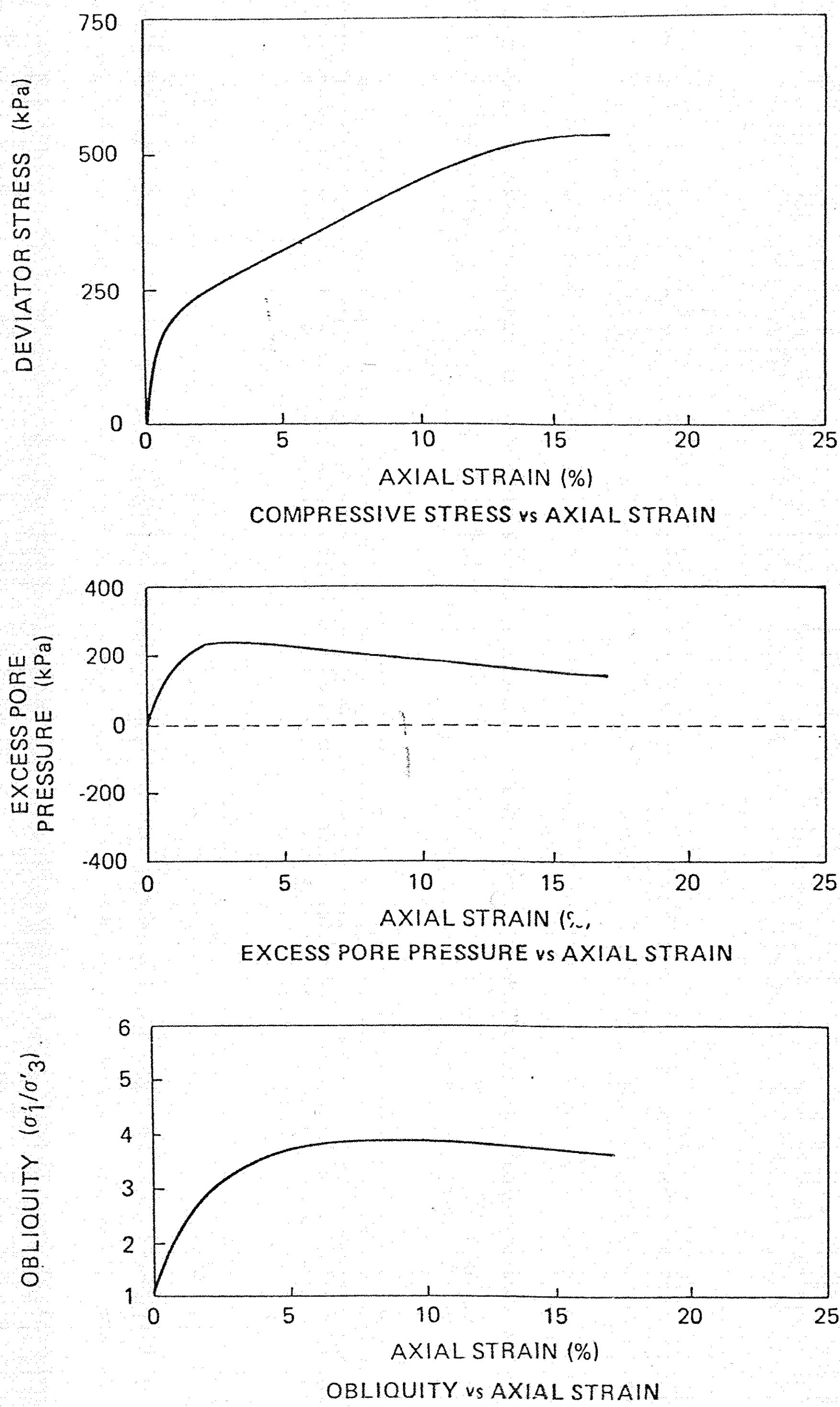
EXCESS PORE PRESSURE vs AXIAL STRAIN



OBLIQUITY vs AXIAL STRAIN

KOPANOAR I-44
SAMPLE: 44B
DEPTH: 81.3-81.4 m
$e_i = 0.84$ $\sigma'_c = 147$ kPa

CONSOLIDATED - UNDRAINED TRIAXIAL TEST



KOPANOAR I-44
SAMPLE: 44D
DEPTH: 81.6-81.7 m
$e_i = 0.63$ $\sigma'_c = 346$ kPa

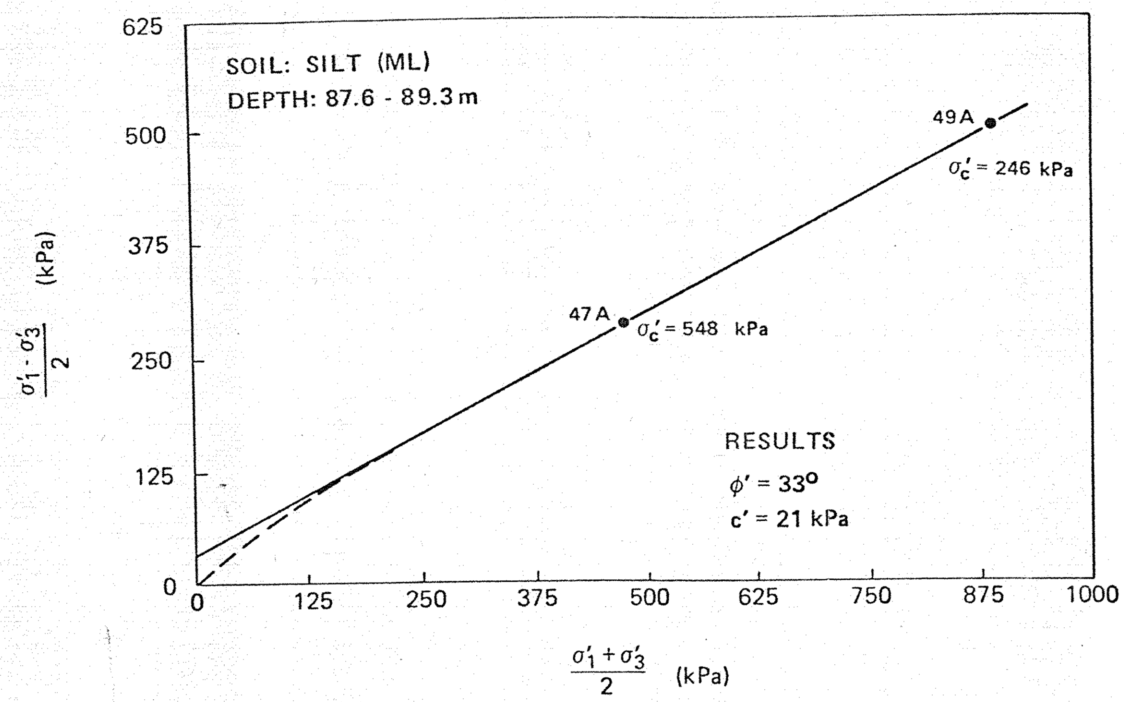
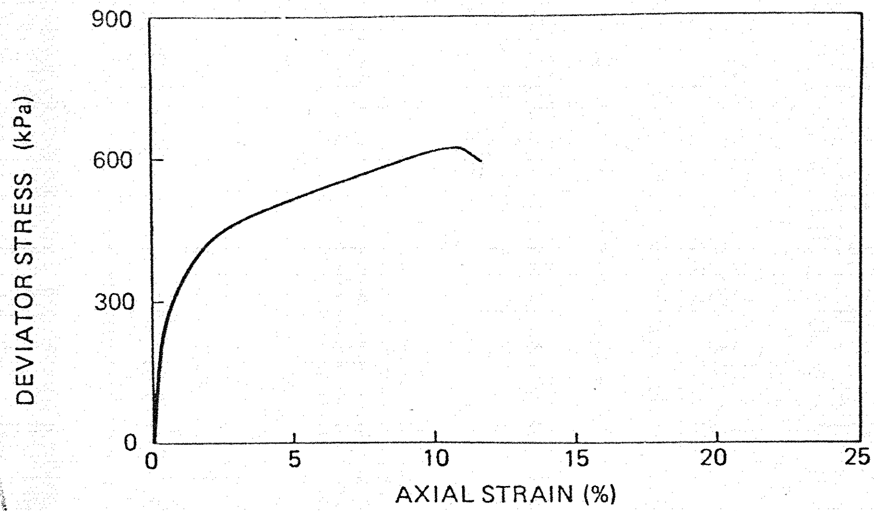
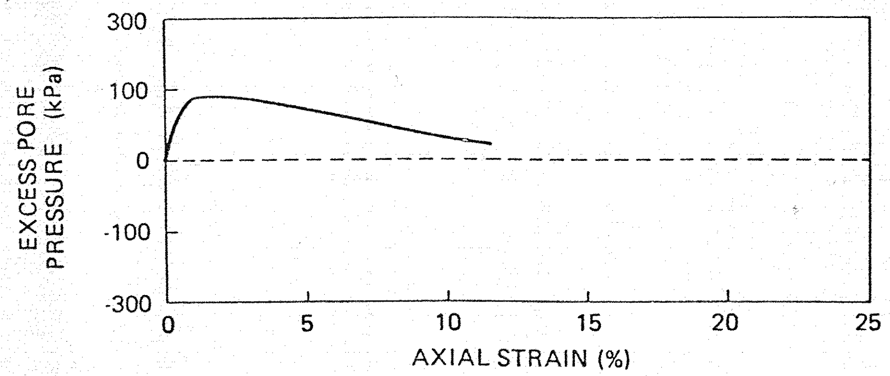


FIGURE D-3 SHEAR STRENGTH ENVELOPE FOR CONSOLIDATED - UNDRAINED TRIAXIAL TEST, KOPANOAR I - 44

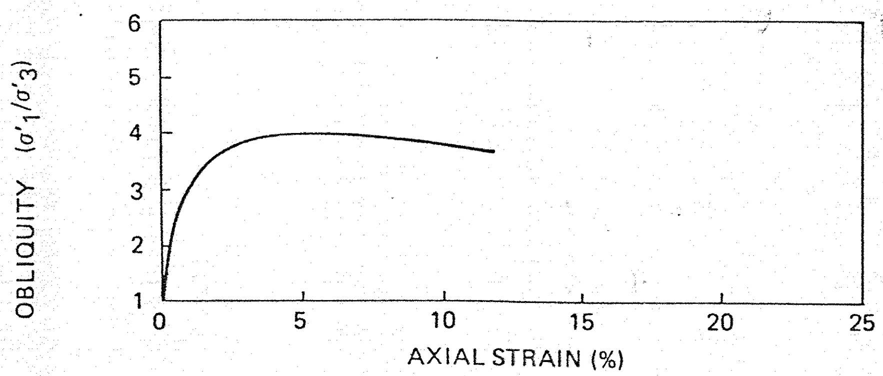
CONSOLIDATED - UNDRAINED TRIAXIAL TEST



COMPRESSIVE STRESS vs AXIAL STRAIN



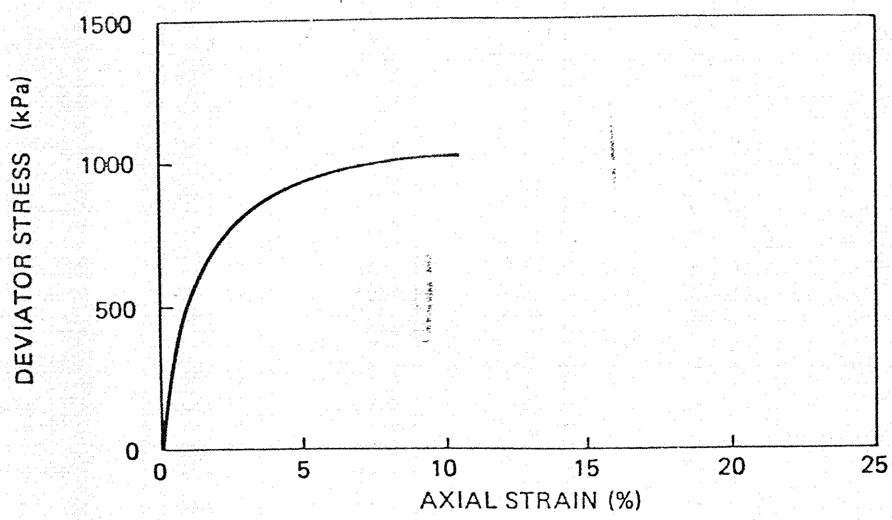
EXCESS PORE PRESSURE vs AXIAL STRAIN



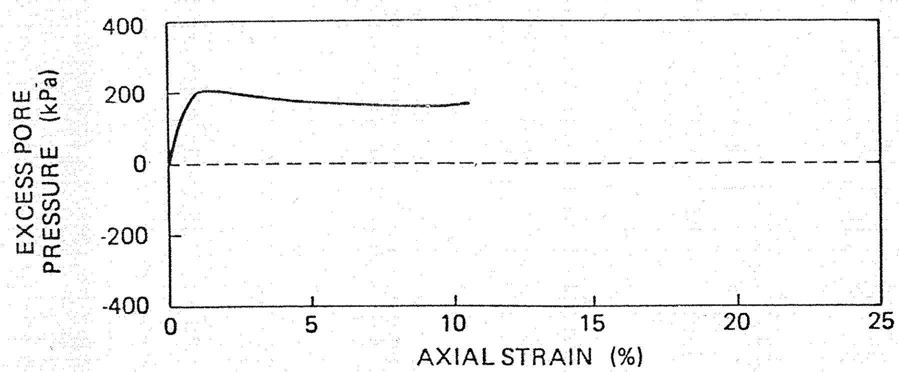
OBLIQUITY vs AXIAL STRAIN

KOPANOAR I-44
SAMPLE: 47A
DEPTH: 87.6-87.8 m
e_i = 0.88 σ'_c = 246 kPa

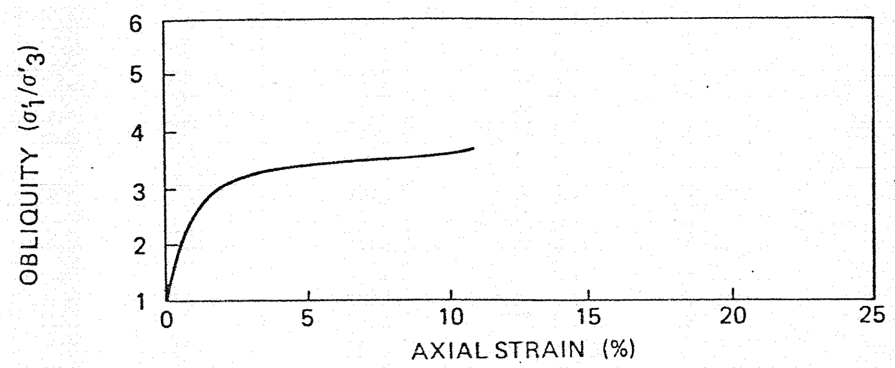
CONSOLIDATED - UNDRAINED TRIAXIAL TEST



COMPRESSIVE STRESS vs AXIAL STRAIN



EXCESS PORE PRESSURE vs AXIAL STRAIN



OBLIQUITY vs AXIAL STRAIN

KOPANOAR I-44
SAMPLE: 49A
DEPTH: 89.2-89.3 m
e_i = 0.79 σ'_c = 548 kPa

A P P E N D I X E

CONSOLIDATION TEST RESULTS (EBA)

APPENDIX E

CONSOLIDATION TEST RESULTS

Appendix - Illustrations & Tables

TABLE E-1 SUMMARY OF CONSOLIDATION TEST RESULTS, KOPANOAR I-44

SAMPLE	DEPTH INTERVAL (m)	USC	EFFECTIVE OVERBURDEN PRESSURE (kPa)	ESTIMATED PRECONSOLIDATION PRESSURE (kPa)	OVERCONSOLIDATION RATIO	COMPRESSION INDEX
1B	0.13 - 0.25	CH	1	15	15.0	0.58
10A	5.55 - 5.67	CL	27	-	-	-
25A	24.00 - 24.15	ML	169	280	1.7	0.21
32C	45.50 - 45.65	ML	363	175	0.5	0.19
40B*	69.90 - 70.05	ML	584	1300	2.2	0.17
52A*	93.65 - 93.90	ML	798	1600	2.0	0.19
59A*	106.30 - 106.70	ML	913	800	0.9	0.15
67B*	121.75 - 121.85	ML	1051	1300	1.2	0.15

NOTE: 1. Samples marked by asterisk were returned frozen from the field. These samples were thawed as a first stage in the testing.

TABLE E-2 CONSOLIDATION TEST RESULTS, KOPANOAR I-44

SAMPLE NUMBER	DEPTH (metres)	USC	MOISTURE CONTENT INITIAL (%)	MOISTURE CONTENT FINAL (%)	BULK DENSITY INITIAL (Mg/m^3)	BULK DENSITY FINAL (Mg/m^3)	P_o EFFECTIVE OVERBURDEN PRESSURE (kPa)	P_c ESTIMATED PRECONSOLIDATION PRESSURE (kPa)	C_c	EFFECTIVE STRESS (kPa)	c_v (m^2/yr)	m_v (1/MPa)	k (m/s)
1B	0.13-0.25	CH	78	61	1.53	1.64	1	15	0.58	1.6			
											9.7E-01	6.7	2.0E-09
										3.2			
											1.6	6.8	3.3E-09
										Unloaded to 1.6 kPa			
										4			
											3.8	1.8	2.2E-09
										8			
											1.7	4.4	2.3E-09
										16			
											1.7	4.4	2.3E-09
										32			
											1.8	3.4	1.9E-09
										64			
											1.6	2.2	1.1E-09
										Incrementally unloaded to 1.1 kPa			

TABLE E-2 CONSOLIDATION TEST RESULTS, KOPANOAR I-44 (Cont'd)

241 P_o 240 P_c 242

SAMPLE NUMBER	DEPTH (metres)	USC	MOISTURE CONTENT INITIAL (%)	MOISTURE CONTENT FINAL (%)	BULK DENSITY INITIAL (Mg/m^3)	BULK DENSITY FINAL (Mg/m^3)	EFFECTIVE OVERBURDEN PRESSURE (kPa)	ESTIMATED PRECONSOLIDATION PRESSURE (kPa)	C_c	EFFECTIVE STRESS (kPa)	c_v (m^2/yr)	m_v (1/MPa)	k (m/s)
10A	5.55-5.67	CL	84	53	1.53	1.75	27	30	0.72	10			
											2.9	3.5	3.2E-09
										23			
											2.2	3.8	2.7E-09
										45			
											1.8	2.8	1.6E-09
										Unloaded to 23 kPa			
										46			
											5.1	4.6E-01	7.2E-10
										92			
											1.5	1.5	6.9E-10
										184			
											1.5	9.2E-01	4.3E-10
										386			
											3.0	3.3E-01	3.1E-10
										Incrementally unloaded to 10 kPa			

TABLE E-2 CONSOLIDATION TEST RESULTS, KOPANOAR I-44 (Cont'd)

SAMPLE NUMBER	DEPTH (metres)	USC	MOISTURE CONTENT INITIAL (%)	MOISTURE CONTENT FINAL (%)	BULK DENSITY INITIAL (Mg/m^3)	BULK DENSITY FINAL (Mg/m^3)	EFFECTIVE OVERBURDEN PRESSURE (kPa) P_o	ESTIMATED PRECONSOLIDATION PRESSURE (kPa) P_c	C_c	EFFECTIVE STRESS (kPa)	c_v (m^2/yr)	m_v (1/MPa)	k (m/s)
25A	24.00-24.15	ML	31	26	1.95	2.07	169	280	0.21	16			
											2.1E 01	4.2E-01	2.7E-09
										35			
											9.3	4.7E-01	1.4E-09
										73			
											2.8	4.0E-01	3.5E-10
										150			
											2.2	2.6E-01	2.1E-10
										300			
											2.5	1.6E-01	1.3E-10
										Unloaded to 150 kPa			
										300			
											1.7E 01	4.6E-02	2.4E-10
										570			
											3.4	9.7E-02	1.0E-10
										1000			
											3.5	6.6E-02	7.2E-11
										2000			
											3.4	4.2E-02	4.4E-11
										Unloaded incrementally to 16 kPa			

242

TABLE E-2 CONSOLIDATION TEST RESULTS, KOPANOAR I-44 (Cont'd)

SAMPLE NUMBER	DEPTH (metres)	USC	MOISTURE CONTENT INITIAL (%)	MOISTURE CONTENT FINAL (%)	BULK DENSITY INITIAL (Mg/m^3)	BULK DENSITY FINAL (Mg/m^3)	Po EFFECTIVE OVERBURDEN PRESSURE (kPa)	Pc ESTIMATED PRECONSOLIDATION PRESSURE (kPa)	C_c	EFFECTIVE STRESS (kPa)	c_v (m^2/yr)	m_v (1/MPa)	k (m/s)
32C	45.50-45.65	ML	26	22	2.00	2.14	363	175	0.19	16			
											2.6E 01	2.8E-01	2.2E-09
										24			
											4.3	7.2E-02	9.7E-11
										40			
											5.4E 01	2.7E-01	4.6E-09
										77			
											5.3	2.9E-01	4.8E-10
										154			
											1.5	2.4E-01	1.1E-10
										308			
											1.8	1.6E-01	8.8E-11
										615			
											2.3	9.2E-02	6.6E-11
										Unloaded to 307 kPa			
										615			
											1.6E 01	2.1E-02	1.0E-10
										1230			
											2.3	4.8E-02	3.5E-11
										2460			
											4.7	2.3E-02	3.4E-11
										3199			
											3.3	3.6E-02	3.6E-11
										Unloaded incrementally to 16 kPa			

TABLE E-2 CONSOLIDATION TEST RESULTS, KOPANOAR I-44 (Cont'd)

SAMPLE NUMBER	DEPTH (metres)	USC	MOISTURE CONTENT INITIAL (%)	MOISTURE CONTENT FINAL (%)	BULK DENSITY INITIAL (Mg/m^3)	BULK DENSITY FINAL (Mg/m^3)	P_o EFFECTIVE OVERBURDEN PRESSURE (kPa)	P_c ESTIMATED PRECONSOLIDATION PRESSURE (kPa)	C_c	EFFECTIVE STRESS (kPa)	c_v (m^2/yr)	m_v (1/MPa)	k (m/s)
40B	69.90-70.05	ML	23	20	2.01	2.21	584	1300	0.17	16	9.0E 01	2.2	6.1E-08
										32	5.5E 01	4.5E-01	7.6E-09
										62	7.9E 01	2.2E-01	5.4E-09
										124	7.3E 01	1.6E-01	3.6E-09
										248	7.6E 01	8.7E-02	2.0E-09
										495	6.7E 01	4.9E-02	1.0E-09
										990	8.4E 01	3.0E-02	8.0E-10
										Unloaded to 495 kPa			
										990	6.4E 01	4.9E-03	9.9E-11
										1980	9.7E 01	1.7E-02	5.3E-10
										3199	8.2E 01	1.9E-02	4.8E-10
										Unloaded incrementally to 16 kPa			

NOTE: 1. Sample was in frozen state prior to testing.
Initial bulk density reported is therefore frozen bulk density.

TABLE E-2 CONSOLIDATION TEST RESULTS, KOPANOAR I-44 (Cont'd)

SAMPLE NUMBER	DEPTH (metres)	USC	MOISTURE CONTENT INITIAL (%)	MOISTURE CONTENT FINAL (%)	BULK DENSITY INITIAL (Mg/m^3)	BULK DENSITY FINAL (Mg/m^3)	Po EFFECTIVE OVERBURDEN PRESSURE (kPa)	Pc ESTIMATED PRECONSOLIDATION PRESSURE (kPa)	C_c	EFFECTIVE STRESS (kPa)	c_v (m^2/yr)	m_v (1/MPa)	k (m/s)
52A	93.65-93.90	ML	31	28	1.87	2.07	798	1600	0.19	10			
											5.6E 01	3.3	5.7E-08
										20			
											1.6E 01	7.8E-01	4.0E-09
										43			
											2.9E 01	3.5E-01	3.2E-09
										85			
											6.1E 01	2.0E-01	3.8E-09
										170			
											5.7E 01	1.1E-01	1.9E-09
										339			
											9.3E 01	6.3E-02	1.8E-09
										678			
											6.5E 01	3.7E-02	7.5E-10
										1355			
											6.3E 01	2.4E-02	4.7E-10
										Unloaded to 678 kPa			
										1355			
											4.0E 01	8.2E-03	1.0E-10
										2710			
											6.0E 01	1.5E-02	2.7E-10
										3199			
											4.9E 01	1.7E-02	2.6E-10
										Unloaded incrementally to 10 kPa			

NOTE: 1. Sample was in frozen state prior to testing.
Initial bulk density reported is therefore frozen bulk density.

TABLE E-2 CONSOLIDATION TEST RESULTS, KOPANOAR I-44 (Cont'd)

SAMPLE NUMBER	DEPTH (metres)	USC	MOISTURE CONTENT INITIAL (%)	MOISTURE CONTENT FINAL (%)	BULK DENSITY INITIAL (Mg/m^3)	BULK DENSITY FINAL (Mg/m^3)	EFFECTIVE OVERBURDEN PRESSURE (kPa)	ESTIMATED PRECONSOLIDATION PRESSURE (kPa)	C_c	EFFECTIVE STRESS (kPa)	c_v (m^2/yr)	m_v (1/MPa)	k (m/s)
59A	106.30-106.70	ML	28	28	1.91	2.07	913	800	0.15	16			
											6.9E 01	7.1E-01	1.5E-08
										49			
											5.3E 01	1.6E-01	2.6E-09
										97			
											7.5E 01	9.7E-02	2.3E-09
										194			
											7.4E 01	6.2E-02	1.4E-09
										387			
											7.3E 01	4.3E-02	9.6E-10
										774			
											1.3E 02	2.9E-02	1.1E-09
										1550			
											6.8E 01	2.3E-02	4.9E-10
										3100			
											8.0E 01	1.5E-02	3.8E-10
										Unloaded to 1550 kPa			
										3199			
											2.7E 01	8.5E-03	7.1E-11
										Unloaded incrementally to 16 kPa			

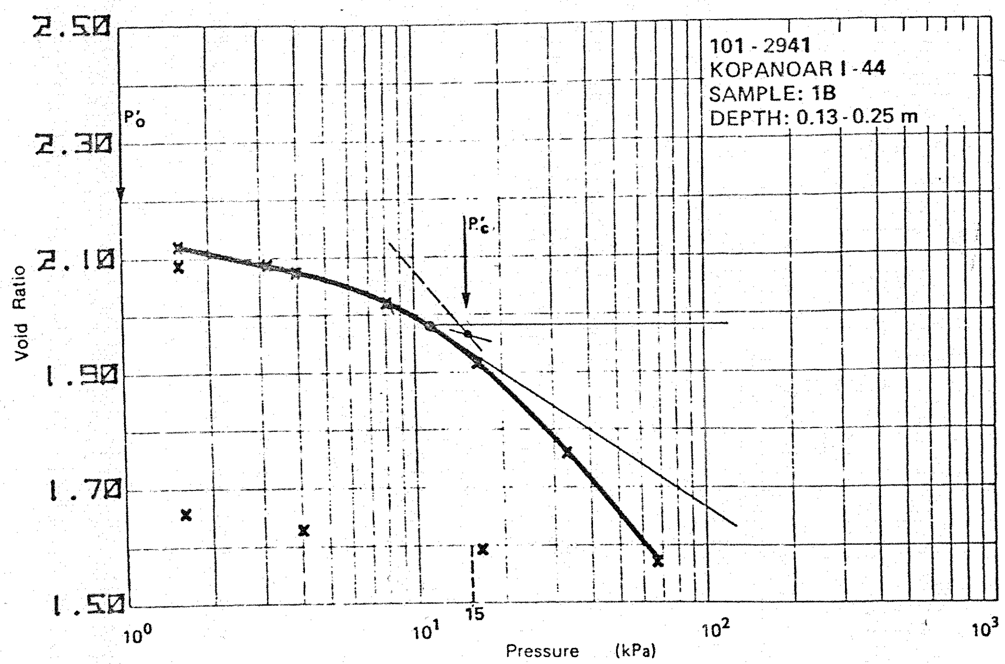
NOTE: 1. Sample was in frozen state prior to testing.
Initial bulk density reported is therefore frozen bulk density.

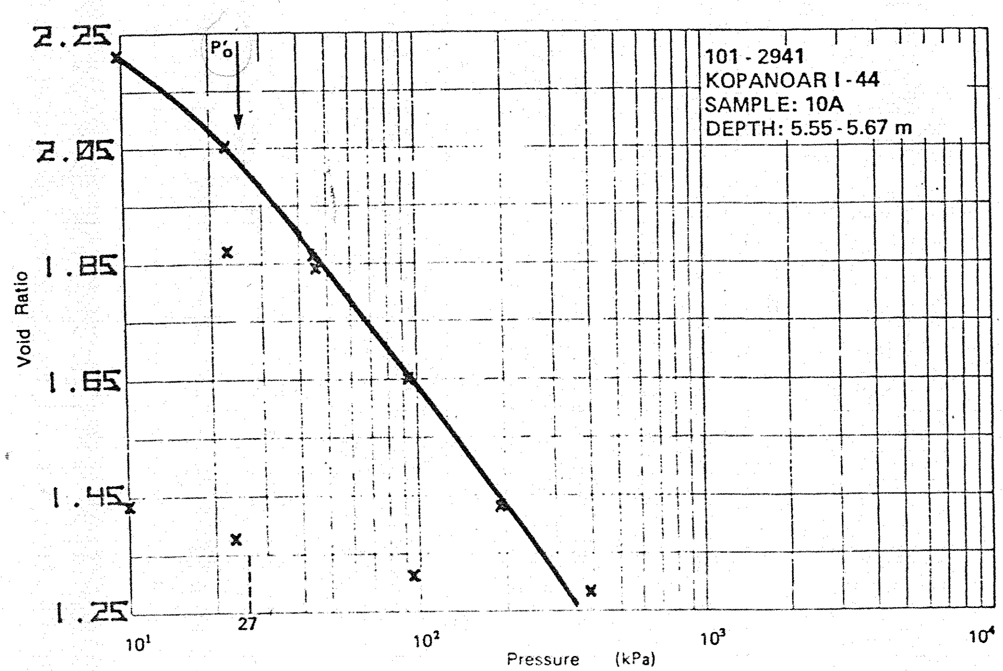
TABLE E-2 CONSOLIDATION TEST RESULTS, KOPANOAR I-44 (Cont'd)

SAMPLE NUMBER	DEPTH (metres)	USC	MOISTURE CONTENT INITIAL (%)	MOISTURE CONTENT FINAL (%)	BULK DENSITY INITIAL (Mg/m^3)	BULK DENSITY FINAL (Mg/m^3)	P_o EFFECTIVE OVERBURDEN PRESSURE (kPa)	P_c ESTIMATED PRECONSOLIDATION PRESSURE (kPa)	C_c	EFFECTIVE STRESS (kPa)	c_v (m^2/yr)	m_v (1/MPa)	k (m/s)
67B	121.75-121.85	ML	28	29	1.89	2.05	1051	1300	0.15	16			
											4.6E 01	6.3E-01	9.0E-09
										28			
											2.3E 01	1.0E-01	7.3E-10
										56			
											7.3E 01	1.3E-01	3.0E-09
										112			
											8.0E 01	4.3E-02	1.1E-09
										223			
											7.6E 01	3.5E-02	8.3E-10
										446			
											7.5E 01	2.3E-02	5.3E-10
										892			
											6.1E 01	1.7E-02	3.3E-10
										1785			
											5.4E 01	1.4E-02	2.4E-10
										Unloaded to 892 kPa			
										1785			
											4.2E 01	2.0E-03	2.6E-11
										3200			
											6.8E 01	1.5E-02	3.2E-10
										Incrementally unloaded to 16 kPa			

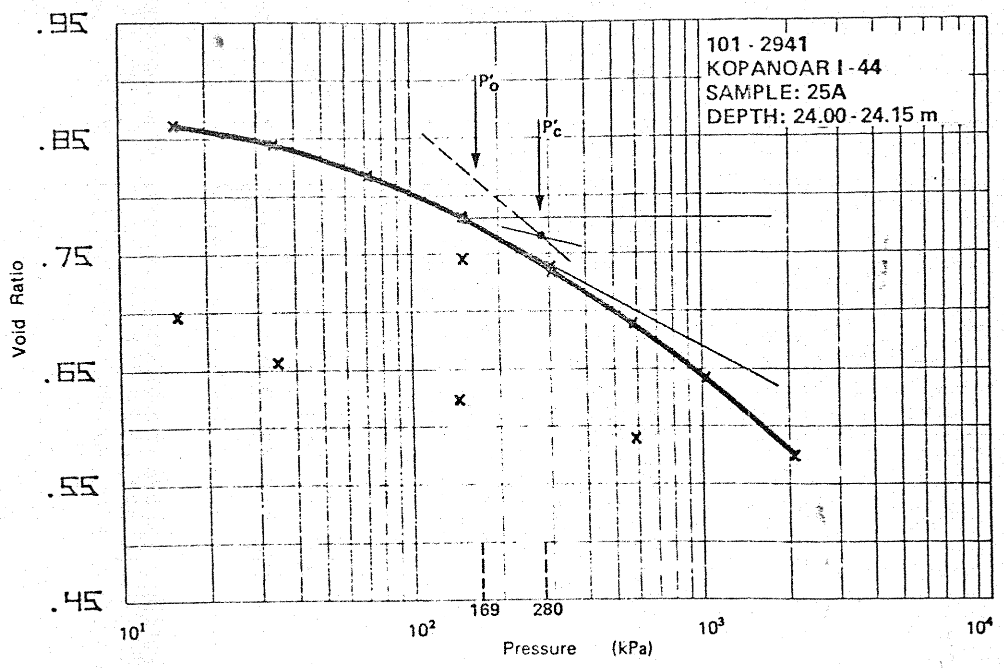
NOTE: 1. Sample was in frozen state prior to testing.
Initial bulk density reported is therefore frozen bulk density.

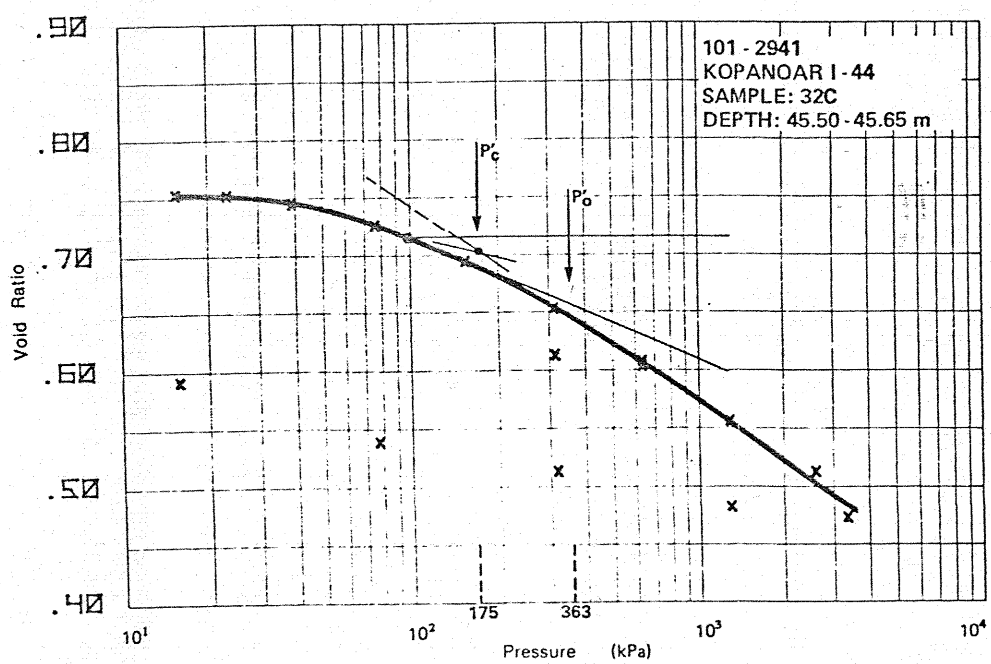
CONSOLIDATION TESTS





CONSOLIDATION TESTS





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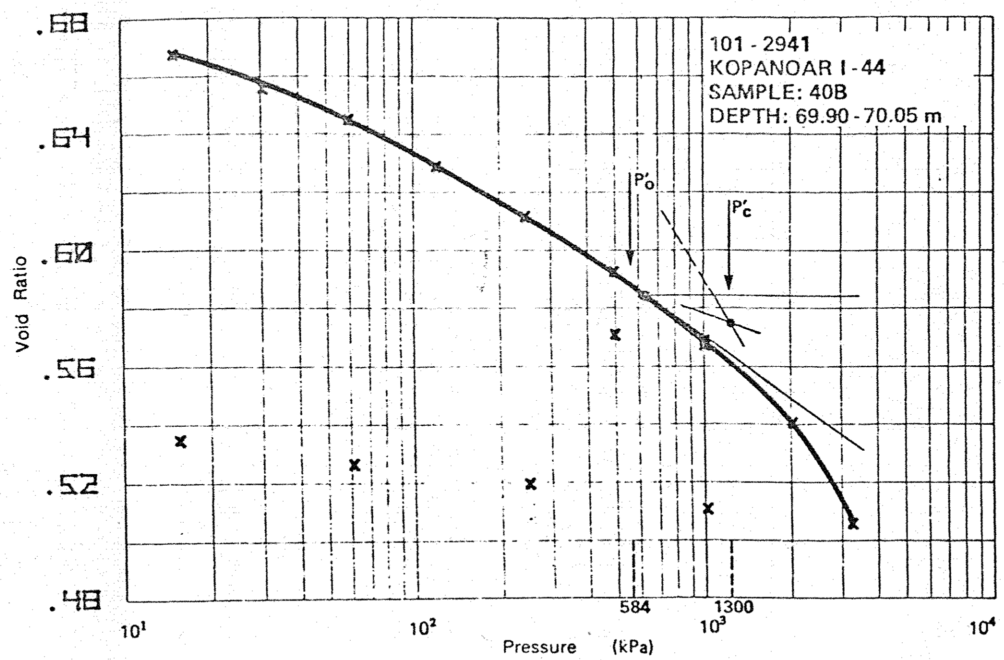
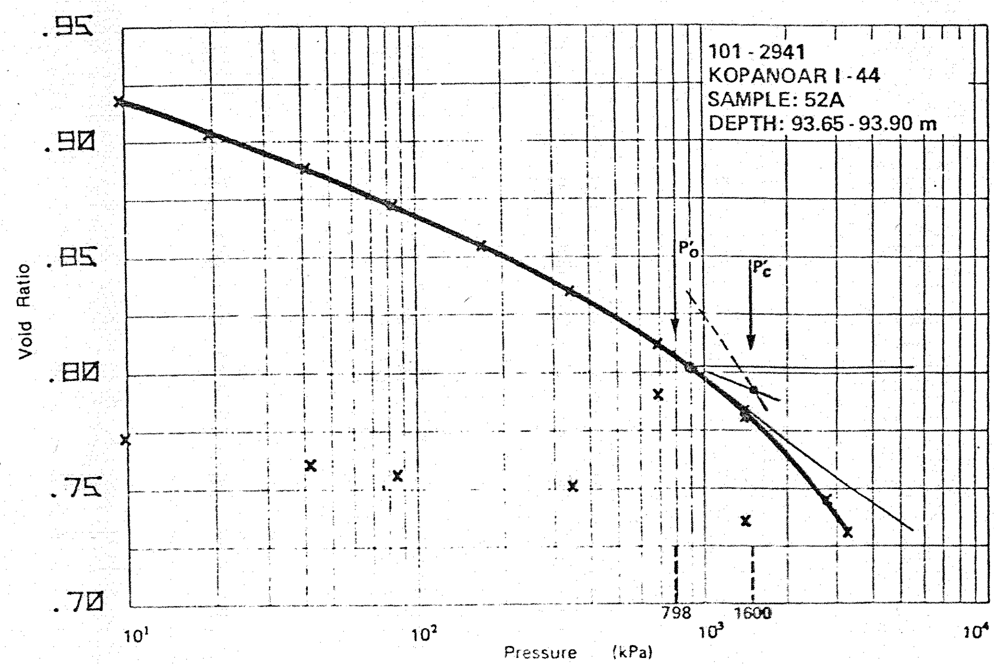
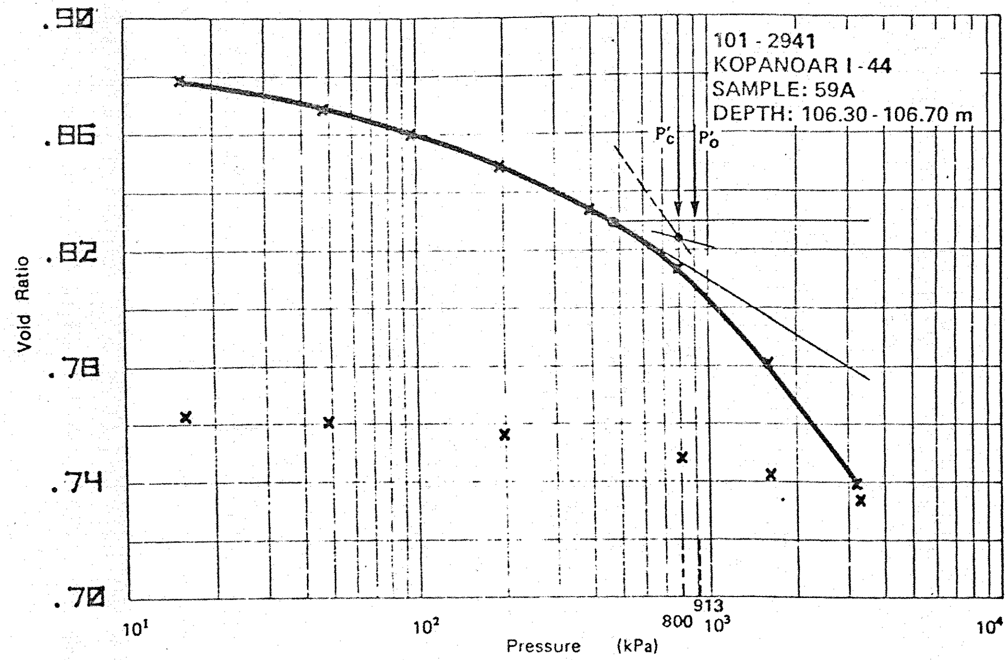




CONSOLIDATION TESTS



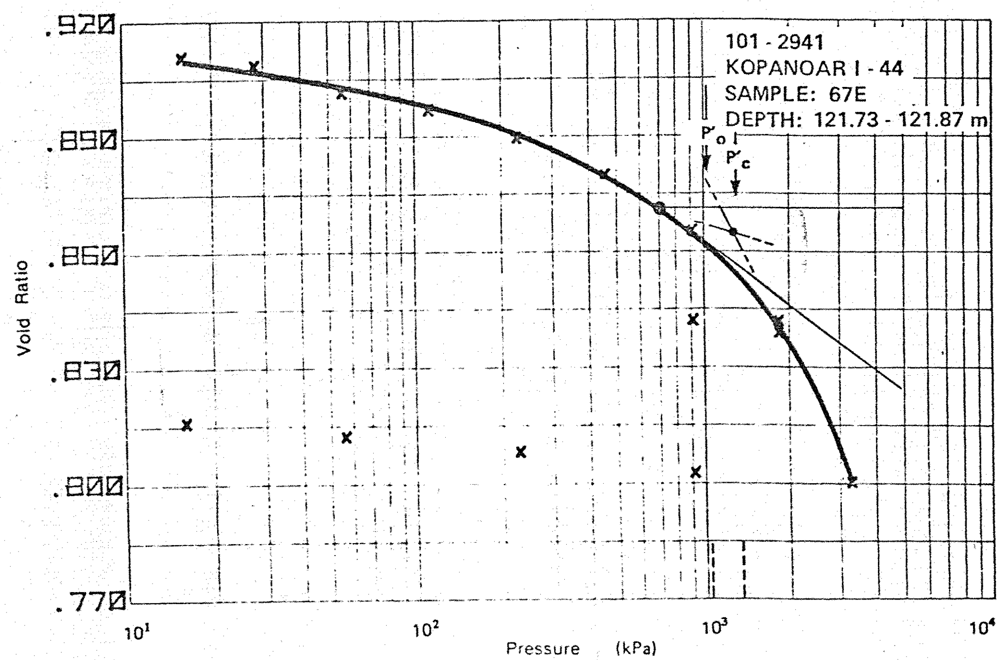


TABLE E-3 THAW SETTLEMENT OBSERVED IN CONSOLIDATION TESTS, KOPANOAR I-44

SAMPLE NUMBER	DEPTH (m)	USC	INITIAL MOISTURE CONTENT (%)	FROZEN BULK DENSITY (Mg/m^3)	STRESS (kPa)	VERTICAL STRAIN (%)	THAW PARAMETERS A_o (%)	a
40B	69.9 - 70.05		23	2.01	1	2.59		
					16	2.60	2.59	.00061
					32	2.61		
52A	93.65- 93.90		31	1.87	1	2.81		
					10	3.44	2.72	0.075
					20	4.24		
59A	106.3-106.7		28	1.91	16	1.20		
					49	1.74	0.85	0.015
					97	2.23		

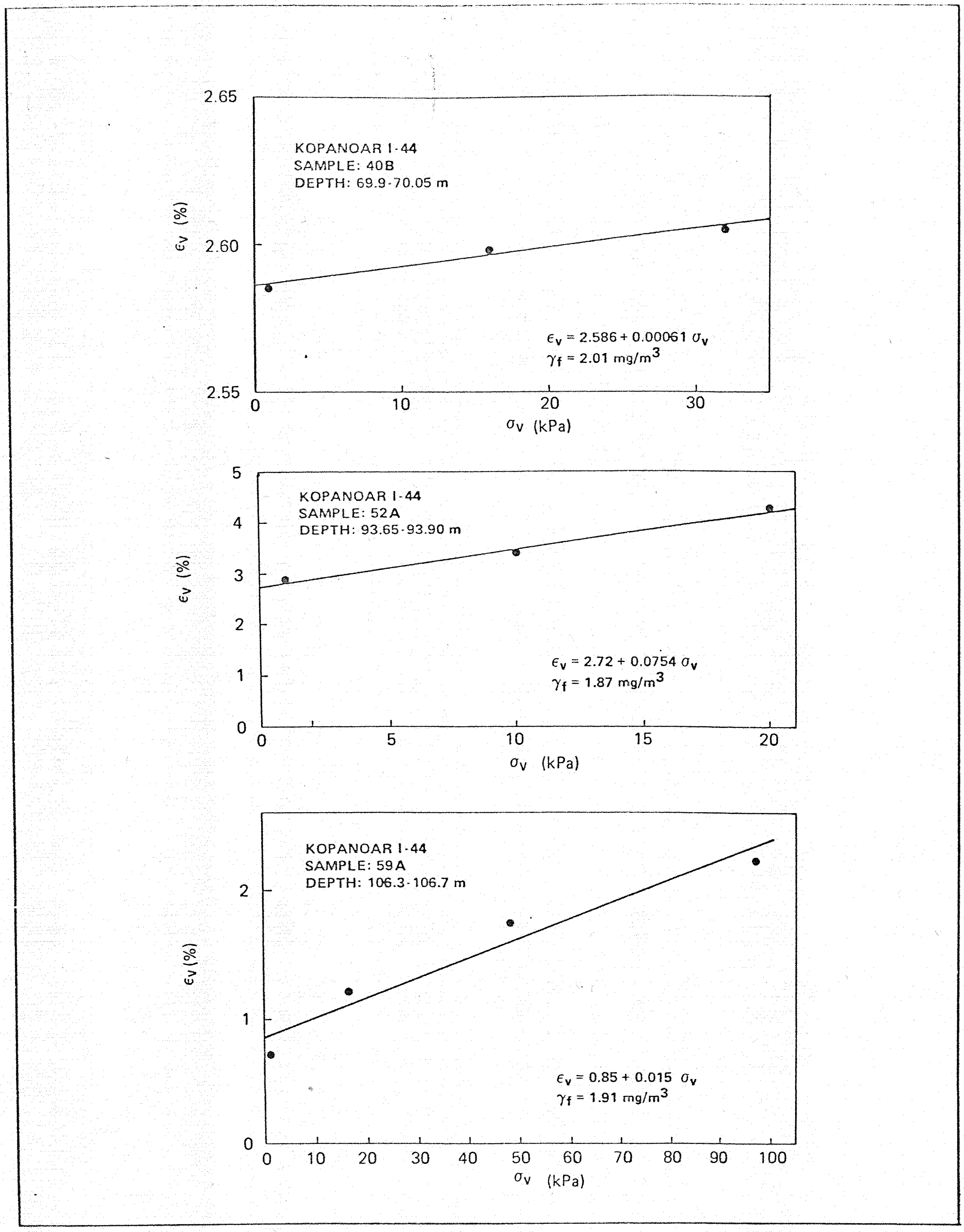


FIGURE E-1 THAW SETTLEMENT IN CONSOLIDATION TESTS, KOPANOAR I-44

APPENDIX F

SUBCONSULTANTS RESULTS (EBA)

APPENDIX F

TESTS PERFORMED BY SUBCONSULTANTS

General

Tests performed outside the confines of EBA's laboratory included x-ray diffraction analyses to determine clay mineralogy, and a broad geochemical investigation. These services were provided by subconsultants.

X-ray diffraction techniques were used to analyze a suite of 6 clay samples from the Kopanoar I-44 location. The purpose of this investigation was to determine clay mineralogies and to examine the mineralogies of fine silt-sized particles by performing diffraction analyses on two size fractions: the 0-2 micron fraction and the 2-10 micron fraction. This work was performed by Dr. Maurice B. Dusseault, P. Eng., who prepared a combined interpretative report on all the samples tested. He also returned the original clay smears on glass slides and the original x-ray diffraction analysis traces. Data from Dr. Dusseault's report have been excerpted, and are presented in Tables F.1A and F.1B. Table F.1A provides a description of each sample tested, and Table F.1B summarizes the clay mineralogies identified in both size fractions for each sample.

Geochemical analyses were performed by Carbon Systems Inc. (CSI) of Baton Rouge, Louisiana. Dr. Whelan of CSI prepared a separate interpretative report discussing the results from all of the 1980 borings. Results for the 14 samples taken at the Kopanoar I-44 location have been excerpted from that report, and are presented in this Appendix. Porewater salinities extracted from the CSI report were combined with salinity results from tests performed in EBA's laboratory. This combined data is presented elsewhere as a diagnostic profile (see Figure B.4, Appendix B).

APPENDIX F

SUBCONSULTANTS RESULTS

Appendix - Illustrations & Tables

APPENDIX F

X-RAY DIFFRACTION CLAY MINERALOGY
AND SAMPLE DESCRIPTIONS
(Results Only)

Report Submitted to EBA by Dr. M. Dusseault, P.Eng.

TABLE F.1A

SAMPLE DESCRIPTIONS

Hole	Sample	Depth Below Seabed (m)	Description
Kopanoar I-44	2B	0.70 - 0.85	Clay and Silt - trace organics - very wet - very soft - high plastic - olive grey - CH
	15C	8.65 - 8.80	Sand and Clay - some silt to silty - faintly laminated - black - olive green in colour - SM/SC
	25C	24.27 - 24.40	Silt - trace of clay and sand - clay laminae and lenses - stiff non-plastic - grey - ML
	33B	48.60 - 48.70	Silt - trace of clay and sand laminae - damp - stiff - low plastic to non-plastic - dark grey - ML
	44A	81.05 - 81.12	Silt - low plastic - clayey - trace of sand - trace organics - faint laminations - stiff - ML
	64C	113.8 - 113.9	Silt - some clay - traces of sand - traces of organics - sand laminations - dark grey - green - ML

TABLE F.1B

X-RAY DIFFRACTION CLAY MINERALOGY

Hole	Sample	Depth Below Seabed (m)	Clay Mineralogy 0-2μm Fraction	Clay Mineralogy 2-10μm Fraction
Kopanoar I-44	2B	0.70 - 0.85	M - trace I - 65% K - 30% C - 5% Quartz	M - trace I - 65% K - 30% C - 5% Quartz (Dom) Feldspar Dolomite
	15C	8.65 - 8.80	M - 5% I - 60% K - 30% C - 5% Quartz Calcite (trace)	I - 70% K - 25% C - 5% Quartz (Dom) Feldspar Dolomite (trace)
	25C	24.27 - 24.40	M - 5% I - 60% K - 30% C - 5% ML - trace Quartz Calcite (trace)	I - 60% K - 30% C - 10% Quartz (Dom) Calcite (strong) Dolomite (strong) Feldspar (medium)
	33B	48.60 - 48.70	M - trace I - 60% K - 35% C - 5% Quartz Calcite (trace) Dolomite(trace) Feldspar(trace)	I - trace (?) I - 60% K - 30% C - 10% Quartz (Dom) Calcite (strong) Dolomite (strong) Feldspar
	44A	81.0 - 81.12	M - 5% I - 60% K - 30% C - 5% Quartz Calcite (trace)	M - trace (?) I - 60% K - 35% C - 5% Quartz (Dom) Calcite Dolomite Feldspar
	64C	113.8 - 113.9	M - 5% I - 60% K - 30% C - 5% Quartz Feldspar(trace) Calcite (trace)	M - trace I - 60% K - 35% C - 5% Quartz (strong) Calcite (Dom) Feldspar (strong)

TABLE G-1 SUMMARY OF PHOTOGRAPHS FROM CORES AND RADIOGRAPHS, KOPANOAR I-44 (Cont'd)

SAMPLE NO.	SAMPLE TYPE	DEPTH (m)	USC	CORE PHOTOS (No. of Prints)	RADIOGRAPHS (No. of Prints)	SHEAR TESTING
31C	-	42.5 - 42.65	CL	1		
32B	V	45.35 - 45.50	CL/ML	1		
32C	W	45.5 - 45.65	ML		2	
34B	W	51.6 - 51.75	ML	1	2	UU
35C	W	54.53 - 54.66	ML			
36A	B	57.55 - 57.70	ML	1		
37B	B	60.60 - 60.75	ML	1		
38A	W	63.68 - 63.8	ML/CL	1	2	UU
39C	B	66.65 - 66.80	ML	1		
40B	PF	69.9 - 70.5	ML		2	
41A	B	72.75 - 72.90	ML	1		
41B	PF	72.9 - 73.10	CL	2	3	UU
43A	PF	79.05 - 79.15	CL	1	2	UU
44A	B	81.00 - 81.12	CL	1		
44B	PF	81.25 - 81.4	CL	2	3	CU
44D	PF	81.55 - 81.7	CL/ML	2	3	CU
46C	B	84.95 - 85.10	ML	1		
46B	PF	85.1 - 85.25	ML	2	3	UU
47B	B	87.47 - 87.60	ML	1		
47A	PF	87.6 - 87.8	ML	1	2	CU
49A	PF	89.15 - 89.3	ML	2	2	CU
50B	G	90.6 - 90.7	ML	1		
51D	B	92.00 - 92.15	ML	1		
51B	PF	92.15 - 92.3	ML		2	
52B	B	93.40 - 93.65	ML	1		
52A	PF	93.65 - 93.9	ML	2	3	UU
53A	PF	95.2 - 95.55	ML	2	3	UU
53B	PF	95.0 - 95.20	ML		2	
54B	PF	96.6 - 96.9	ML		4	
55B	PF	97.3 - 97.5	ML		2	
56B	PF	98.85 - 99.05	ML	2	2	UU
57A	PF	100.15 -100.6	ML		2	
58B	B	104.2 -104.35	ML	1		
58A	PF	104.35 -104.55	ML		2	
59B	B	106.1 -106.3	ML	1		
59A	PF	106.3 -106.7	ML	2	5	UU
61B	PF	110.25 -110.50	ML		2	
61A	B	110.5 -110.65	ML	1		
63A	B	112.65 -112.80	CL/ML	1		
64B	PF	113.9 -114.1	ML	2	3	UU
64A	PF	114.1 -114.3	ML		2	
65A	PF	115.6 -115.8	ML	2	4	UU
67C	B	121.55 -121.75	ML	1		
67B	PF	121.5 -121.85	ML		2	

TABLE G-1 SUMMARY OF PHOTOGRAPHS FROM CORES AND RADIOGRAPHS, KOPANOAR I-44 (Cont'd)

SAMPLE NO.	SAMPLE TYPE	DEPTH (m)	USC	CORE PHOTOS (No. of Prints)	RADIOGRAPHS (No. of Prints)	SHEAR TESTING
CANMAR		3.10 - 3.15	MH	1		
1A (CPT)	L	3.15 - 3.30	MH	2		
1B (CPT)	L	3.30 - 3.45	CH	2		
1C (CPT)	L	3.45 - 3.60	CH	2		
2B (CPT)	G	21.5 - 21.7	CH	1		
3A (CPT)	PF	30.50 - 30.69	SM		2	CU

Note:

1. UU - Unconsolidated-Undrained Triaxial Test
   CU - Consolidated-Undrained Triaxial Test

2. All photos have been included in Volume 7D

APPENDIX H

METHODS FOR PREDICTING PILE CAPACITIES (FUGRO)

APPENDIX H

METHOD FOR PREDICTING PILE CAPACITIES

CONTENTS

ILLUSTRATIONS

METHOD FOR PREDICTING PILE CAPACITIES

Fugro predicted the ultimate axial capacity of piles using the static method of analysis. In this method, the ultimate compressive capacity, Q, for a given penetration is taken as the sum of the skin frictional capacity, Q_s, and the end bearing capacity, Q_p, so that:

$$Q = Q_s + Q_p = fA_s + qA_p$$

A_s and A_p represent the embedded pile surface area and the pile tip area, respectively; f and q represent the unit skin friction and the unit end bearing, respectively. The second term of this equation is neglected when computing ultimate tensile capacity.

Cohesive Soils

CPT Method. Unit skin friction, f, in cohesive soils is computed from the expression:

$$f = \alpha s_u$$

where α = empirical adhesion factor and

s_u = undrained cohesive shear strength.

Data developed from our experience in the North Sea indicate that the empirical adhesion factor is equal to 1.0 for normally consolidated clays and 0.5 for overconsolidated clays. We used an adhesion factor of 1.0 for the normally consolidated to slightly overconsolidated clays and silty clays.

Lambda Method. In cohesive soils, the frictional capacity, Q_s, at a particular penetration is related to both effective vertical stress and undrained shear strength by a factor λ as follows:

$$Q_s = \lambda (\bar{\sigma}_m + 2s_{um}) A_s$$

where λ = dimensionless coefficient (function of pile penetration),

$\bar{\sigma}_m$ = mean effective vertical stress between the ground surface and the pile tip,

s_{um} = mean undrained cohesive shear strength along the pile length, and

A_s = surface area of the pile.

Values of s_{um} and $\bar{\sigma}_m$ for various penetrations in the clay strata are computed from the undrained shear strength and submerged unit weight values. Values of λ are obtained from Fig. 1 of the paper presenting this procedure.(1)

API RP 2A, 1980 Method. According to the API RP 2A, 1980 Method(2), the unit skin friction, f, in clay at any particular depth is a function of the undrained shear strength, s_u, of the clay.

The unit skin friction, f, shall be equal to the undrained shear strength s_u, for s_u less than or equal to 1/4 ton per square foot. For s_u in excess of 1/4 ton per square foot but less than or equal to 3/4 ton per square foot, the ratio f to s_u shall decrease linearly from unity at s_u equal to 1/4 ton per square foot to 1/2 at s_u equal to 3/4 ton per

(1) Vijayvergiya, V.N. and Focht, J.A., Jr. (1972), "A New Way to Predict Capacity of Piles in Clay," Proceedings, Fourth Offshore Technology Conference, Houston, Vol. 2, pp. 865-874.

(2) American Petroleum Institute (1980), Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms, API RP 2A, 11th Edition.

square foot. For s_u in excess of 3/4 ton per square foot, f shall be taken as 1/2 of s_u.

Grouted Conductor. Unit skin friction, f, in cohesive soils is computed from the expression:

$$f = \alpha s_u$$

where α = empirical adhesion factor and

s_u = undrained cohesive shear strength.

Empirical adhesion factors recommended by Kraft(3) vary from 0.3 to 1.0 depending upon the consolidation history of the soil. We recommend an adhesion factor equal to 0.5 for the slightly overconsolidated soil conditions at this location.

Unit End Bearing. For CPT, API and Lambda Methods, the unit end bearing in clay is computed using the expression:

$$q = s_u N_c$$

where s_u = undrained shear strength and

N_c = a dimensionless bearing capacity factor (N_c = 9 for deep footings).

Unit end bearing was not computed for grouted conductors in cohesive soils.

Granular Soils

CPT Method. Unit skin friction, f, in granular soils is determined

(3) Kraft, L. M. and Lyons, C. G., (1974), "State-of-the-Art: Ultimate Axial Capacity of Grouted Piles." Proceedings, Sixth Annual Offshore Technology Conference, Houston, 1974, Vol. 2, pp. 485-503.

from the expression:

$$f = \beta q_c$$

where β = empirical coefficient and

q_c = cone resistance

Data from load tests on piles driven in sand both onshore and offshore indicate the empirical coefficient, β, is equal to 1/300 for compression and 1/400 for tension (4). Cone resistance is taken from the WISON cone penetrometer soundings.

API and Lambda Methods. The frictional capacity developed in granular soils is determined using the following equation:

$$f = K \bar{\sigma}_v \tan \delta$$

where K = coefficient of lateral earth pressure,

$\bar{\sigma}_v$ = effective vertical stress, and

δ = angle of friction between foundation soil and pile.

The value of K is taken as 0.7 for compressive loads. Effective vertical stress is computed from the submerged unit weight values.

Grouted Conductor. Unit skin friction in granular soils is determined using the same equation presented above for the API Method. This procedure is recommended by Kraft(3).

Unit End Bearing. Unit end bearing, q, in granular soils for the CPT Method is a function of the cone resistance, pile penetration, and pile diameter. The procedure used to compute unit end bearing at this site is illustrated on Plate H-1 (4). Computed unit end bearing (from

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(4) te Kamp, W. G. B., (1977) Second Fugro-Cesco CPT Symposium.

Plate H-1) is corrected, if necessary, to account for degree of overconsolidation (OCR) and grain size according to Plate H-2 [4]. For the granular soils encountered at this location, OCR is assumed equal to 1.0; therefore, computed unit end bearing was not corrected.

For API and Lambda Methods, unit end bearing, q, for piles installed in granular soils is computed using the following equation:

$$q = \bar{\sigma}_v N_q$$

where $\bar{\sigma}_v$ = effective vertical stress, and

N_q = a dimensionless bearing capacity factor which is a function of ϕ, the angle of internal friction of the soil.

Unit end bearing was not computed for grouted conductors in granular soils.

Limiting Values

CPT Method. Unit skin friction in granular soils is limited to the measured sleeve friction, f_s, taken at the given depth from the Wison cone penetrometer soundings, up to 1.20 tsf (0.115 MPa). In other words, the design skin friction is the lower of the computed skin friction, βq_c, the measured sleeve friction, f_s, or 1.20 tsf (0.115 MPa).

Unit end bearing of piles in granular soils depends on such factors as density, internal friction, and grain crushing strength. Data from pile load tests in granular soil [4] [5] indicate maximum unit end bearing is equal to 150 tsf (14.4 MPa).

API and Lambda Methods. The computed values of f and q for

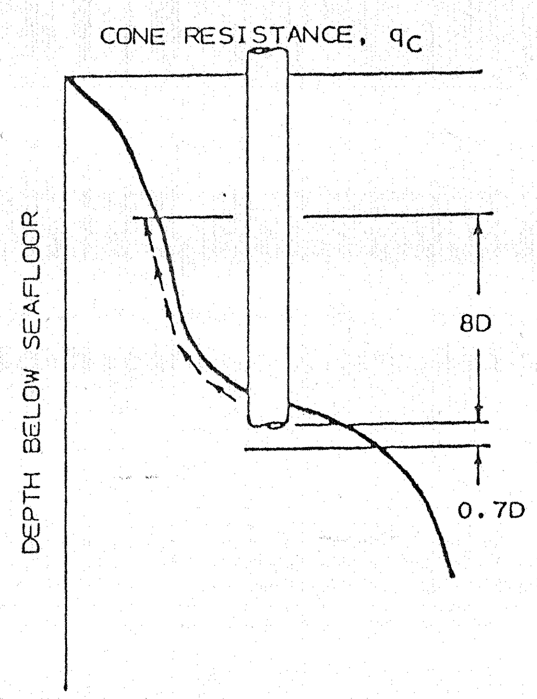
(5) de Ruiter, J., and Beringen F.L. (1979), "Pile Foundations for Large North Sea Structures," Marine Geotechnology, Vol. 3.

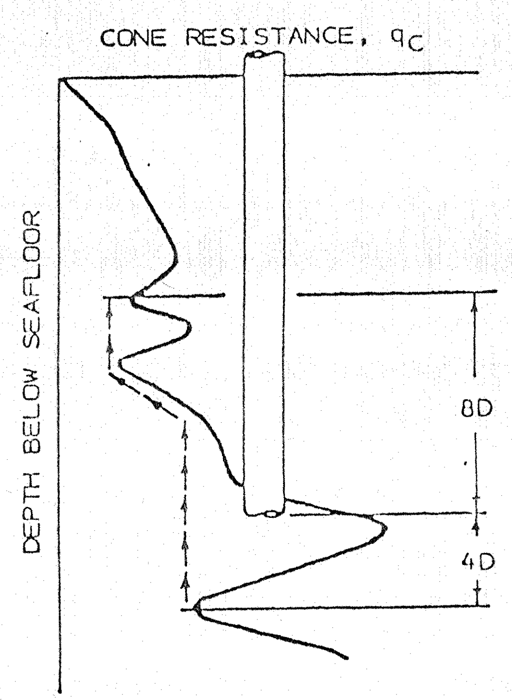
granular soils are not allowed to exceed certain values given in the table below. These values are based on our experience and data presented elsewhere(6).

Soil Type	$\bar{\phi}$	δ	f_{max} (tsf)	N_q	q_{max} (tsf)
Sand	35°	30°	1.0	40	100
Silty Sand	30°	25°	0.85	20	50
Sandy Silt	25°	20°	0.70	12	30
Silt and Clayey Silt	20°	15°	0.50	8	20

Grouted Conductor. The computed values of unit skin friction in cohesive soils are limited to a value of 1.5 tsf (144 KPa) based upon Kraft's(3) recommendations. Maximum unit skin friction in granular soils follows the values tabulated above.

(6) American Petroleum Institute (1969), Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms, API RP 2A, First Edition.



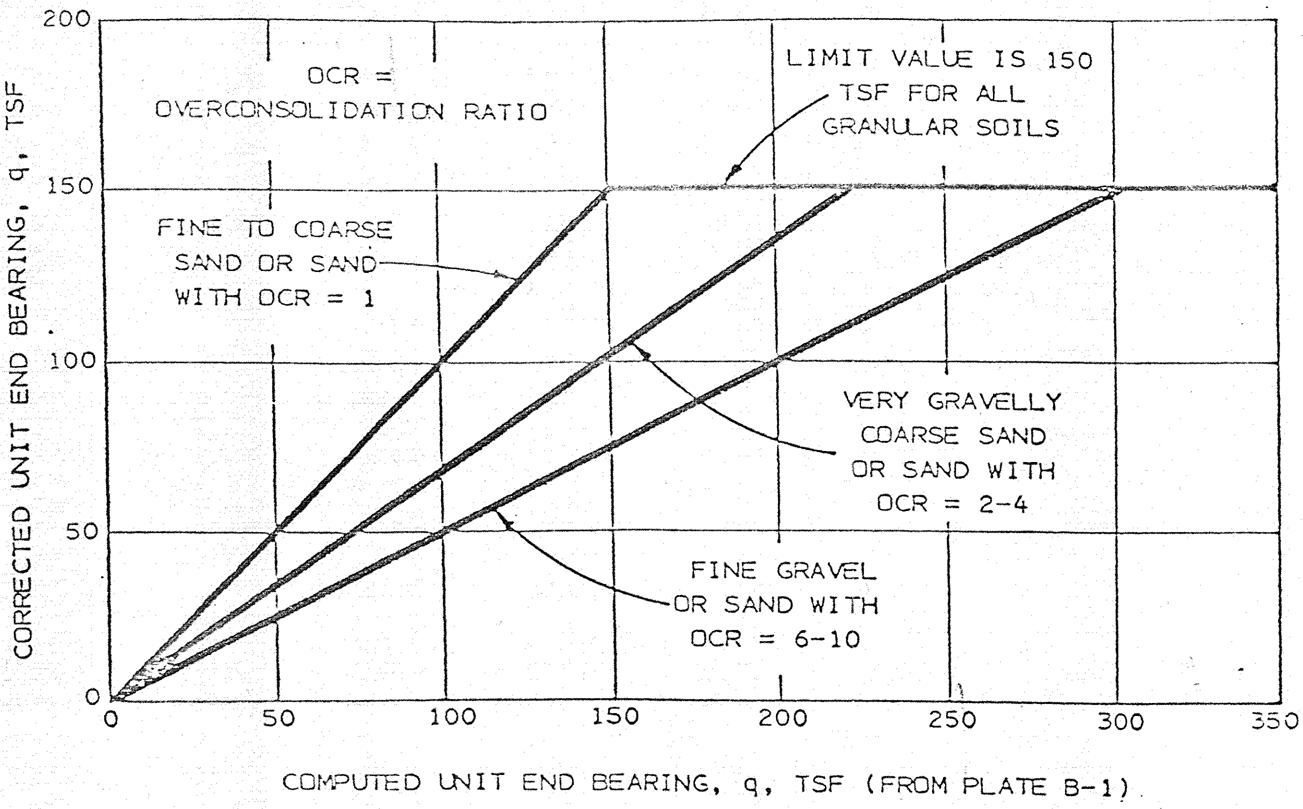


$$q = \frac{(I + II)/2 + III}{2}$$

KEY

- q = ULTIMATE UNIT END BEARING OF THE PILE.
- D = DIAMETER OF THE PILE.
- I = AVERAGE CONE RESISTANCE BELOW THE TIP OF THE PILE OVER A DEPTH WHICH MAY VARY BETWEEN 0.7D TO 4D.
- II = MINIMUM CONE RESISTANCE RECORDED BELOW THE PILE TIP OVER THE SAME DEPTH OF 0.7D TO 4D.
- III = AVERAGE OF THE ENVELOPE OF MINIMUM CONE RESISTANCES RECORDED ABOVE THE PILE TIP OVER A HEIGHT WHICH MAY VARY BETWEEN 6D AND 8D. IN DETERMINING THIS ENVELOPE, VALUES ABOVE THE MINIMUM VALUE SELECTED UNDER II ARE TO BE DISREGARDED.

DETERMINATION OF UNIT END BEARING IN GRANULAR SOILS
CPT METHOD
AFTER TE KAMP, 1977



LIMITING UNIT END BEARING IN GRANULAR SOILS
CPT METHOD
(AFTER TE KAMP, 1977)

APPENDIX I

IN SITU TEST INTERPRETATION AND RESULTS (FUGRO)

APPENDIX I

IN SITU TEST INTERPRETATION AND RESULTS

CONTENTS

ILLUSTRATIONS

IN SITU TEST INTERPRETATION AND RESULTS

WISON Cone Penetrometer Test Interpretation

WISON cone penetrometer test (CPT) results are presented on Plates I-1 and I-2 as curves of cone resistance, q_c, and sleeve friction, f_s, versus depth below seafloor. Interpretation of this data provides estimates of soil type and cohesive soil shear strength or granular soil density. Shear strength and density data from CPT results are combined with field and laboratory soil test results to obtain the best estimate of soil parameters needed to compute unit skin friction, f, and unit end bearing, q, for pile design analyses.

The ratio of sleeve friction, f_s, to cone resistance, q_c, is termed the friction ratio, F_R, and has generally been correlated with unfrozen soil types (1), as shown in Plate I-3. Friction ratio can be used to identify unfrozen soil type at depths where no samples have been taken.

In cohesive soils, in situ undrained shear strength can be estimated from the equation:

$$s_u = \frac{q_c - \bar{\sigma}}{N_k}$$

where s_u = undrained cohesive shear strength,

q_c = cone resistance,

$\bar{\sigma}$ = effective vertical stress, and

N_k = cone factor.

Values of N_k are normally based on undrained shear strengths determined

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(1) te Kamp, W.G.B., Fugro In House Seminar, February 13, 1975.

from triaxial compression test results on soils recovered from the borehole. N_k values used in this analysis are shown on Plates I-1 and I-2.

We estimated in situ relative density of unfrozen granular soils using the following:

Density	Cone Resistance, q_c, kgf/cm2	Relative Density, Percent
Loose	less than 40	0 to 40
Medium Dense	40 to 120	40 to 70
Dense	120 to 200	70 to 90
Very Dense	greater than 200	90 to 100

These values are based on Fugro's experience with CPT's in sand both onshore and offshore. Schmertmann (2) presented a correlation of q_c, relative density, and vertical effective stress for specific granular soil conditions. Schmertmann's correlation is illustrated on Plate I-4 for comparison purposes only.

WISON Temperature Probe

In situ temperature measurements made in the borehole are presented on Plates I-1 and I-2 and also on Plates 2, 3, and 6 in the report. We measured temperatures using our specially designed temperature sensitive cone. This cone replaces the normal cone and measures cone tip resistance, q_c, and in situ temperature along the sleeve. Sleeve friction is not measured while using the temperature cone. Measured temperatures normally stabilized between 8 and 33 minutes after completion of the cone sounding.

We checked the temperature sensitive cone against a mercury thermometer before and after each test conducted in the field. In addition,

(2) Schmertmann, John H., (1977) "Guidelines for Cone Penetration Test Performance and Design", U. S. Department of Transportation, FHWA-75-78-209.

the mercury thermometer was checked by a calibration company at the completion of the field work; calibration results are presented on Plate I-5. Temperature measurements presented in this report have been corrected.

In Situ Vane Test Interpretation

The C-Floor 9, a remotely operated, seabed supported, in situ testing unit, was used to perform five in situ vane tests from 2.6 to 10 feet (0.8 to 3.0m) penetration below the seafloor. A description of the field operation of this unit was presented in our draft field report dated October 30, 1980. In the vane test, the torque, T, required to shear the soil is measured and soil shear strength is computed using the following equation for the rectangular blade (3):

$$s_u = T \frac{0.023}{(D^2H/2) \times [1 + (D/3H)]} = 0.00073\ T$$

where s_u = undrained shear strength, tsf,

T = measured torque, in-lb,

D = width or diameter of vane blade, 3 inches, and

H = measured height of vane blade, 6 inches.

In situ vane test results are plotted in the strength graph on the boring log, Plate 2.

(3) American Society for Testing and Material (1979), "Standard Method for Field Vane Shear Test in Cohesive Soil," ASTM D2573-72, Part 19, pp. 386-394.

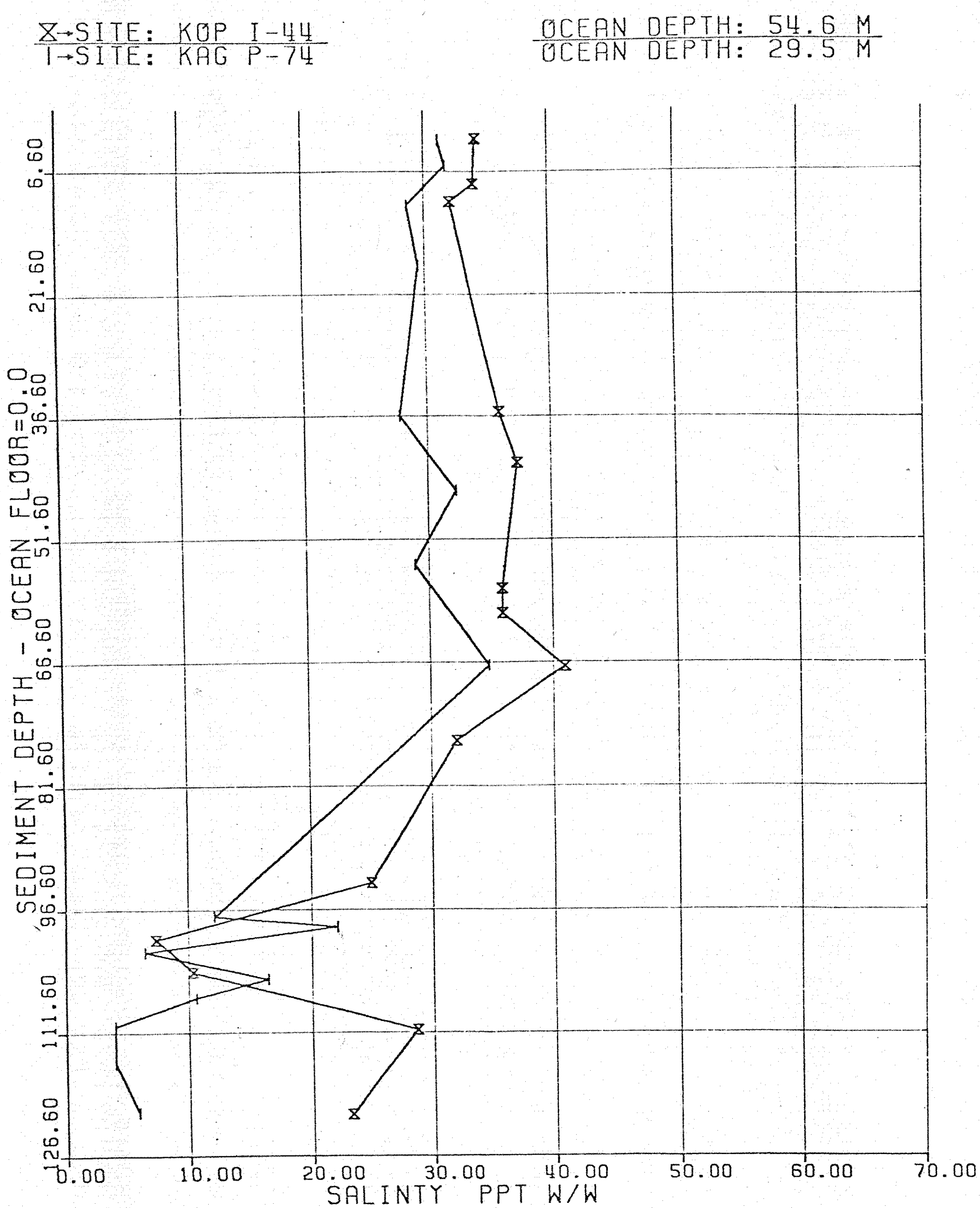
TABLE B-1 SUMMARY OF ATTERBERG LIMIT TESTING, KOPANOAR I-44

SAMPLE NUMBER	DEPTH INTERVAL (m)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	USC	LIQUIDITY INDEX
1C	0.25 - 0.30	73	55	27	28	CH	1.6
2B	0.70 - 0.85	--	64	32	32	CH	---
3A	1.59 - 1.63	87	66	30	36	CH	1.6
4A	2.15 - 2.28	78	56	31	25	MH	1.9
5D	2.87 - 3.00	85	64	32	32	MH	1.7
6D	3.48 - 3.60	87	64	31	33	CH	1.7
7D	4.07 - 4.20	63	53	23	30	CH	1.3
8A	4.65 - 4.80	78	63	28	35	CH	1.4
9A	5.25 - 5.32	81	53	31	28	CH	1.8
10C	5.80 - 5.93	48	51	27	24	CH	0.9
12A	6.90 - 7.00	50	45	19	26	CL	1.2
13B	7.57 - 7.70	37	32	17	15	CL	1.3
15A	8.60 - 8.65	38	27	13	14	CL	1.8
22A	17.70 - 17.85	22	29	18	11	CL	0.4
23B	18.05 - 18.15	26	25	15	10	CL	1.1
24A	20.95 - 21.15	29	nonplastic			ML	
24B	21.15 - 21.25	27	32	20	12	CL	0.6
25B	24.15 - 24.27	25	29	16	13	CL	0.7
26C	27.15 - 27.30	24	30	15	15	CL	0.6
27A	30.10 - 30.25	25	30	16	14	CL	0.6
28A	33.25 - 33.45	22	23	19	4	CL-ML	0.8
29C	36.25 - 36.40	23	26	15	11	CL	0.7
32A	45.20 - 45.35	24	24	21	3	CL-ML	1.0
35C	54.53 - 54.66	--	22	14	8	CL	---
36A	57.55 - 57.70	--	25	21	4	CL-ML	---
37B	60.60 - 60.75	--	31	18	13	CL	---
38A	63.68 - 63.80	23	28	17	11	CL	0.5
39C	66.65 - 66.80	21	23	16	7	CL-ML	0.7
43B	79.15 - 79.25	22	25	17	8	CL	0.6
45C	84.55 - 84.70	28	nonplastic			ML	
51A	92.30 - 92.35	26	21	18	3	ML	2.7
58B	104.20 - 104.35	28	nonplastic			ML	
59B	106.10 - 106.30	21	24	15	9	CL	0.7
63A	112.65 - 112.80	22	23	17	6	CL-ML	0.8
67C	121.55 - 121.75	27	nonplastic			ML	
1A(CPT)	3.15 - 3.30	92	64	33	31	MH	1.9
1B(CPT)	3.30 - 3.45	86	68	29	39	CH	1.5
1C(CPT)	3.45 - 3.60	81	64	14	50	CH	1.3
1F(CPT)	3.90 - 4.00	85	62	28	34	CH	1.7

APPENDIX F

GEOCHEMICAL AND GAS ANALYSES
(Results Only)

Report Submitted to EBA by Carbon Systems, Inc.



NOTE: 1. Salinity variation reflect seasonal pattern in river discharge or large sea level changes.
2. The lowest salinities occur near 100 m penetration.

FIGURE F-1 SALINITY PROFILE

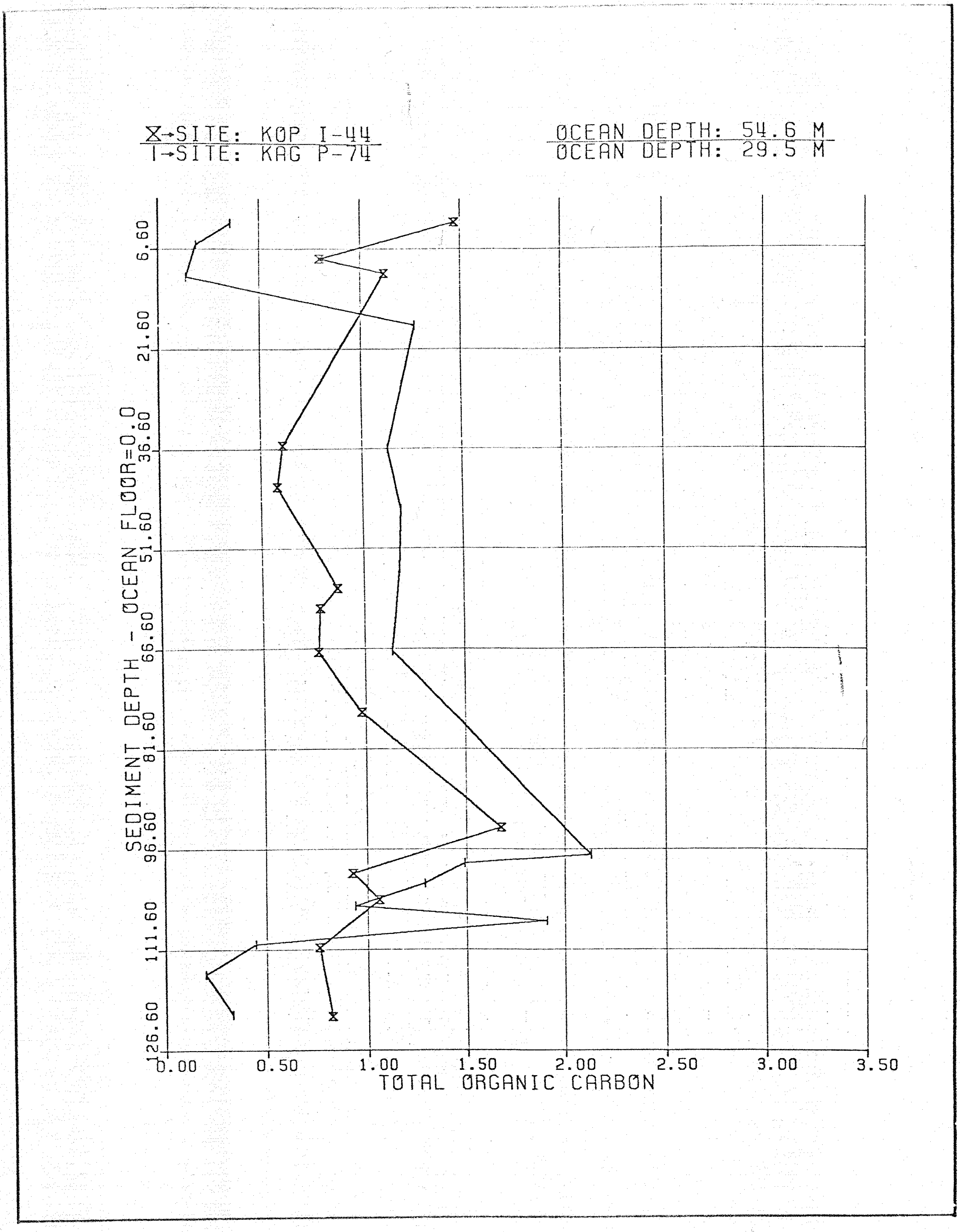


FIGURE F-2 DEPTH PROFILE FOR TOTAL ORGANIC CARBON

TABLE F.2 PORE WATER AND SEDIMENT PROPERTIES

SITE: KOP I-44

OCEAN DEPTH (M): 54.60

DEPTH METER.	WATER CONT. WT. PERCENT	SALINITY PPT W/W	OBS. SULFATE PPT W/W	CONDUCTIVITY MICRO-MHO	PH	TOTAL ORG. C WT. PERCENT	DIOC MIL-MOL/L
2.60	80.00	34.19	2.50	49700.00	7.57	1.47	2.50
8.10	30.00	33.99	0.78	47700.00	7.70	0.80	4.25
10.30	28.00	32.04	0.31	44200.00	7.87	1.12	4.53
36.10	22.00	35.84	0.45	50000.00	7.69	0.61	4.41
42.30	21.00	37.23	0.27	51000.00	7.76	0.58	4.81
57.60	21.00	35.94	0.06	51900.00	7.55	0.87	4.38
60.60	21.00	35.94	0.14	49300.00	7.58	0.78	5.04
67.10	21.00	40.91	0.05	55100.00	7.71	0.77	4.68
76.10	25.00	32.04	0.26	45000.00	7.69	0.98	5.08
93.40	22.00	24.91	0.06	36800.00	7.77	1.68	4.49
100.20	22.00	7.38	0.23	12400.00	7.92	0.93	4.11
104.20	22.00	10.42	0.55	17000.00	7.84	1.06	4.52
111.30	20.00	28.57	0.18	41500.00	7.88	0.76	5.22
121.60	23.00	23.17	0.08	34800.00	7.84	0.82	3.72

TABLE F.3 HYDROCARBON GASES

SITE: KOP I-44

OCEAN DPETH: 54.6 m

Depth (m)	Methane (ppm)	Ethene (ppm)	Ethane (ppm)	Propene (ppm)	Propane (ppm)	I-Butane (ppm)	N-Butane (ppm)	Sum Satrd (ppm)
2.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3
8.1	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.7	4.3	0.0	0.0	0.0	0.3	0.0	0.0	0.3
32.8	31.8	4.3	1.1	0.0	1.0	0.6	0.1	2.8
36.1	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42.4	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49.2	12.7	2.9	0.4	0.0	0.5	0.4	0.0	1.3
57.6	12.6	0.0	0.0	0.0	0.3	0.0	0.0	0.3
60.6	27.7	0.0	0.3	0.0	0.3	0.1	0.0	0.7
67.1	6.5	0.0	0.0	0.0	0.2	0.0	0.0	0.2
76.1	6.7	0.0	0.0	0.0	0.1	0.1	0.0	0.2
90.7	7.3	0.0	0.0	0.0	0.3	0.6	0.0	0.9
93.4	7.2	0.0	0.1	0.0	0.6	0.1	0.0	0.8
100.2	2.1	0.0	0.0	0.0	0.3	0.1	0.0	0.4
104.2	7.6	0.0	0.1	0.0	1.4	0.1	0.0	1.6
110.3	5.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2
121.6	263.5	0.0	0.0	0.0	0.6	0.4	0.0	1.0

NOTES:
1. Hydrocarbon gases measured in canned samples sealed on board ship.
2. Unsaturated gases, ethene and propane, as well as methane are excluded from the sum of saturated gases given in the last column.
3. Values are in ppm v/v (microlitres gas per litre sediment).

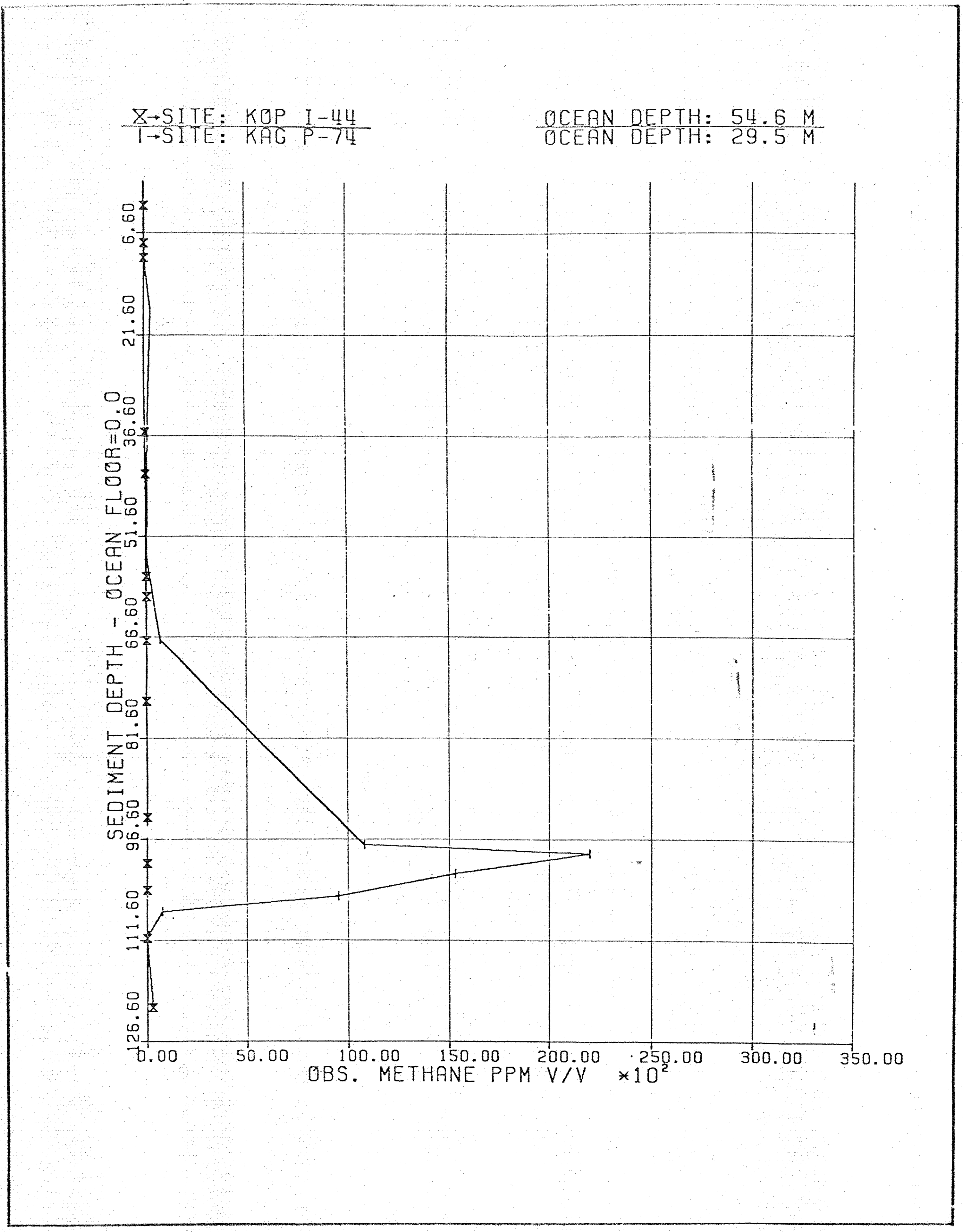
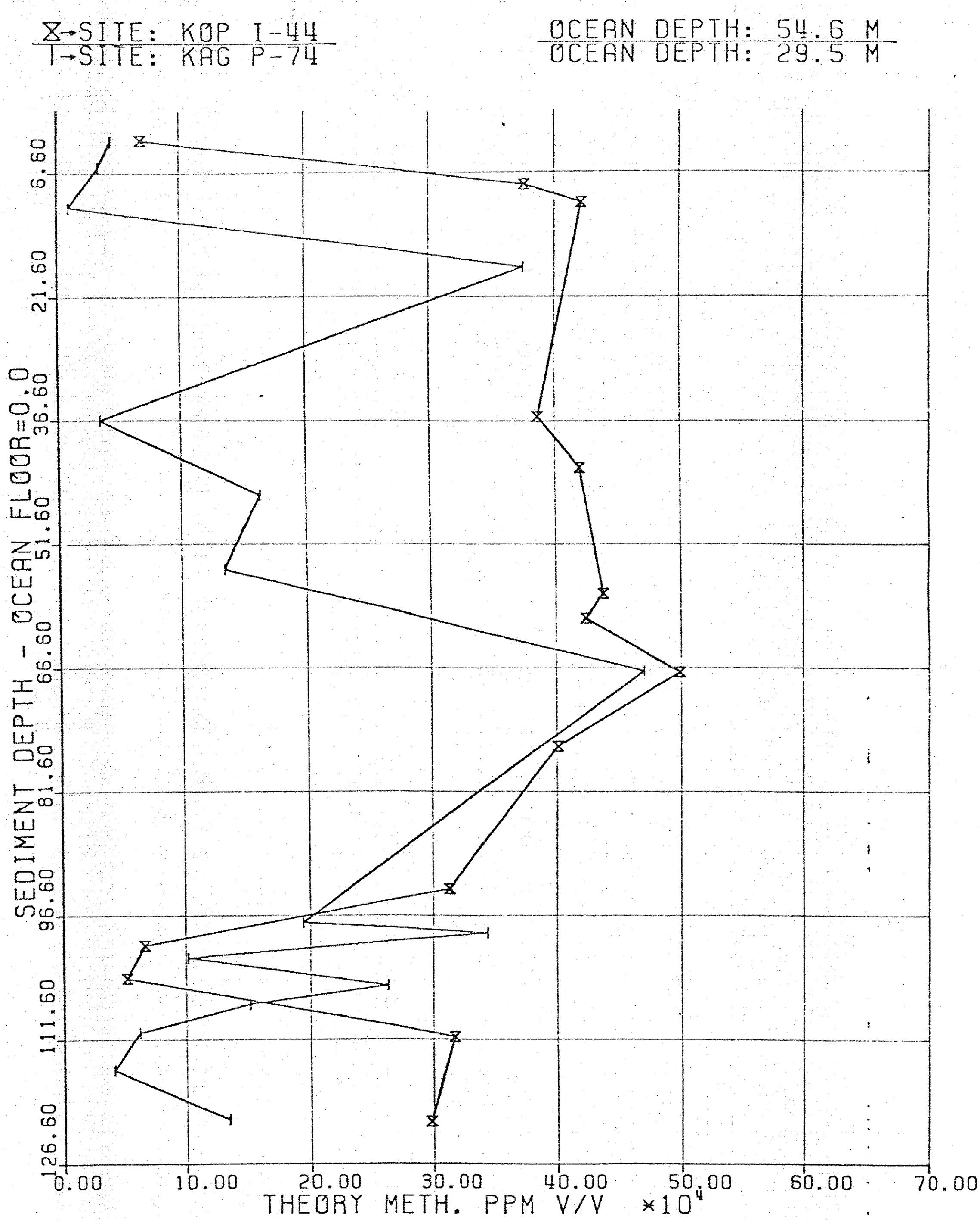
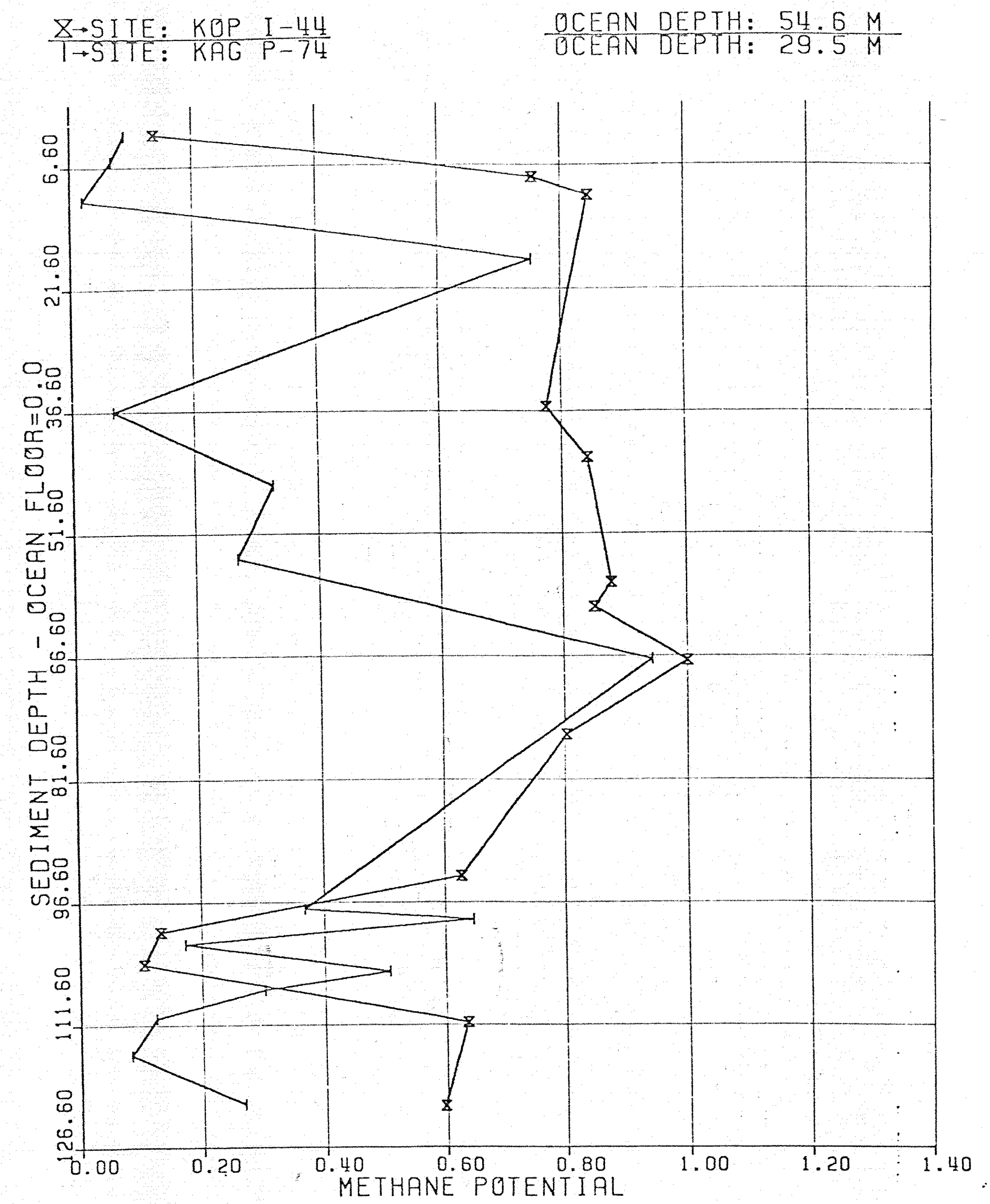


FIGURE F-3 DEPTH PROFILE FOR OBSERVED METHANE



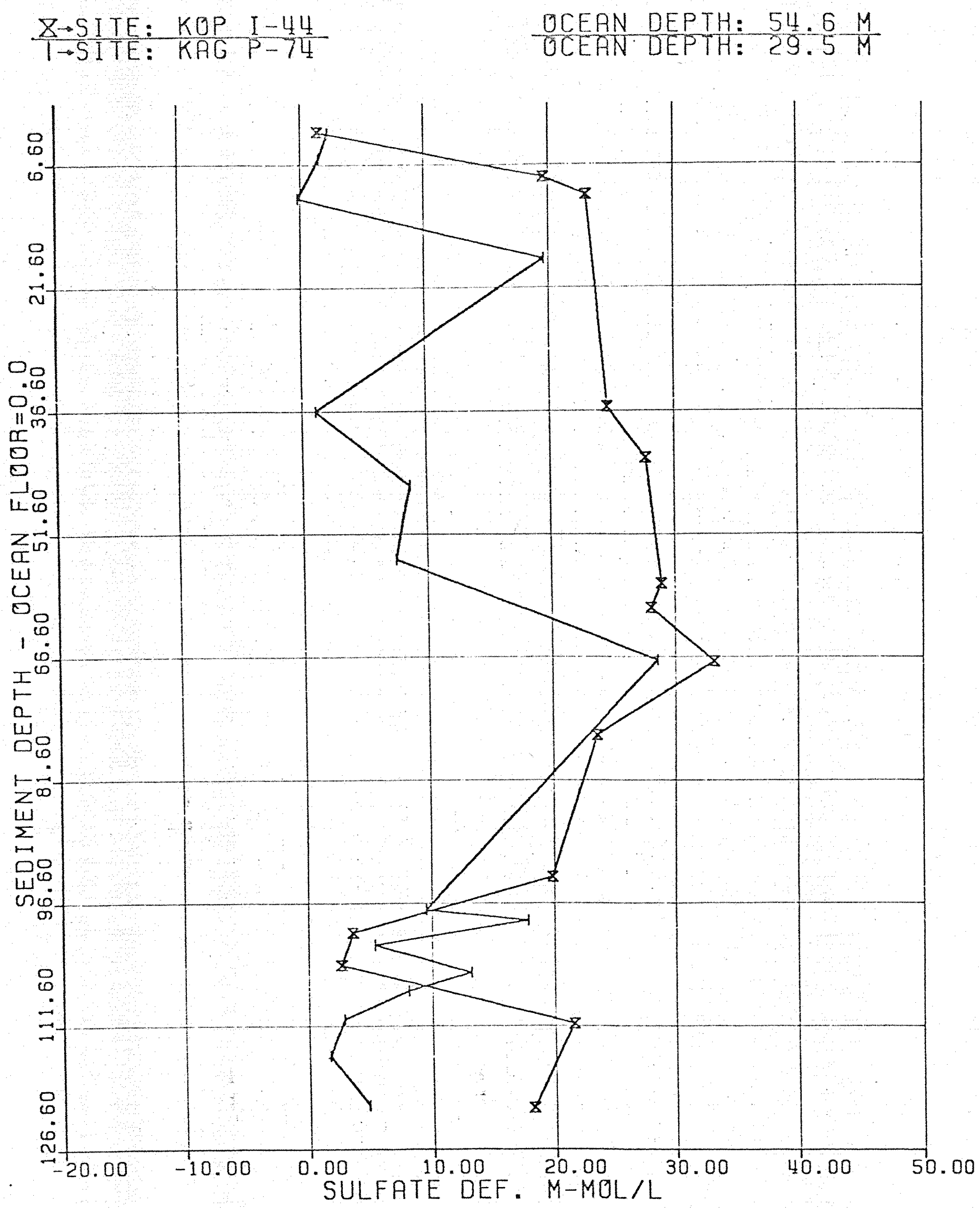
NOTE; 1. Theoretical methane is calculated from analysis at pressure independant pore water geochemistry, whereas observed methane represents concentrations measured from canned samples.

FIGURE F-4 DEPTH PROFILE FOR THEORETICAL METHANE



NOTE: 1. The highest potential for future methane production is normalized to 1 and occurs in each boring at or near 60 m penetration.

FIGURE F-5 DEPTH PROFILE FOR METHANE POTENTIAL



NOTE: 1. *This parameter is used for calculating theoretical methane and also illustrates the relative depletion in pore water sulfate based on the conservative sea water value.*

2. *Less sulfate is depleted at lower salinities. (below 60 m).*

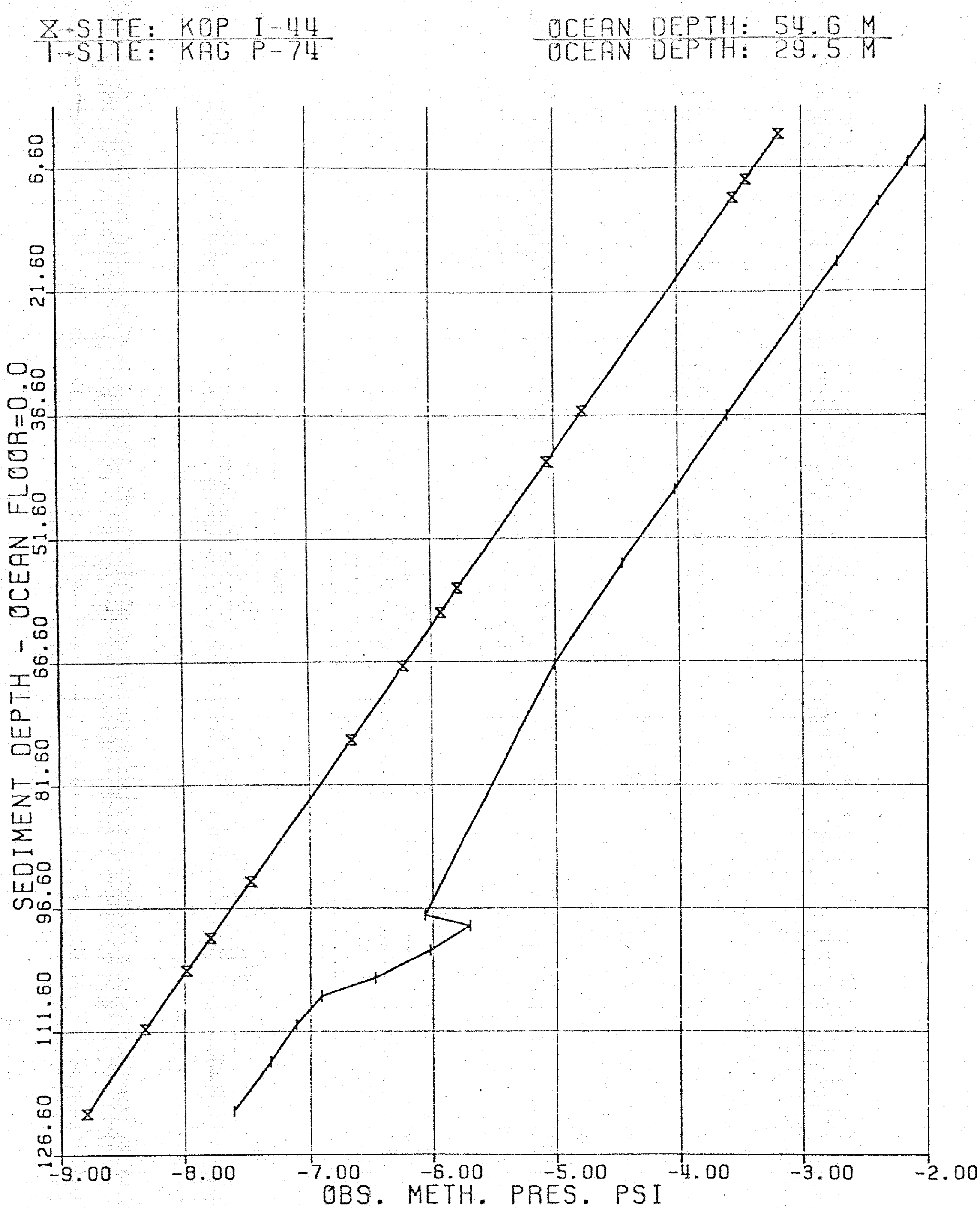
FIGURE F-6 DEPTH PROFILE FOR SULFATE DEFICIT

TABLE F.4 COMPARISON OF THEORETICAL CALCULATED VALUES OF METHANE AND SULFATE WITH THE MEASURED PARAMETERS

SITE: KOP I-44

OCEAN DEPTH (M): 54.60

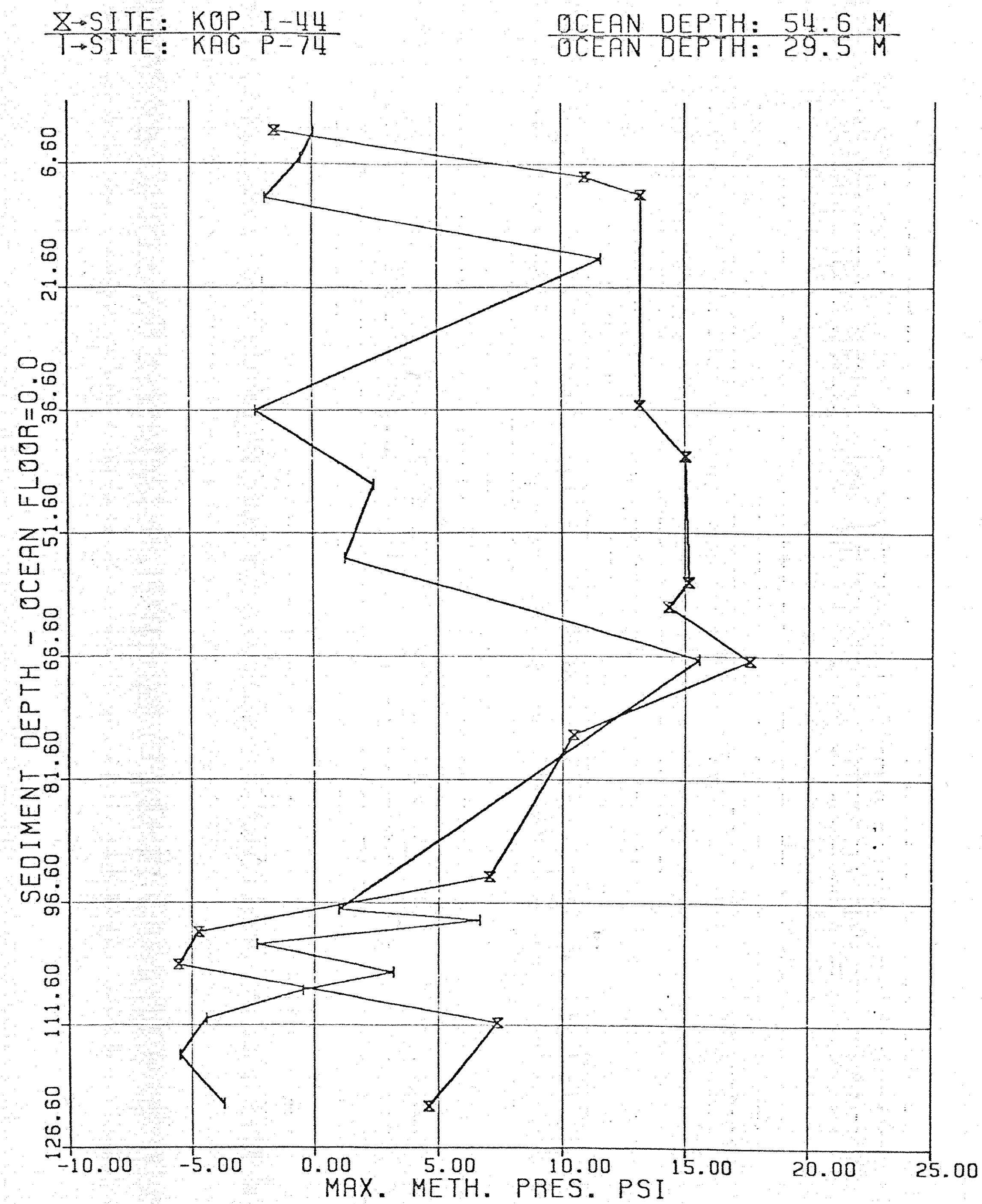
DEPTH METER.	OBS. METHANE PPM V/V	THEOR. METH PPM V/V	METH. POTENT NORMALIZED	OBS. SULFATE MIL-MOL/L	SULFATE DEF. MIL-MOL/L
2.60	0.00	68763.63	13.78	26.68	1.42
8.10	1.60	376552.90	75.43	8.32	19.60
10.30	0.00	421442.80	84.43	3.31	23.02
36.10	5.40	386826.30	77.49	4.80	24.65
42.30	5.40	419686.20	84.07	2.88	27.71
57.60	12.60	437754.30	87.69	0.64	28.89
60.60	27.70	424180.60	84.97	1.49	28.04
67.10	6.50	499184.00	100.00	0.53	33.08
76.10	6.70	400891.30	80.31	2.77	23.55
93.40	7.20	313303.60	62.76	0.64	19.83
100.20	2.10	66870.13	13.40	2.45	3.61
104.20	7.60	52294.19	10.47	5.87	2.69
111.30	5.00	317558.30	63.62	1.92	21.55
121.60	264.00	297989.90	59.64	0.85	18.18



NOTE: 1. *This parameter represents the lowest excess pressure which could develop from biologic methane production.*

2. *All values shown are negative which indicated that insufficient methane was present for bubble formation.*

FIGURE F-7 DEPTH PROFILE FOR OBSERVED METHANE PRESSURE



NOTE: 1. These values represent maximum pressures which could develop from biogenic methane production.

FIGURE F-8 DEPTH PROFILE AT MAXIMUM METHANE PRESSURE

TABLE F.5 GAS PRESSURE DERIVED FROM MEASURED METHANE AND THEORETICAL METHANE

SITE: KOP I-44

OCEAN DEPTH (M) : 54.60

DEPTH METER.	OBS. PRES. PSI	MAX. PRES. PSI	OBS. PRES. ATM	MAX. PRES. ATM
2.60	-3.18	-1.52	-0.22	-0.10
8.10	-3.44	10.95	-0.23	0.74
10.30	-3.54	13.23	-0.24	0.90
36.10	-4.76	13.17	-0.32	0.90
42.30	-5.06	15.01	-0.34	1.02
57.60	-5.78	15.16	-0.39	1.03
60.60	-5.92	14.36	-0.40	0.98
67.10	-6.23	17.64	-0.42	1.20
76.10	-6.65	10.46	-0.45	0.71
93.40	-7.47	7.05	-0.51	0.48
100.20	-7.80	-4.69	-0.53	-0.32
104.20	-7.98	-5.56	-0.54	-0.38
111.30	-8.32	7.38	-0.57	0.50
121.60	-8.80	4.61	-0.60	0.31

TABLE F.6 TOTAL CARBONATE IN SEDIMENT FROM BORING TAR D-14

Depth (m)	Total carbonate (wt. %)
2.6	0.41
8.1	0.95
10.3	0.68
36.1	2.33
42.3	2.43
57.6	1.53
60.6	2.52
67.1	2.31
76.1	1.77
93.4	1.23
100.2	1.71
104.2	1.75
111.3	2.13
121.6	1.97

APPENDIX G

INDEX TO CORE PHOTOGRAPHY AND RADIOGRAPHY (EBA)

APPENDIX G

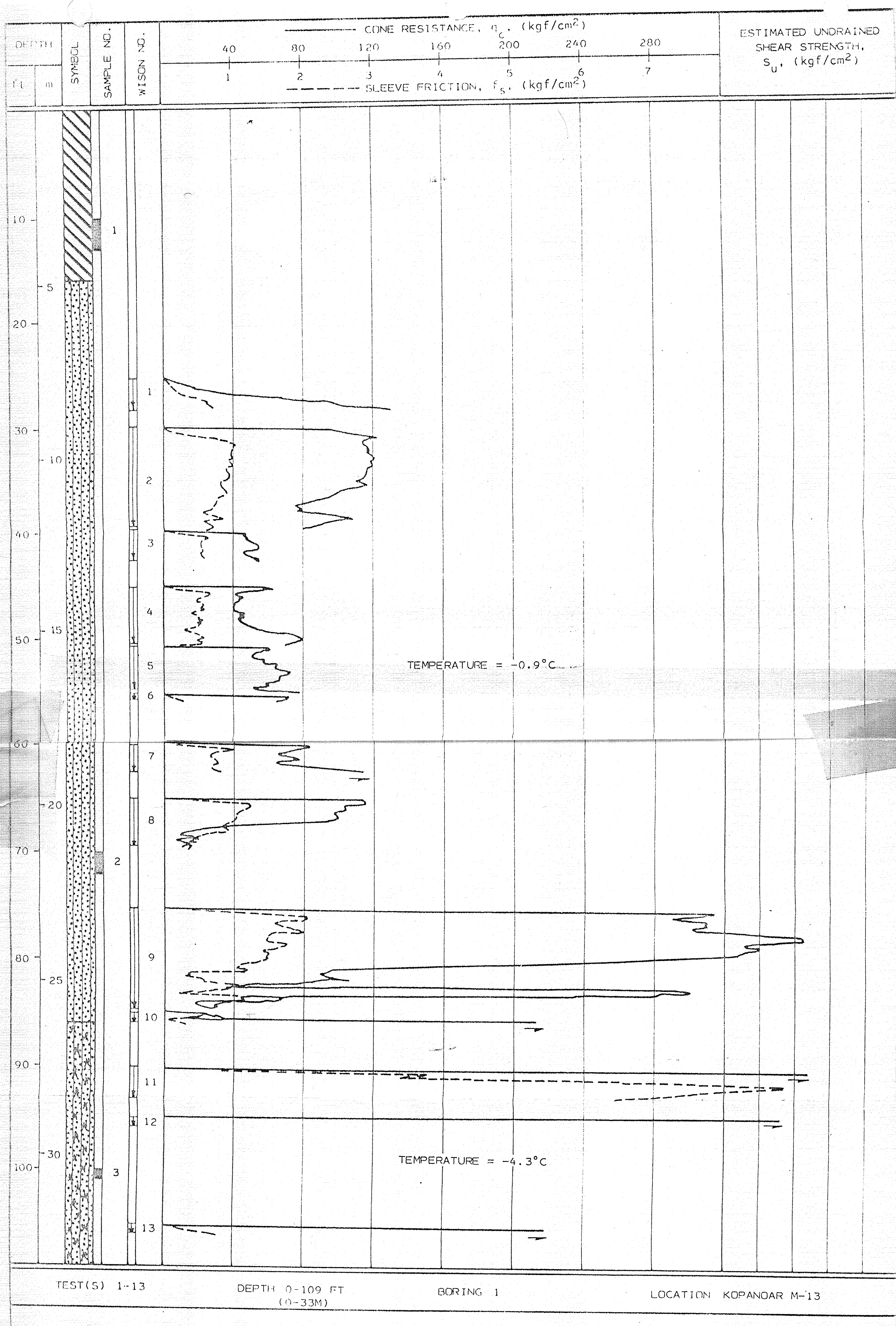
INDEX TO CORE PHOTOGRAPHY AND RADIOGRAPHS

Appendix - Tables

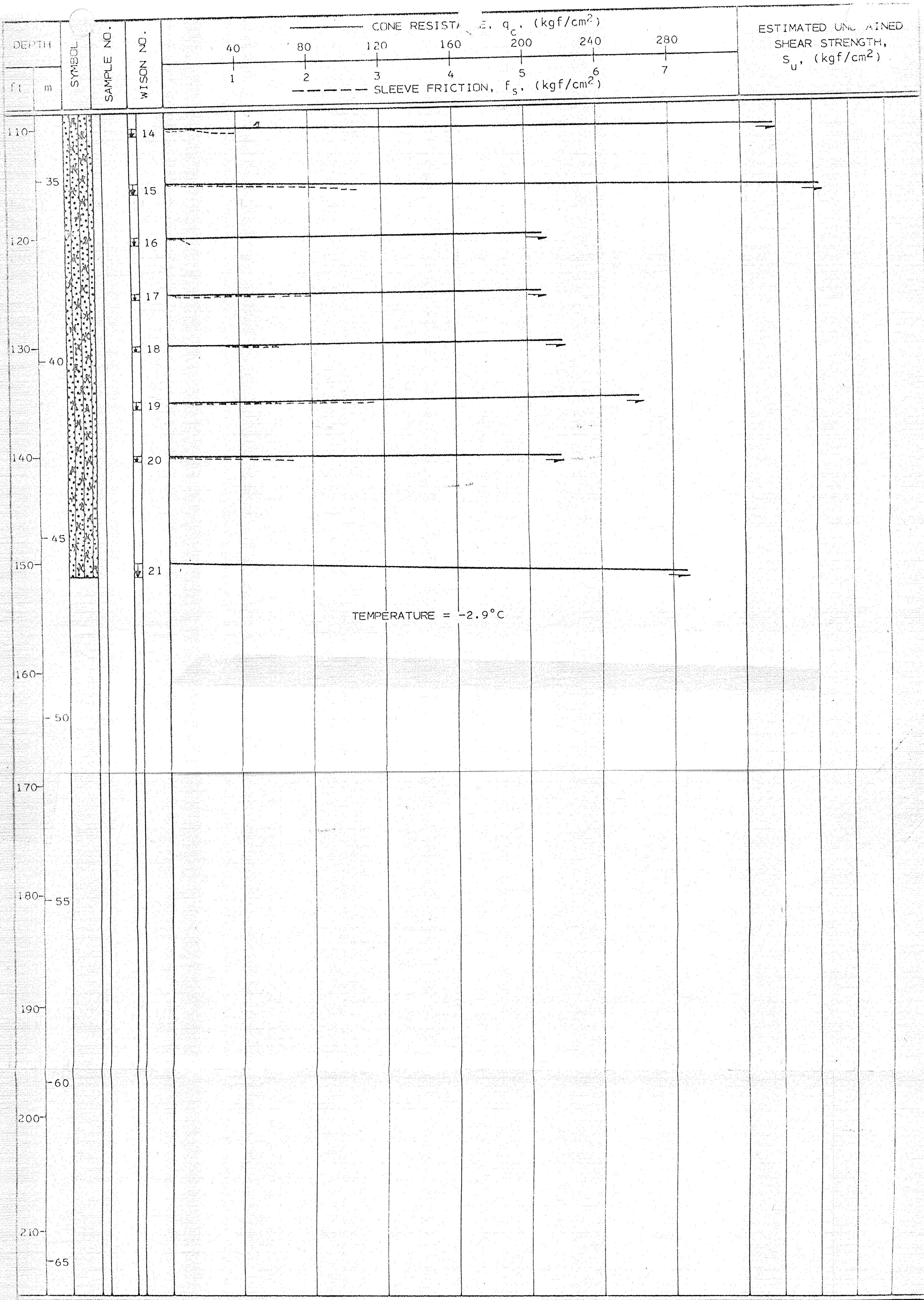
Summary of Photographs from Cores and Radiographs — Table G.1

TABLE G-1 SUMMARY OF PHOTOGRAPHS FROM CORES AND RADIOGRAPHS,
KOPANOAR I-44

SAMPLE NO.	SAMPLE TYPE	DEPTH (m)	USC	CORE PHOTOS (No. of Prints)	RADIOGRAPHS (No. of Prints)	SHEAR TESTING
1A	L	0. - .125	CH		2	
1B	L	0.125- 0.25	CH		1	
2A	B	0.6 - 0.7	CH	1		
2B	L	0.7 - 0.85	CH		2	UU
2C	L	0.85 - 1.0	CH		1	
3B	L	1.63 - 1.75	CH		1	
4B	L	2.28 - 2.4	CH		1	
5B	L	2.62 - 2.75	CH		1	
5C	L	2.75 - 2.87	CH	1	2	UU
5D	V	2.87 - 3.00	CH/MH	1		
6A	L	3.1 - 3.23	CH		1	
6B	L	3.23 - 3.35	CH		1	
6C	L	3.35 - 3.48	CH		1	
7A	L	3.7 - 3.82	CH		1	
7B	L	3.82 - 3.95	CH		1	
7C	L	3.95 - 4.07	CH		1	
9B	L	5.32 - 5.45	CH	1	2	UU
10A	L	5.55 - 5.67	CH		1	
10B	L	5.67 - 5.80	CH		1	
10D	B	5.93 - 6.05	SC	1		
12B	W	7.0 - 7.15	CL		3	UU
13A	W	7.45 - 7.57	CL	2	1	CU
13B	B	7.57 - 7.70	CL	1		
14B	B	8.05 - 8.20	SM/SC	1		
15A	B	8.60 - 8.65	CL	1		
16B	B	9.45 - 9.60	SM/SC	1		
17B	G	10.25 - 10.35	SM/SC	1		
18B	B	10.75 - 10.87	SM/SC	1		
20B	B	11.97 - 12.10	SM/SC	1		
21B	B	15.05 - 15.20	SP/SM	1		
22A	B	17.70 - 17.85	CL	1		
23A	W	17.45 - 18.05	ML	1	1	UU
24B	B	21.15 - 21.25	CL	1		
25A	W	24.0 - 24.15	ML		1	
25B	B	24.15 - 24.27	ML	1		
26B	B	27.00 - 27.15	CL	1		
26C	W	27.15 - 27.3	ML	1	2	UU
27A	B	30.10 - 30.25	CL	1		
27B	W	30.37 - 30.4	CL	1	1	UU
28A	B	33.25 - 33.45	CL	1		
29B	W	36.1 - 36.25	ML		1	
29C	B	36.25 - 36.40	CL	1		
29D	W	36.4 - 36.55	CL	1	1	UU



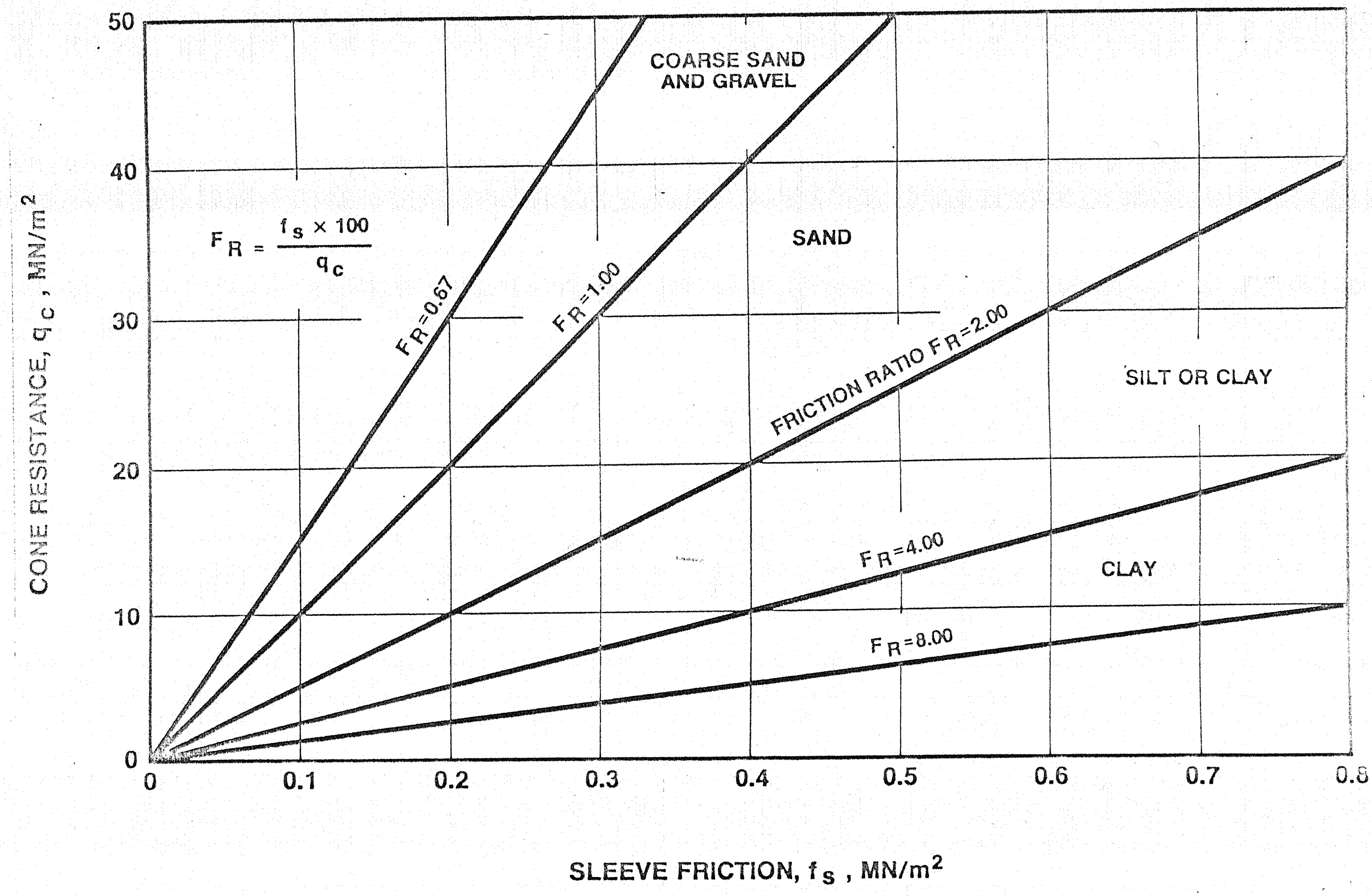
WISON CONE PENETROMETER TESTS
BEAUFORT SEA, OFFSHORE CANADA



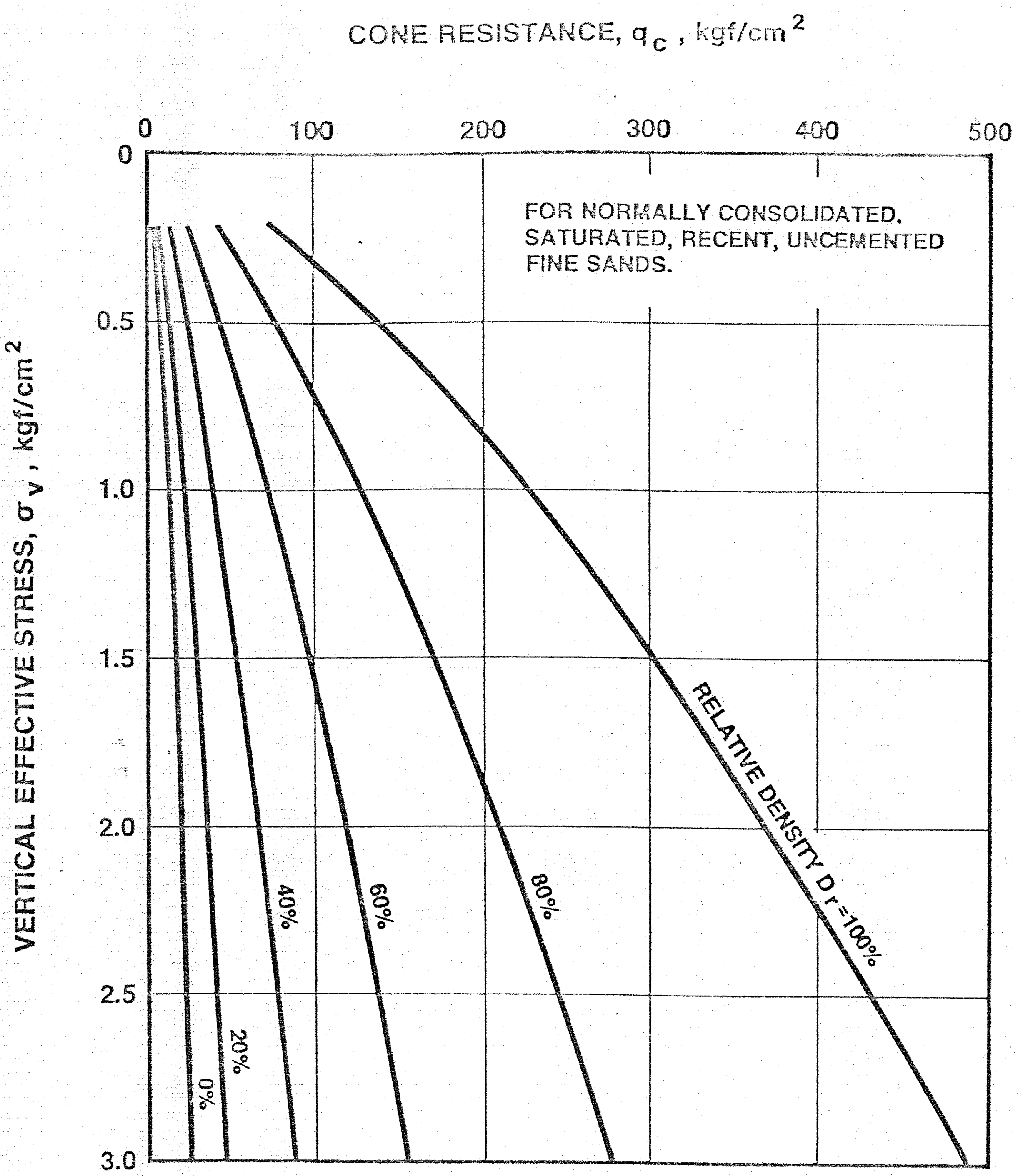
TEST(S) 14-21 DEPTH 109-151 FT. (33-46M) BORING 1 LOCATION KOPANOAR M-13

WISON CONE PENETROMETER TESTS
BEAUFORT SEA, OFFSHORE CANADA

PLATE I-2



UNFROZEN SOIL CLASSIFICATION BY FRICTION RATIO
FOR WISON CONE PENETROMETER
AFTER SANGLERAT AND FUGRO



CORRELATION OF CONE RESISTANCE
AND RELATIVE DENSITY
AFTER SCHMERTMANN (1977)

MEASURED TEMPERATURE Degrees Celsius	TEMPERATURE CORRECTION Degrees Celsius
+4.0	0
0.0	+0.1
-4.0	+0.1

Notes: 1. Temperature correction uncertainty is less than 0.2° Celcius.

2. Temperatures provided in this report have been corrected.

3. Temperatures certified by Dienst van Het Ijkwezen.

CALIBRATION OF MERCURY THERMOMETER

1980 CANMAR PROJECT

BEAUFORT SEA, OFFSHORE CANADA

A P P E N D I X J

GEOPHYSICAL BOREHOLE LOGS (ROKE)

ROKE

GAMMA RAY
SIDEWALL DENSILOG
CALIPER

OIL ENTERPRISES LTD. CALGARY, ALBERTA

FILE NO.

COMPANY CANADIAN MARINE DRILLING LIMITED

WELL KOPANOAR I - 44 BORING HOLE # 2

LOCATION LAT 70° 23' 44.2058" N, LONG 135° 14' 26.4415" W

FIELD KOPANOAR

PROVINCE NORTHWEST TERRITORIES

Other Services: GR, FBL, TEMP

...nent Datum SEA FLOOR Elev. ____

...Measured from SEA FLOOR Above Perm. Datum

Depths Measured from SEA FLOOR

K.B. ____ CSG ____ G.L. ____

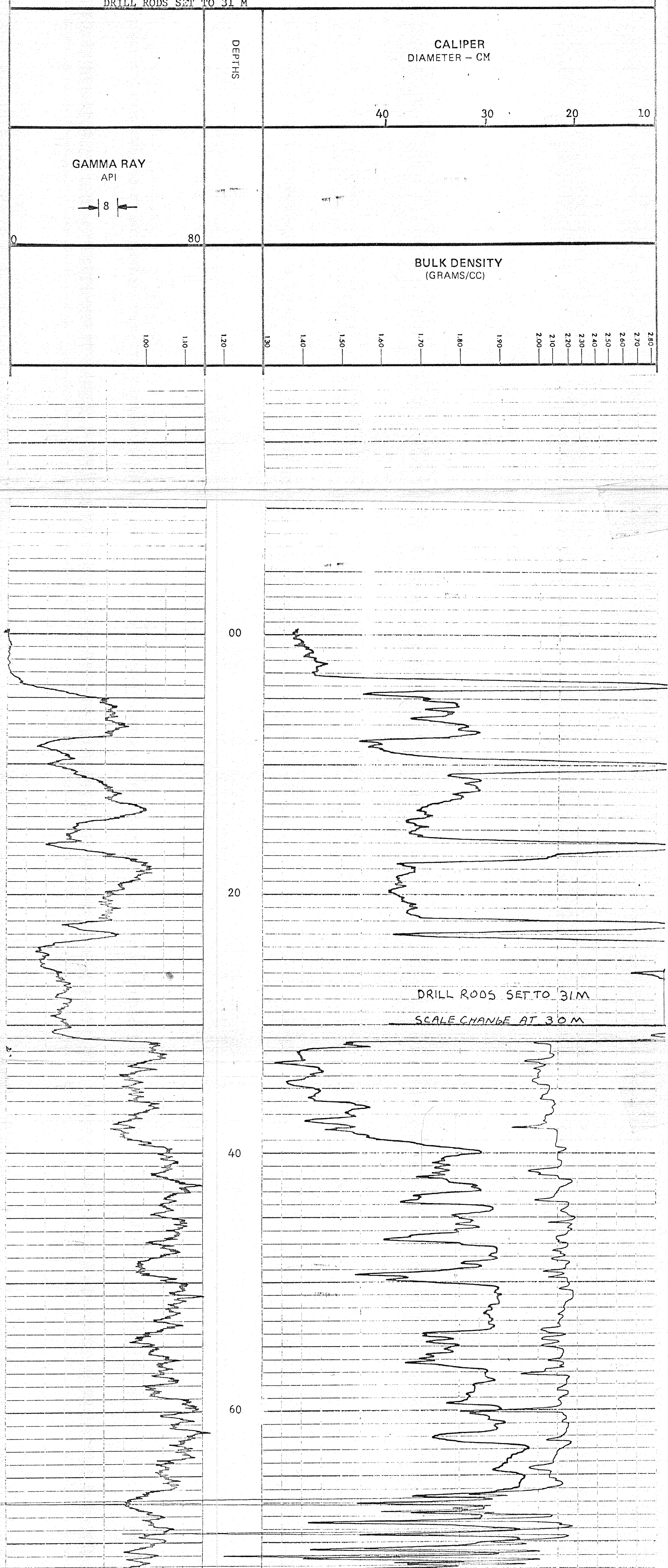
METRIC

...No.	ONE		
...e	9 AUG. 1980		
...t Reading	121 M		
...t Reading	0		
...tage Logged	121		
...th Reached	122		
...th Driller	123.1		
...ing Roke			
...ing Driller			
...id Type	MUD/SEA WATER		
...uid Level	FULL		
... Diam.	17.8 CM		
...erating Time	2 HOURS		
...ck No.	SU # 2		

...corded By KALUGIN Witnessed By HARRINGTON

GENERAL				GAMMA RAY				SIDEWALL DENSILOG			
RUN NO.	DEPTHS FROM	DEPTHS TO	SPEED M MIN	T.C. SEC.	SENS SETTINGS	ZERO DIV.L OR R	API G.R. UNITS PER LOG DIV.	T.C. SEC.	SENS SETTINGS	ZERO DIV.L OR R	CPS/ DIV
1	0	30	8		CALIPER			.5	5 K	2.89 R	74.59
1	30	121	8		CALIPER			.5	5 K	2.96 R	158.13
1	0	121	4	3	100	0	8				

REMARKS GR TOOL # 15 ———— DENSITY LOG PEN
DENS TOOL # 422AS ———— CALIPER LOG PEN
CAL TOOL # 785
DRILL RODS SET TO 31 M



ROKE

GAMMA RAY

OIL ENTERPRISES LTD. CALGARY, ALBERTA

FILE NO.	
COMPANY	CANADIAN MARINE DRILLING LIMITED
WELL	KOPANOAR I - 44 BORING HOLE # 2
LOCATION	LAT 70° 23' 44.2058" N, LONG 135° 14' 26.4415" W
FIELD	KOPANOAR
PROVINCE	NORTHWEST TERRITORIES
LSD	
SEC	
TWP	
RGE	
W	M

Other Services: TEMP, FBL, GR-DENS-CAL

Permanent Datum	SEA FLOOR	Elev. - 54.6 M	K.B.
Log Measured from	SEA FLOOR	Above Perm. Datum	CSG
Well Depths Measured from	SEA FLOOR		G.L.
			METRIC

Run. No.	ONE		
Date	9 AUG. 1980		
First Reading	119 M		
Last Reading	0		
Footage Logged	119		
Depth Reached	120.1		
Depth Driller	123.1		
Casing Roke			
Casing Driller			
Fluid Type	MUD/SEA WATER		
Liquid Level	FULL		
Min. Diam.	17.8 CM		
Rm @ °			
Operating Time	1 HOUR		
Truck No.	SU # 2		

Recorded By KALUGIN

Witnessed By HARRINGTON

Remarks: GR TOOL # 15 RECORDED 1.27 M HIGH

LOGGED THROUGH DRILL PIPE

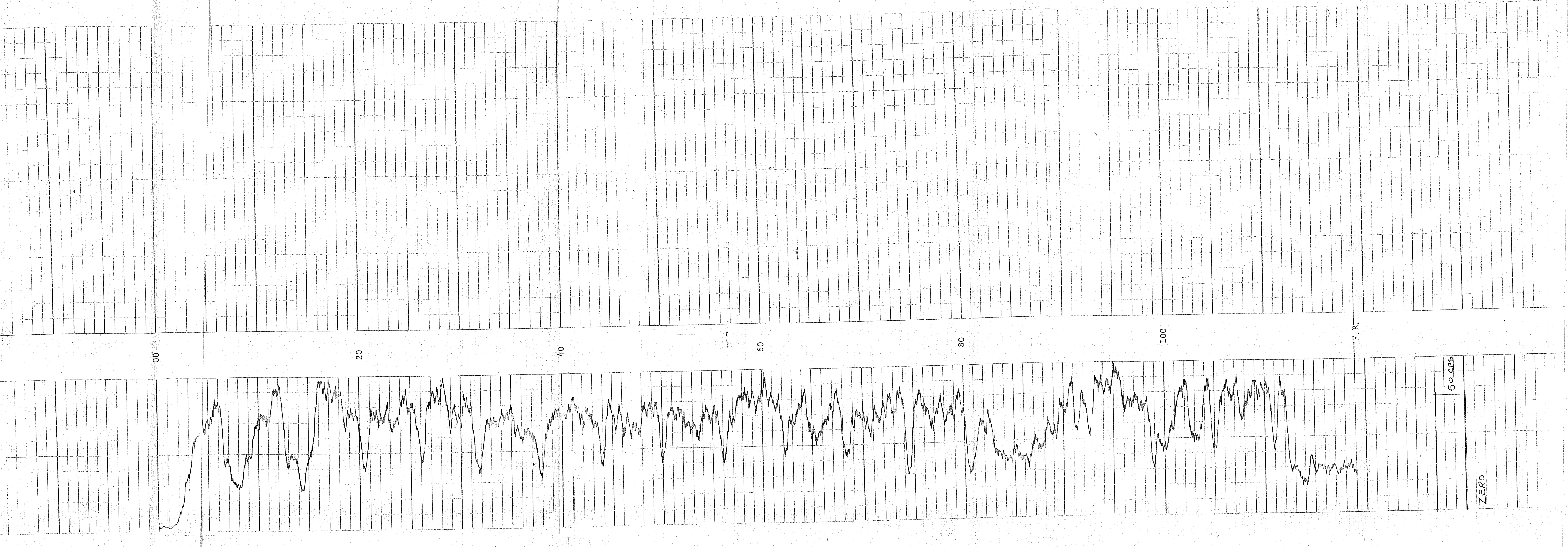
SPONTANEOUS - POTENTIAL (MILLIVOLTS) – SP +

Depths

RESISTANCE

GAMMA RAY API 6 0 60

OHMS



ROKE FOCUSED BEAM LOG 20 CM

OIL ENTERPRISES LTD. CALGARY, ALBERTA

FILE NO.	
COMPANY	CANADIAN MARINE DRILLING LIMITED
WELL	KOPANOAR I - 44 BORING HOLE # 2
LOCATION	LAT 70° 23' 44.2058" N, LONG 135° 14' 26.4415 W
FIELD	KOPANOAR
PROVINCE	NORTHWEST TERRITORIES
LSD / SEC / TWP / RGE / W. M	
Other Services	GR, TEMP; GR-DENS-CAL
Permanent Datum	SEA FLOOR; Elev. - 54.6 M Above Perm. Datum
Log Measured from	SEA FLOOR
Depths Measured from	SEA FLOOR
K.B. / CSG / G.L.	METRIC

Run No.	ONE		
Date	9 AUG. 1980		
First Reading	121 M		
Last Reading	30		
Footage Logged	91		
Depth Reached	122		
Depth Driller	123.1		
Casing Roke			
Casing Driller			
Fluid Type	MUD/SEA WATER		
Liquid Level	FULL		
Min. Diam.	17.8 CM		
Rm @ °C	.25 @ 25° C		
Operating Time	1 HOUR		
Truck No.	SU # 2		

Recorded By KALUGIN Witnessed By HARRINGTON

Remarks FBL # 4 CURRENT RANGE HIGH MUDFISH RESISTANCE 2.5 OHMS
7 ELECTRODE SONDE 20 CM BEAM WIDTH 100 CM ARRAY
PRIMARY 2.5 OHM/DIV SECONDARY 5 OHM/DIV
DRILL RODS SET TO 31 M

ROKE

TEMPERATURE

OIL ENTERPRISES LTD. CALGARY, ALBERTA

FILE NO.	
LSD / SEC / TWP / RGE / W___M	
COMPANY	CANADIAN MARINE DRILLING LIMITED
WELL	KOPANOAR I - 44 BORING HOLE # 2
LOCATION	LAT 70° 23' 44.2058" N, LONG 135° 14' 26.4415" N
FIELD	KOPANOAR
PROVINCE	NORTHWEST TERRITORIES
Other Services:	GR, FBL, GR-DENS-CAL
Permanent Datum	SEA FLOOR, Elev. - 54.6 M
Log Measured from	SEA FLOOR, Above Perm. Datum
Well Depths Measured from	SEA FLOOR
K.B. / CSG / G.L.	METRIC

Run No.	ONE
Date	9 AUG. 1980
First Reading	00 M
Last Reading	120
Footage Logged	120
Depth Reached	120
Depth Driller	123.1
Casing Roke	
Casing Driller	
Fluid Type	MUD/SEA WATER
Liquid Level	FULL
Min. Diam.	17.8 CM
Rm @ °	
Operating Time	1 HOUR
Truck No.	SU # 2
Recorded By	KALUCIN
Witnessed By	HARRINGTON

Remarks: TEMP. TOOL # CT23C107 RATEMETER 206 - #141 - 500 RANGE, 1.00 CPS/DIV
TEMP. LOG STARTED AT 1:40 P.M. AUG. 9; 4 HOURS AFTER CIRCULATION WAS STOPPED. TEMPERATURE LOG FINISHED 2:10 P.M.
LOGGING SPEED 4.6 M/MIN, GOING DOWN HOLE. DRILL RODS SET TO 31 M

Depths	TEMPERATURE
	DEGREES C.
	- 2.33 - 1.92 - 1.52 - 1.13 - .74

APPENDIX K

LABORATORY TEST PROCEDURES (EBA)

APPENDIX K

LABORATORY TEST PROCEDURES

Classification and Index Tests

Triaxial Shear Tests

Direct Shear Tests

Consolidation Tests

Pore Water Salinity Tests

LABORATORY TEST PROCEDURES

Classification and Index Tests

These tests are quite routine and the standard ASTM procedures employed are listed below:

TEST	ASTM DESIGNATION
Moisture Content	D 2216
Liquid Limit*	D 423
Plastic Limit and Plasticity Index	D 424
Grain Size	D 421 & 422
Specific Gravity	D 854
Relative Density	D 2049
Unified Soil Classification	D 2487
Bulk Unit Weight**	N/A

In addition to the specific procedures described in the following sections, samples programmed for strength and consolidation tests had several other basic tests performed. These were:

1. Moisture content
2. Bulk density
3. Core photography and radiograph (where practical)
4. Detailed description of sedimentological features, and
5. Identification and preservation of any discrete organic material encountered.

NOTES: *All liquid limit determinations were performed with a 3 point procedure.

**Bulk unit weights were determined directly from external dimensions and sample weight in air.

LABORATORY TEST PROCEDURES

Triaxial Shear Tests

Unconsolidated-Undrained Triaxial Tests

Procedure 1* - Standard unconfined compression test procedure. Stress-strain curve produced.

Procedure 2* - Sample mounted in triaxial cell and jacketed. Cell pressure equivalent to estimated total horizontal stress applied without sample drainage. Sample sheared by increasing axial stress at controlled rate of strain. Frozen samples permitted to thaw (undrained) before commencing shear. Stress-strain curve produced.

Consolidated-Undrained Triaxial Tests

Procedure 1 - Sample mounted in triaxial cell and jacketed. Cell pressure equivalent to estimated total horizontal stress applied with drainage permitted. With consolidation complete, drainage is shut off. Frozen samples were placed in a pre-chilled triaxial cell and permitted to thaw before commencing consolidation. A pore pressure response test was carried out prior to shearing. If a B value of less than 0.95 was obtained, back pressure was applied to obtain saturation. Samples were sheared by increasing axial stress at a controlled rate of strain. Stress-strain curves and other diagnostic plots produced. Generally performed minimum of 2 tests on each material type to define strength parameters in terms of effective stress.

LABORATORY TEST PROCEDURES

Triaxial Shear Tests

Consolidated-Drained Triaxial Tests

Procedure 1 – Frozen samples required that the triaxial apparatus be pre-chilled. Sample mounted in triaxial cell and jacketed, thawed under nominal pressure. Consolidated to cell pressure equivalent to estimate horizontal in situ effective stress. With drainage open, sample was sheared by increasing the axial stress at a controlled rate of strain. Stress-strain curve and other diagnostic plots produced. Generally performed minimum of 2 tests on each material type to define strength parameters in terms of effective stress.

Procedure 2 – Lack of undisturbed samples of sand from certain strata required reconstituting disturbed samples for strength testing. Relative density test conducted on the sand and reconstituted samples are prepared to approximately 70% relative density. Sample was consolidated to cell pressure equivalent to the estimated in situ horizontal effective stress. With the drainage permitted, the sample was sheared by increasing the axial stress at a controlled rate of strain. Stress-strain curve and other diagnostic plots produced. Generally performed minimum of 2 tests on each material type to define strength parameters in terms of effective stress.

NOTES:

1. Unconsolidated-undrained triaxial procedure according to ASTM D2850.
2. Consolidated-undrained and-drained triaxial procedures follow those recommended Bishop & Henkel (1969).
3. Samples reconstituted following procedures outlined in Bjerrum, Kringstad, and Kummeneje (1961).
4. Tests denoted by asterix were occasionally performed with back pressure and porewater pressure measurement during shear.

LABORATORY TEST PROCEDURES

Direct Shear Tests

Procedure 1 - Standard direct shear procedure. Frozen samples permitted to thaw and stage-consolidate under applied normal pressure before commencing shear. Resheared strength measured on plane cut after peak strength had been determined. Stress-strain curve and other diagnostic plots produced. Generally performed minimum of 3 tests on each material type to define strength parameters in terms of effective stress.

Procedure 2 - If available sample consisted of disturbed material, test specimen was reconstituted and sheared following the same general procedure indicated above.

NOTES: 1. Standard direct shear procedure according to ASTM D 3080.

2. Samples reconstituted following procedures outlined in Bjerrum, Kringstad, and Kummeneje (1961).

LABORATORY TEST PROCEDURES

Consolidation Tests

Procedure 1 - Sample set up in 64 mm (2.5 in) oedometer with dry stones. Load increments increased by 50% were applied to obtain a specified vertical effective stress exceeding the estimated in situ effective overburden pressure. The oedometer was then flooded, unloaded and permitted to rebound. After rebound, the specimen was reloaded in 50% increments until a vertical effective stress of approximately 400 kPa was obtained. Thereafter, the standard doubling of pressures was resumed to test completion. An e-log p' curve, c_v, k, m_v, and estimate of preconsolidation pressure produced.

Procedure 2 - Sample set up frozen in oedometer, then moved from cold room to standard apparatus. Moderate stress was applied to seat load cap, and sample was then thawed under nominal pressure. Procedure then continued as outlined above. An e-log p' curve, c_v, k, m_v, and estimate of preconsolidation pressure produced. Thaw strain data also obtained.

NOTE: Modifications made to standard procedure (ASTM D 2435) taken from Andresen et al. (1979) and Broms (1980) as recommended for overconsolidated soils.

LABORATORY TEST PROCEDURES

Pore Water Salinity Tests

Procedure 1 - Samples trimmed to remove disturbed material. Porewater extruded from thawed sample. Titration was then performed to establish equivalent salinity (NaCl).

Procedure 2 - Salinities originating from Carbon Systems, Inc. were determined using a modified Mohr titration and verified by conductivity.

NOTES: 1. A silver nitrate titration was performed to determine the chloride ion content (chlorinity) following ASTM D 512, Method B.

2. Chloride ion content was converted to an equivalent salinity using the empirical relationship that follows.

Salinity (o/oo) = 0.03 + (1.805 x Chlorinity (o/oo))

REFERENCES

Andresen, A.T. Berre, A. Kleven, and T. Lunne. 1979. Procedures Used to Obtain Soil Parameters for Foundation Engineering in the North Sea. Marine Geotechnology, Vol. 3, No. 3, pp. 201-265.

Bishop, A.W. and J.D. Henkel. 1969. The Measurement of Soil Properties in the Triaxial Test. 2nd Edition, London, Edward Arnold, 228 pp.

Bjerrum, L., S. Kringstad, and O. Kummeneje. 1961. The Shear Strength of a Fine Sand. Proceeding 5th International Conference of Soil Mechanics and Foundation Engineering, Paris, 1, pp. 29-37.

Broms, Bengt B. 1980. Soil Sampling in Europe: State-of-the-Art. ASCE Journal of the Geotechnical Engineering Division, Vol. 106, No. GT1, pp. 65-97.

APPENDIX L

EVALUATION OF LABORATORY TEST DATA (EBA)

APPENDIX L

EVALUATION OF LABORATORY TEST DATA

SUMMARY

A geotechnical investigation of soil and foundation conditions was performed for Canadian Marine Drilling Ltd. at the Kopanoar I-44 exploratory drilling site in the Beaufort Sea. The study consisted of a foundation boring drilled to 122 m seabed penetration in 55 m of water. Laboratory tests were subsequently performed on tube and core samples recovered from this borehole. Geophysical logging was performed following completion of the borehole.

The sequence encountered is predominated by fine grained soils that vary texturally from silt to clay, and contains occasional interbeds of fine sand. The surficial soils consist of very soft, highly plastic silts and clays to a depth of 7.7 metres below seabed. This is underlain by approximately 10 metres of fine sand, in a loose to compact density state. Interbedded, uniform, low plastic silts and clays are present in the 18 to 70 metre depth interval. Well bonded, nonplastic silt with frequent laminations and interbeds of fine sand were encountered from 70 to the final penetration of 122 metres below seabed. Discrete ice crystals were also noted throughout this interval.

Field and laboratory tests were performed on soils samples retrieved from the boring. Field testing included determination of moisture content, bulk density, core temperature, core photography, and measurement of the undrained shear strength with the torvane and miniature vane apparatus. Laboratory testing conducted in Edmonton consisted of additional classification and index testing, more sophisticated shear strength testing, and consolidation testing.

The most significant findings emerging from the geotechnical information presented in this report are listed below:

1. Six to eight metres of very soft, highly plastic, homogeneous clay are present at the seabed. This clay is underlain by 10 metres of loose to compact sand. Sedimentary structures such as laminations and thin bedding were noted at all depths greater than about 2 metres.

2. Undrained shear strength increases slightly from 8 kPa at seabed to approximately 12 kPa at a penetration of 7.5 m. Within the silt and clay strata penetrated below the sand at depths of 18 to 70 metres, undrained shear strengths measured in laboratory tests increased gradually from 50 kPa to about 120 kPa at a depth of 45 m. Below that, some lower strengths were obtained, but the lithology was also slightly siltier.

3. On the basis of shear strength and consolidation data, soils to a depth of at least 70 m below seabed exhibit normally consolidated to slightly underconsolidated behaviour. Below that depth, permafrost conditions dominate thawed properties.

4. Ground ice and ice bonding were encountered from about 70 m below seabed to the end of the borehole. The transition to permafrost conditions was abrupt.

5. Test results demonstrate that sample disturbance has probably had a significant effect on both shear strength and consolidation properties. The magnitude of these disturbance effects has not yet been defined.

LABORATORY TEST RESULTS

Permafrost and Ground Ice

Permafrost is defined as any earth material that has been at or below 0°C for a prolonged period of time without regard to the phase composition of moisture present in the pore spaces. For the purposes of this report, soils have been classified as frozen only if either visible ice or ice bonding was encountered concurrent with core temperatures of less than 0°C.

Ice bonded sandy soils were encountered first at a seabed penetration of 70 m below seabed. The overlying silts, clays and a sand stratum from 7.7 to 17.7 m showed no evidence of bonding or visible ice. Core temperatures recorded at surface generally fell between 0°C and +1°C over the 0 to 70 m, interval from seabed. Between 65 and 70 m, core temperatures fell rapidly to -2°C or slightly colder and remained constant there to 85 m penetration. Below that depth, core returned to surface was frozen so hard that the hand probe should not be inserted far enough to permit reliable temperature readings. This notation suggests that even colder temperatures are encountered between 85 to 122 m penetration.

Soil Properties

Silts, silty clays, fine sands and (surficial) clays were the predominant soil types encountered. These can be separated into three distinct units on the basis of soil properties.

The first unit consists of soils encountered from seabed to penetration of 7.7 m. These soils are characterized by water contents well in excess of the liquid limit, high plasticity, and clay contents of 50 to 60 percent.

Bulk density increases from about 1.50 Mg/m^3 at seabed to 1.75 Mg/m^3 just above the sand contact at 7.7 m. The consistency remains very soft over the entire inteval, with undrained shear strength increasing only slightly from an estimated 8 kPa at seabed to 12 kPa at 7.7 m penetration. The compression index of 0.58 at seabed is significantly higher than values obtained in the deeper silts and clays. Liquidity indices and estimated preconsolidation pressures infer a normally consolidated or even unconsolidated state.

The second unit consists of a fine-grained sand from 7.7 m to 17.7 m. Note that a 1 metre layer of sand was also penetrated (5.9 - 6.9 m) in the overlying clay. Blow counts to advance a 2 1/4 inch (57 mm) thin-walled tube infer a loose to compact density state in situ. Fines contents vary from 10 to 40 percent. Consolidated-drained triaxial tests on samples reconstituted at a relative density of approximately 70% defined an effective friction angle of 33° for the sand.

The third unit consists of silt and clay over the interval from 17.7 m to 122 m final penetration. The sequence generally fines upward from a silt with sandy beds and laminations to a silty clay, again with silt and sand lenses and laminations. From 17.7 m to 70 m, USC classifications falls near the borderline between low plastic silt and clay. Below 70 m, the silt is occasionally nonplastic. Liquidity indices generally fall between 0.5 and 0.7. The lithology throughout this unit is dominated by silt sizes, and variations in plasticity are quite closely tied to small vairations in clay content. Moisture contents generally vary between 20% and 30% with long intervals remaining nearly constant at 22% to 25%. Bulk densities average about 2.0 Mg/m^3. Consistencies vary from stiff to very stiff: the corresponding undrained shear strengths range from 50 kPa to 175 kPa, with occasional values in excess of 300 kPa. The data indicates a trend for gradually increasing shear strengths with depth, defining a minimum C_u/P_o of approximately 0.15, which seems low for even a normally consolidated profile in low plastic silts and clays. Consolidated-undrained tests on silts in the 80 to 90 m depth interval defined effective friction angles of 30 to 33 degrees. Compression indices throughout this unit fall within the narrow range of 0.15 to 0.19: values at the lower end of the range are invariably associated with silt.

The frozen silts (and sandy interbeds) below 70 m were generally classified as containing little or no visible ice. Ground ice encountered consisted of of nonvisible bonding (Nbn) with rare crystal inclusions (V_x). The high bulk densities and low moisture contents are characterisitc of an ice-poor soil. Settlements resulting from thaw would be in the order of 1 to 2 percent, and this is borne out by vertical strains measured during phase change in oedometer tests. All samples recovered from this zone were stored in freezers maintained at about -18°C. All subsequent strength and consolidation tests were preformed on thawed samples.

Sample Quality

The soil properties discussed in this appendix are directly affected by sample quality. The two most significant factors influencing sample quality in the context of this project are:

1. The method of sampling, and
2. Sample storage and transport procedures.

Emrich (1971) conducted a study of the performance of a wireline percussion sampler similar to the one used in connection with this project. Results of his comparative studies indicate that the 2.25 in (57 mm) wireline percussion sampler produces measureable disturbance in clays. However, since the level of disturbance is usually consistent, he suggests that application of appropriate correction factors to measured shear strength values should permit selection of suitable design shear strength parameters. An appropriate correction factor has not been determined for use of this sampler in Beaufort Sea sediments, so this report presents uncorrected shear strength results. Neither has the consolidation data been corrected to take into account the effects of sample disturbance.

GEOTECHNICAL CONSIDERATIONS

Soft Seabed Soils

Six or eight metres of very soft to soft, highly plastic, homogeneous clay are present at seabed. This unit will have a significant effect on the design and stability of bottom-founded structures. Since there is a transition to fine sand within a few metres of seabed, a reasonable solution to the problems associated with this soft clay can be obtained by simply removing it over those area critical to the stability of a gravity structure. Soundings to establish the depth to sand would be used to specify the thickness of clay that would have to be removed prior to construction.

In order to specify the depth of the subcut required, it is important to bear in mind that all clay would have to be removed. In this instance, the clay bed between 6.9 m and 7.7 m would have a negative effect on foundation stability if it were inadvertently left in place. Therefore, a cutterhead dredge might afford the best means of achieving the required subcut dimensions. If left in place, this clay would drain both upward to the fill and downward into the sand stratum.

Normal Consolidation

Normal consolidation of the seabed soils can be inferred from both the undrained shear strength profile (in silts and clays) and consolidation data to penetrations of at least 70 m. This presents a departure from the overconsolidation that has been inferred at several other locations. Still, the e-log p' curves show definite signs of sample disturbance. Interpretation of consolidation tests on thawed permafrost is less definitive in terms of implied stress history.

Permafrost

Frozen and well bonded silt encountered at a penetration of 70 m implies that for preliminary settlement calculations, a rigid base can be assumed at the permafrost table.

Longterm performance of any gravity structure will require a comprehensive geothermal investigation to assess the impact of any changes in thermal regime that may occur. It may also be necessary to reassess stability under these conditions since any thermal degradation means that the different soil properties will be encountered upon phase change. No attempt has been made to characterize the strength or deformation behaviour of soils encountered in a frozen state in situ.

Sample Disturbance

The consequences of sample disturbance present a strong argument for the continued development of experience with in situ testing devices. Virtually all sampling methods expose the soil to some degree of mechanical disturbance and stress relief. Suitable correction factors can be developed from in situ tests to account for these disturbance effects. With the improvement and standardization of in situ testing techniques, higher quality samples and testing procedures can be developed for use in conjunction with empirical corrections based on performance and experience.

It is considered that thermal disturbance of unfrozen soils has a damaging effect on soil structure. Unfrozen soils exist in situ at temperatures ranging from about +2°C to -1.5°C. These samples can be exposed to temperatures as high as 30°C in transit. Even though the specimens are stored at a temperature of +4°C, tests are routinely performed at +18°C. Temperature increases are known to result in accompanying increases in porewater pressure, and hence, in decreased effective stresses, reduced shear strengths, and volume change (Mitchell and Campanella, 1968). Therefore, this cycling and net increase in sample temperature undoubtedly affects the results of both shear strength and consolidation tests. Frozen soils exist in situ at temperatures ranging from -1.5°C to -6°C, and are routinely stored in a freezer at -18°C for an extended period of time prior to testing in a thawed condition. In this process, moderate to poorly bonded soils become completely frozen. The disturbance associated with subjecting specimens to a complete freeze/thaw cycle can also result in a significant reduction in undrained shear strength.

For the present, it should be noted that both the shear strength and consolidation data reported herein have probably been significantly affected by sample disturbance, so design parameters selected on the basis of these tests should be tempered accordingly. It is clear that some research and development to reduce these effects could be extremely cost effective.

If the issue of disturbance becomes more critical, one alternative to long term research and development of appropriate in situ testing techniques may be to mobilize a modular (trailer) testing facility to Tuktoyaktuk, or even on board the coring vessel. This would permit immediate testing and specialized temperature-controlled sample handling procedures.

Ground Temperatures

To date, core temperatures measured on deck with a hand probe constitute the principal method of collecting soil temperature data. Geotechnical characteristics of these seabed soils are highly temperature-dependent, and it is felt that core temperatures do not accurately represent the in situ thermal regime. Improved drilling techniques combined with in situ temperature measurements could provide representative in situ soil temperature data. Soil temperatures measured in this manner can exert a direct impact on the selection of appropriate geotechnical parameters for design.

Clay Mineralogy

X-ray diffraction data from samples selected throughout the borehole indicate no significant variations in clay mineralogy with depth. Typically, the relative proportions of clay minerals were 65% illite, 30% kaolin, 5% chlorite and occasionally trace amounts of montmorillonite.

Porewater Salinity

Salinities of 35 ppt or higher are typical of the values measured from seabed to a penetration of about 70 m. Below this depth, somewhat lower salinities are indicated. This could reflect a change in depositional environment, but perhaps by coincidence, the change occurs at the transition to bonded permafrost conditions.

Sediment Gases

Methane, ethene, ethane, propane, and I-butane are the hydrocarbon gases that were detected. Methane concentrations of 1 to 260 ppm were measured with most values falling between 1 and 10 ppm. These concentrations are 1 to 2 orders of magnitude greater than for any of the other hydrocarbons detected. The highest methane concentration detected was at the bottom of the borehole.

Methane concentrations measured here are significantly lower than those obtained for samples taken from similar depths at either the Tarsiut or Kaglulik locations.

Methane pressures observed represent the lowest excess pressure that could develop from the biological production of methane. All values obtained were negative, indicating that there is insufficient methane present for bubble formation. Bubble formation in the sediments during sampling would seem to be a reasonable criterion for signalling geotechnical concern regarding gas-charged sediments. In situ, the cold temperature and the presence of frozen sediments at depth has minimized the formation of free gas that might otherwise influence excess pore water pressures; however, this situation can change when large temperature changes occur.