The present study deals with the preparation and microscopic investigations for 56 ditch samples (cuttings), provided from J No. 19 Arif El-Naga. These samples represent the interval from depth 10 to 901 m.

In the following, a short account is given for the results obtained for each of the provided samples.

- Sample , depth 10m

Residue : With rather common presence of planktonic forams as : *Globotruncana aegyptiaca* Nakkady, *G. arca* (Cushman), *G. rosetta* (Carsey), *G. stuarti* (de Lapparent), *Rugoglobigerina macrocephala* (Bronn.), some benthic forams as : *Neofladellina* sp., ITextualria sp., also with presence of valves of ostracoda.

- Sample , depth 20m

Residue : With the same previously mentioned foraminiferal assemblage, but less in abundance.

- Sample , depth 40m

Residue : With some pyrite, chert fragments; almost non-fossiliferous except for some micro-organic debris.

- Sample , depth 50m

Residue : With some gypsum debris, non-fossiliferous except for some shell fragments.

- Sample , depth 70m

Residue : With some shell fragments, chert debris, no free forams.

- Sample , depth 90m

Residue : With some shell remains, rare ostracoda : *Bairdia* sp., absence of free forams.

- Sample , depth 110m

Residue : With rare chert fragments, absence of index microfossils.

- Sample , depth 120m

Residue : Highly crystalline calcareous residue, absence of free micro-fossils.

- Sample , depth 130m

Residue : Highly calcareous, with some valves of ostracoda.

- Sample , depth 140m

Residue : With some shell remains, some valves of ostracoda, chert fragments.

- Sample , depth 150m

Residue : With presence of rare benthic forams : *Textualria* sp.

- Sample , depth 160m

Residue : With presence of some shell fragments, some valves of ostracoda.

- Sample , depth 170m

Residue : With chert, pyrite fragments, some valves of ostracoda, rare shell remains.

- Sample , depth 180m

Residue : With pyrite fragments, valves of ostracoda.

- Sample , depth 190m

Residue : sandy with pyrite fragments, some valves of ostracoda, some shell remains, dwarfed gastropoda.

- Sample , depth 200m

Residue : With pyrite remains, no free forams.

- Sample , depth 210m

Residue : Quartzitic, with presence of shell fragments, pyrite and chert remains, rare valves of ostracoda, some reworked forams.

- Sample , depth 220m

Residue : Quartzitic, with shell remains, some valves of ostracoda.

- Sample , depth 230m

Residue : With pyrite fragments, some valves of ostracoda, rare reworked planktic forams.

- Sample , depth 240m

Residue : With *Hedbergella*sp., *Heterohelix* sp., *Globotruncana* sp., valves of ostracoda : *Planileberis* sp., some other micro-organic remains, pyrite fragments.

- Sample , depth 260m

Residue : Some shell fragments, chert and pyrite remains, rare benthic forams : *Textularia* sp., some valves of ostracoda.

- Sample , depth 280m

Residue : With presence of some ostracoda : *Cytherella* cf., *C. austinensis* Alex., *Cythereis* cf., *C. rawashensis* Van den Bold, pyrite fragments.

- Sample , depth 300m

Residue : With rare reworked ostraoda, some pyrite remains.

- Sample , depth 310m

Residue : With chert and pyrite debris, valves of ostracoda : *Cytherella* sp., *Cythereis* sp.

- Sample , depth 320m

Residue : With rare ostracoda, *Cythereis* sp., rare pyrite fragments.

- Sample , depth 330m

Residue : With rare ostracoda, *Paracypris* sp., no other free microfossils.

- Sample , depth 340m

Residue : With pyrite fragments, rare ostracoda, *Cytherella* sp., no other free microfossils.

- Sample , depth 358m

Residue : Non-fossiliferous.

- Sample , depth 360m

Residue : With rare arenaceous forams, *Pseudocyclammina* sp., and some other reworked tests.

- Sample , depth 370m

Residue : Calcareous, dolomitic, with some chert fragments, some pyrite remains, devoid of free microfossils.

- Sample , depth 390m

Residue : Dolomitic limestone with some pyrite fragments, devoid of index microfossils.

- Sample , depth 408m

Residue : Calcareous dolomitic, with some chert fragments, rare macro-invertebrate shell remains, echinoid spines, no inde forams.

- Sample , depth 430m

Residue : Calcareous, quartizitic, with some chert, pyrite fragmetns, rare valves of ostracoda : *Planileberis* sp., rare planktic forams : *Hedbergella* sp.

Age : Cenomanian or late Turonian

- Sample , depth 450m

Residue : Calcareous, with presence of some reworked planktics, rare ostracoda, *Cytherella* sp.

- Sample , depth 468m

Residue : Dolomitic, with some chert fragments, rare pyrite remains, devoid of index free microfossils.

- Sample , depth 480m

Residue : Calcareous with some valves of ostracoda, *Bythocypris* sp., *Metacytheropteron berbericum* (Bassoullet and Damotte), *Paracypris* sp., *Dolocytherida atlasica* Bass. and Dam., small gastopoda.

- Sample , depth 495m

Residue : Calcareous, with some pyrite fragments, valves of ostracoda, *Cytherella ovata* (Roemer), *Dolocytherida atlasica* Bassoullet and Damotte.

- Sample , depth 510m

Residue : Dolomitic, with pyrite fragments, valves of ostracoda, *Bairdia* sp., *Metacytheropteron berbericum* (Bassoullet & Damotte), *Cytherella* sp., some small gastropoda, some other shell remains.

- Sample , depth 520m

Residue : Calcareous, with pyrite fragments, some valves of ostracoda, *Paracypris* so.

- Sample , depth 530m

Residue : Dolomitic, with some pyrite fragments, and some shell remains.

- Sample , depth 540m

Residue : Sandy, glauconitic, with calcareous and pytite fragments, some small gastropoda, some arenaceous forams, *Pseudocyclammina* sp.

- Sample , depth 552m

Residue : Glauconitic, quartzitic, with some shell fragments, chert remains, pyrite debris.

Age : This horizon probably belongs to Early Cenomanian.

- Sample , depth 715m

Residue : Sandy with iron oxides, pyrite and chert remains.

Age : Lower Jurassic may be assigend starting from this sample and the following samples until depth, 901m, as matched by the study presented by Allam & Khalil (1988).

- Sample , depth 780m

Residue : Quartzitic, with some pyrite fragments, devoid of index micro-organic remains.

- Sample , depth 790m

Residue : Quartzitic, with presence of some holothuroid ? pyritic remains.

- Sample , depth 805m

Residue : Shaley, silicified, with some gypsum and pyrite fragments, absence of index microfossils.

- Sample , depth 815m

Residue : Shaley, highly pyritic, sandy, non-fossiliferous.

- Sample , depth 830m

Residue : Shaley, quartzitic, with some small gastopoda, some chert debris.

- Sample , depth 838m

Residue : Shaley, pyritic, with chert fragments, slightly sandy, non-fossiliferous.

- Sample , depth 845m

Residue : Shaley, quartzitic with pyrite and other various rock fragments, non-fossiliferous.

- Sample , depth 855m

Residue : Shaley, quartzitic, chert, pyrite and various rock fragments, slightly sandy, with some macro-invertebrate remains and small gastropoda.

- Sample , depth 867m

Residue : Sandy, chert fragments, iron stained rock fragments.

- Sample , depth 874m

Residue : Sandy, rare echinoid remains, some pyrite fragments.

- Sample , depth 885m

Residue : Sandy, with chert and pyrite fragments, non-fossiliferous.

- Sample , depth 895m

Residue : Sandy, carbonaceous with some pyrite fragments, non-fossiliferous.

- Sample , depth 901m

Residue : Carbonacoeous, quartzitic, with some pyrite fragments non-fossiliferous.

The best possible figured determination for these stages could be summarized as follows:

from	10 - 240m	Maastrichtian - Santonian
	240 - 430m	Coniacian - Turonian
	430 - 552m	Cenomanian
	552 - 715m	Lower Cretaceous
	715 - 901m	Lower Jurassic

TECHNICAL REPORT

III

GRAIN SIZE ANALYSIS OF LOWER CRETACEOUS

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1 INTRODUCTION

The Lower Cretaceous formation outcrops in south Sinai covering considerable areas overlain Palaeozoic rocks. The formation extends east and west on the scarp face of El Tih Plateau and are overlain by Cenomanian limestone. It consists mainly of quartzose sandstone of different grain size, due to the contental facies. This formation is about 200 to 300 meter thick and gently dips to north. The Lower Cretaceous formation is overlain by Upper Cretaceous and Eocene sediments at the El Teh and Egma Plateau.

The Lower sandstone occasionally appears in certain areas in north Sinai due to the tectonic movements. Some outcrops of Lower Cretaceous are observed at many domes and along fault structures.

Although some test wells were sunk to the Lower Cretaceous aquifer to determine the physical properties, the number of the test wells is limited considering the extension of the Lower Cretaceous over the study area (Section 7-3-3, Technical Report I).

In order to draw a general feature of continuity, homogeneity and change in facies of the sandstone of the Lower Cretaceous, detailed description of geologic columns were undertaken at 11 sites, and the rock samples of these sandstones were obtained for grain size analysis. The distribution of the grain size is a one of clues to estimate the permeability of the strata.

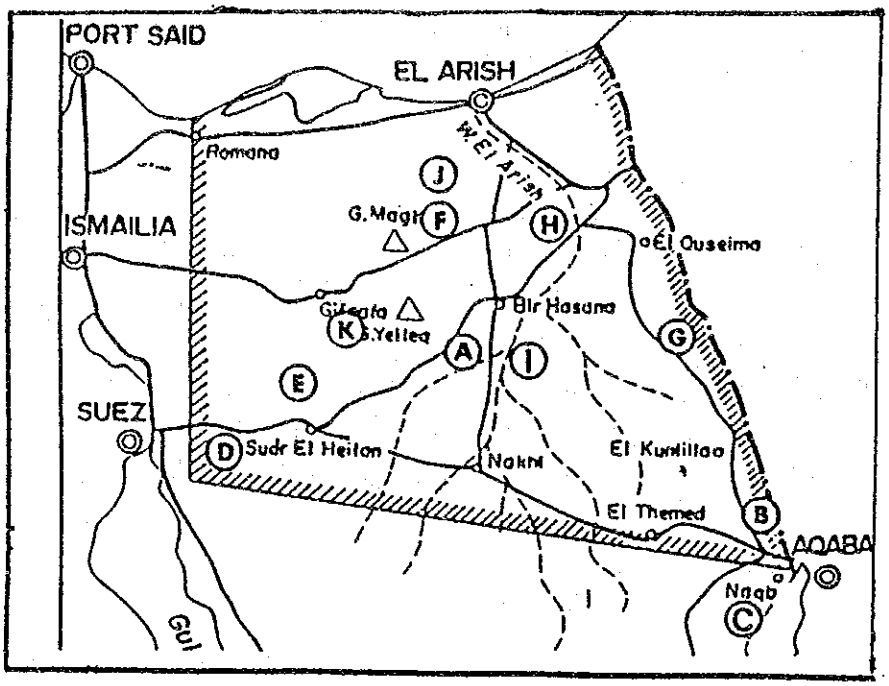
It is intended to evaluate hydrogeological properties of the Lower Cretaceous aquifer by the comparison of the results of aquifer test and grain size analysis.

2 SAMPLING SITES

The location of the outcrops of the Lower Cretaceous in the study area is listed below;

Location	Number of Sampling Sites
Maghara (G. Maghara, G. Mafruth)	2
Yelleq (G. Falig)	1
Halal	1
Kherim	1
Minshera	1
Giddi	1
Raha	1
Arif El Naga	1
Naqb (East to Wade Watir, G. Alada)	2
Total	11

According to the results of the detailed geological field investigation of these outcrops, eleven sampling sites are selected. The outcrops at Raha and Giddi are narrow and compact so that these samples are discarded for the grain size analysis. Detailed lithological columns are recorded. Location of these outcrops is shown in Fig 2-1.



A : G. Minshera
B : G. Alada
C : East To Wadi Watir
D : G. Raha
E : G. Giddy
F : G. Maghara
G : Arif El Naga
H : G. Halal
I : G. Kherim
J : G. Mafruth
K : G. Falig

FIG 2-1 SAMPLING SITES

3 GEOLOGICAL DESCRIPTION OF SAMPLING SITES

3-1 Introduction

Although detailed geological descriptions are given in the Chapter 6, Geology of the Main Report, the geological spatial conditions are summarized in the following part of this section.

3-2 Gebel Minshera

Gebel Minshera is formed as an elongated dome structure with trend in a N80°E direction disrupted by the fault at the northern side. The sandstone of the Lower Cretaceous is observed in 300 m thick, overlaying the rocks of the Jurassic land overlain by the limestone of the Upper Cretaceous. The Jurassic consists of limestone, sandstone and shale which are observed in the center of the dome structure.

3-3 Gebel Alada

Gebel Alada is located at the northern side of the Ragalet El-Naam Fault. In this area, the Lower and the Upper Cretaceous are gently tilting toward NW direction. The outcrop of about 100 meter thick Lower Cretaceous is observed, however, the lower limit is unidentifiable.

3-4 East to Wadi Watir

This site is located at about 10 km south from the Naqb Air Port where a gently undulating plateau on the Upper Cretaceous is steeply incised toward the Gulf of Aqaba. The sandstones of the Lower and the Upper Cretaceous are gently tilting toward NW to W direction unconformably underlain by the Precambrian rocks.

3-5 Gebel Raha

This is a dome structure located in the south west of Sadr El Heitan. Different formations varying from the Jurassic to the Tertiary are observed, however, the thickness of the Lower Cretaceous is only 40 m in the outcrop since the outcrop is dissected by many faults.

3-6 Gebel Giddi

This site is located in the graben between Gebel El Heitan and Gebel Hamra at 20 km from Sadr El-Heitan to the northwest. The strata gently tilt toward the east to north east direction and formations from the Lower Cretaceous to the Tertiary are observed, although the Lower Cretaceous encounters only the top 15 m at the outcrop.

3-7 Gebel Maghara

This site is located at the southern fringe of the dome structure 3 km west from the outlet of the Wadi Hama at the Gebel Maghara.
The thickest Jurassic is observed in the center of the dome under the outcrops of the Lower Cretaceous and limestone of the Upper Cretaceous and Eocene. However, the boundary between the Jurassic and the Lower Cretaceous is covered by the sand dunes and the Quaternary deposits. The Lower Cretaceous is observed in 180 m thick at this site.

3-8 Gebel Arif El Naga

This site is located on the inner wall of the dome structure. The Triassic and the Jurassic are observed in the core. The Lower and the Upper Cretaceous outcrops are observed in the inner wall of the dome. Although the boundary between the Lower Cretaceous and the Jurassic is covered by the Quaternary deposits, a 300 m thick outcrop of the Lower Cretaceous is exposed.

3-9 Gebel Halal

This site is located in the dome structure of the Gebel Halal which is also a large dome structure as the Gebel Maghara. The central part of the dome is heavily eroded and the Lower Cretaceous is exposed. The thickness of the Lower Cretaceous is estimated at more than 600 m. The boundary with the Jurassic is under the deposits of debris.

3-10 Gebel Kherim

This site is located in the dome structure 6 km from Hasana to the southeast. The central part of the dome is heavily eroded and the Lower

Cretaceous is exposed. On the eroded wall of the dome, the limestone of the Upper Cretaceous is observed overlying the Lower Cretacecous. The thickness of the Lower Cretaceous in the outcrop is 250 m. The bottom is covered by the debris.

3-11 Gebel Mafruth

This site is located on the inner cliff of the northern side of the dome. On this cliff, the Lower Cretaceous and the Upper Cretaceous are observed gently tilting toward the north. The thickness of the Lower Cretaceous is over 245 m.

3-12 Gebel Falig

This site is located in the dome structure in the northwest of the Gebel Yelleq. In the core of the dome, about 30 m thick Lower Cretaceous is exposed and overlain by the limestone of the Upper Cretaceous. The bottom of the Lower Cretaceous is below the ground surface.

4 GRAIN SIZE ANALYSIS

4-1 Introduction

Prior to the collection of the rock samples, detailed litho-stratigraphic columns are recorded at each sampling site (see Attachment). It is empirically known that the grain size distribution generally correlate with the permeability of the stratum, so that 20% value of the accumulation curve of the grain size distribution (D_{20}) is obtained to estimate the permeability of each sampled section. Finally, above mentioned litho-stratigraphic columns are evaluated their nature as an aquifer by interpreting by the grain size distribution and estimated permeability.

4-2 Analysis

4-2-1 Samples

Prior to sampling rocks, the route map is constructed and the true thickness is estimated referring to the dip and strike. Rock samples are collected in each 2 to 3 m intervals of the true thickness. A total of 1,400 rock samples are collected at 720 sampling points in 11 sites including some duplicate samples;

Table 4-1 Samples and Sampling Sites

Site number	Site name	Thickness observed	Number of sampling point
A	Gebel Minshera	327 m	102
B	Gebel Alada	116 m	58
C	Easet to Wadi Watir	192 m	62
D	Gebel Raha	42 m	22
E	Gebel Giddi	14 m	6
F	Gebel Maghara	178 m	57
G	Gebel Arif El Naga	290 m	106
H	Gebel Halal	665 m	114
I	Gebel Kherim	239 m	114
J	Gebel Mafruth	245 m	68
K	Gebel Falig	30 m	11

The sieve analysis is undertaken at the laboratory of the Suez Canal University in order for determination the grain size distribution.

Table 4-2 Classification of Grain Size

over 4 mm	:	Gravel
4 - 2 mm	:	Granule
2 - 1 mm	:	Very Coarse Sand
1 - 0.5 mm	:	Coarse Sand
0.5 - 0.25 mm	:	Medium Sand
0.25 - 0.125 mm	:	Fine Sand
0.125 - 0.063 mm	:	Very Fine Sand
under 0.063 mm	:	Clay and Silt

Based on the obtained D_{20}, the permeability of each sample is estimated according to the table shown below:

Table 4-3
Correlation of D_{20} with Permeability

D_{20} (mm)	k (cm/sec)	Classification	D_{20} (mm)	k (cm/sec)	Classification
0.005	3.00E-06	clay	0.18	6.85E-03	
0.01	1.05E-05		0.20	8.90E-03	fine sand
0.02	4.00E-05	silt	0.25	1.40E-02	
0.03	8.50E-05		0.30	2.20E-02	
0.04	1.75E-04		0.35	3.20E-02	
0.05	2.80E-04		0.40	4.50E-02	
0.06	4.60E-04		0.45	5.80E-02	medium sand
0.07	6.50E-04	very fine	0.50	7.50E-02	
0.08	9.00E-04	sand	0.60	1.10E-01	
0.09	1.40E-03		0.70	1.60E-01	
0.10	1.75E-03		0.80	2.15E-01	coarse sand
0.12	2.60E-03		0.90	2.80E-01	
0.14	3.80E-03	fine sand	1.00	3.60E-01	
0.16	5.10E-03		2.00	1.80E+00	fine gravel

K : permeability coefficient (cm/sec)
D20 : 20% value of accumulation curve of grain size distribution (mm)

4-2-2 Litho-stratigraphic Column

The geological columns were recorded on the site when samples were collected, and were interpreted with the results of the sieve analysis to complete the litho-stratigraphic column of each site (Attachment).

Description items given to the litho-stratigraphic column are:

1) Thickness of each bed
2) Lithology
3) Grain size description
4) Passing D_{20}
5) Permeability

5 GRAIN SIZE DISTRIBUTION

According to the results of the analysis, the general feature of the grain size distribution of the sandstone of the Lower Cretaceous is summarized as described below:

1) Gebel Minshera(Column-A) (Page III-21)

* The sandstone of the Lower Cretaceous consists of quartz sand intercalated with limestone. Sandstone facies in 80 m thickness appears at the base of the Cenomanian.

* Thin shale layer less than 10 m thickn is observed at some places in the upper part of the Lower Cretaceous.

* The sandstone consists mainly of medium sand and the matrix hardly contains silt and clay.

* Cross-bedding is commonly observed.

* Very coarse sand and granule are predominating from 180 m to 327 m from the top of the Lower Cretaceous.

* Clay in the matrix tends to be accompanied by very fine and fine sand rather than coarse sand.

2) Gebel Alada(Column-B) (Page III-25)

* The intercalation of limestone and sandstone is observed at the base of the Cenomenian of the Upper Cretaceous. The thickness is less than 10 m which is much thiner than that observed at Gebel Minshera.

* The sandstone consists of predominating medium and fine sands.

* Relatively thick silt is observed at the top 20 m, however silt is hardly contained in the lower part of the top 20 m.

* Shale is rarely observed.

* A 10 m thick fine sand bed encounters between 40 m and 50 m from the top.

* Cross bedding is commonly observed in the sandstone of the Lower Cretaceous.

3) Gebel Al Mostadul(Column-C) (Page III-27)

* No intercalation of the limestone and sandstone is observed at the base of the Cenomanian of the Upper Cretaceous.

* Down to 10 m from the top, medium to coarse sand predominate intercalating with occasional granule and gravel. The portion of silt and clay increases from the depth of 120 m toward the lower part. Cross beddings are also commonly observed in this part.

* Granule and gravel predominate at 180 m from the top.

* The Lower Cretaceous unconformably overlays the Precambrian rocks.

4) Gebel Raha (Column-D) (Page III-29)

* The sandstone consists of fine sand and coarse sand. The former predominates in the column. No interbed of thin shale is observed.

* Samples of this site was so solid that no grain size analysis by the sieve test was carried out. Therefore, the porosity was measured by comparing the specific gravities in moist and dry samples;

Table 4-4 Porosity of Rock Samples

Sample number	Porosity (%)
D1	3.28
D3	13.38
D5	9.09
D7	10.22
D8	13.73
D9	10.62
D10	7.53
D11	16.57
D13	8.21
D15	14.75
D16	17.16

5) Gebel Giddi (Column-E) (Page III-30)

Sandstone consists of fine sand with occasional coarse sand. This bed was consolidated so that the porosity was measured instead of the sieve analysis;

Table 4-5 Porosity of Rock Sample

Sample number	porosity (%)
E1	5.72
E3	4.48
E6	7.77

6) Gebel Maghara(Column-F) (Page III-31)

* A intercalation of shale and sandstone is observed at the top 110 m. The sandstone in this alternation consists of fine sand and smaller particles.

* The proportion of the sandstone in the alternation increases more than that in the above layer. The sand increases in size to coarse to medium sand.

* Cross bedding is commonly observed through the column. Sand larger than 1mm diameter is hardly observed.

7) Gebel Arif El Naga(Column-G) (III-33)

* A intercalation of sandstone and limestone is observed at the base of the Cenomanian.

* In general, fine sandstone predominates over the Lower Cretaceous. Shale are observed between 140 m and 180 m from the top of the Lower Cretaceous.

* Cross bedding is commonly observed.

* Matrix composed of silt and clay is observed in the fine to medium sand rather than coarse sand.

8) Gebel Halal (Column-H) (Page III-36)

* A more than 600 m thick Lower Cretaceous is identified at this site. Intercalation of limestone and sandstone is observed at the base of the Cenomenian.

* Medium to fine sands predominate with frequent shale of less than 5 m thick in the upper 140 m from the top.

* A thick shale encounters between 145 m and 255 m from the top partly covered by the Quaternary. Further down most of the part is covered by the Quaternary deposit, however where it is exposed frequently shale is observed.

* Matrix of silt and clay is observed in the calcareous sandstone.

9) Gebel Kherim(Column-I) (Page III-43)

* Medium to coarse sands are predominating over the profile and shale less than 10 m thick appears at 80 m and 95 m from the top.

* Shale encounters occasionally in the upper 105 m from the top, however no shale appears further below.

* All samples contain coarse sands more than 1 mm of grain size to a certain extent.

10) Gebel Mafruth(Column-J) (Page III-46)

* The outcrop of the Lower Cretaceous is recognized down to 250 m from the top, however the bottom is unidentifiable. Medium and coarse sands predominate over the section and matrix hardly contains silt.

* Intercalation of sandsstone and limestone is observed at the base of the Upper Cretaceous.

* Shale appears at the upper part in 30 m thick and occasionally a thin shale with less than 10 thickness encounters in the lower part of the outcrop and also limestone encounters. The maximum thickness of the limestone reaches 10 m.

* Granule and gravel are commonly observed in the coarse sand.

11) Gebel Falig(Column-K) (Page III-49)

* The Lower Cretaceous is identified for 30 m below the base of the Cenomenian, the rest is covered by the Quaternary deposits.

* The sandstone consists of very fine to fine sands and consolidated with silt and clay matrix. Sands with more than 1mm diameter is hardly observed.

6 EVALUATION OF SANDSTONE AQUIFER OF LOWER CRETACEOUS

6-1 Geological Characteristics of Sandstone of the Lower Cretaceous

Based on the above analysis, a general feature of the sandstone of the Lower Cretaceous is observed.
In general, the sandstone consists of predominating medium to coarse sands of which grain size is between 0.25 mm and 1.0 mm. Crossbeds are often observed in the sandstone especially in the fine sandstones.

The whole sequence of the Lower Cretaceous is recognized at five sites; Gebel Minshera, Arif El Naga, Kherim, Maghara and Mafruth. The thickness of the Lower Cretaceous at these sites varies from 200 m to 300 m. However, the thickness of the Lower Cretaceous is more than 600 m only at Gebel Halal.

At Gebel Halal a thick shale bed is observed at the middle to lower part of the section, however the interbedded shale in the sandstone is observed only occasionally and their thickness rarely reaches 10 m.
In the south of Naqb area siltstone or claystone are occasionally interbedded in the sandstone instead of shale.

The continuity of the stratigraphic sequence among these sampling sites is not proofed, however a general feature of the Lower Cretaceous is summarized that the sandstone is predominating throughout this formation with occasional interbeds of lenticular shale and the size of the sand granule varies even in a single bed. However, this sandstone is porous to a certain extent.

The medium to coarse sands predominating in the sandstone hardly contain matrix and even very fine to fine sands contain matrix only to a certain extent.

6-2 Hydrogeological Characteristics of Sandstone of Lower Cretaceous

Majority of the estimated permeability coefficients by the grain size analysis is in a range between 10^{-2} cm/sec and 10^{-3} cm/sec which is recognized as a favorable property of the aquifer from a hydrogeological point of view.

Each sample is collected in 2 to 3 m intervals so that the estimated permeabilities are classified in the following criteria by each 50 m thickness of the sequence;

1) The layer of which permeability coefficient is more than 10^{-3} cm/sec,
2) The layer of which permeability is less than 10^{-3} cm/sec,
3) The layer of which sample is not collected because it is so hard and
4) The layer of which facies is shale or covered by debris.

The percentage of the total thickness of the above classified layers in each 50 m thick column at each sampling site is shown in Fig 6-1. The percentage of the thickness of shale in each 50 m thick column is also shown on the left side of the diagram.

The top 100 m to 150 m bed at Halal and Arif El-Naga consists of highly permeable sandstone. The section lower than 150 m from the top is occupied by impermeable shale at Halal and there is an another permeable bed between 200 m and 250 m from the top at Arif El-Naga.

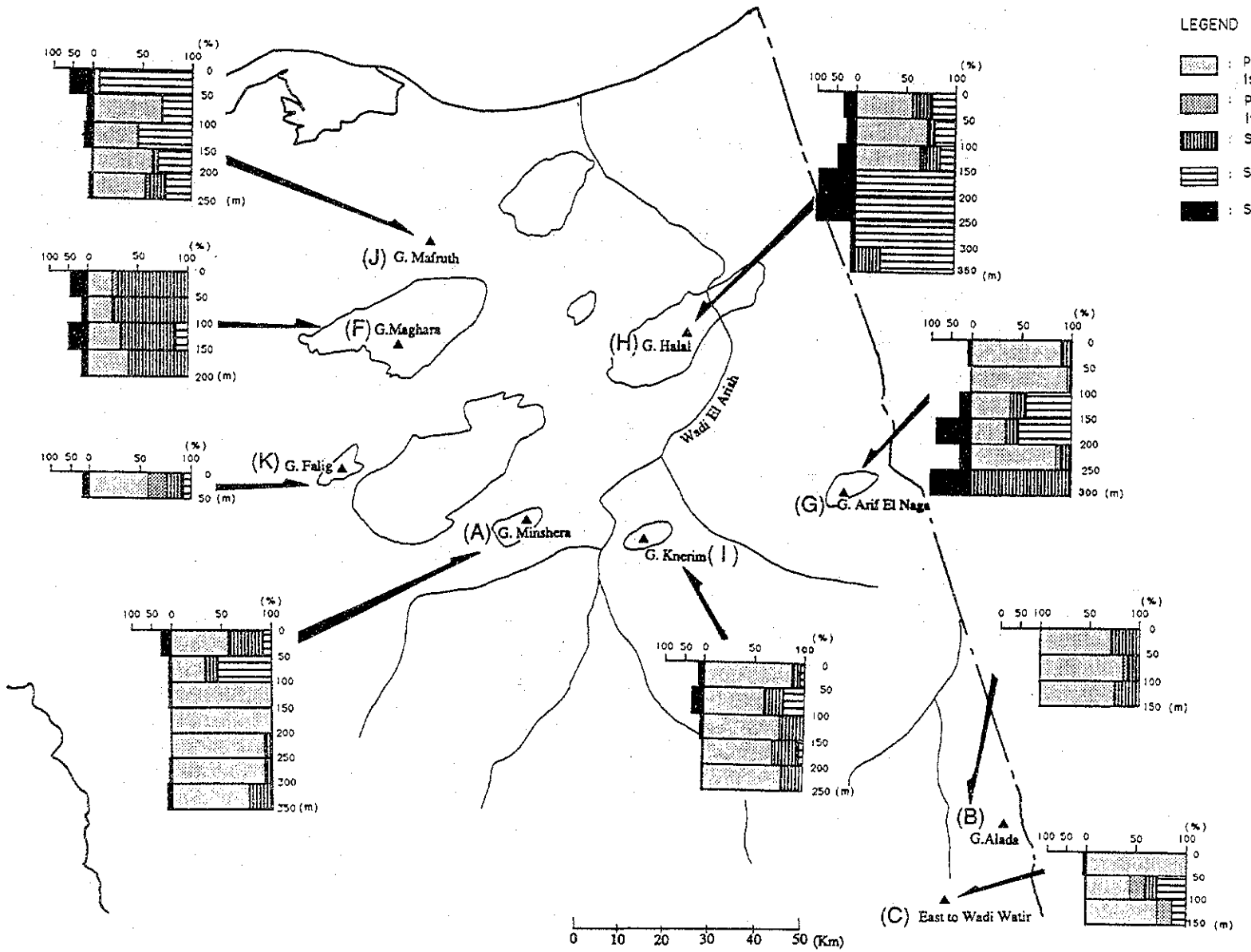


Fig. 6-1 DISTRIBUTION OF PERMEABILITY OF EACH 50m LAYERS

There is impermeable bed at the top 50 m at Mafruth, however almost 50 % of the section consists of permeable sandstone. The permeable sandstone consists only 20 to 40 % of the section and shale occupies greater part of the section at Maghara. These two sites may represent the lithological sequence in the northern part of the study area.

Although the observed thickness of the geological sequence is only 50 m at Falig, most of the geologic column sequence is occupied by the permeable sandstone at Falig, Minshera and Kherim distributing in the central part of the study area. The shale appears in the upper part of the section at these site, however it is a kind of a thin lenticular type.

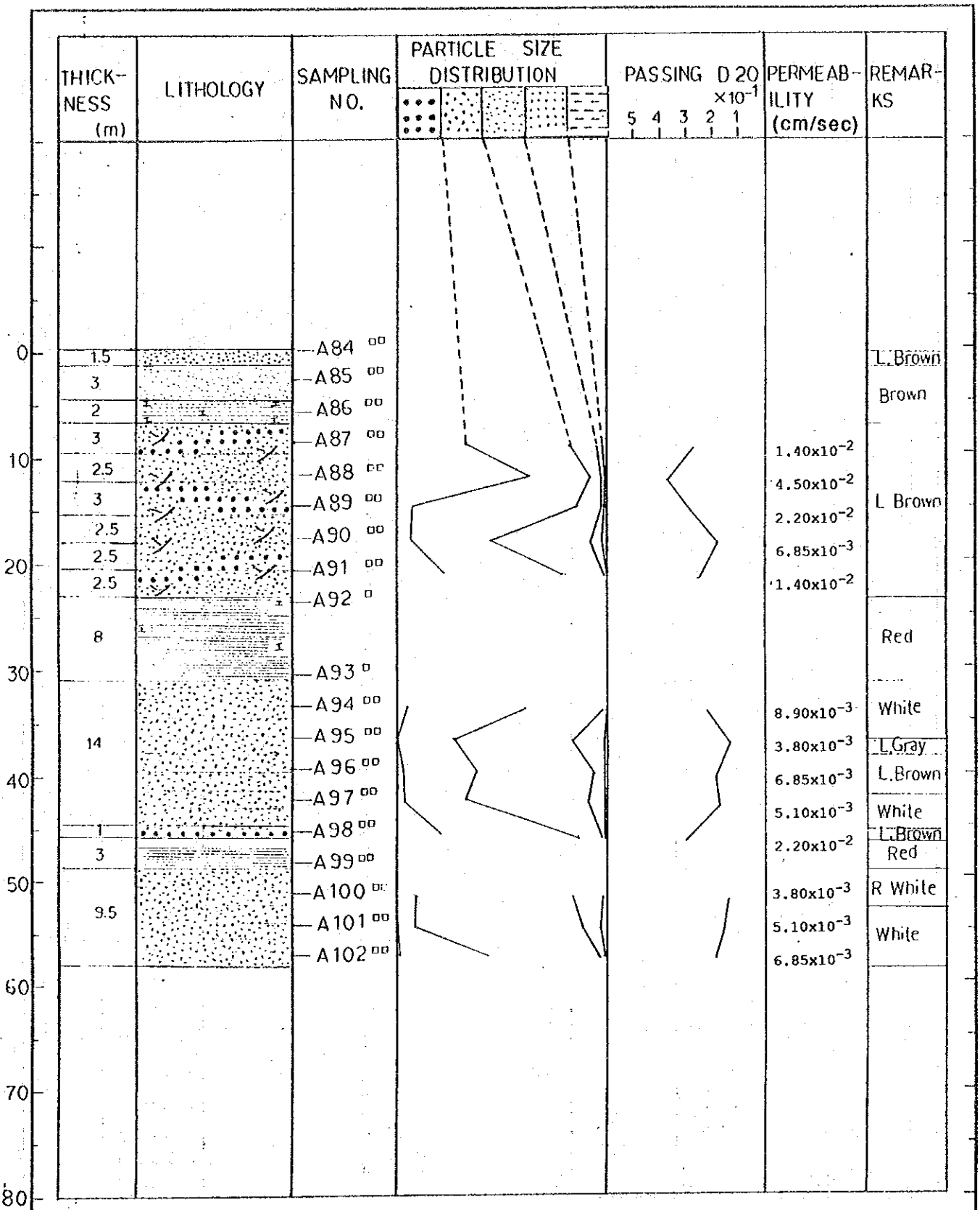
In the southeastern area of the study area at Alada and East to Wadi Watir the shale is hardly observed and almost of whole section is occupied by the permeable sandstone.

In conclusion, it would be summarized that the Lower Cretaceous sandstone consists mainly of a thick sequence of medium to coarse quartzose sandstone, sandy clay interbedded with shale and clay beds in study area. In the northern area thick shale beds appears in a part of the formation. In the central area the sandstone sequence is observed through the whole section interbedded with thin shale, however these are lenticular, discontinuous. In Naqb, the southeastern corner of the study area, the Lower Cretaceous sandstone consists of pure sandstone.

ATTACHMENT

LITHO-STRATIGRAPHIC COLUMNS

No. 1



1/500

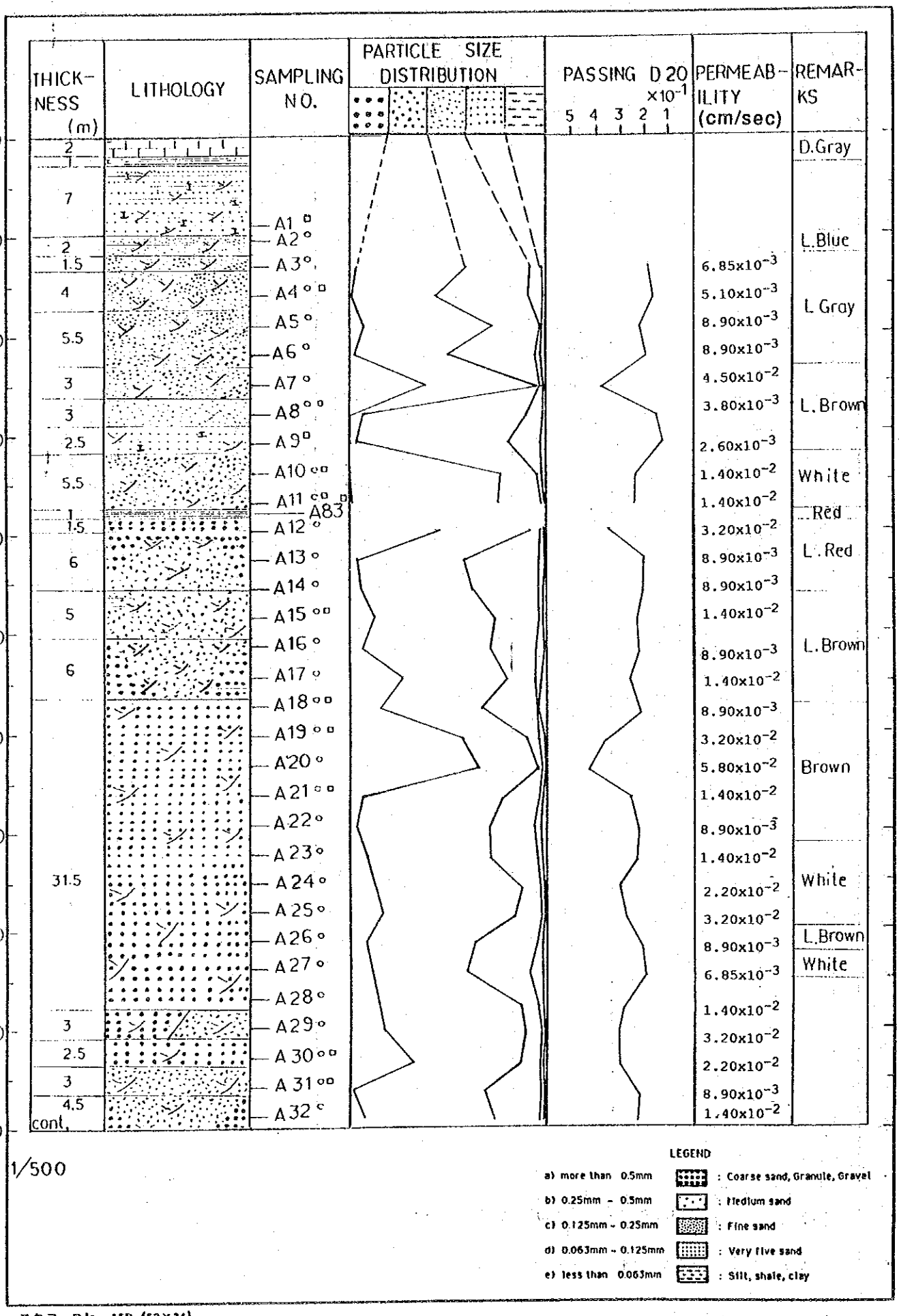
LITHO-STRATIGRAPHIC COLUMN-A

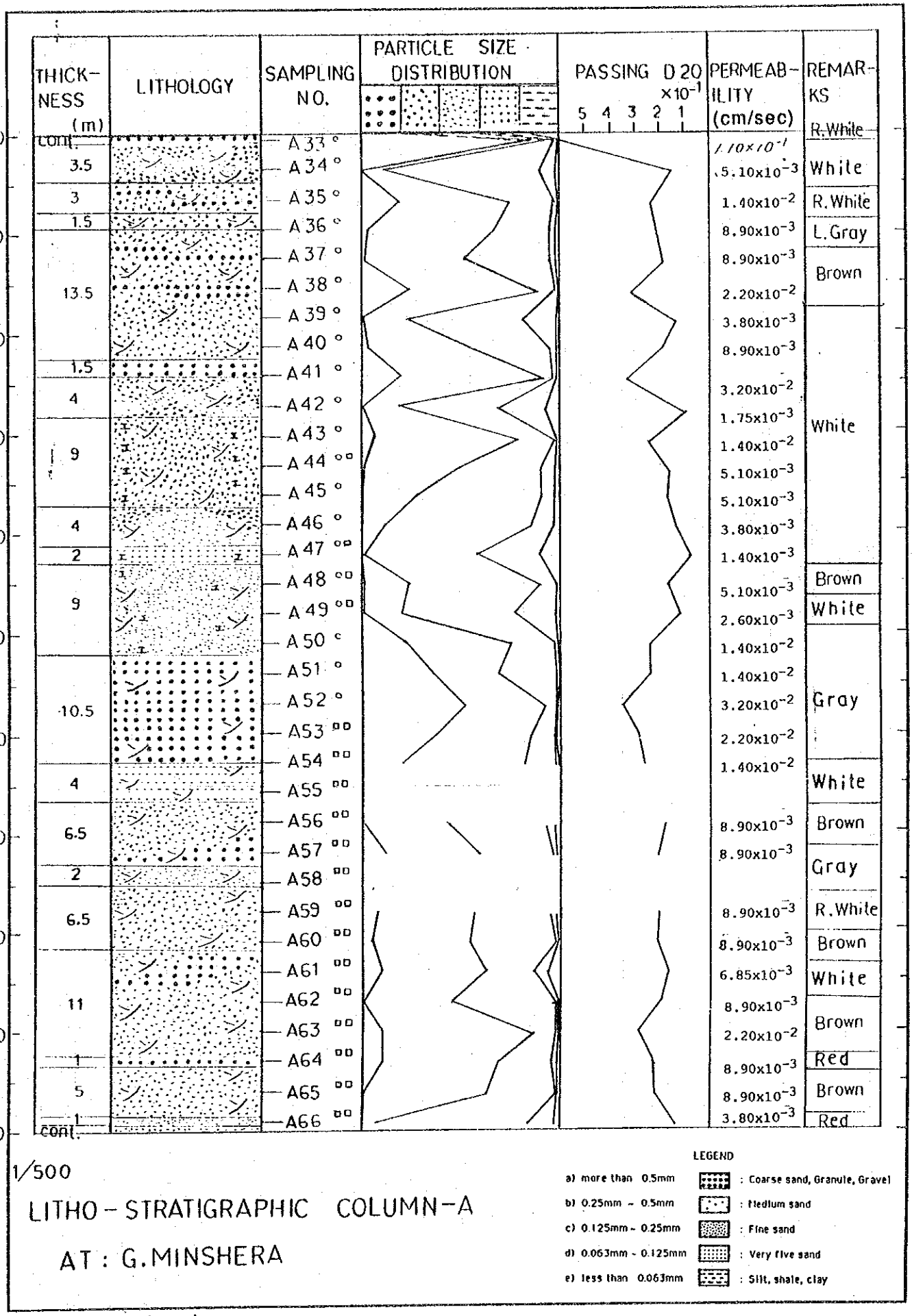
AT : G. MINSHERA

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

No. 2


THICK-NESS (m)
LITHOLOGY
SAMPLING NO.
PARTICLE SIZE DISTRIBUTION
PASSING D 20 ×10⁻¹
5 4 3 2 1
PERMEAB-ILITY (cm/sec)
REMAR-KS
80
90
100
110
120
130
140
150
160
170
180
2
1
7
2
1.5
4
5.5
3
3
2.5
5.5
1
1.5
6
5
6
31.5
3
2.5
3
4.5
cont.
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A83
A12
A13
A14
A15
A16
A17
A18
A19
A20
A21
A22
A23
A24
A25
A26
A27
A28
A29
A30
A31
A32
6.85x10⁻³
5.10x10⁻³
8.90x10⁻³
8.90x10⁻³
4.50x10⁻²
3.80x10⁻³
2.60x10⁻³
1.40x10⁻²
1.40x10⁻²
3.20x10⁻²
8.90x10⁻³
8.90x10⁻³
1.40x10⁻²
8.90x10⁻³
1.40x10⁻²
8.90x10⁻³
3.20x10⁻²
5.80x10⁻²
1.40x10⁻²
8.90x10⁻³
1.40x10⁻²
2.20x10⁻²
3.20x10⁻²
8.90x10⁻³
6.85x10⁻³
1.40x10⁻²
3.20x10⁻²
2.20x10⁻²
8.90x10⁻³
1.40x10⁻²
D.Gray
L.Blue
L.Gray
L.Brown
White
Red
L.Red
L.Brown
Brown
White
L.Brown
White
1/500
LEGEND
a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay



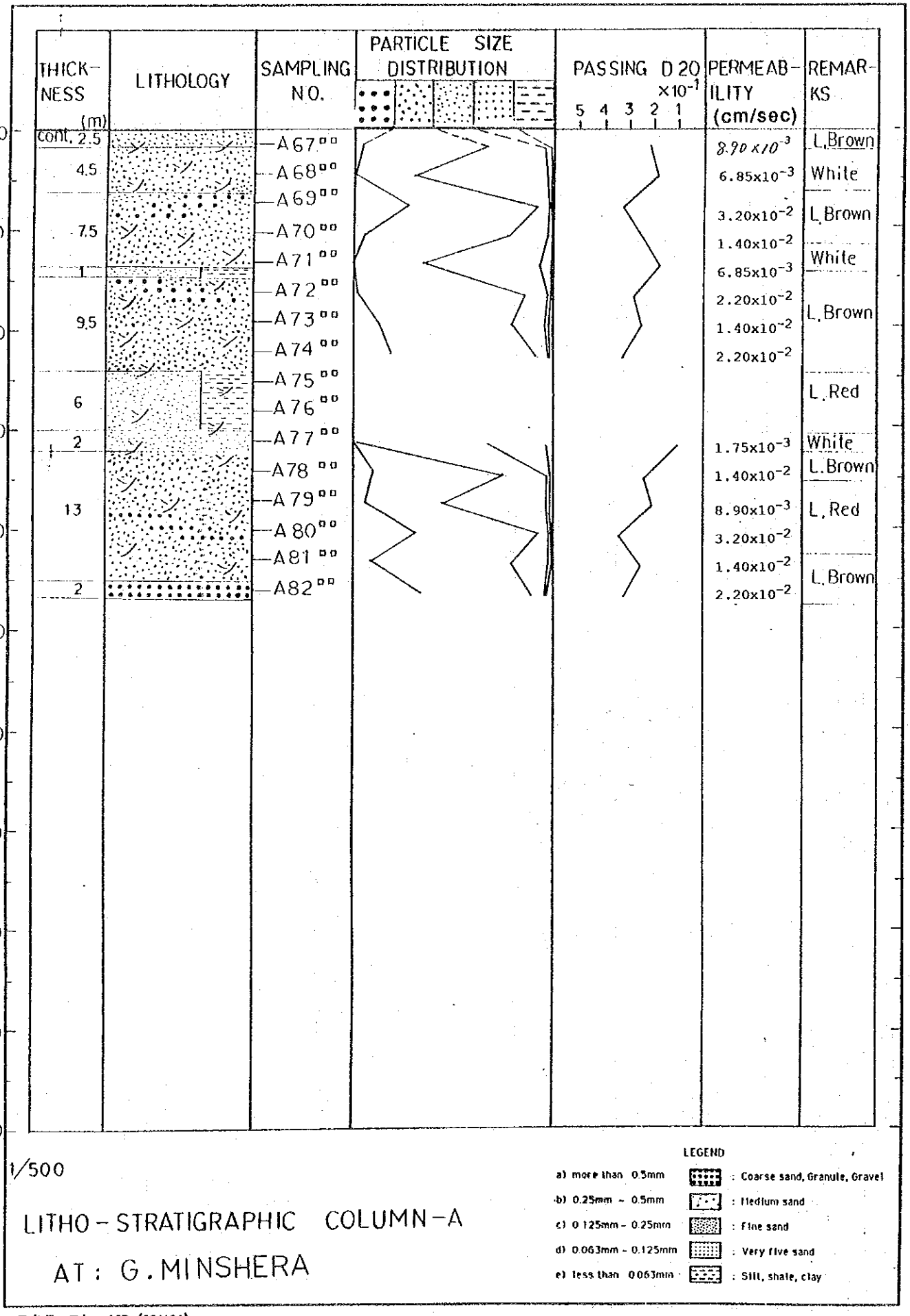
1/500

LITHO - STRATIGRAPHIC COLUMN-A

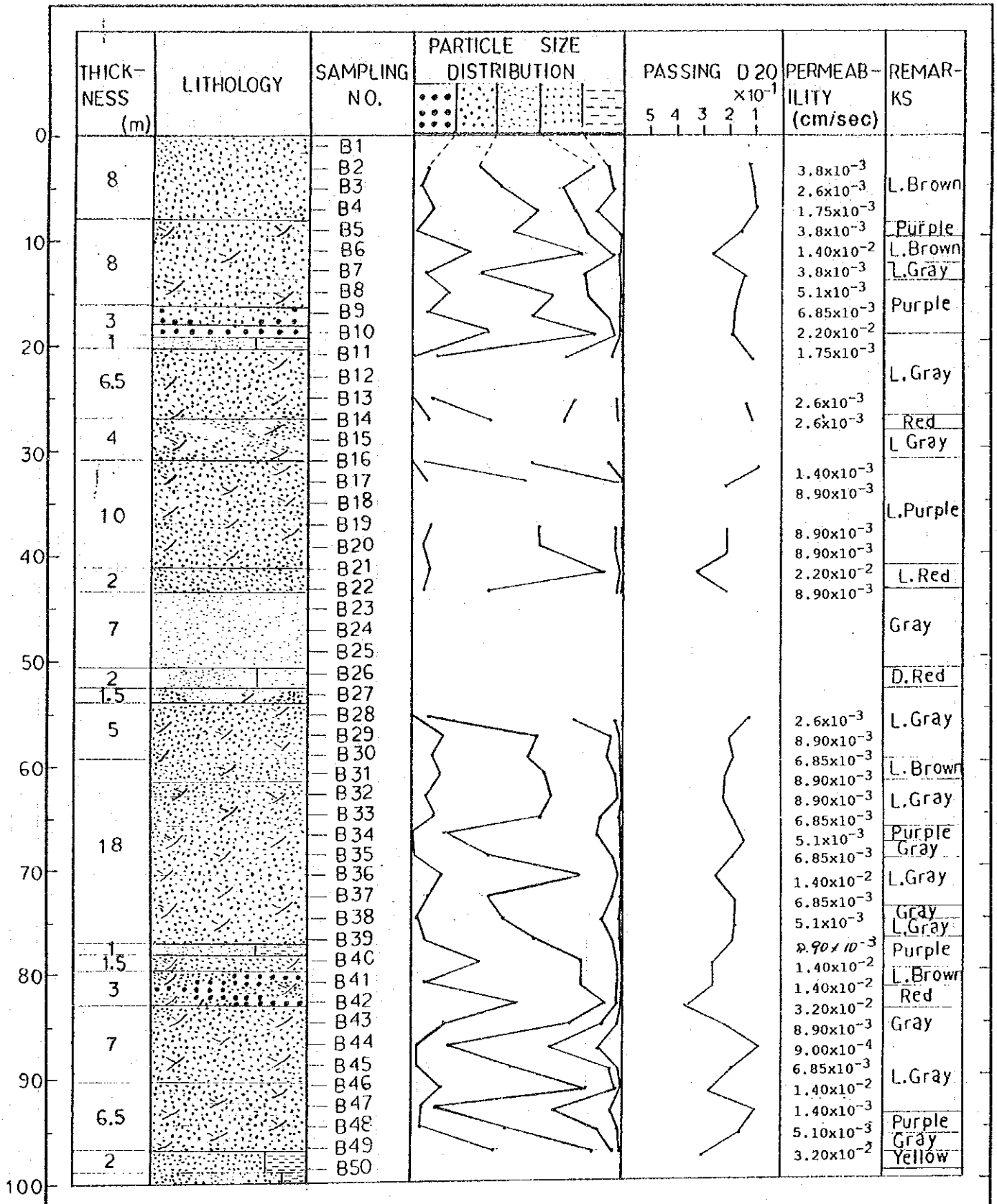
AT : G.MINSHERA

LEGEND

a) more than 0.5mm		: Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm		: Medium sand
c) 0.125mm ~ 0.25mm		: Fine sand
d) 0.063mm ~ 0.125mm		: Very fine sand
e) less than 0.063mm		: Silt, shale, clay


THICK-NESS (m)
LITHOLOGY
SAMPLING NO.
PARTICLE SIZE DISTRIBUTION
PASSING D 20 ×10⁻¹
5 4 3 2 1
PERMEAB-ILITY (cm/sec)
REMAR-KS
280
290
300
310
320
330
340
350
360
370
380
cont. 2.5
4.5
7.5
1
9.5
6
2
13
2
A67
A68
A69
A70
A71
A72
A73
A74
A75
A76
A77
A78
A79
A80
A81
A82
8.90 x10⁻³
6.85x10⁻³
3.20x10⁻²
1.40x10⁻²
6.85x10⁻³
2.20x10⁻²
1.40x10⁻²
2.20x10⁻²
1.75x10⁻³
1.40x10⁻²
8.90x10⁻³
3.20x10⁻²
1.40x10⁻²
2.20x10⁻²
L.Brown
White
L.Brown
White
L.Brown
L.Red
White
L.Brown
L.Red
L.Brown
1/500
LITHO - STRATIGRAPHIC COLUMN - A
AT : G. MINSHERA
LEGEND
a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

No. 1



1/500

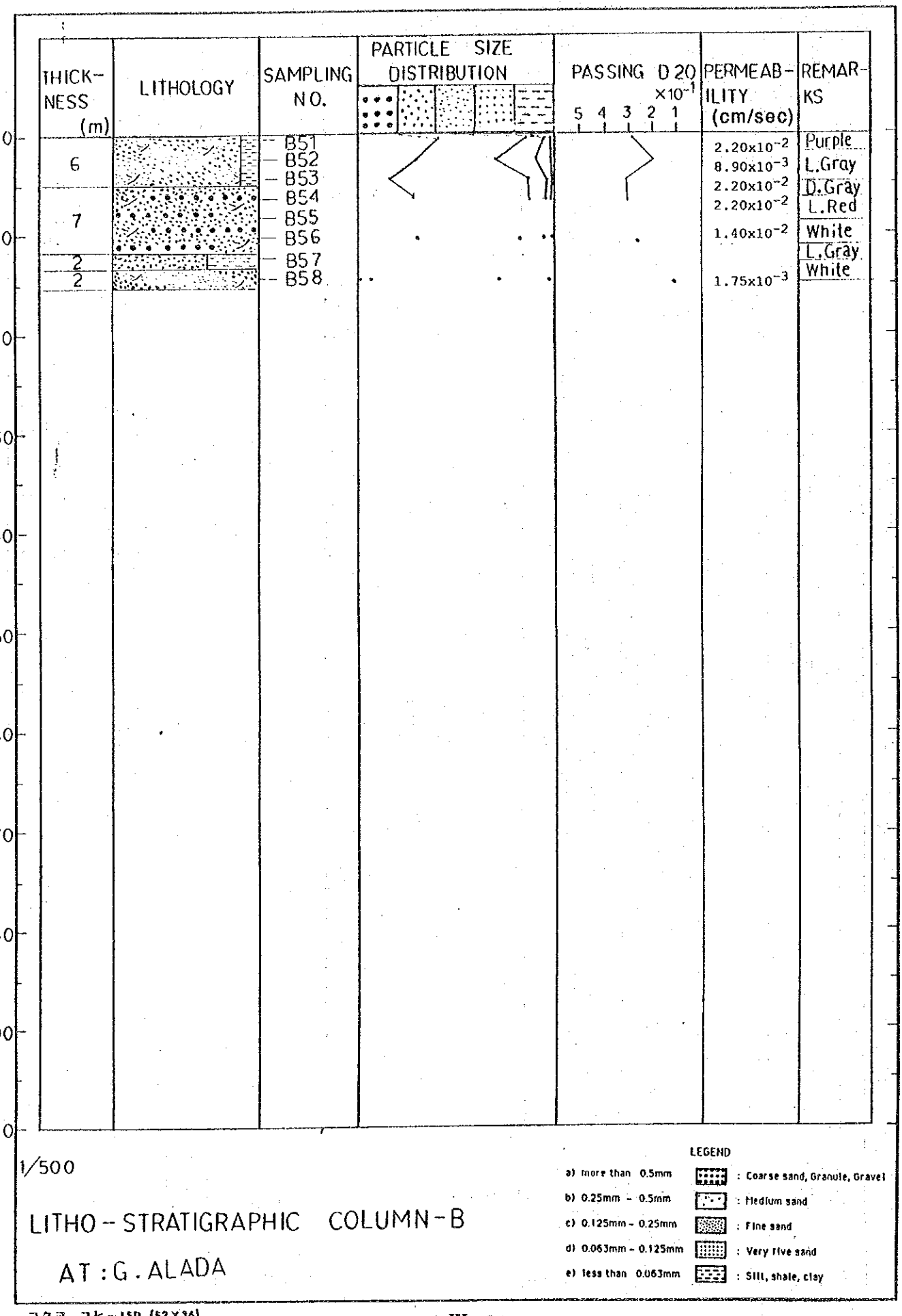
LITHO-STRATIGRAPHIC COLUMN-B

AT : G. ALADA

Sample : Undisturbed Fx2 Total 116

LEGEND

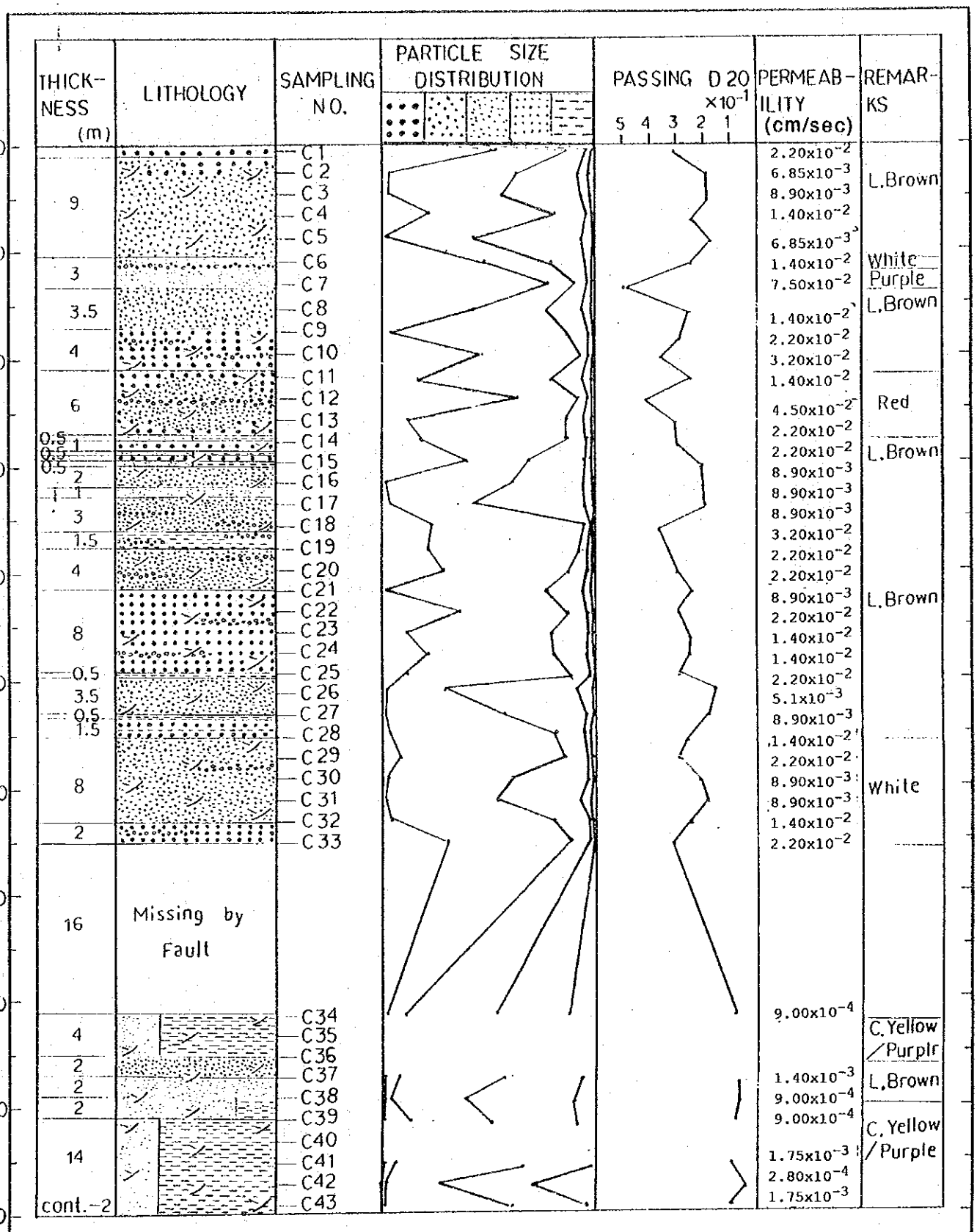
a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay



LITHO - STRATIGRAPHIC COLUMN - B

AT : G. ALADA

No. 1



1/500

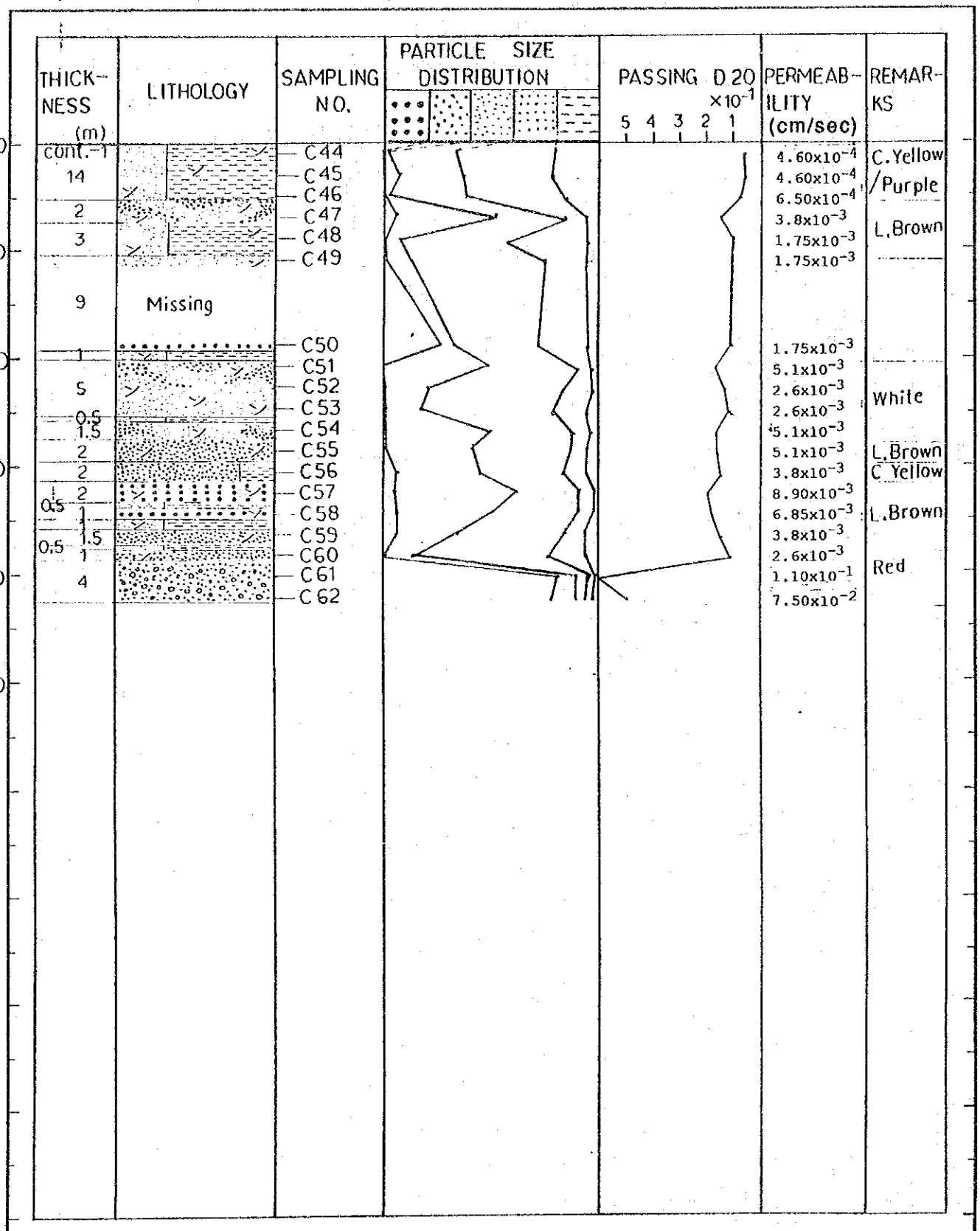
LITHO-STRATIGRAPHIC COLUMN-C

AT : G.AL-MOSTADUL

Sample : Undisturbed C ×2 Total 124

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very five sand
e) less than 0.063mm : Silt, shale, clay



1/500

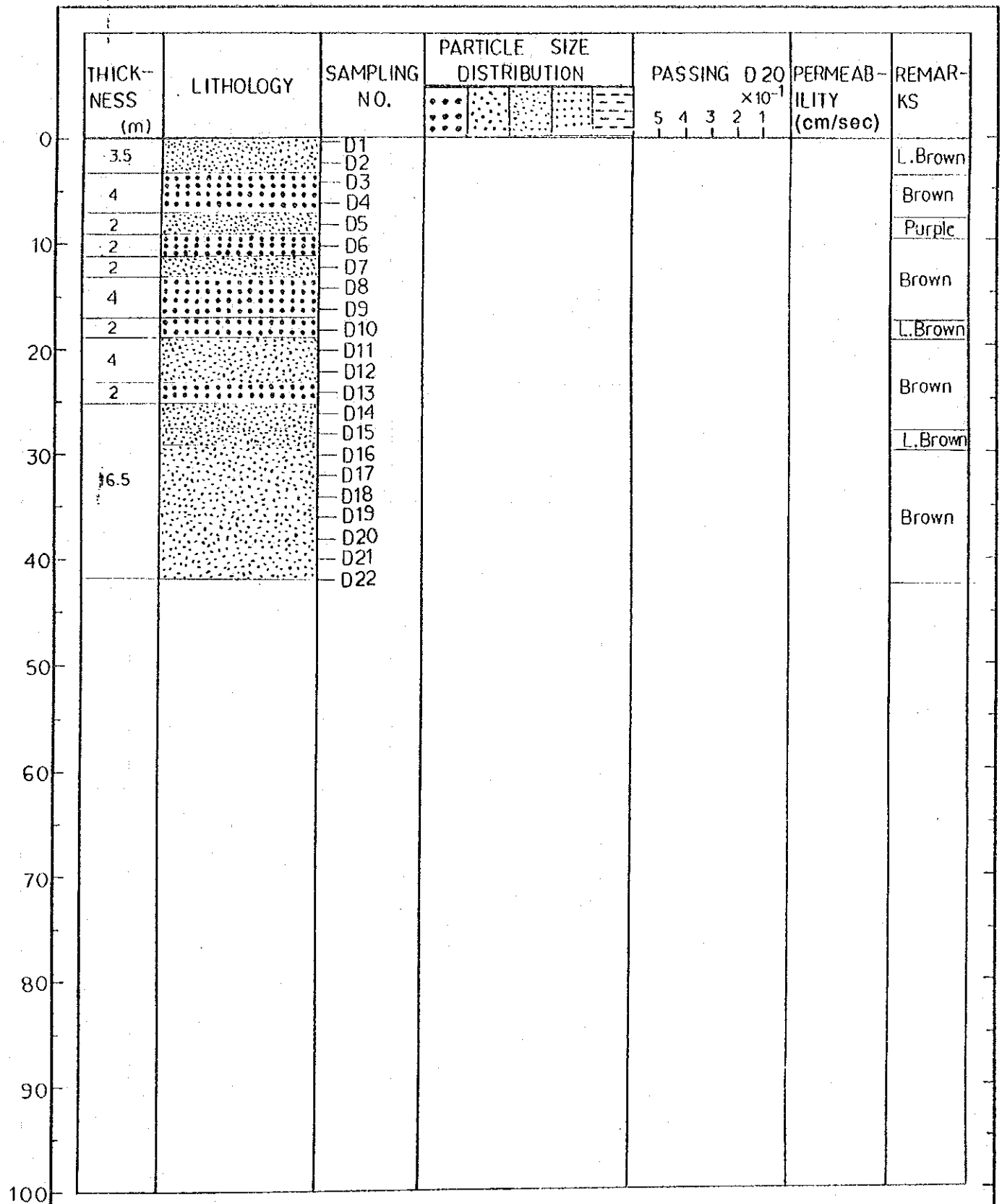
LITHO - STRATIGRAPHIC COLUMN-C

AT : G. AL-MOSTADUL

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm - 0.5mm : Medium sand
c) 0.125mm - 0.25mm : Fine sand
d) 0.063mm - 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

No. 1



1/500

LITHO-STRATIGRAPHIC COLUMN-D

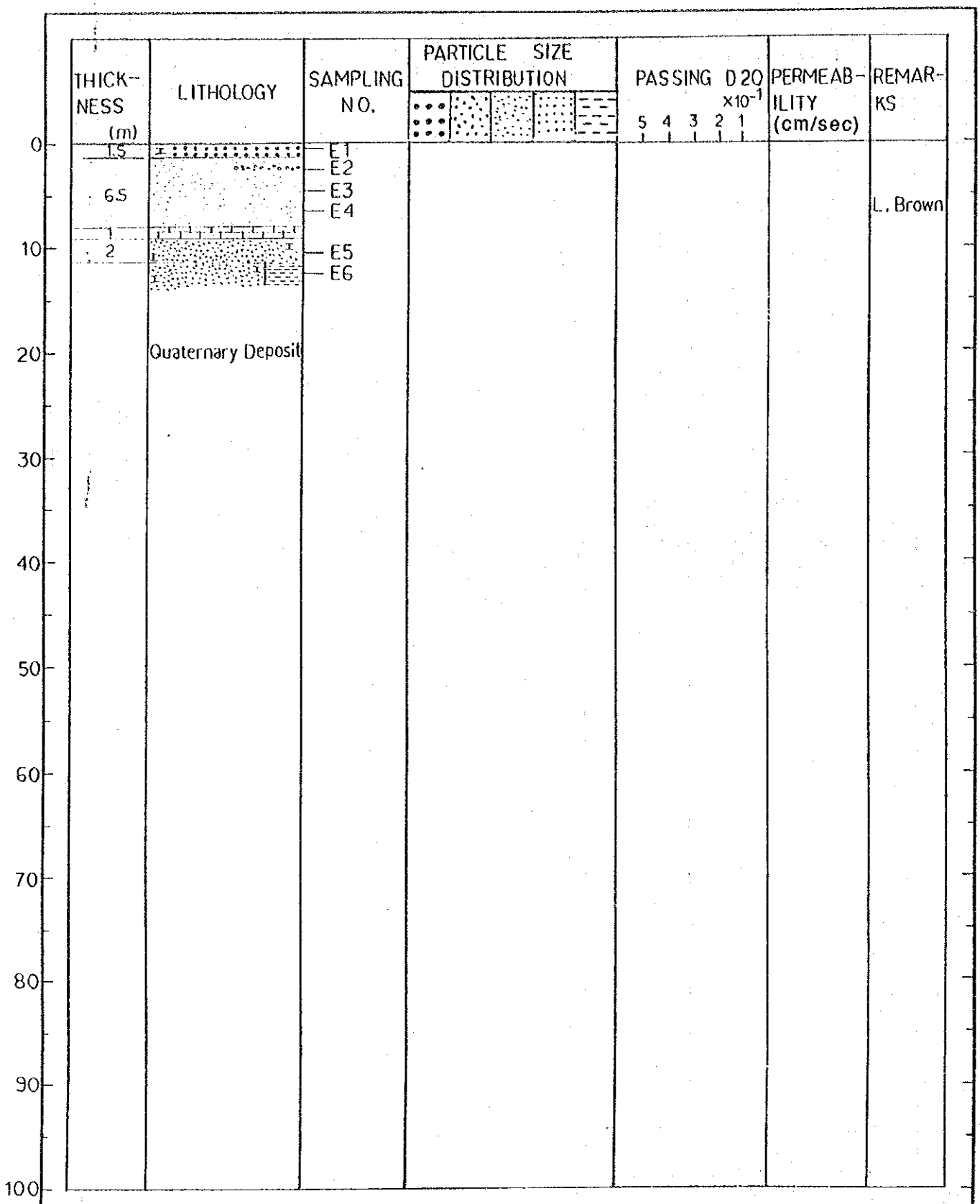
AT : G. RAHA

Sample : Undisturbed , D×2 Total 44

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

No. 1



1/500

LITHO-STRATIGRAPHIC COLUMN-E

AT : G. GIDDI

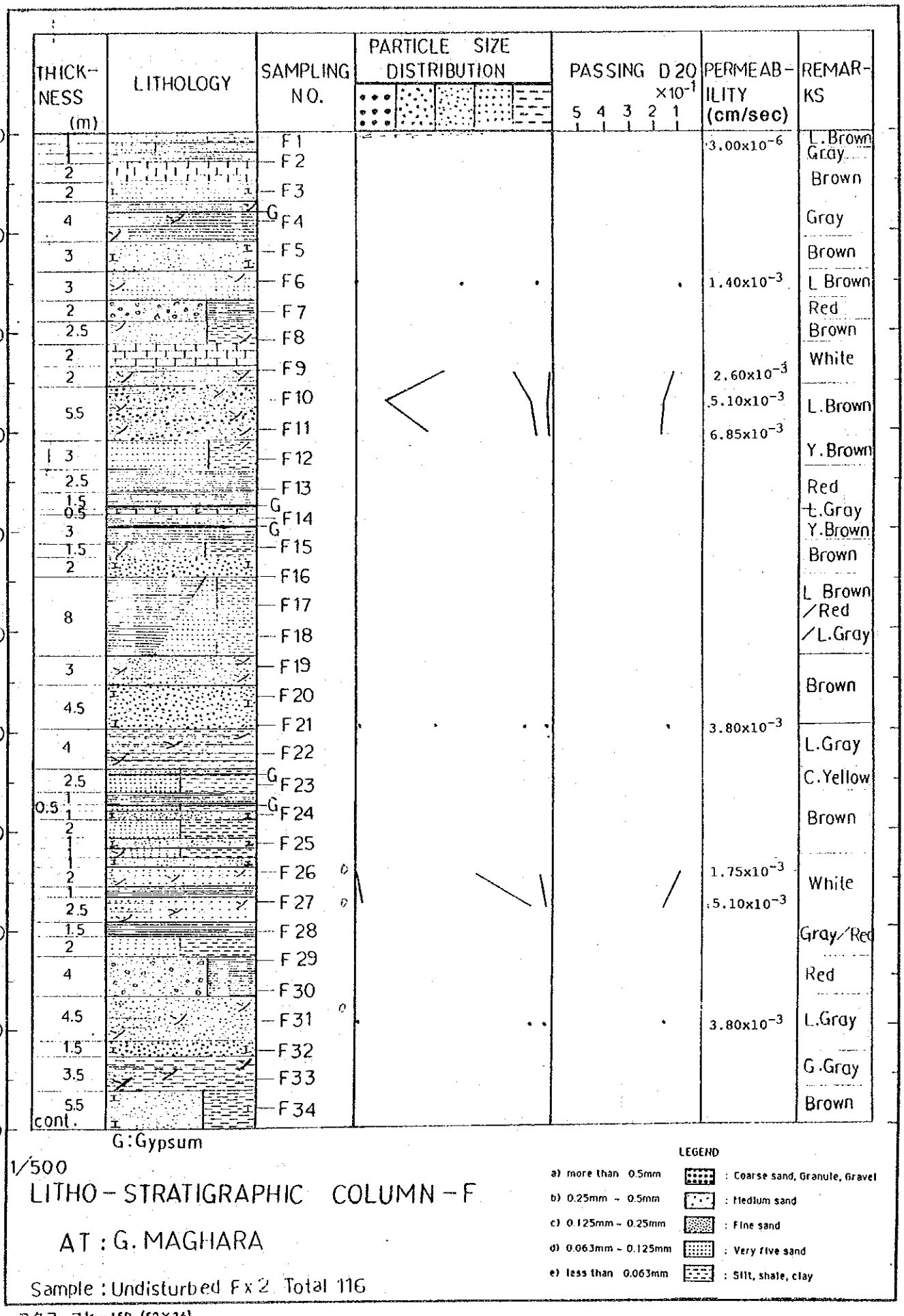
Sample : Undisturbed E×2 Total 12

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

コクヨ コヒ-150 (52×36)

No. 1

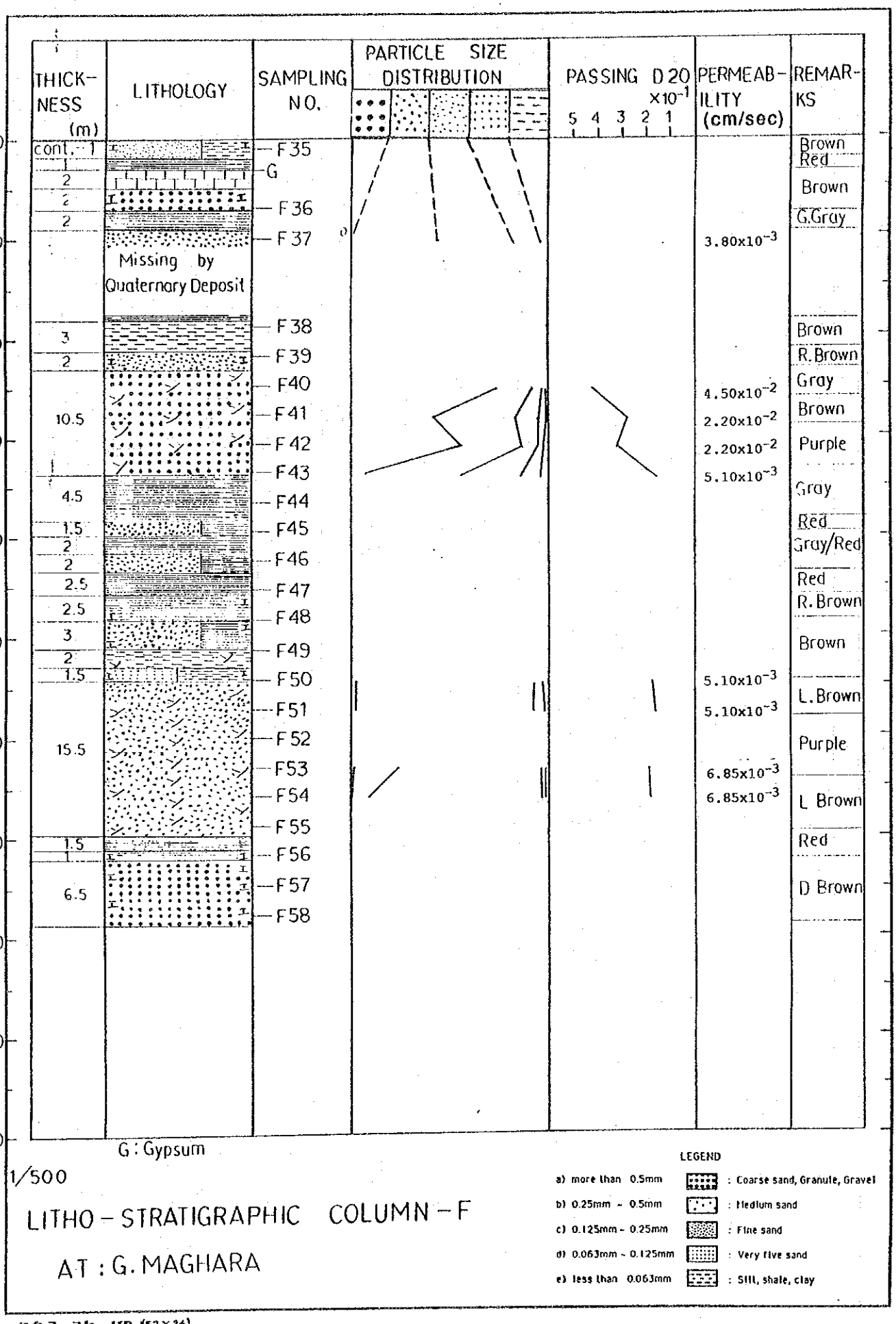


1/500

LITHO – STRATIGRAPHIC COLUMN – F

AT : G. MAGHARA

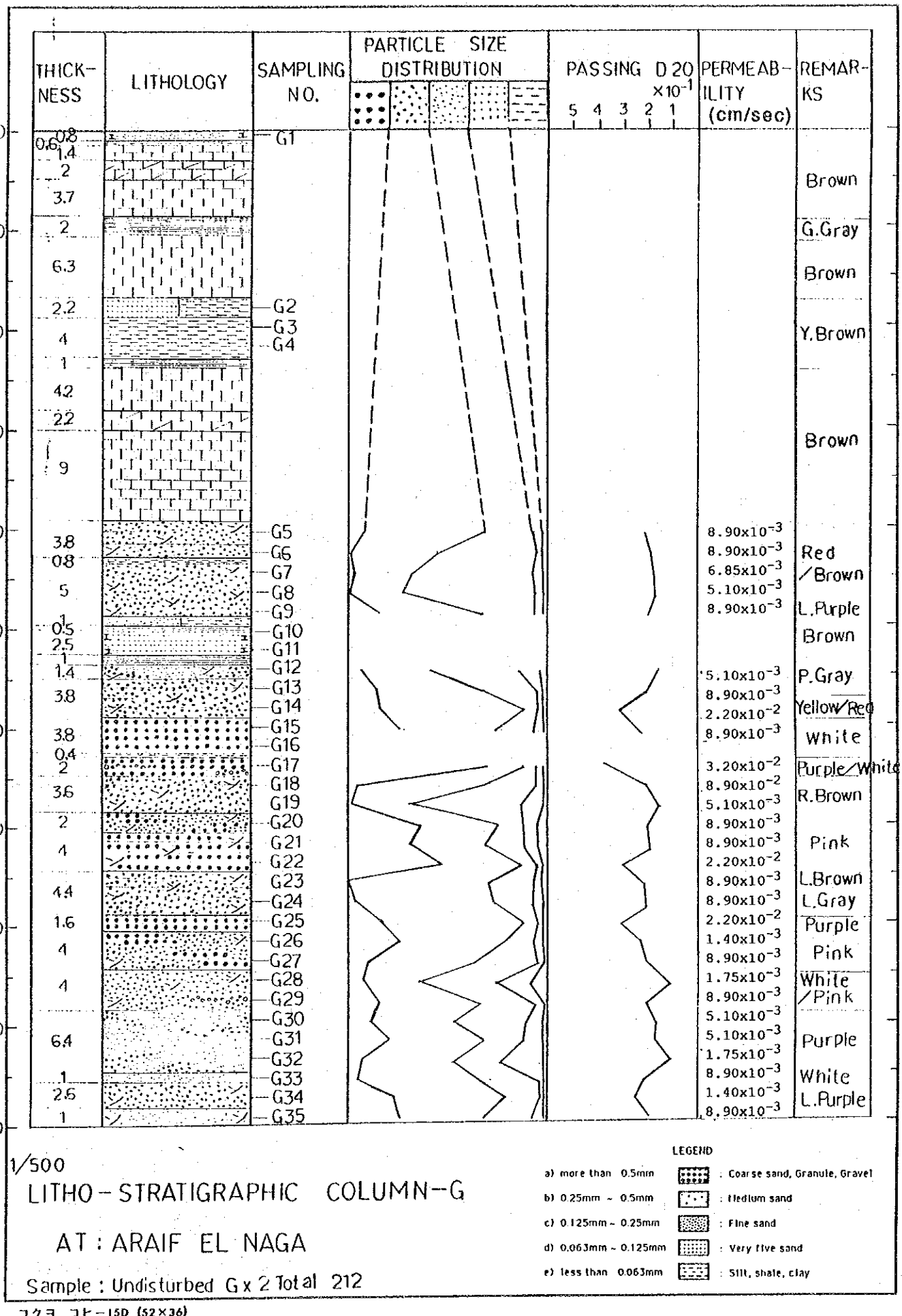
Sample : Undisturbed F x 2 Total 116



1/500

LITHO – STRATIGRAPHIC COLUMN – F

AT : G. MAGHARA



1/500

LITHO-STRATIGRAPHIC COLUMN-G

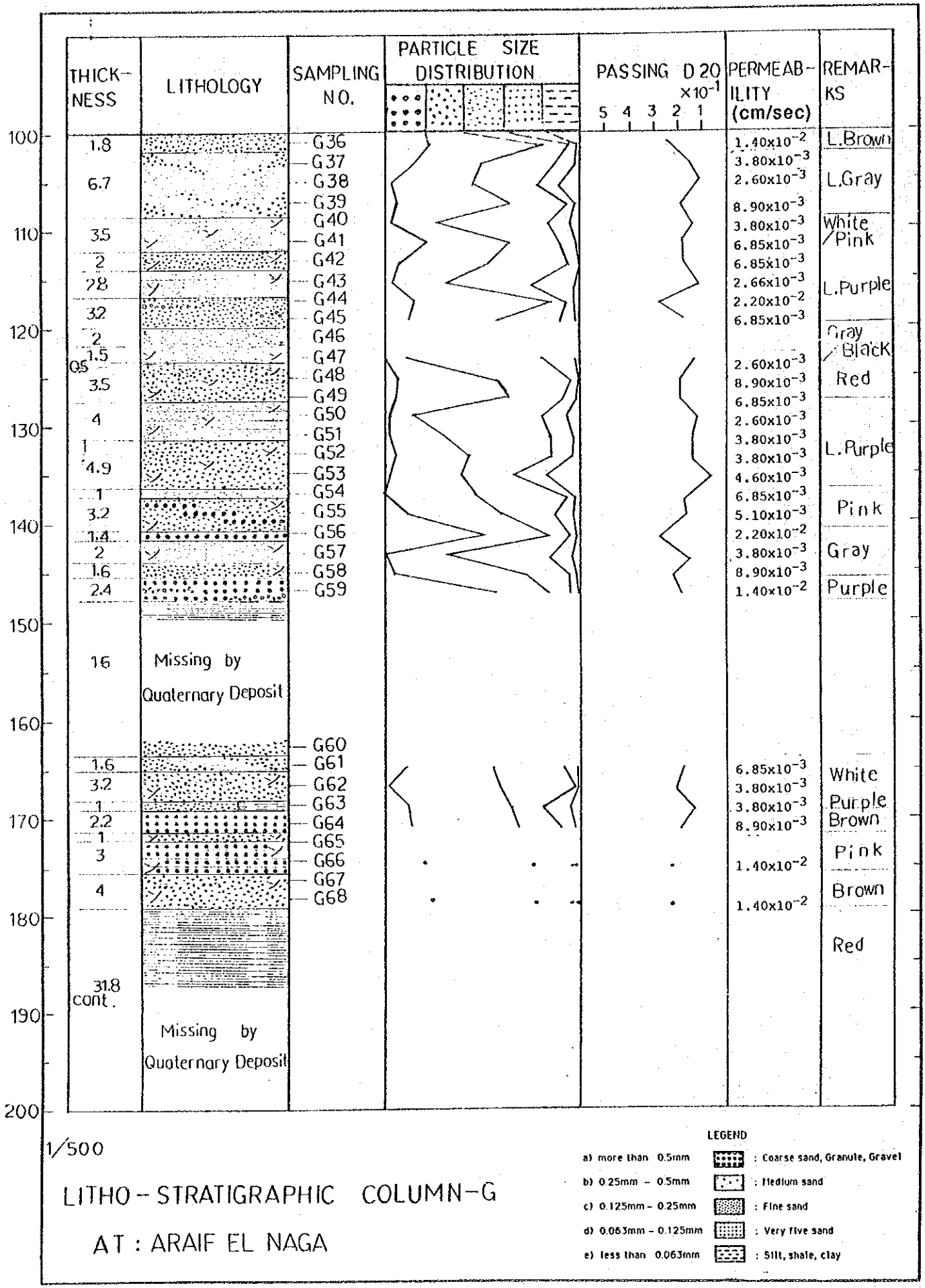
AT : ARAIF EL NAGA

Sample : Undisturbed G x 2 Total 212

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

No. 2



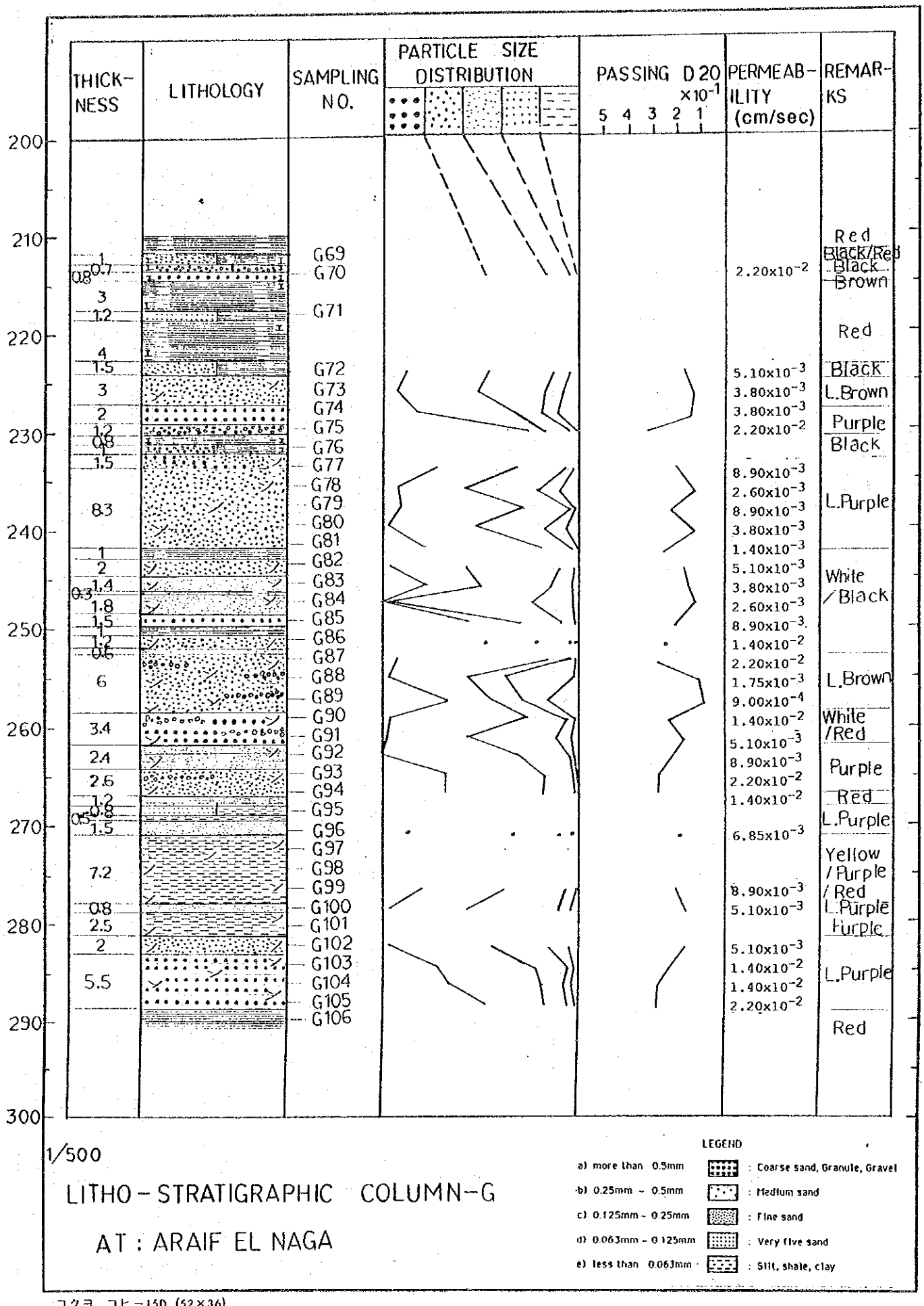
1/500

LITHO-STRATIGRAPHIC COLUMN-G

AT : ARAIF EL NAGA

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm - 0.5mm : Medium sand
c) 0.125mm - 0.25mm : Fine sand
d) 0.063mm - 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay



1/500

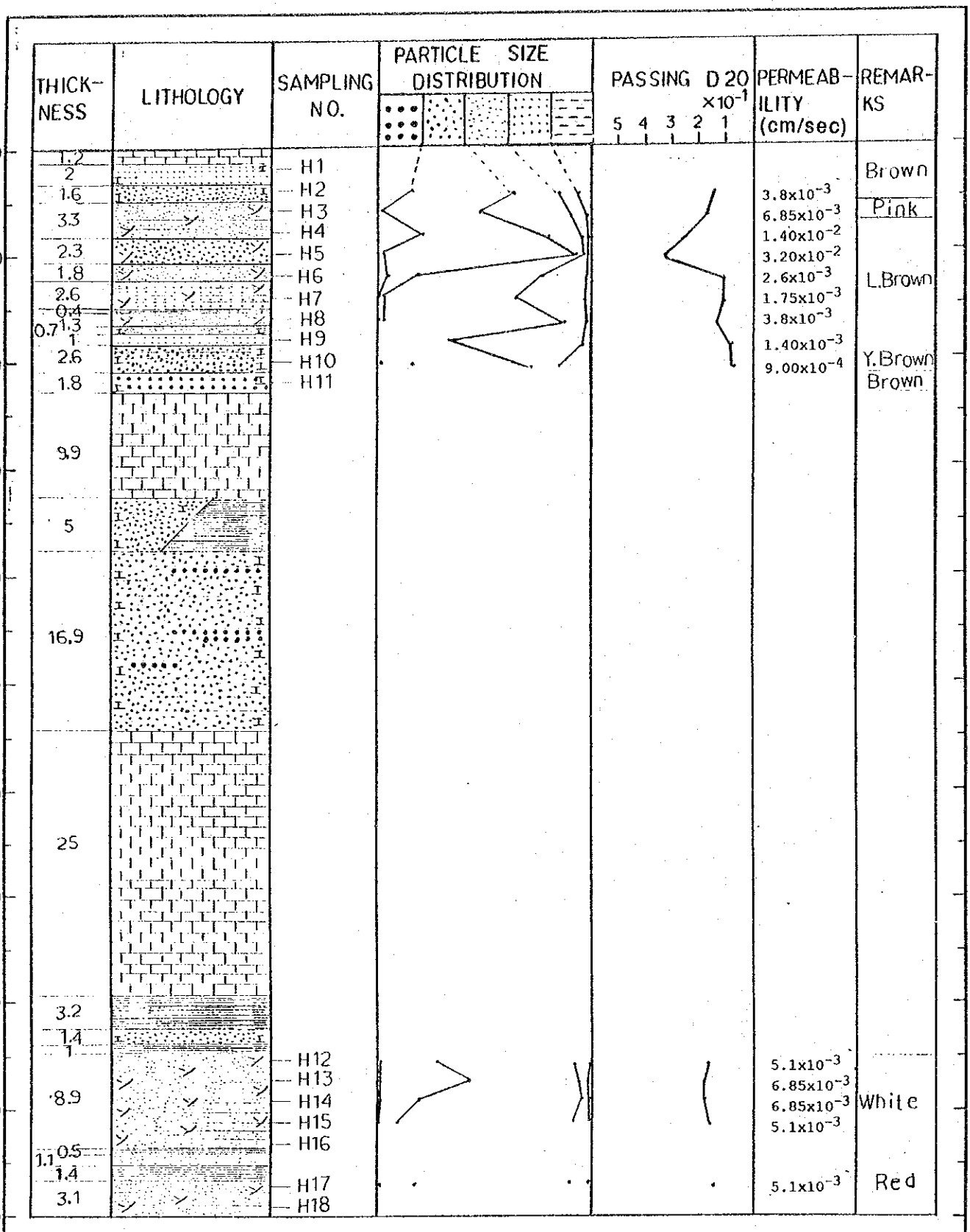
LITHO-STRATIGRAPHIC COLUMN-G

AT : ARAIF EL NAGA

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

No. 1



1/500

LITHO-STRATIGRAPHIC COLUMN-H

AT : G. HALAL

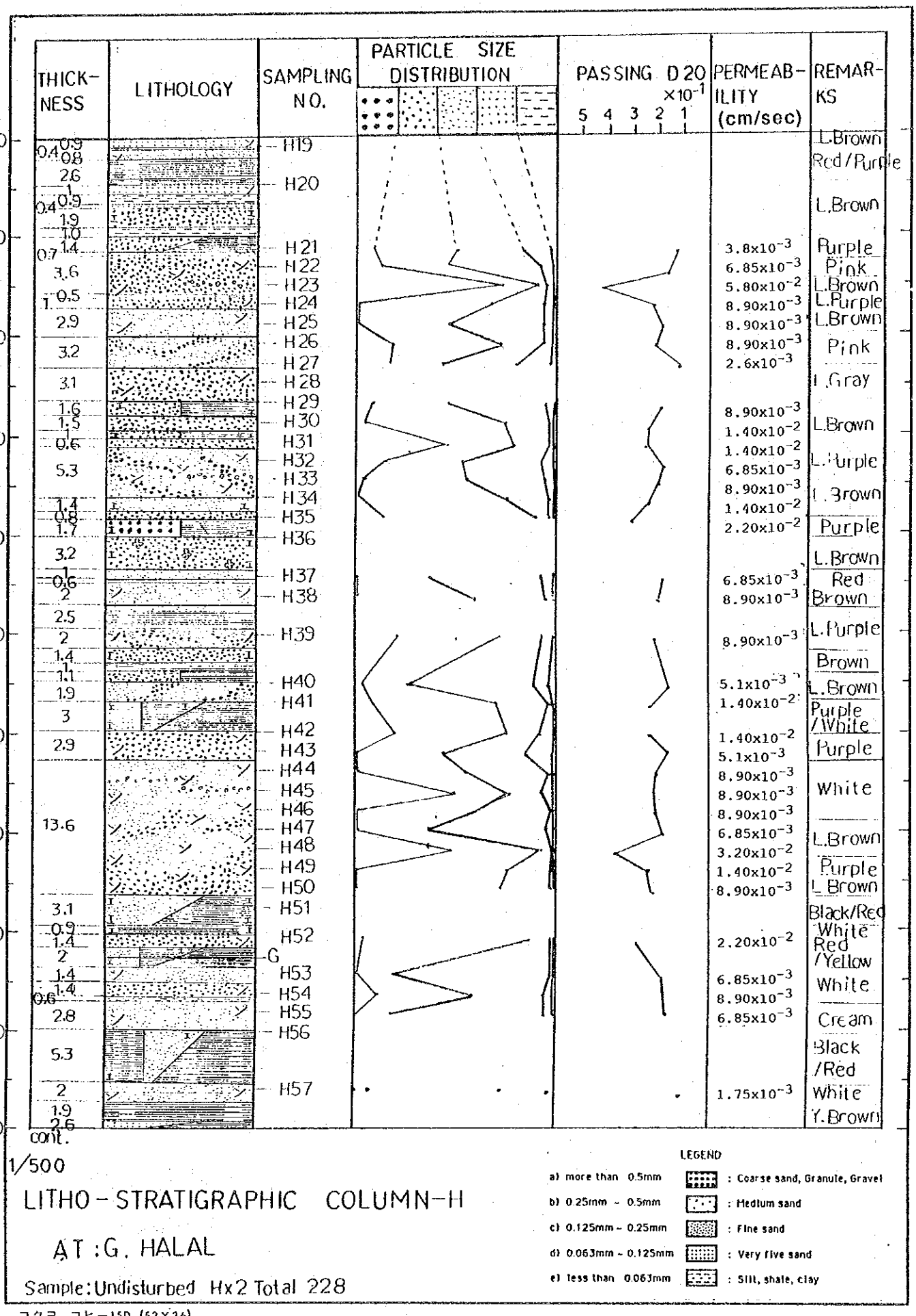
Sample : Undisturbed H×2 Total 36

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

コクヨ コヒ-15D (52×36)

No. 2



1/500

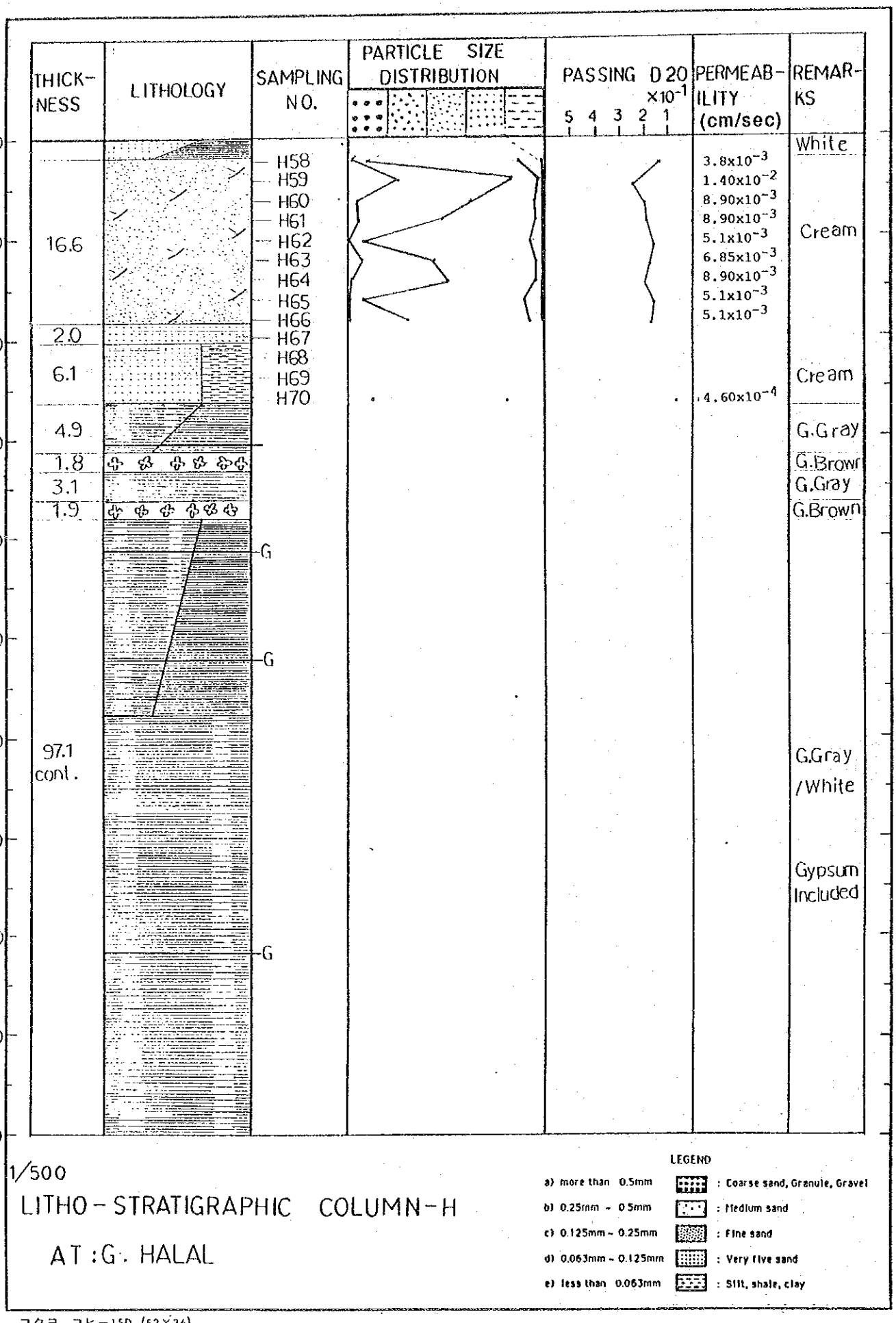
LITHO-STRATIGRAPHIC COLUMN-H

AT : G. HALAL

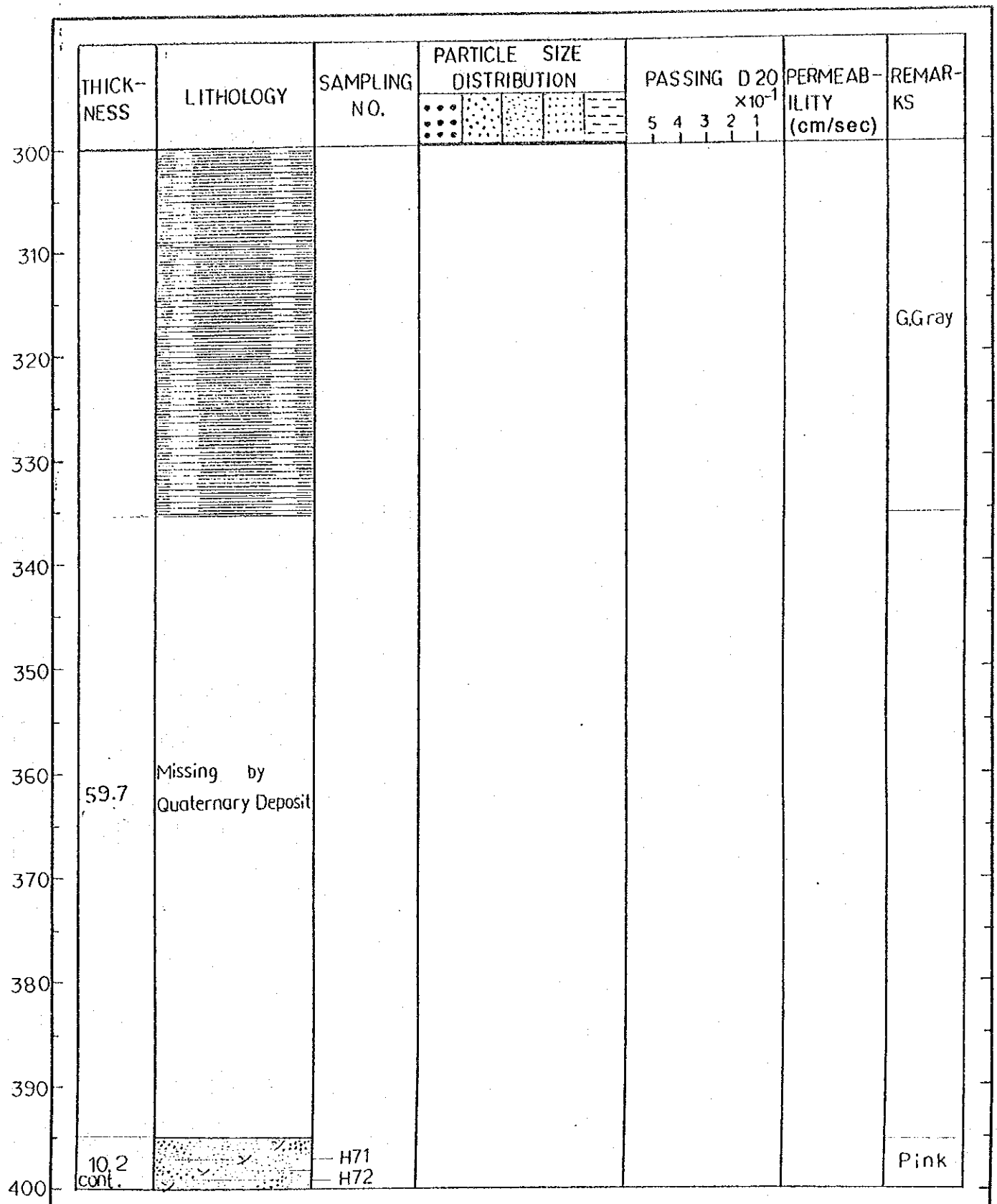
Sample: Undisturbed Hx2 Total 228

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay


THICK-NESS
LITHOLOGY
SAMPLING NO.
PARTICLE SIZE DISTRIBUTION
PASSING D 20 ×10⁻¹
5 4 3 2 1
PERMEAB-ILITY (cm/sec)
REMAR-KS
200
210
220
230
240
250
260
270
280
290
300
16.6
2.0
6.1
4.9
1.8
3.1
1.9
97.1 cont.
H58
H59
H60
H61
H62
H63
H64
H65
H66
H67
H68
H69
H70
G
G
G
3.8x10⁻³
1.40x10⁻²
8.90x10⁻³
8.90x10⁻³
5.1x10⁻³
6.85x10⁻³
8.90x10⁻³
5.1x10⁻³
5.1x10⁻³
4.60x10⁻⁴
White
Cream
Cream
G.Gray
G.Brown
G.Gray
G.Brown
G.Gray /White
Gypsum Included
1/500
LITHO-STRATIGRAPHIC COLUMN-H
AT : G. HALAL
LEGEND
a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

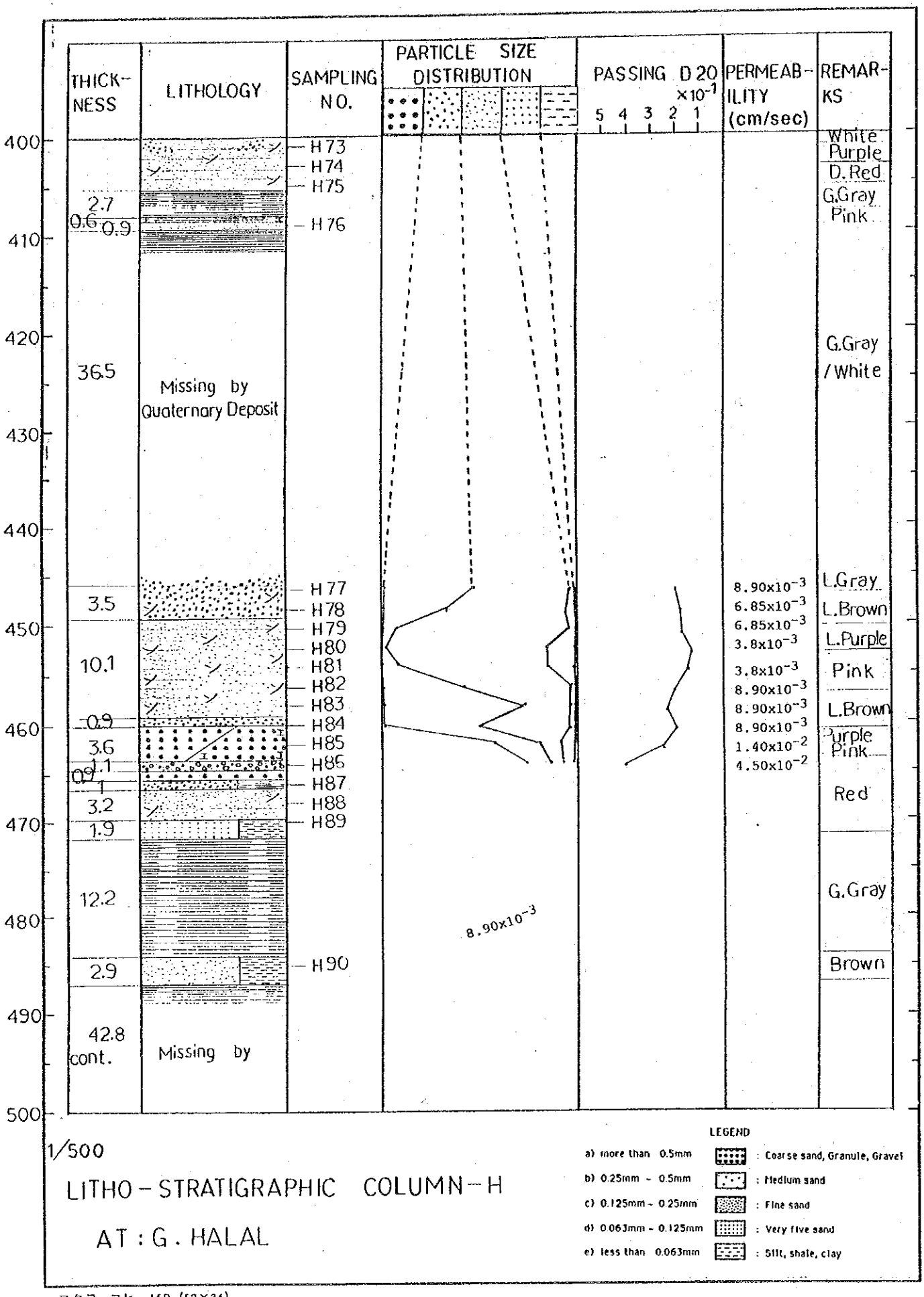
No. 4

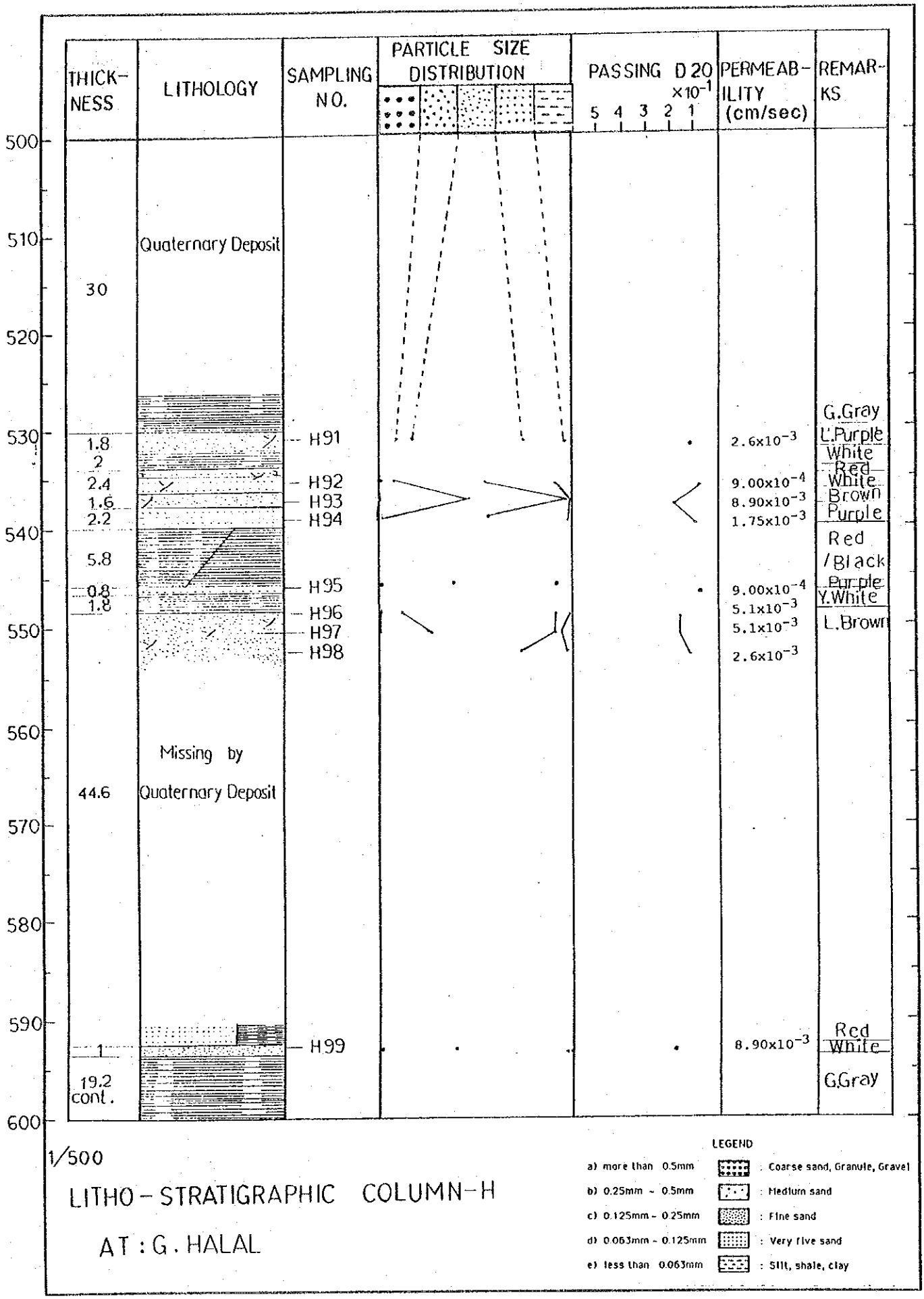


1/500

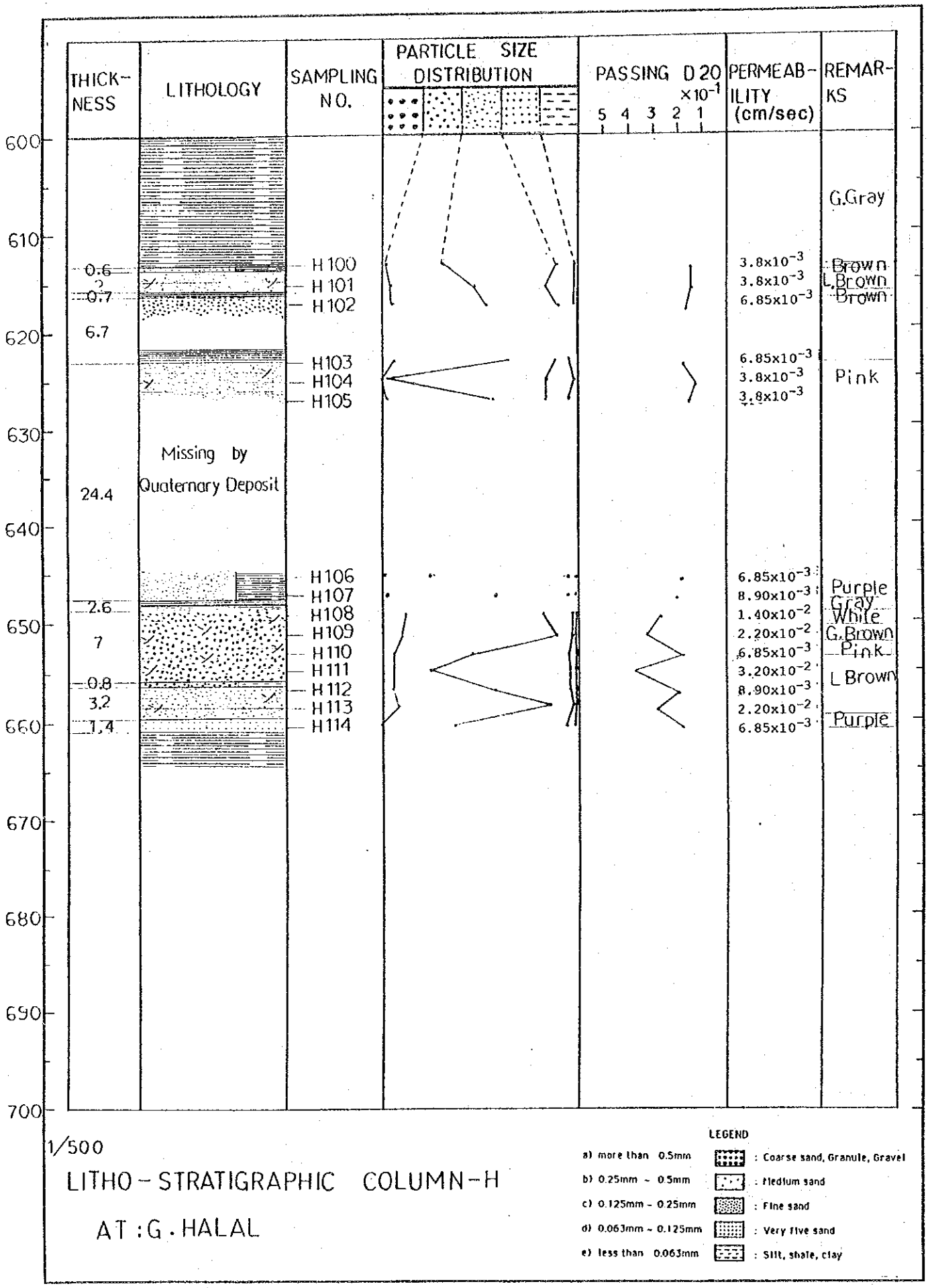
LITHO - STRATIGRAPHIC COLUMN - H

AT : G . HALAL

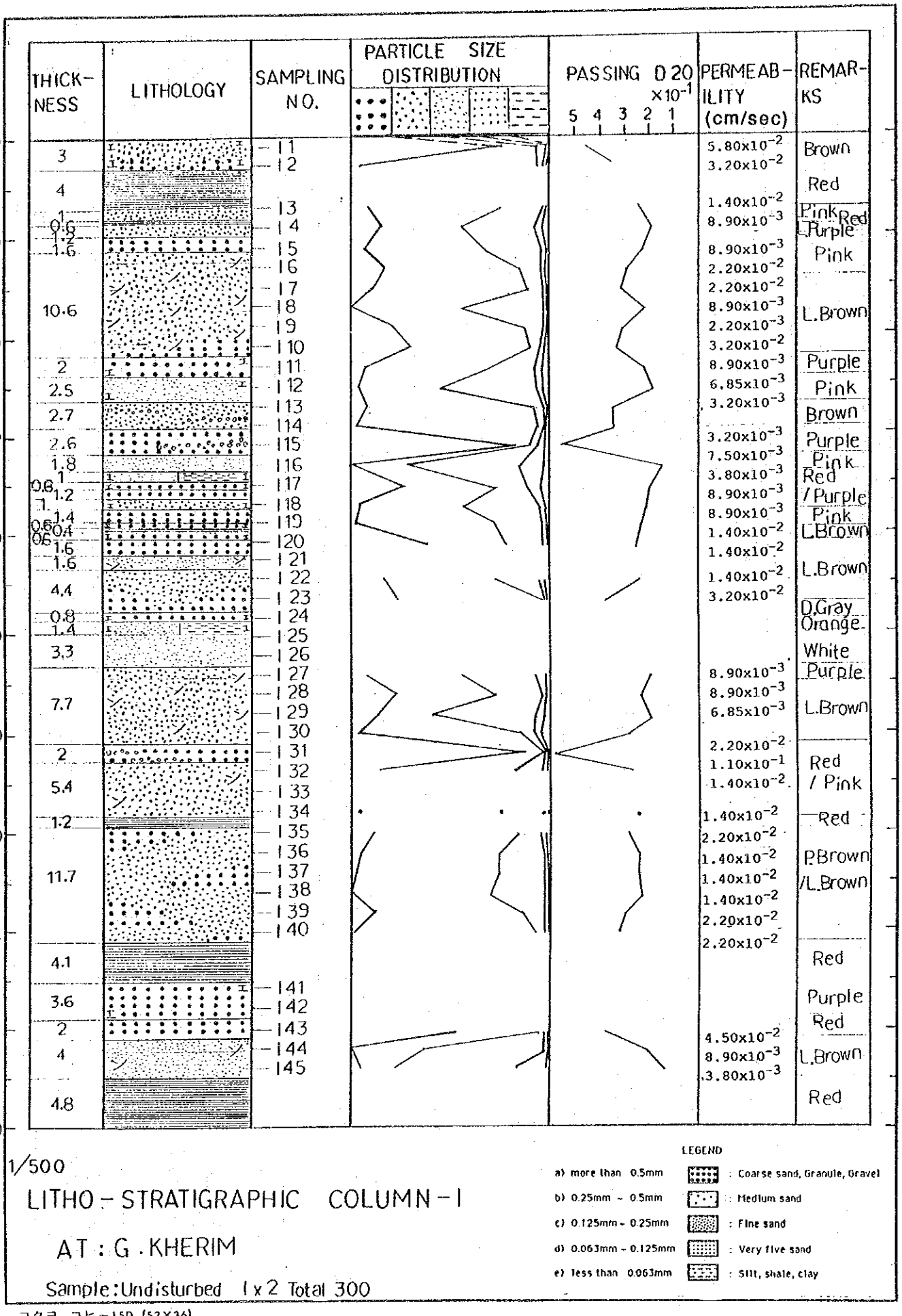

THICK-NESS
LITHOLOGY
SAMPLING NO.
PARTICLE SIZE DISTRIBUTION
PASSING D 20 ×10⁻¹
5 4 3 2 1
PERMEAB-ILITY (cm/sec)
REMAR-KS
400
410
420
430
440
450
460
470
480
490
500
2.7
0.6
0.9
36.5
Missing by Quaternary Deposit
3.5
10.1
0.9
3.6
1.1
0.9
1
3.2
1.9
12.2
2.9
42.8 cont.
Missing by
H 73
H 74
H 75
H 76
H 77
H 78
H 79
H 80
H 81
H 82
H 83
H 84
H 85
H 86
H 87
H 88
H 89
H 90
8.90x10⁻³
8.90x10⁻³
6.85x10⁻³
6.85x10⁻³
3.8x10⁻³
3.8x10⁻³
8.90x10⁻³
8.90x10⁻³
8.90x10⁻³
8.90x10⁻³
1.40x10⁻²
4.50x10⁻²
White Purple
D. Red
G.Gray Pink
G.Gray / White
L.Gray
L.Brown
L.Purple
Pink
L.Brown
Purple Pink
Red
G.Gray
Brown
1/500
LITHO – STRATIGRAPHIC COLUMN – H
AT : G . HALAL
LEGEND
a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay


THICK-NESS
LITHOLOGY
SAMPLING NO.
PARTICLE SIZE DISTRIBUTION
PASSING D 20 ×10⁻¹
5 4 3 2 1
PERMEAB-ILITY (cm/sec)
REMAR-KS
500
510
520
530
540
550
560
570
580
590
600
30
Quaternary Deposit
1.8
2
2.4
1.6
2.2
5.8
0.8
1.8
H91
H92
H93
H94
H95
H96
H97
H98
2.6x10⁻³
9.00x10⁻⁴
8.90x10⁻³
1.75x10⁻³
9.00x10⁻⁴
5.1x10⁻³
5.1x10⁻³
2.6x10⁻³
G.Gray
L.Purple
White
Red
White
Brown
Purple
Red
/Black
Purple
Y.White
L.Brown
Missing by
Quaternary Deposit
44.6
1
19.2
cont.
H99
8.90x10⁻³
Red
White
G.Gray
1/500
LITHO-STRATIGRAPHIC COLUMN-H
AT : G. HALAL
LEGEND
a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

No. 7



No. 1



1/500

LITHO - STRATIGRAPHIC COLUMN - I

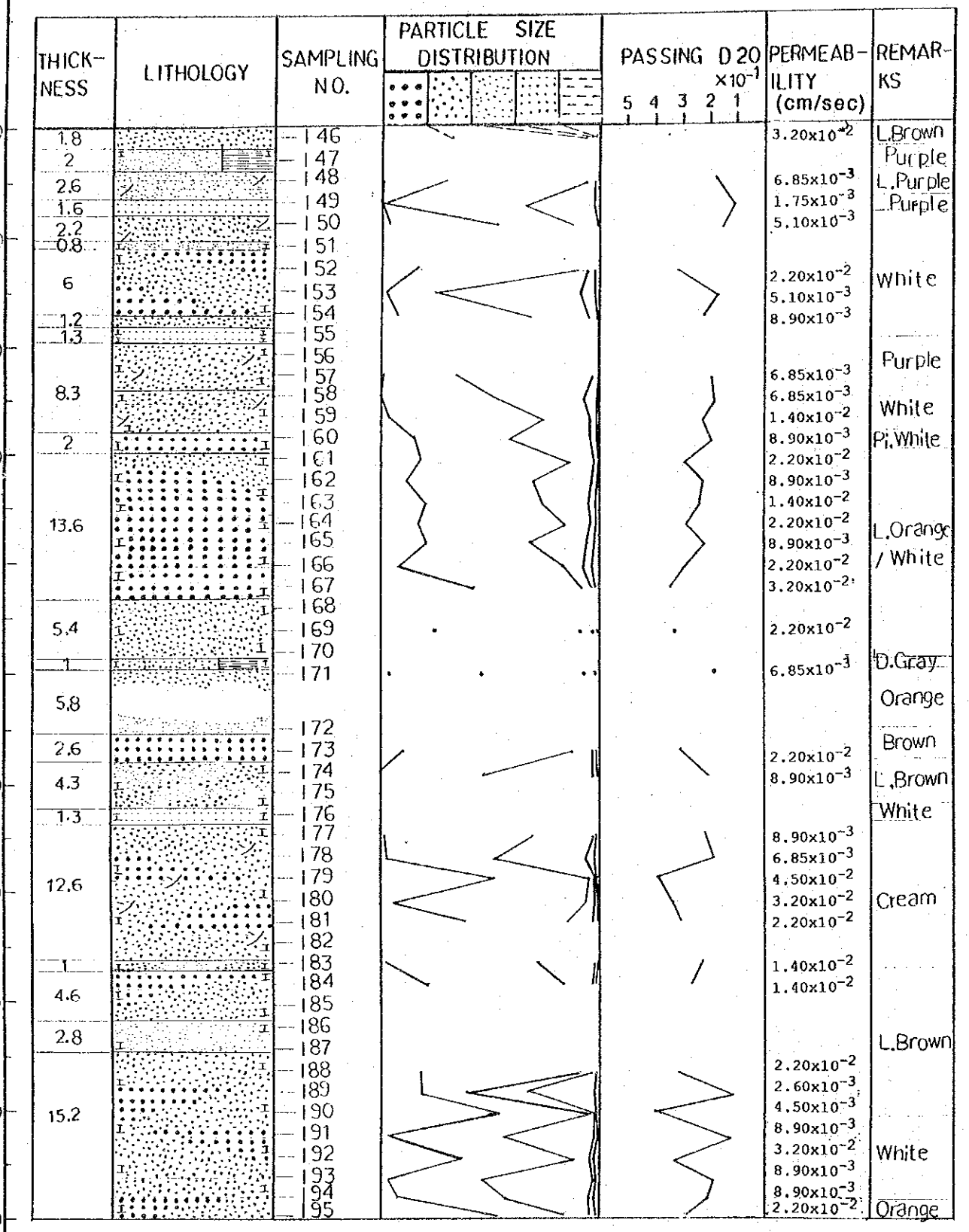
AT : G . KHERIM

Sample : Undisturbed 1 x 2 Total 300

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

No. 2



1/500

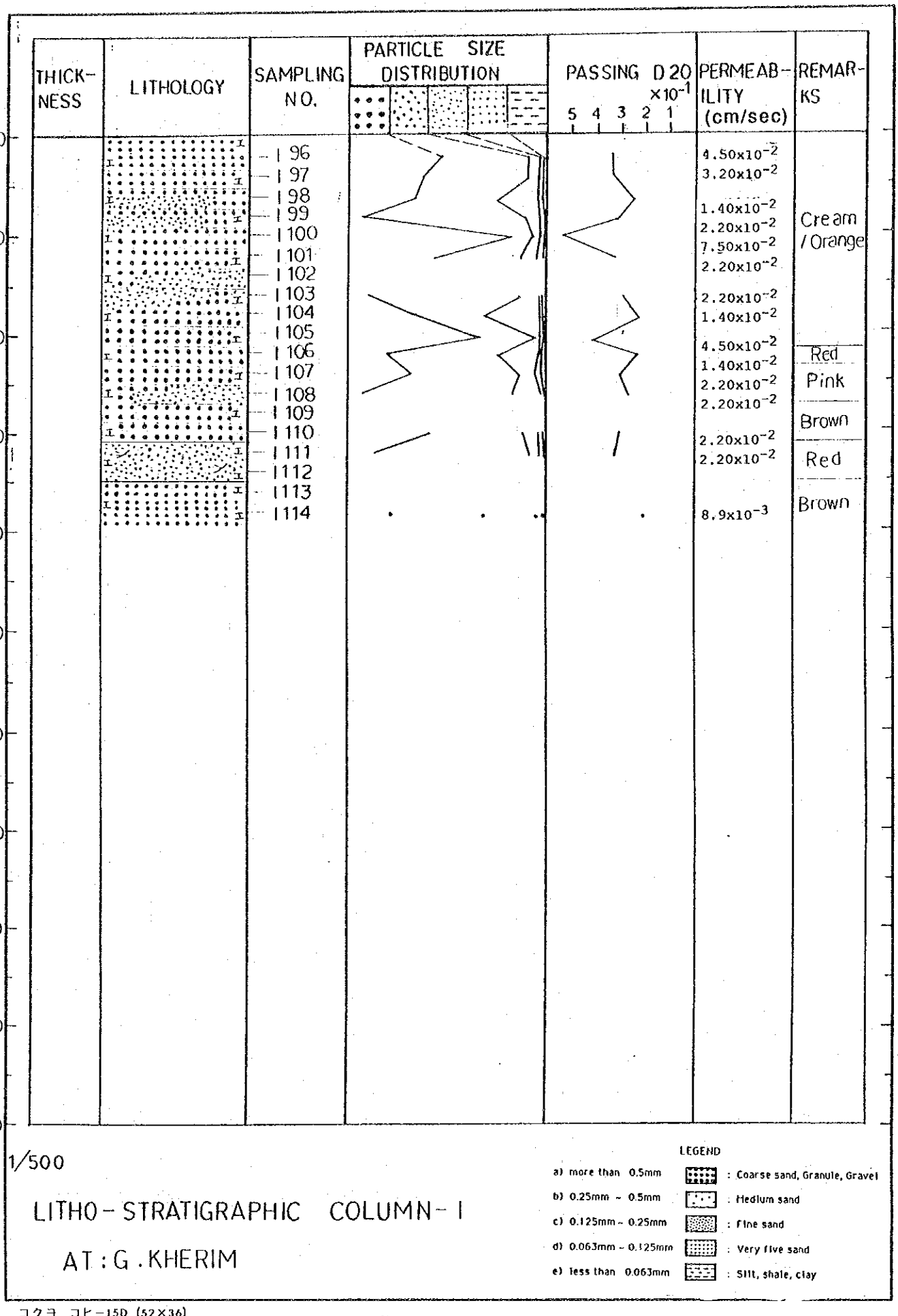
LITHO - STRATIGRAPHIC COLUMN - I

AT : G. KHERIM

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

No. 3



1/500

LITHO-STRATIGRAPHIC COLUMN-1

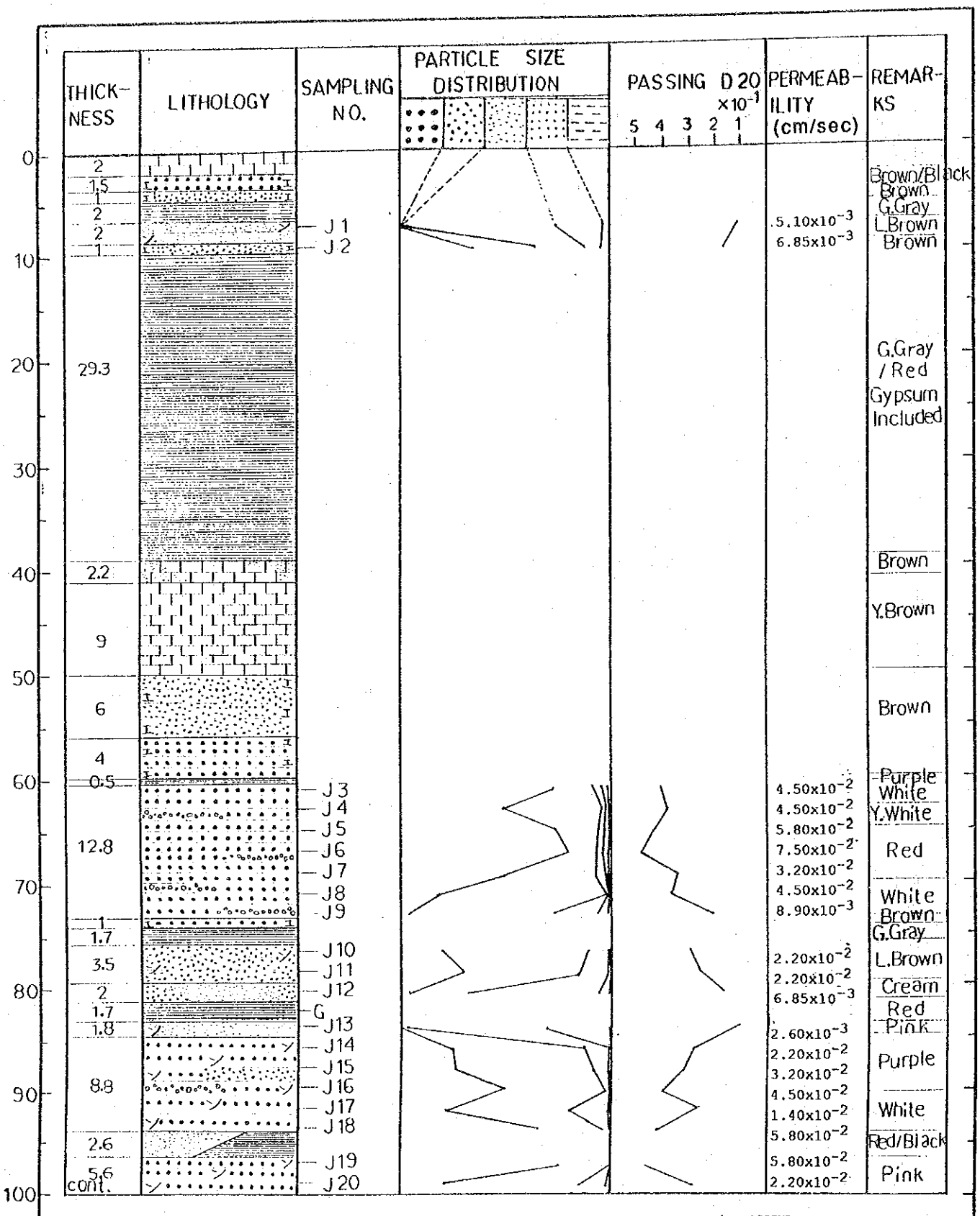
AT : G. KHERIM

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

コクヨ コヒ-15D (52×36)

No. 1



1/500

LITHO-STRATIGRAPHIC COLUMN-J

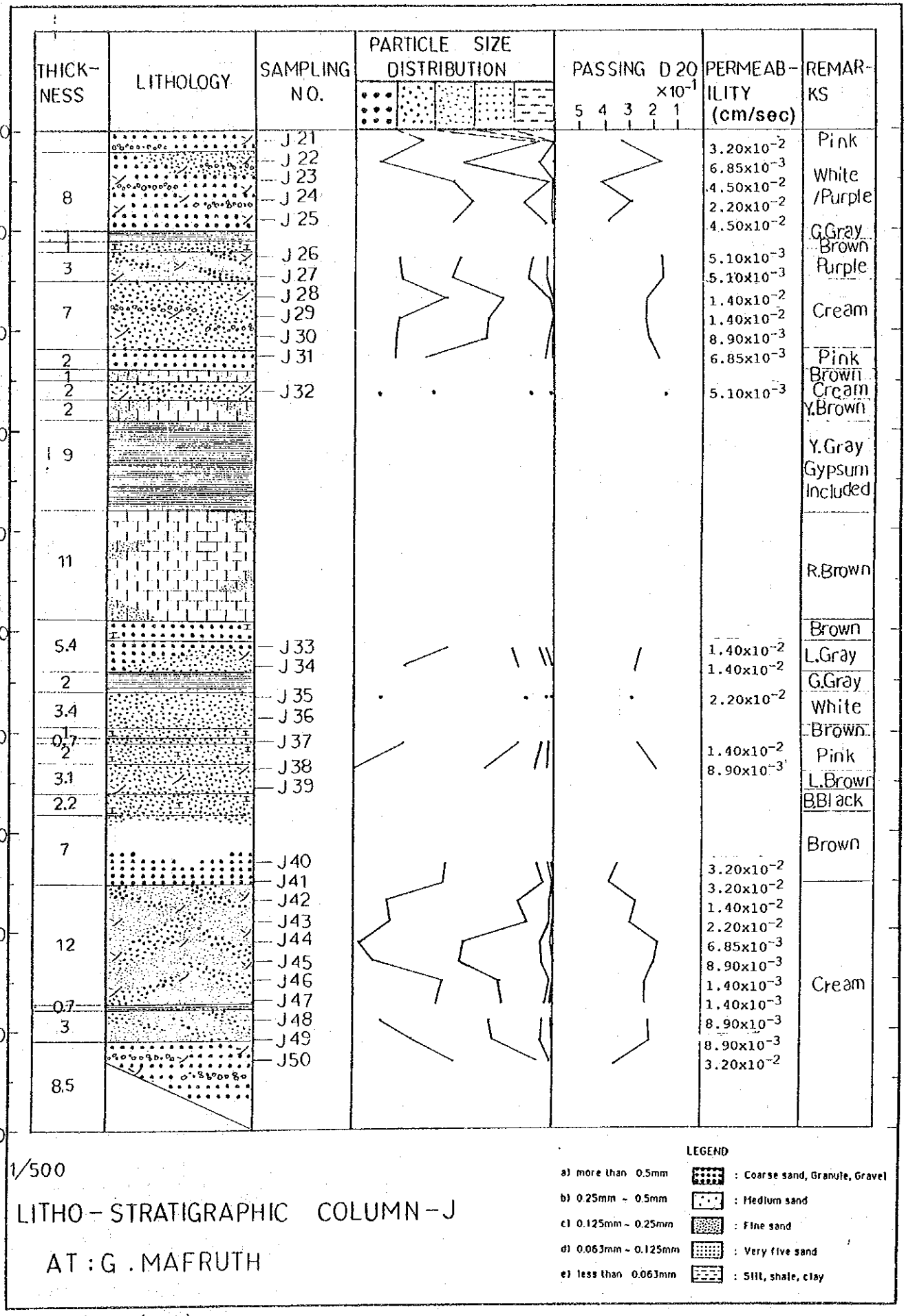
AT : G. MAFRUTH

Sample : Undisturbed J x 2 Total 136

LEGEND

a) more than 0.5mm : Coarse sand, Granule, Gravel
b) 0.25mm ~ 0.5mm : Medium sand
c) 0.125mm ~ 0.25mm : Fine sand
d) 0.063mm ~ 0.125mm : Very fine sand
e) less than 0.063mm : Silt, shale, clay

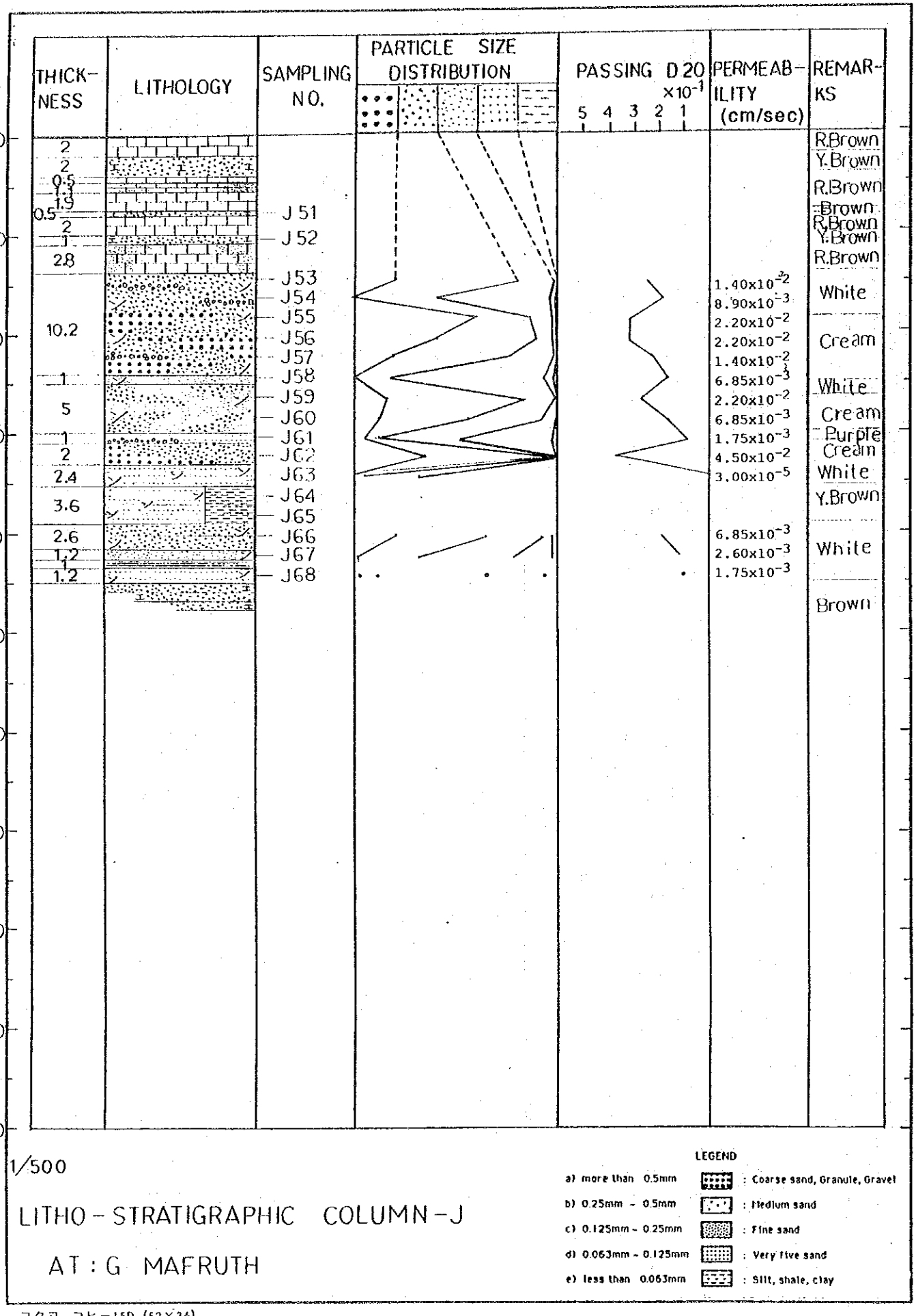
コクヨ コヒ-15D (52×36)



1/500

LITHO - STRATIGRAPHIC COLUMN - J

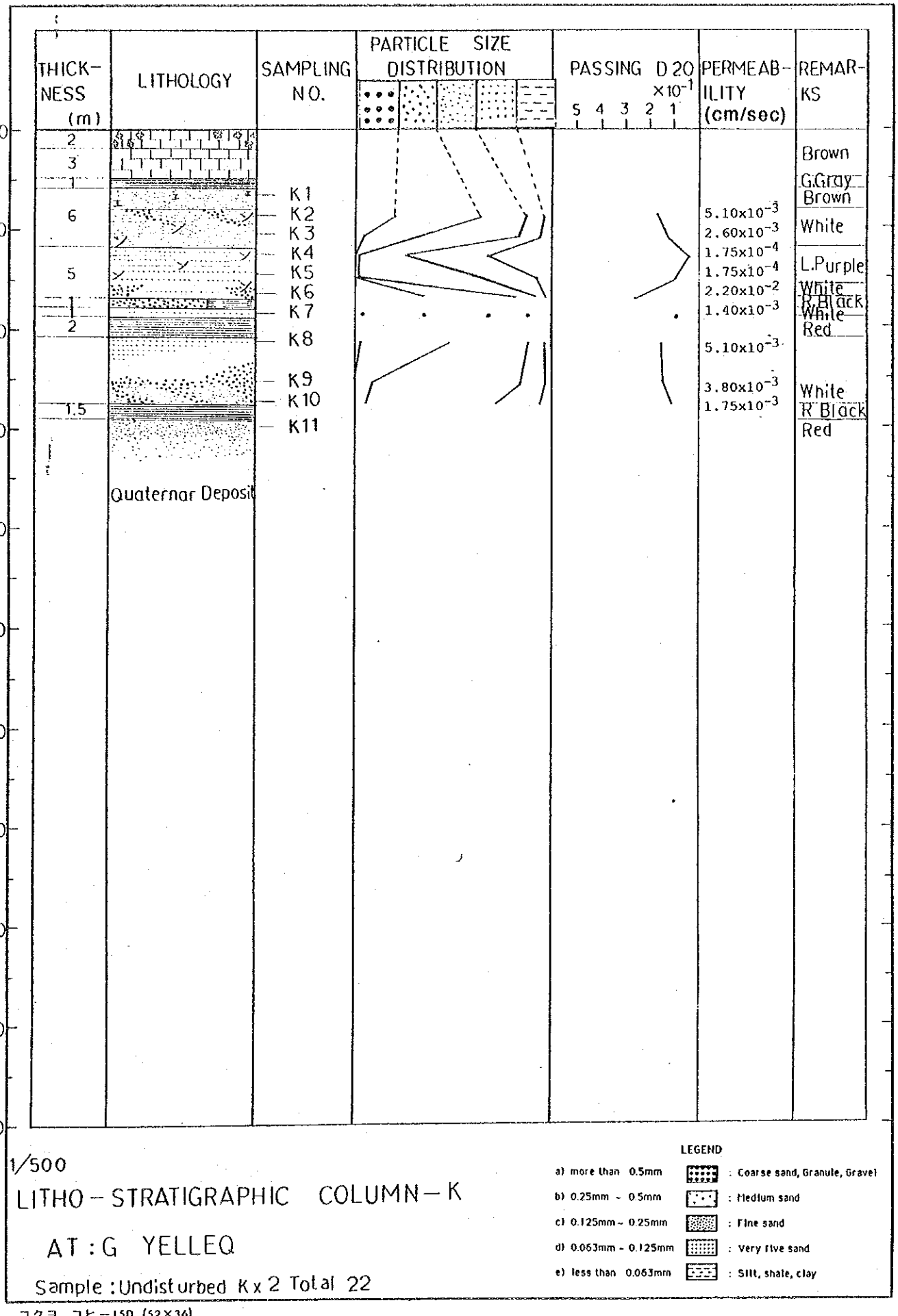
AT : G . MAFRUTH



LITHO - STRATIGRAPHIC COLUMN - J

AT : G MAFRUTH

No. 1



TECHNICAL REPORT

IV

COMPOSITE COLUMN

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COMPOSITE COLUMNS IV-12

1. INTRODUCTION

In order for preparation of a hydrogeological map reliable geological columns and borehole profiles are inevitable to determine lithology and stratigraphy of the objective area. The borehole profiles prudently analyzed by interpretation of geological logging data and slime conditions are major sources of the hydrogeological information.

However, most of water well profiles do not have age determination and lithological descriptions sometimes do not correspond to the logging data. Also these data collected on some geological columns and profiles of some petroleum wells were not detailed enough to refer to correlate with. As the result it was difficult to identify rocks in which horizon form the aquifer.

For this reason, much of efforts were made to produce detailed geological maps at many key areas and to record detailed geological columns in the second phase study (Geological Map, Porttolio).

At the same time, additional detailed reliable petroleum well data were obtained in cooperation with RIWR.

These geological columns and detailed petroleum well data enabled us to reanalyze lithology and stratigraphy of existing well data for determination of the composite columns.

The hydrogeolosical structure, the basis of the hydrogeological maps, is figured out by detailed analysis of these composite columns together with results of the geophygical investigation (Section 6-3, Main Report).

2. AVAILABLE DATA

A total of 311 of geological columns and lithological profiles were obtained from various sources.

Available Data of the Pre-Quaternary Sections are listed as below:

Type of data	Number of data collected	No. of revised profiles	Logging Data		Description Available	
			R	γ	Age	Lithology
1) Geological Column						
JICA Study	13	13	0	0	13	13
Other sources	29	29	0	0	29	29
2) Springs	17	0	0	0	0	0
3) Petroleum Wells	63	37	0	0	37	37
4) Water Well						
JICA	7	7	7	7	7	7
UNICEF	15	10	3	7	1	7
RIWR	73	45	15	36	19	39
Others	94	8	0	0	5	-
Total	311	149	25	50	111	140

Note : R : Resistivity logging
γ : Gamma ray logging

3. DETERMINATION OF COMPOSITE COLUMNS

Based on a detailed analysis, 149 composite columns were determined out of 311 data collected. The remaining 162 data consist of springs (17), Petroleum wells out side of the North Sinai (26), wells drilled by UNICEF (5) RIWR wells cited in SDS (28) and dug wells (86) which have no geological description except these of petroleum wells. The composite columns (146) consist of the following groups :

3-1 Field Observation of Outcrops

(1) JICA column (13 columns)

Detailed geological columns were described at 13 sites of outcrops during the second phase study. For detailed age determination, the geological column at Minsherah collected by (Farag and Shata), 1954 and results of micro fossil analysis obtained through cooperation with RIWR were also referred.

(2) Other sources (29 columns)

These are geological columns mainly cited in SDS. Descriptions of geology is rather approximate. However, the lithofacies and their thickness at the Lower Cretaceous, at Wadi Giddi and the one in the southern part of Maghara may require confirmation so that these parts are deleted from the data.

3-2 Well Logs

(1) Petroleum Wells (37 columns)

These columns are treated as reliable both in lithology and age.

(2) Water Wells (70 columns)

Most of these well data are accompanied by gamma ray logging, however resistivity curves are recorded either incompletely or improperly in many cases. Problems of there data are;

a) Lithology dose not correspond to logging curves,
b) Description of lithology is missing,
c) Ages are not determined and
d) Logging curves are incomplete.

Completion of lithological descriptions are undertaken. Detailed interpretation of the data is made comparing the description of lithology with the logging data, however, these which do not have complete description of lithology or are mistakenly described, are revised according to the logging data available.

In our experience in analysis of interrelationship between lithology of core samples and logging data of wells of Mesozoic and Paleozoic, it is found that the value of resistivity corresponds to the lithology. In many cases a certain relationship among resistivities of different rocks is found. In general the magnitude of resistivity values has significant influence of the water quality in the aquifers, however, the resistivity of shales indicates a relatively low resistivity value within a certain limited range.

Empirically it is known that taking the value of resistivity of shale as an unit value, a certain multiplied value of the unit value corresponds to the resistivity value of the other type of rock with in the complex in the vicinity. Of course the value of resistivity of the rock varies depending on its solidity and contents of minerals so that the unit value of the resistivity of the shale has to be determined in each complex and locality.

Taking the above in mind a detailed analysis has been made in comparison of the lithological profiles and with of lodgings at the test hole of Minsherah, Gifgafa, Halal, Naqb and Wadi Sheira referring to occurrence of the lithological sequences of 13 geological columns collected by the study team.

The conclusion of the above analysis is summarized as shown below;

1) Identification of lithology in sandstone and shale group in the Cenomanian of the Upper Cretaceous and in the Lower Cretaceous.

   a) When the low value of the resistivity of the shale is assumed as one unit (it is preferable to take the short normal):

      * 1.0 ~ 2.0 times of the unit corresponds to the resistivity of the shale.

      * 2.0 ~ 3.0 times of the unit corresponds to the alternation of shale and sandstone or sandstone with high content of mud or shale.

      * The resistivity indicating more the 4.0 times of the unit corresponds to the sandstone.

b) When the low value of the gamma ray of the sandstone is assumed as one unit:

* 1.0 ~ 1.5 times of the unit corresponds to that of sandstone.

* 1.5 ~ 3.0 times of the unit corresponds to that of the intermediate type of rocks between shale and sandstone.

* More then 3.0 times of the unit indicate that of shale. It must be mooted that the gamma ray often shows at nominally high value indifferent to the lithology so that it is easily misleading.

2) Identification of lithology in the limestone and shale group of Cenomanion and others in Upper Cretaceous.

a) When the low value of the resistivity of shale is taken as one unit:

* 1.0 ~ 2.0 times of the unit corresponds to that of shale. .

* 2.0 ~ 4.0 times of the unit corresponds to that of marl

* More than 4.0 times of the unit corresponds that of limestone.

b) When the low value of the gamma ray of limestone is one unit:

* 1.0 ~ 1.5 times of the unit corresponds to that of limestone. .

* 1.5 ~ 2.0 times of the unit corresponds to that of limestone with high content of mud.

* 2.0 ~ 3.0 times of the unit corresponds to that of marl

* More then 3.0 times of the unit corresponds that of shale.

However, dolomite usually indicates high gamma ray value so that the occurrence of dolomite shall be carefully interpreted through the detected resistivity values and geological columns in the vicinity. Also attention has to be paied to chalk.
In this manner, 50 water well profiles out of 70 were carefully interpreted referring to the relevant data.

Thus lithological descriptions of 70 borehole data have been finalized and further analyzed to determine ages. The geological columns obtained by field observation in the second stage of the study and a publication of Farag & Shata (1954) were referred for this purpose,

Major item of revision for composite columns are summarized in the Attachment 1.

The finalized composite columns are shown in the Attachment-2.

ATTACHMENT - 1

MAJOR ITEM OF REVISION

Well Name	Major Item of Revision
Darag No.1	* Considering the resistivity value the muddy sandstone in the Lower Cretaceous is revised as the sandstone. * The lithology is undifferentiated between 782m - 800m.
Nakhl 1	* The lower Cretaceous between 1,118m - 1,414m is revised as the Jurassic. * The lithology is revised between 683m - 1,143m according to the resistivity log.
Nakhl 2	* Lithology is revised according to the resistivity log. * Shale between 736m - 870m could be dolomite. * The aquifer is assumed at the layer between 940m and 1,073m. * The static water level is assumed to be at ASL 190m in - stead of GL-190m.
El Themed	* Lithology is revised according to logging results and the ages are determined.
Bir Guraid	* Lithology and ages are determined.
Naqb 3	* Lithology is revised and age determination is made.
Naqb 2	* Lithology was analized according to the log data and age was determined. The low value of gamma ray log of the pre-cambrian may indicate that it could be the metamorphic rocks rather than acidic igneous rocks.
Bir El Abd	* The boundary between the Miocene and the Pliocene is determined. There is a possibility that the Miocene between 192m to 306m might be the Pliocene.
No.69 Wadi Umm Zroub	* The Quaternary is specified.
No.70 Wadi Maleiz Well No. 1	Partly the lithology is revised and the ages are determined.
Pl Gifgafa	* The age determination is made.
Gebel Amrar	* The Upper Senonian might be read as the Lower Senonian.
Gebel Halal	* The same as Gebel Libni above.
Gebel Arf	* The Upper Cretaceous appears to be Upper Senonian. The Location shall be confirmed.

Talet El Badan	* The Upper Cretaceous appears to be the Upper Senonian. The location shall be confirmed.
Gifgafa	There are many questions: Is there dolomite in the Turonian?; Is the Senonian is only in this thickness? and is there shale in the Palcocene?
Abu Ghazala 1	The location shall be confirmed.
No. 49 El Arish Well No. 14 (Bir Hasana Well No. 15)	The lithology is revised and ages are determined.
No. 50 El Arish Well No. 15	The lithology is revised and ages are determined.
No. 57A El Arish Well No. 19 (Gebel Menshera Well)	Ages are revised referring to the geological column and also the lithology was revised. There is a possibility that microfossils collected from 49 - 50m and 100 - 103m might drop from the upper part.
No. 62 El Bruk No. 2	The age determination is made.
No. 61 El Bruk No. 1	The age is determined.
No. 65 El Menshera 2	The age is revised referring to the geological column.
No. 66 Umm Gholam No. 1	The age is revised referring to the geological column.
No. 67 El Resha No. 1	The age is determined.
No. 94 El Hasana	The lithology shall be confirmed. Ages are determined.
No. P18 Egyptian Army Hasana	The alternation of shale and sandstone between 860m and 1,060m is revised as sandstone. The ages are determined.
Gebel Kherim	The thickness of the Turonian is identified to be 70m thick, however, this column indicates 200m thick.
Gebel Umm Mafruth	The Lower Cretaceous between 500m and 745m is revised as the Cenomanian.
Maghara El Maaza	The Lower Cretaceous between 667m and 900m is revised as the Cenomanian.

No. 8 Coal mine	The age was determined.
No. 47B El Arish Well No. 12	The basement of the Quaternary is assumed at 150m from the ground surface.
No. 51B El Arish Well No. 16	The lithology is revised as well as the boundary of the age.
No. 52A El Arish Well No. 17A	Ages are determined, however, the part between 50m and 92m is subject to confirmation whether it is a part of the Quaternary or the Jurassic.
No. 53A El Arish Well No. 18	Ages are determined.
No. 54A El Fath Well No. 4	Ages are determined.
No. 55 El Massaid Well No. 4	The lighology is revised and ages are determined.
No. WX2 Coal Mine	The age is determined.
El Hemma	The age is determined. The part between 16m and 64m might be the Paleocene.
Risan Aneiza	The part between 400m and 630m is revised as the Cenomanian. Sandstone between 630m and 886m is subject to confirmation.
No. 63A Gebel Libni No. 1	Ages are determined, however further confirmation is required.
No. 41 El Arish Well No. 6	Ages are determined.
No. 42 El Arish well No. 7	The lithology is determined according to the logging data and ages are determined.
No. 45 El Arish Well No. 10	According to the logging data marls between 2m - 15m, 32m - 54m and 114m - 132m are revised as shale. The part between 150m and 290m is revised as the Eocene.
No. 60 Gebel Halal Well No. 1	Ages are determined.
No. 64 Libni No. 4	Ages are determined and the lithology is revised referring to the lithology of No. 63A.
Baghdad No. 1	The lighology and ages are determined.

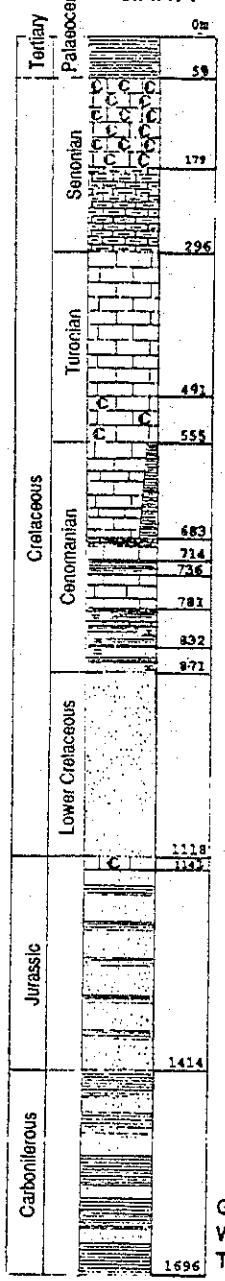
El Girai	Ages are determined.
No. 58 El Rawafa 1	The lighology and ages are determined.
No. P16 El Amro	The lithology is revised and ages are determined.
No. 76A Wadi El Amro No. 2	The lithology and the age are determined.
No. 76B Wadi El Amro No. 1	Ages are determined.
No. 78 Wadi El Husseiny	The lithology and ages are determined.
No. 79 El Merterah	The lithology and ages are determined.
No. 80A El Quseima	Neither the lithology nor the age are differentiated due to poor quality of the data.
No. 81 El Gouderate, No. 82 El Gorour	The same as No. 80A.
No. 82 El Gorour	The same as No. 80A.
No. 83 El Mewaleh Well No. 1	The lithology and ages are determined referring the result of fossil analysis, however the thickness of the Paleocene appears to be too thick.
No. 84 El Ghifi	The lithology and ages are determined.
No. 85 Abu Raty	The lithology and ages are determined.
El Monbateh Well No. 2	Logging data are required to analyze.
El Barth (B)	The kurkar between 0m and 24m described as the Recent is revised as the Pleistocene.
El Khabra	Ages are revised.
No. 55: Lehfein Well No.2	Ages are determined, however, no analysis of the lithology is made due to incomplete logging data.
El Goura Well No. 1	The Pliocene between 60m and 84m is revised.

El Girai: Well - 1	The lithology is revised however, the location shall be confirmed.
Kuntilla	The lithology is partly revised and ages are determined.
Sheira Well No. 1	The lithology and ages are revised.
Misri-1 (Water Well)	The part between 0m and 16m is revised as the Pleistocene.
No. 72 Wadi El Gady Well No. 1	The lithology is revised and ages are determined.

ATTACHMENT - 2

COMPOSITE COLUMNS

Nakhl1



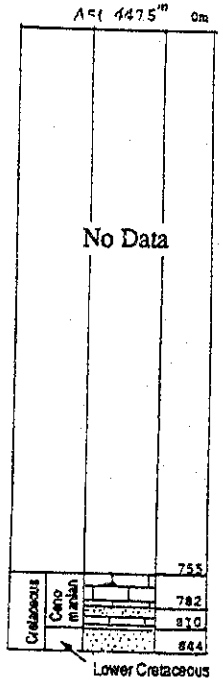
Grid : G5
W.L. : 269 m ASL
TDS : 1,635 ppm

Abu Hamth

Oil Exploration Well

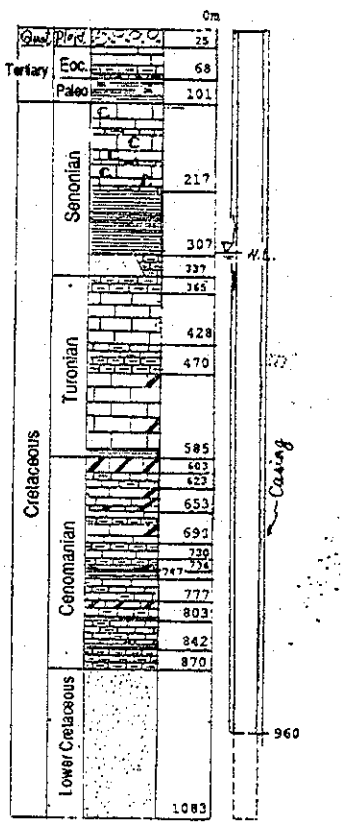
Grid : G5
W.L. : - mASL
TDS : - ppm

Darag No.1



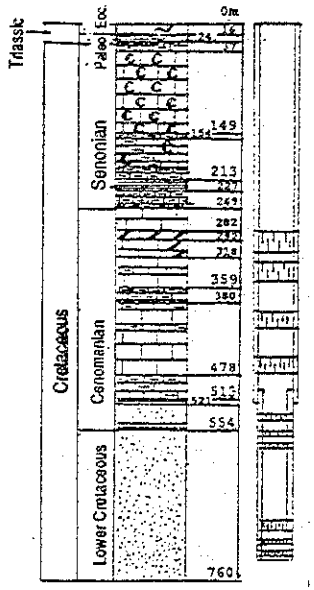
Grid : G5
W.L. : 263 m ASL
TDS : 1,490 ppm

Nakhl2



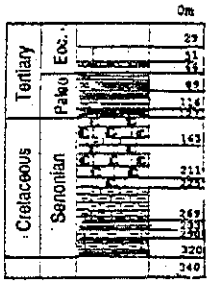
Grid : G5
W.L. : 260 m ASL
TDS : 1,200 ppm

El Themed



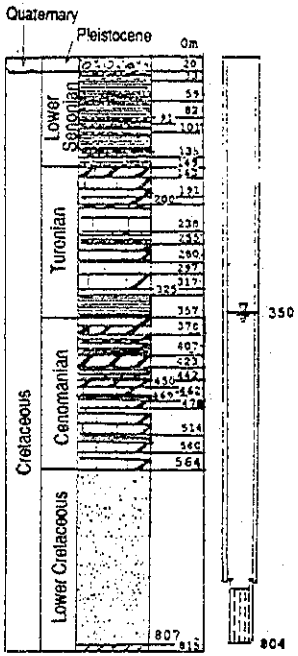
Grid : G6
W.L. : - m ASL
TDS : 3,500 ppm

Bir Guraid



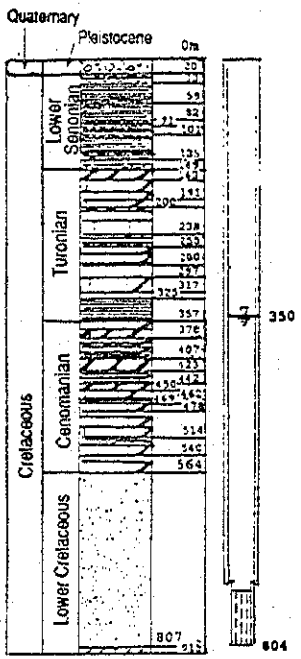
Grid : G6
W.L. : - mASL
TDS : - ppm

Sheira Well 1



Grid : H3
W.L. : 420 m ASL
TDS : 1,575 ppm

Seira Well 2
(Shira Well 1)



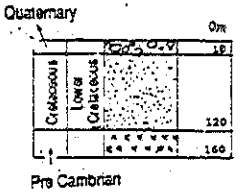
Grid : H3
W.L. : 679 m ASL
TDS : 1,100 ppm

JNo.15 Naqb

Refer Technical Report I

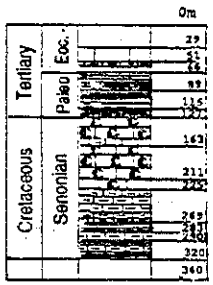
Grid : H3
W.L. : - mASL
TDS : - ppm

Naqb 2



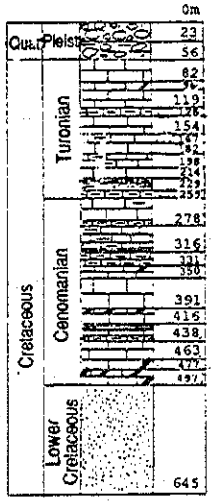
Grid : H4
W.L. : - mASL
TDS : DRY ppm

Naqb 3



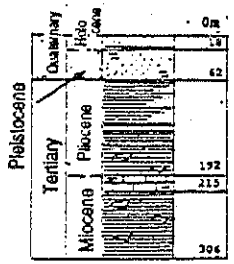
Grid : H4
W.L : 290 m ASL
TDS : 35,000 ~40,000 ppm

Kuntilla



Grid : H4
W.L : - mASL
TDS : - ppm

Bir El Abd



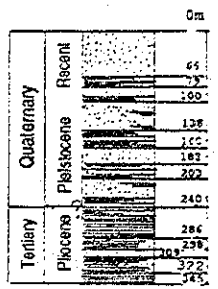
Grid : J6
W.L : - mASL
TDS : - ppm

Katib

Oil Exploration Well

Grid : J6
W.L : - mASL
TDS : - ppm

South Shohat



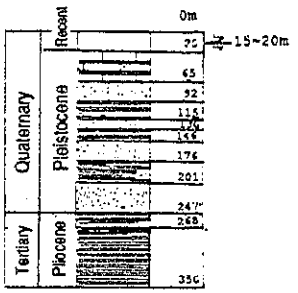
Grid : J6
W.L : - mASL
TDS : - ppm

Sheh-1

Oil Exploration Well

Grid : J6
W.L : - mASL
TDS : - ppm

Quitia Well No.1



30°55'00"N
32°25'00"E

RIWR DASCO 1987

12000~16000ppm (TDS)

Pumping Rate 25 m³/H

<J6 1:100,000>

<注> 地表

岩相および時代は不明確.

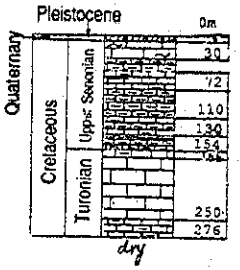
Grid : J6
W.L : 5 mASL
TDS : 12000~15000 ppm

Manna-1

Oil Exploration Well

Grid : J6
W.L : - mASL
TDS : - ppm

No. 71 Wadi El Baha-1



30°18'00"N
33°13'00"E

RIWR. DASCO. 1985

<K1 1:100,000>

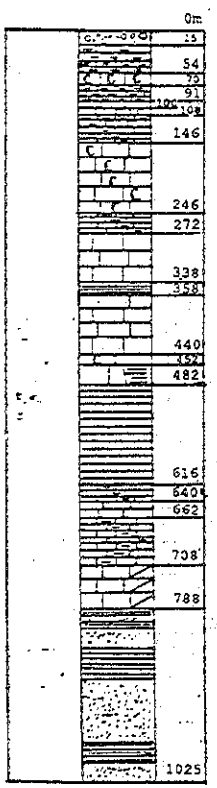
<注> 地表

50-53m : Upper Cretaceous (Campanian Maastrichtian)

378-551m : 同上 (")

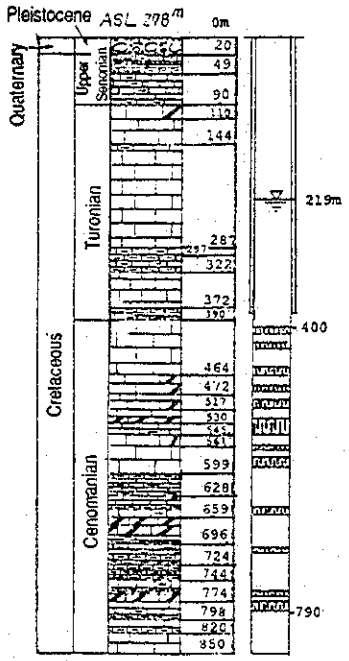
Grid : K1
W.L : - mASL
TDS : - ppm

Sudr El Heitan



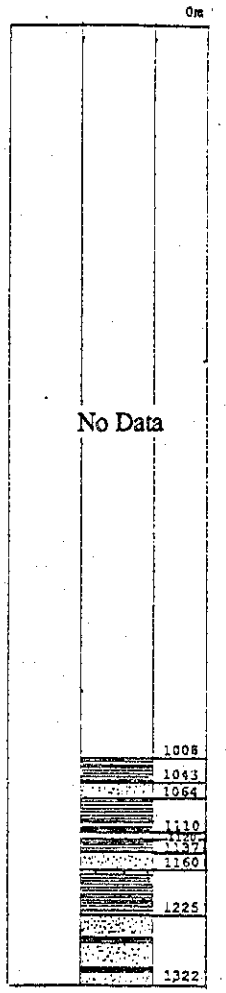
Grid : K1
W.L : 205 mASL
TDS : 1246 ppm

P1 Gifgafa



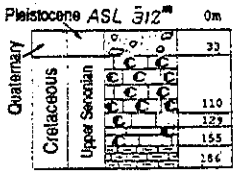
Grid : K1
W.L. : 79 m ASL
TDS : 3,500 ppm

Abu Ghazala



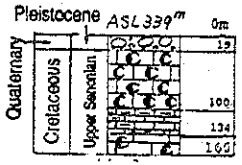
Grid : K1
W.L. : 101 m ASL
TDS : - ppm

No. 68 El Hagaib



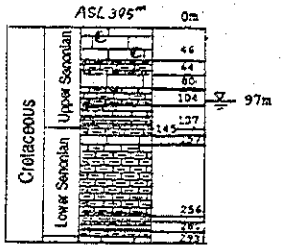
Grid : K1
W.L. : - mASL
TDS : - ppm

No. 69 Wadi Umm Zroub



Grid : K1
W.L. : - mASL
TDS : - ppm

No. 70 Wadi El Maleiz-1



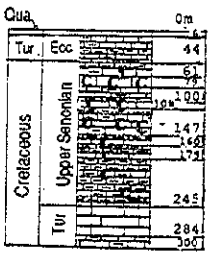
Grid : K1
W.L. : 298 m ASL
TDS : 8,480 ppm

JNo.13 Falig

Refer Technical Report I

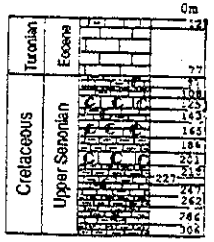
Grid : K1
W.L : 67 mASL
TDS : - ppm

No. 61 El Bruk No.1



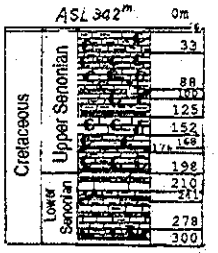
Grid : K2
W.L : - mASL
TDS : -ppm

No. 62 El Bruk No.2



Grid : K2
W.L : - mASL
TDS : - ppm

No. 65 El Menshera2



Grid : K2
W.L : - mASL
TDS : - ppm

JNo.12 Minsherah

Refer Technical Report I

Grid : K2
W.L : 198 mASL
TDS : 2,973 ppm

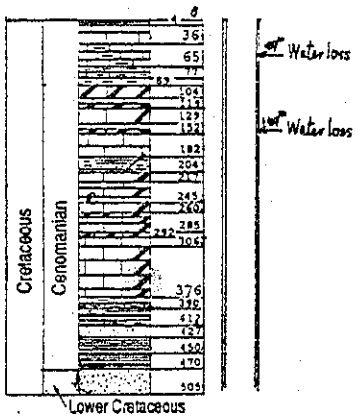
Grid : K2
W.L : 198 mASL
TDS : 2973 ppm

JNo.16 El Bruk-1

Refer Technical Report I

Grid : K2
W.L : 203 mASL
TDS : 2,318 ppm

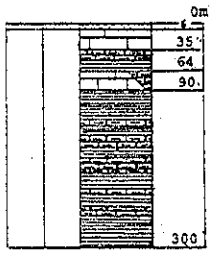
JNo. 17 El Bruk-2
(JNo. 16 El Bruk-1)



Grid : K2
W.L. : 203 m ASL
TDS : 2,318 ppm

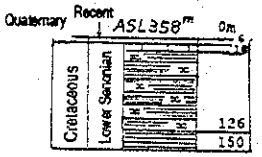
Grid : K2
W.L : 223 mASL
TDS : 5,628 ppm

El Monshareh No.1



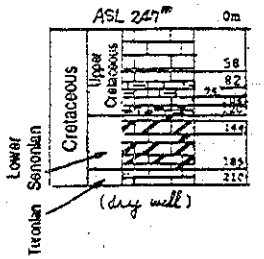
Grid : K2
W.L : - mASL
TDS : - ppm

El Resha No.1



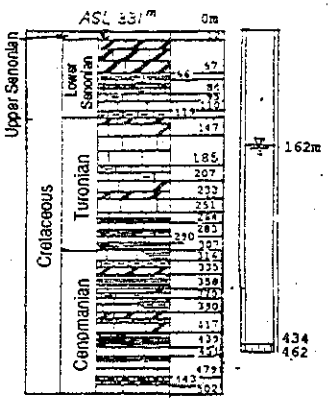
Grid : K2
W.L : - mASL
TDS : - ppm

No. 49
El Arish Well No.14



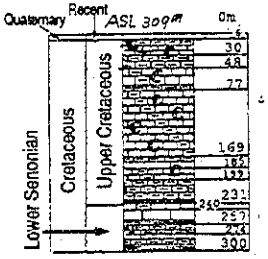
Grid : K2
W.L. : 107 m ASL
TDS : 2,200 ppm

No. 57A
El Arish Well No.19



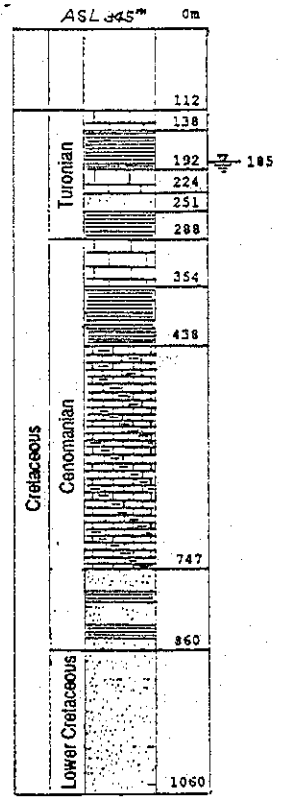
Grid : K2
W.L. : 169 m ASL
TDS : 2,740 ppm

No. 66
Umm Gholam No.1



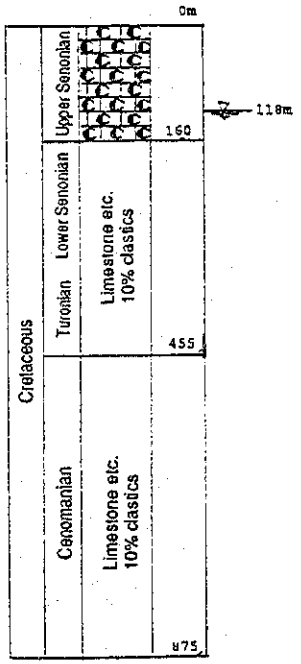
Grid : K2
W.L. : - mASL
TDS : - ppm

No. p18
Epytian Army Hasana



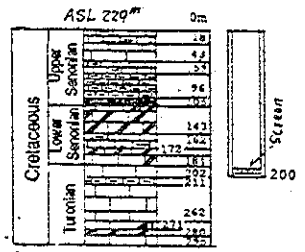
Grid : K2
W.L. : 160 m ASL
TDS : 1,500 ppm

Bir Hasana



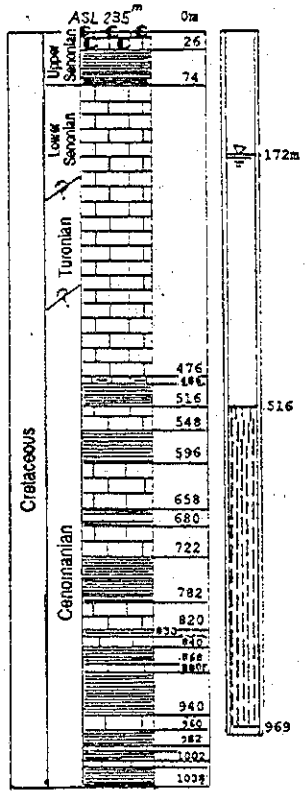
Grid : K2
W.L. : 142 m ASL
TDS : 1,500 ppm

No. 50
El Arish Well No.15



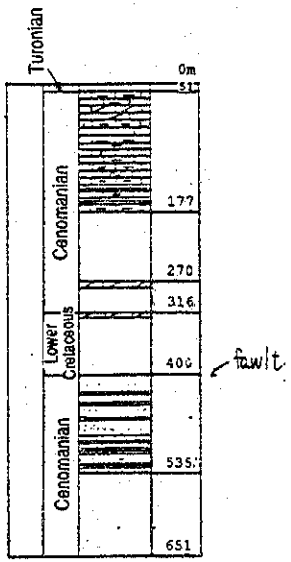
Grid : K2
W.L. : 39 m ASL
TDS : 7,000 ppm

P4 El Hasana



Grid : K2
W.L. : 63 m ASL
TDS : 4,120 ppm

Talet El Badan



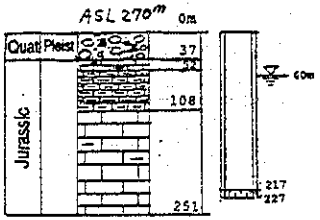
Grid : K3
W.L. : 72 mASL
TDS : 5360

JNo.19 Arif El Naga

Refer Technical Report I

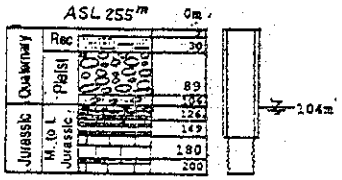
Grid : K3
W.L. : 159 mASL
TDS : 3008 ppm

No. 46 El Arish Well -11



Grid : K4
W.L. : 210 m ASL
TDS : 3,600 ppm

No. 47B El Arish Well -12



Grid : K4
W.L. : 151 m ASL
TDS : 1,650 ppm

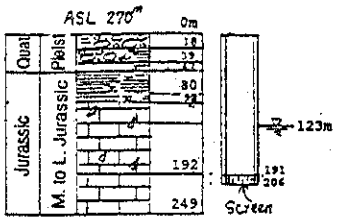
Note M. to L. : Middle to Lower

No. 51B
El Arish Well-16

Oil Exploration Well

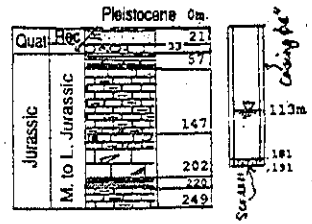
Grid : K4
W.L. : - mASL
TDS : - ppm

No. 52A
El Arish Well -17A



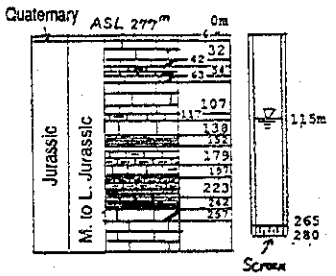
Grid : K4
W.L. : 147 m ASL
TDS : 3,450 ppm

No. 54A
El Fath Well -4



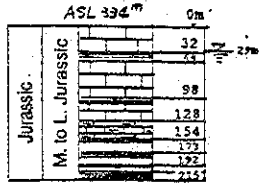
Grid : K4
W.L. : 167 m ASL
TDS : - ppm

No. 55
El Massajid Well No.4



Grid : K4
W.L. : 162 m ASL
TDS : 2,800 ppm

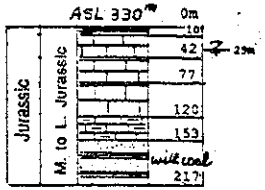
No.5 Coal Mine



Grid : K4
W.L. : 305 m ASL
TDS : 4,140 ppm

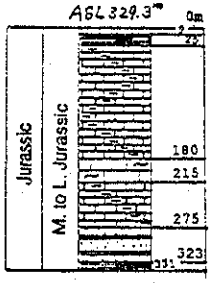
Note M. to L. : Middle to Lower

No.6 Coal Mine



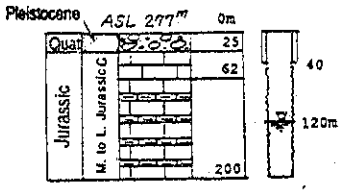
Grid : K4
W.L. : 301 m ASL
TDS : 7,300 ppm

No.8 Coal Mine



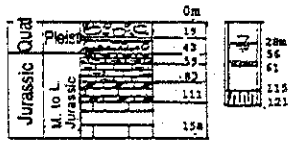
Grid : K4
W.L. : - m ASL
TDS : 7,455 ppm

No.WX2 Coal Mine



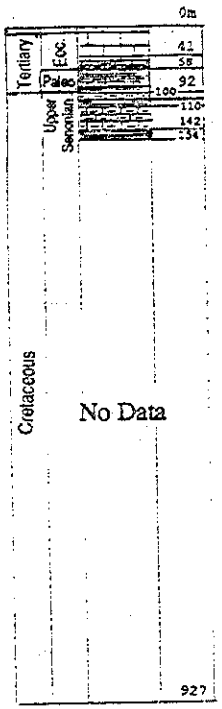
Grid : K4
W.L. : 157 m ASL
TDS : 2,700 ppm

No. 53A El Arish Well -18



Grid : K4
W.L. : 232 m ASL
TDS : 3,810 ppm

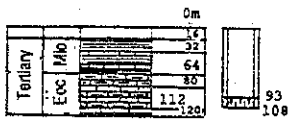
Baghdad No.1



Grid : K5
W.L. : - mASL
TDS : - ppm

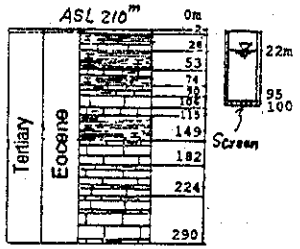
Note M. to L. : Middle to Lower

El Hemma



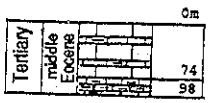
Grid : K5
W.L : - mASL
TDS : - ppm

No. 45A
El Arish Well No.10



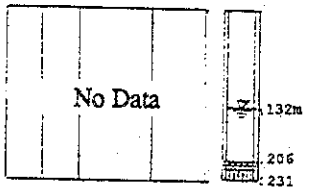
Grid : K5
W.L. : 188 m ASL
TDS : 5,200 ppm

No. 48
El Arish Well No.13



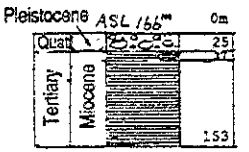
Grid : K5
W.L : - mASL
TDS : - ppm

No. 63C
Libni Well No.3



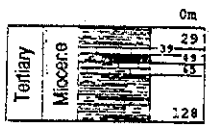
Grid : K5
W.L : 58 mASL
TDS : 4500 ppm

No. 41
El Arish Well No.6



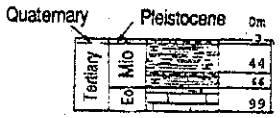
Grid : K5
W.L : - mASL
TDS : - ppm

No. 43
El Arish Well No.8



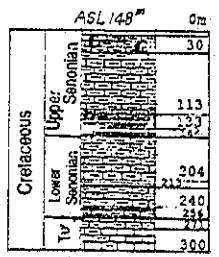
Grid : K5
W.L : - mASL
TDS : - ppm

No. 42
El Arish Well No.7



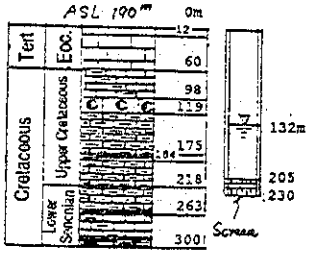
Grid : K5
W.L : - mASL
TDS : - ppm

No. 60
Gebel Halal Well No.1



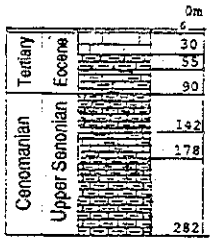
Grid : K5
W.L : - mASL
TDS : - ppm

No. 63A
Gebel Libni No.1



Grid : K5
W.L. : 58 m ASL
TDS : 4,500 ppm

No. 64
Libni No.4



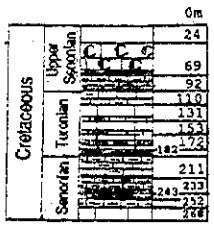
Grid : K5
W.L : - mASL
TDS : - ppm

JNo.18 Lehfen

Oil Exploration Well

Grid : K5
W.L. : - mASL
TDS : - ppm

Abu Raty



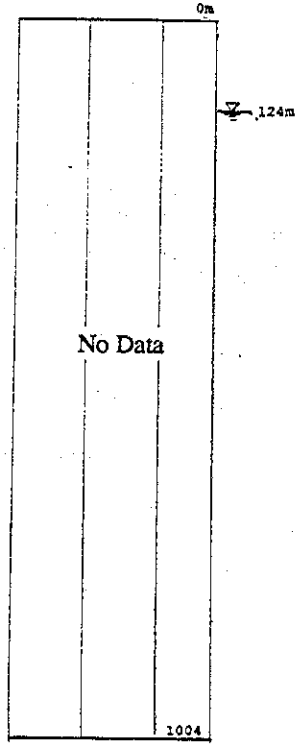
Grid : K6
W.L. : - mASL
TDS : - ppm

El Halal Israeli Well

Oil Exploration Well

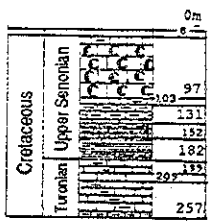
Grid : K6
W.L. : 24 mASL
TDS : 1410 ppm

El Monbateh Well2



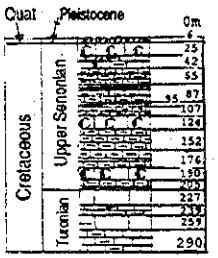
Grid : K6
W.L. : 76 m ASL
TDS : 3,200 ppm

No. 78 Wadi El Husseiny



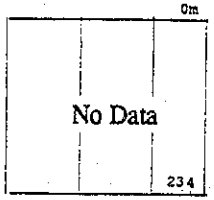
Grid : K6
W.L. : - mASL
TDS : - ppm

No. 79
El Merterah



Grid : K6
W.L : - mASL
TDS : - ppm

No. 82
El Gorour



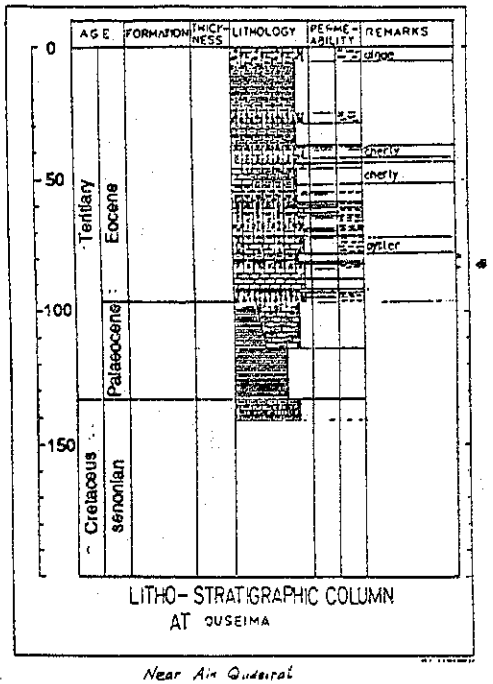
Grid : K6
W.L : - mASL
TDS : - ppm

JNo.14 Halal

Refer Technical Report I

Grid : K6
W.L : - mASL
TDS : - ppm

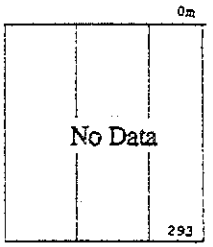
Ain Gudeirat



Near Ain Qudeirat

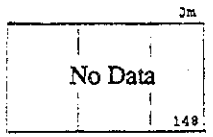
Grid : K6
W.L : m ASL
TDS : 1440 ppm

No. 80A
El Quseima



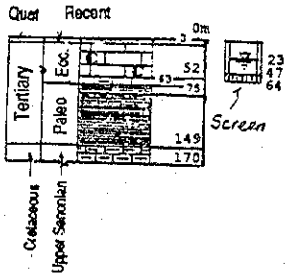
Grid : K6
W.L : - mASL
TDS : - ppm

No. 81 El Gouderate



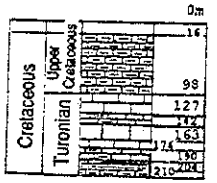
Grid : K6
W.L. : - mASL
TDS : - ppm

No. 83 El Mewaleh Well -1



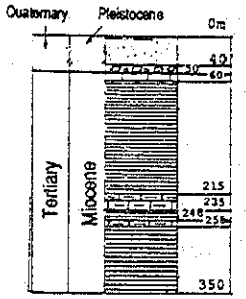
Grid : K6
W.L. : 257 m ASL
TDS : - ppm

No. 84 El Ghifi



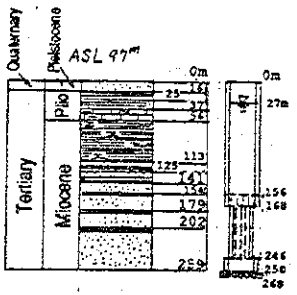
Grid : K6
W.L : - mASL
TDS : - ppm

El Girai



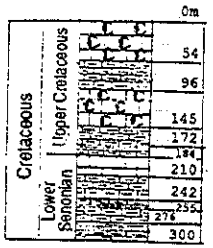
Grid : K6
W.L. : - mASL
TDS : - ppm

Misri 1



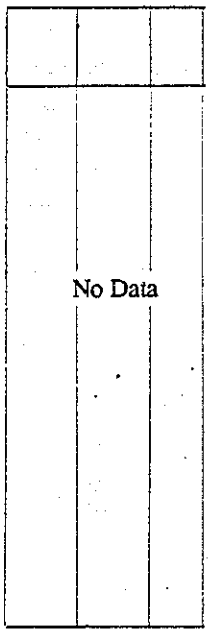
Grid : K6
W.L. : 70 m ASL
TDS : 10,450 ppm

No. 58 El Rawafa1



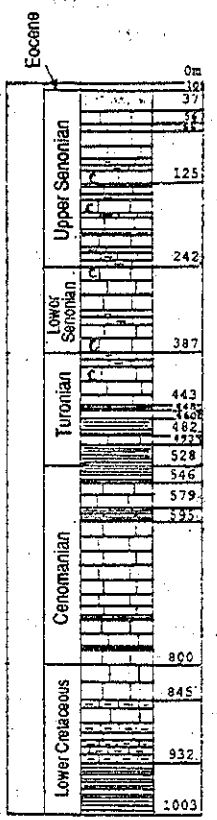
Grid : K6
W.L : - mASL
TDS : - ppm

El Magdaba



Grid : K6
W.L : - mASL
TDS : 2500 ppm

Umm Shihan



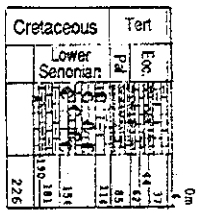
Grid : K6
W.L : 25 mASL
TDS : - ppm

JNo.4 Rawafa Dam

Oil Exploration Well

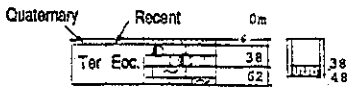
Grid : K6
W.L : - mASL
TDS : - ppm

No. 76A Wadi El Amro No.2



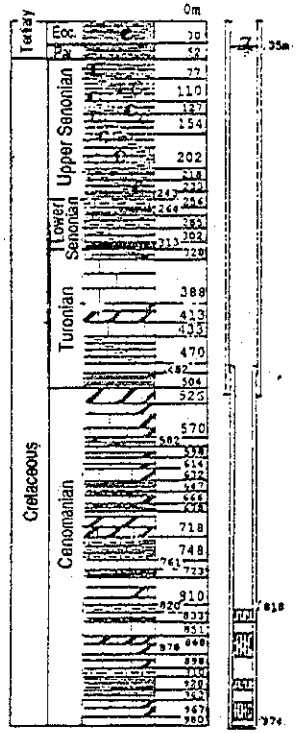
Grid : K6
W.L : -3 mASL
TDS : 5050 ppm

No. 76B
Wadi El Amro No.1



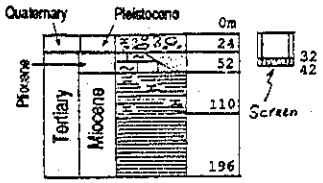
Grid : K6
W.L : - mASL
TDS : - ppm

P16 El Amro



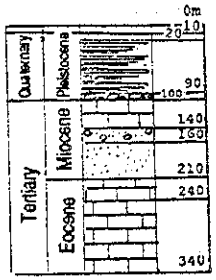
Grid : K6
W.L. : 175 m ASL
TDS : 4,000 ppm

El Barth (B)



Grid : K6
W.L : - mASL
TDS : 3720 ppm

El Khabra



Grid : K6
W.L : 0 mASL
TDS : - ppm

Khabra-1

Oil Exploration Well

Grid : K6
W.L : - mASL
TDS : - ppm

JNo.10 Barth

Oil Exploration Well

Grid : K6
W.L : 104 mASL
TDS : 3,622 ppm

JNo.11 Barth

Oil Exploration Well

Grid : K6
W.L : - mASL
TDS : - ppm

Rommana-1X

Oil Exploration Well

Grid : N3
W.L : - mASL
TDS : - ppm

Bougaz-1

Oil Exploration Well

Grid : N3
W.L : - mASL
TDS : - ppm

Pelusion

Oil Exploration Well

Grid : O1
W.L : - mASL
TDS : - ppm

Gofer-1

Oil Exploration Well

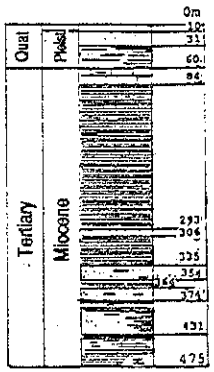
Grid : O1
W.L : - mASL
TDS : - ppm

Slav-1

Oil Exploration Well

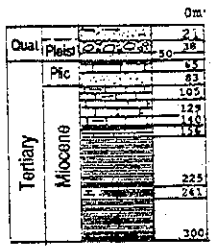
Grid : O1
W.L : - mASL
TDS : - ppm

El Goura Well No.1



Grid : O2
W.L : - mASL
TDS : - ppm

No. 5-5 Lehfin Well No.2



Grid : O2
W.L : - mASL
TDS : - ppm

Arish-1

Oil Exploration Well

Grid : O2
W.L : - mASL
TDS : - ppm

JNo.1 El Medan

Refer Technical Report I

Grid : O2
W.L : - mASL
TDS : - ppm

JNo.2 El Tawil

Refer Technical Report I

Grid : O2
W.L : -- mASL
TDS : - ppm

JNo.3 El Tawil

Refer Technical Report I

Grid : O2
W.L : 3.0 mASL
TDS : 5,562 ppm

JNo.5 El Kharoba

Refer Technical Report I

Grid : O3
W.L : 8.1 mASL
TDS : 4,290 ppm

Haruvit-1

Oil Exploration Well

Grid : O3
W.L : - mASL
TDS : - ppm

JNo.6 El Sheikh Zuwayed

Refer Technical Report I

Grid : O3
W.L : 4.9 mASL
TDS : 4,830 ppm

JNo.7 El Sheikh Zuwayed

Refer Technical Report I

Grid : O3
W.L : 4.5 mASL
TDS : 5560 ppm

JNo.8 El Massora

Refer Technical Report I

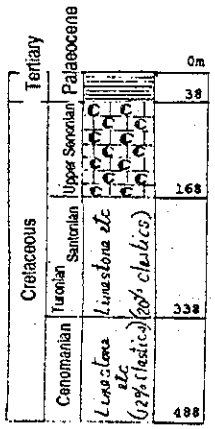
Grid : O3
W.L : 5.2 mASL
TDS : 2,192 ppm

JNo.9 El Massora

Refer Technical Report I

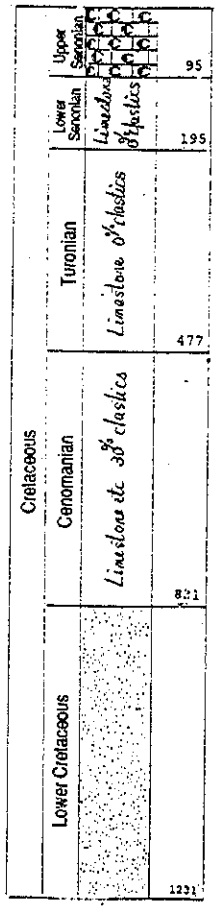
Grid : O3
W.L : 0.7 mASL
TDS : 3,470 ppm

Gebel Somar



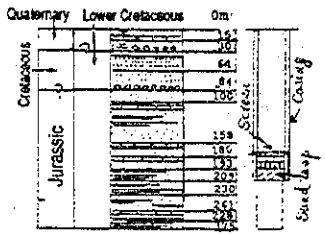
Grid : G4
W.L : - mASL
TDS : - ppm

Gebel Giddi



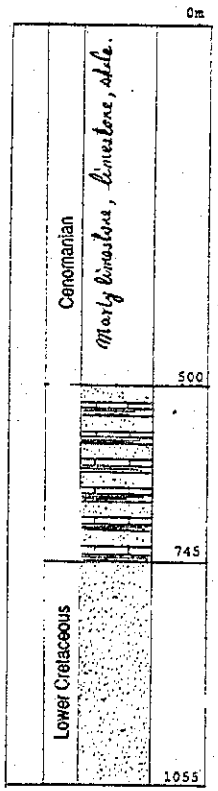
Grid : K1
W.L : - mASL
TDS : - ppm

Wadi El Giddi



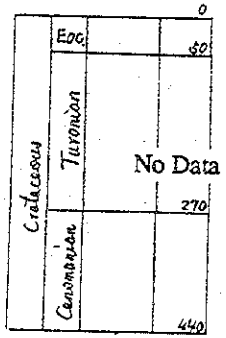
Grid : K1
W.L : - mASL
TDS : - ppm

Gebel Umm Mafrouth

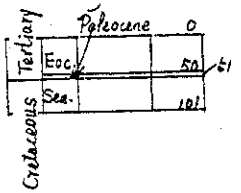


Grid : K4
W.L : - mASL
TDS : - ppm

Gebel Amrar



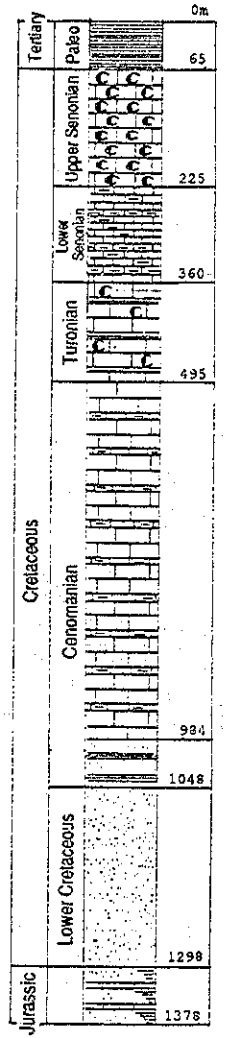
Gebel El Maghara



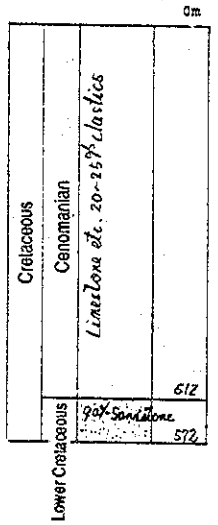
Gebel El Arf

Oil Exploration Well

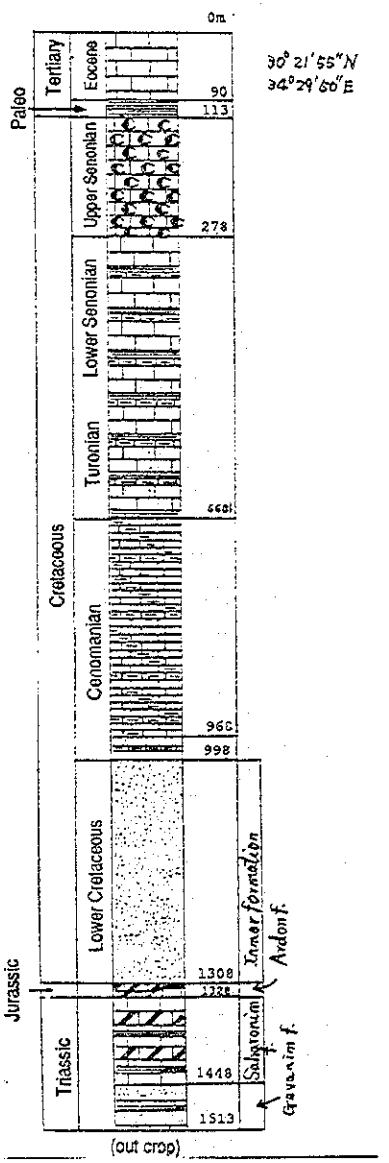
Gebel El Menshera



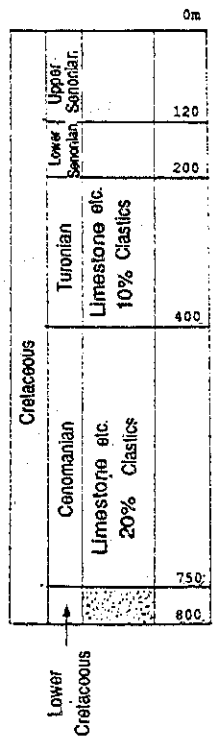
Gebel Yelleq



Gebel Arif El Naga

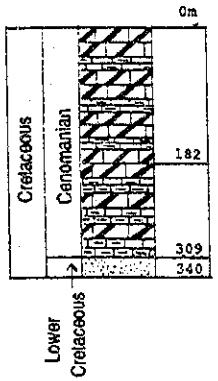


Gebel Kherim



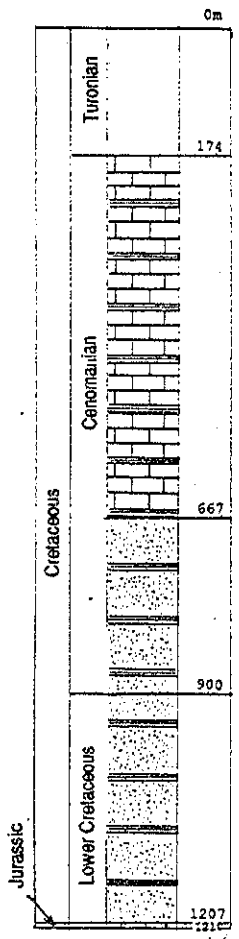
Grid : K3
W.L : - mASL
TDS : - ppm

Wadi Khareiza



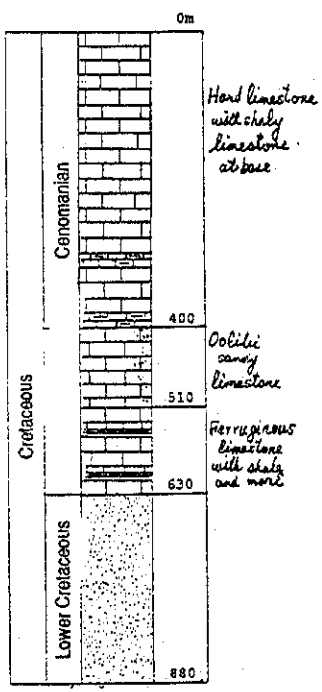
Grid : K3
W.L : - mASL
TDS : - ppm

Maghara El Maaza



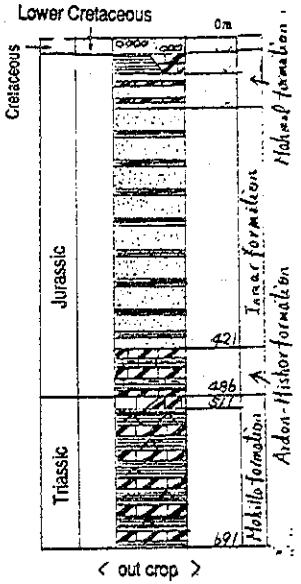
Grid : K4
W.L : - mASL
TDS : - ppm

Risan Aneiza



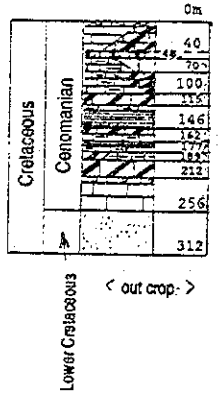
Grid : K5
W.L : - mASL
TDS : - ppm

Makhtesh Ramon



Grid : L4
W.L : - mASL
TDS : - ppm

East To Wadi Watir



Grid : H3
W.L : - mASL
TDS : - ppm

TECHNICAL REPORT

V

LANDFORM CLASSIFICATION

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1 INTRODUCTION

Landsat image analysis was carried out for preparation of landform classification map of 1/250,000 scale. This analysis has been carried out in the phase-I stage of the study for the purpose of obtaining data required to comprehensively recognize the geomorphological feature of the study area.

The ground truth was carried out based on the results of landform classification obtained through the first stage study, in order for further detailed classification of the distribution of each landform unit.

2 SITE SURVEY

For North Sinai, monochrome aerial photographs in scale of 1/10,000 and 1/15,000 have been obtained and interpreted. In addition a 1/50,000 mosaic photographs have also been prepared based on these aerial photographs.

On the occasion of the site survey, landform classification was carried out using the aerial photographs, in addition to the Landsat images. Since these aerial photographs are extremely in large scale, the amount of information was considered to be too aboundant for this study. Therefore, site survey for this study was carried out based upon the Landsat image data, while improving the reliability of landform classification the aerial photographs were interpreted. Then, the final results were compiled into the landform classification map in scale of 1/250,000.

3 PREPARATION OF LANDFORM CLASSIFICATION MAP

In the first stage study, the landform in North Sinai was classified preliminarily into the following eleven items; Namely, 1) Mountain, 2) hilly upland, 3) Rock platform, 4) Diluvial upland, 5) Old fan, 6) Aluvial fan, 7) Wadi, 8) Sand dune, 9) Sand bar, 10) Lagoonal lowland, 11) Talus and 12) Coastal lowland. As a result of this site survey, the tableland and lowland were further subdivided, and the landform was classified into seventeen items in total. Thereby, the landform was summarized in a 1/250,000 scale map. The respective items of the landform classification are described below.

(1) Mountain (M)

The distribution of mountains has been dominated entirely by the geological structure. The mountains consist of those ranging over the so-called Syrian Arc and are distributed in a block form in the east-northeast and west-southeast directions. The mountains distributed in a block form along the Syrian Arc have been formed due to tectonic movements. Such mountains include the Gebel El Magara, Gebel El Yelleq and Gebel El Halal. These mountains consisting mainly of limestone and other sedimentary rocks have also been formed on the east and west-south sides of the study area along the border with Israel. The elevations of the mountains range from several hundreds to 1,000 meters.

(2) Hilly upland (E)

Judging from the distribution of elevation, the hilly uplands are distributed widely in the intermediate zone between the mountain and desert zones. The base rocks of these hilly uplands consist of chalk and limestone of the Tertiary system with the elevation ranging from 200 - 300m to 500 - 700m at high places. In view of landform, the drainage system dominates where there are moderate ups and downs. Although small scale cuesta landform and erosional monadnock landform are distributed as a result of differential erosion.

(3) Plateau (PL)

The landform wherein a wide and flat area is formed on a summit surrounded by a steep ridge, is classified as plateau. The distribution of the plateau is comparatively limited. Regarding the causes of formation, the strata of chalk, limestone, etc. sedimented roughly horizontally are presumed to have been formed into plateau as a result of differential erosion.

(4) Terrace (TR1 and TR2)

In the study area, formation of clear terrace landforms are observed. The terrace landforms are formed particularly around Gebel El Maghara and Gebel El Yelleq, and also around the major tributaries upstream of the Wadi El Arish. Considering the fact that two stage terrace landform is observed in the study area, the landform in the land classification map is classified into higher terrace (TR1) and a lower Terrace (TR2). These terrace landforms are presumed to have been affected largely by variation in climatic conditions in the past. In other words, there existed a distinct period during which the sedimentation action played a major role, and another period during which the erosion action played a major role. Consequently, such landforms are considered to have been formed due to the change in environment in the Quaternary period.

Basically, the terraces are comprised chiefly of sand and gravel deposits. These deposits seem to be comparatively thin on the inland side.

(5) Fans (F1 and F2)

This fan landform has been formed due to the sedimentation action of rivers in mountainous areas. Under this study, the fan landform is divided into two types, F1 and F2. The fan F1 refers to the summit portion where the action of erosion has progressed to some extent in the past but is not subjected any erosion at present, while the fan F2 was not virtually been subjected to any erosion in the past but is subjected to considerable erosion at present.

Basically, such fans consist of sand and gravel. On the inland side, such fan sediments are presumed to be comparatively thin due to exposed conditions of bedrock. On the other hand, under the sand dune on the Mediterranean sea side, a fan is presumed to have been formed during the sea level reduction period (about 20,000 - 30,000 years ago), due to the fluctuation of the sea level associated with the change in climate during the Quaternary period.

(6) Pediment (P)

As a landform inherent to dry area, the pediment is a moderate mountain slope formed due to the action of erosion chiefly on the portion of pediment. Without any major river, only small scale drainage systems have developed on the slope of the pediment. The pediment is distributed as if surrounding the mountain of a pediment of hilly upland.

(7) Rock plain (RP)

The lowland with small ups and downs with mainly exposed rock is classified as a rock plain. Its distribution is comparatively limited and observed at the northeastern part of Hasane.

(8) Gravel plain (GP)

This plain is a lowland with small ups and downs where sand and gravels are mainly distributed on the ground surface, with small sand dune sediments. A part of the area is also presumed to have been affected by flash floods. This plain is considered to have been formed due to the sedimentation action in the past corresponding to the flow route of wadis. At some places, sand and gravels are quarried and supplied as aggregates for construction work.

(9) Talus (TL)

This is a landform formed due to sedimentation of collapsed materials under steep ridge by exposure of bedrock. The distribution of this talus landform is rather limited.

(10) Sand dune (SD)

The desert formed widely around the Suez Canal on the west side of the study area that extends towards the Mediterranean side is covered by this sand dune.

(11) Coastal sand dune (CSD)

The coastal sand dune is distributed along the coast from El Arish on the northeast side of the study area to Rafah. This area is entirely whitish according to the Landsat images, and is clearly different from the inland sand dune of the desert. The specific elevation of the coastal sand dune ranges from 20 to 30m and even to about 5km at places with a large width. As the rainfall is comparatively high (100 - 300mm per year) in the area from El Arish to Rafah, the rain stored in the coastal sand dune is utilized as groundwater source to the farmlands in this area.

(12) Coastal plain (CP)

This coastal plain has been formed on the Suez Bay side, located towards the west side of the study area.

(13) Lagoonal lowland (LL)

This coastal lowland lies along the Bardawil Lagoon of the coast towards the north side of the study area, and is surrounded by sand bar and inland sand dunes.

(14) Sand bar (SB)

An extremely long sand bar has been formed at the northern part of Sabkhet el Bardawil.

(15) WADI (W)

Tributaries of the Wadi El Arish system which include their respective floodplains. With the sediments mainly consisting of sand and gravel, localized groundwater is observed at times of floods. The width of the floodplain is extremely large. Although such sediments could generally be potential aquifers, the stratum is so thin with no significant potential for ground water development. A part of the Wadi sand and gravel sediments are also quarried as aggregates for construction work.

Legend

M	MOUNTAIN
H	HILLY UPLAND
PL	PLATEAU
TR1	HIGHER TERRACE
TR2	LOWER TERRACE
F1	OLD FAN
F2	ALLUVIAL FAN
P	PEDIMENT
RP	ROCK PLAIN
GP	GRAVEL PLAIN
TL	TALUS
SD	SAND DUNE
CSD	COASTAL SAND DUNE
CP	COASTAL PLAIN
LL	LAGOONAL LOWLAND
SB	SAND BAR
W	WADI