SEDIMENTARY STRUCTURES AND THICKNESS AND FACIES VARIATION IN THE BASAL CRETACEOUS SANDSTONES OF CENTRAL LEBANON

MOHAMED FAISAL KANAAN

1966

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GRES DE BASE OF CENTRAL LEBANON

Kana'an

ABSTRACT

The "Basal Cretaceous Sandstone" formation or "Gres de Base" of Lebanon consists, in most parts, of a sequence of quartz sandstones and argillaceous sandstones, interbedded with clays, shales, lignites, and locally volcanic material; except in the southwest where the sequence consists of marine sandstones, marls, marly limestones, limestones, dolomites, clays and shales.

Stratification and cross-bedding are the main sedimentary structures that were studied in detail; the former are mainly lithologic in character, and vary from laminated to massive beds, that exhibit more or less a general rhythmic alternation. Cross-bedding is characterized by the predominanse of the tabular type, and lesser occurence of the wedge and trough types. Both tangential and non-tangential foresets were observed, accompanied by frequent truncation of the upper zones of cross-bedded units, and giving rise to uniform surfaces, or "bedding". Graded distribution is mostly observed in the cross-laminations within cross-bedded units, this grading being rhythmic. Current directions as obtained from rose diagram analysis and stereographic pole projections show a general westerly trend, with a concentration of 85°/o of the readings within azimuths of 160°N and 360°N, or within sector of 200°. There is a close association between the regional mode of reading (260°N), and the vector mean of readings (255°N). The variance is found to range between 830 and 7900; while the standard deviation of scatter ranged between 21° and 62°. A fluvial-deltaic environment in which these sedimentary

structures occured is strongly suggested by these observations.

Two broad facies are recognisable in the "Basal Cretaceous Sandstones" of Lebanon. (I) a non-marine to transitional, deltaic or terrestrial fluvial facies consisting of sandstones, with some clays, shales, and subordinate lignites, and calcereous sandstones, and occasionally volcanic material, and (2) a marine facies consisting of limestones, marly limestones, clays, shales, and sandstones. These two facies broadly correspond to the main ones proposed by Picard (1959), for the equivalent deposits to the formation in Palestine and Jordon. The "Hathira Sandstone Formation" of Upper Jurassic and Lower Cretaceous age is considered equivelant to the "Basal Cretaceous Sandstones" of Lebanon. It is mainly continental to fluvial-deltaic in Jordon, becoming progressively more marine in a westerly and northwesterly direction going into west Palestine and southwest Lebanon.

In Lebanon the "Basal Cretaceous Sandstones" die out towards the north, thin towards the east, and probably disappear towards the west (where they give way to a marine formation?); some thinning seems to occur in a southerly direction. In Palestine and Jordon it follows roughly the same trend. Two centres of large thicknesses are observed in the Jezzin area (in Lebanon 388m), and the Makhtesh Hathira area (in Palestine 450m). Regional thickness variations are apparently more controled by the irrigularities in the depositional surface rather than by pronounced regional basin development, downwarpings or subsidences on a local scale, but local thickness variations seem to be due to the environment of deposition itself.

The prevailing climate was wet and rather warm, with heavy concentrated seasonal rainfall. Diverse river drainage networks were extensive. The provenance or source area of the sands transported and deposited by these networks was either from primary granitic sources to the south, or from desertic sand bodies nearer at hand which accumulated prior to the development of the wet climate.

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INTRODUCTION

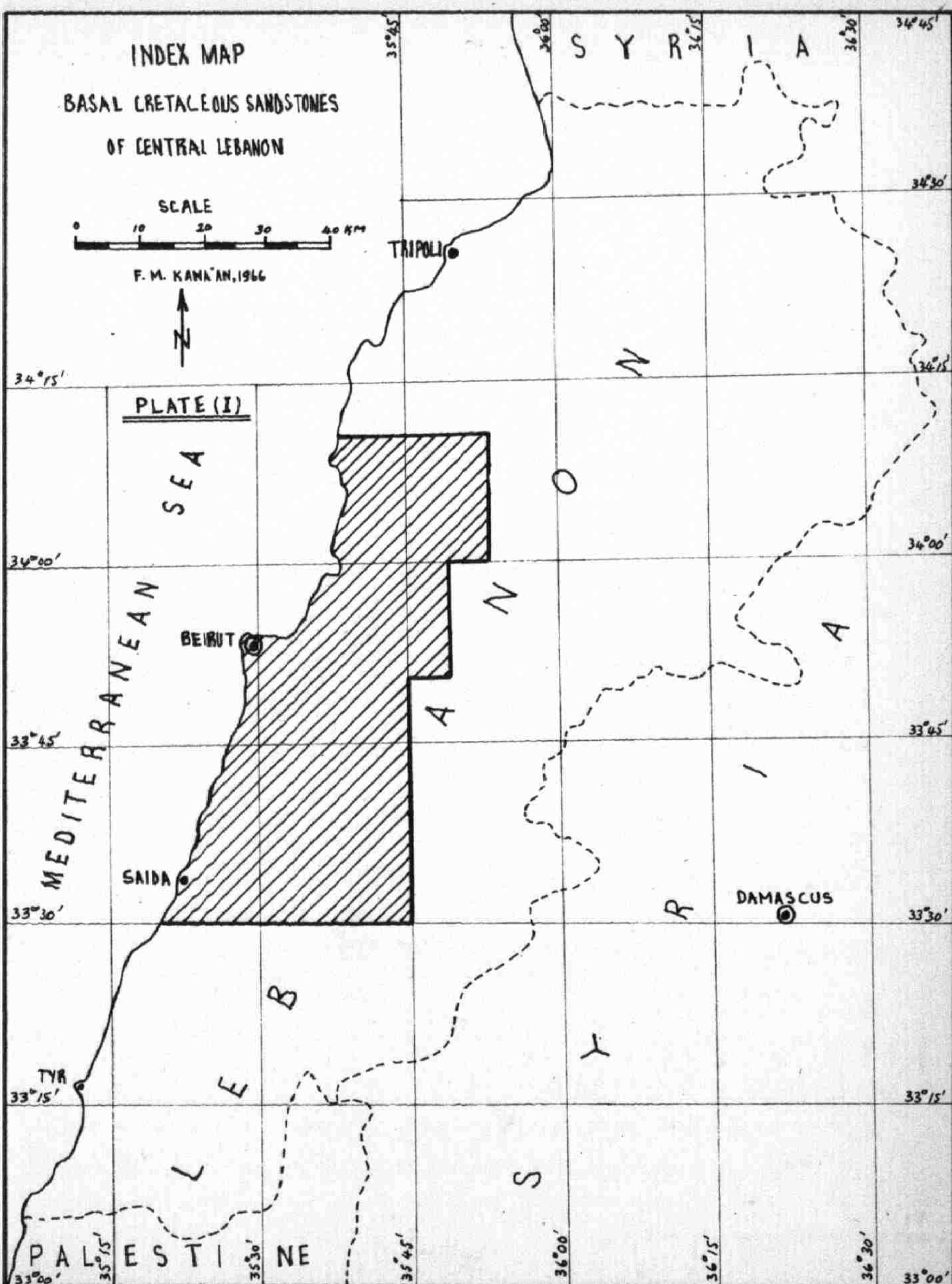
Location

The field area in which the present work was carried out lies in the central part of Lebanon within the western or Lebanon range. Qartaba area form the nothern limit, and the Jezzine area the southern limit. The Bekaa plain and the Mediterranean Sea mark the eastern and western limits, respectively. See plate (I) for exact location.

Physiography

The area forms part of the Lebanon mountainous range of Mount Lebanon running roughly NNE-SSW and paralleling the Mediterranean coast. Altitudes decrease in a southerly direction in this chain; the highest peak is located at Kornet as Saouda (about 34 km northeast of Qartaba), and is 3088 meters in elevation. In the southeast of Jezzine at Jabal Niha the maximum altitude in 1853 meters.

Along this range most of the outcrops of the "Basal Cretaceous Sandstones" formation are widely distributed; they are best seen along ridges. Most of the outcrops are well covered by vegetation, particularly pine trees; this vegetation cover generally serves as an indication for the presence of sandstones and is especially useful in aerial photographs examination, but limits the number of good workable exposures. The present work was carried on nearly most of these good outcrop areas within central Lebanon.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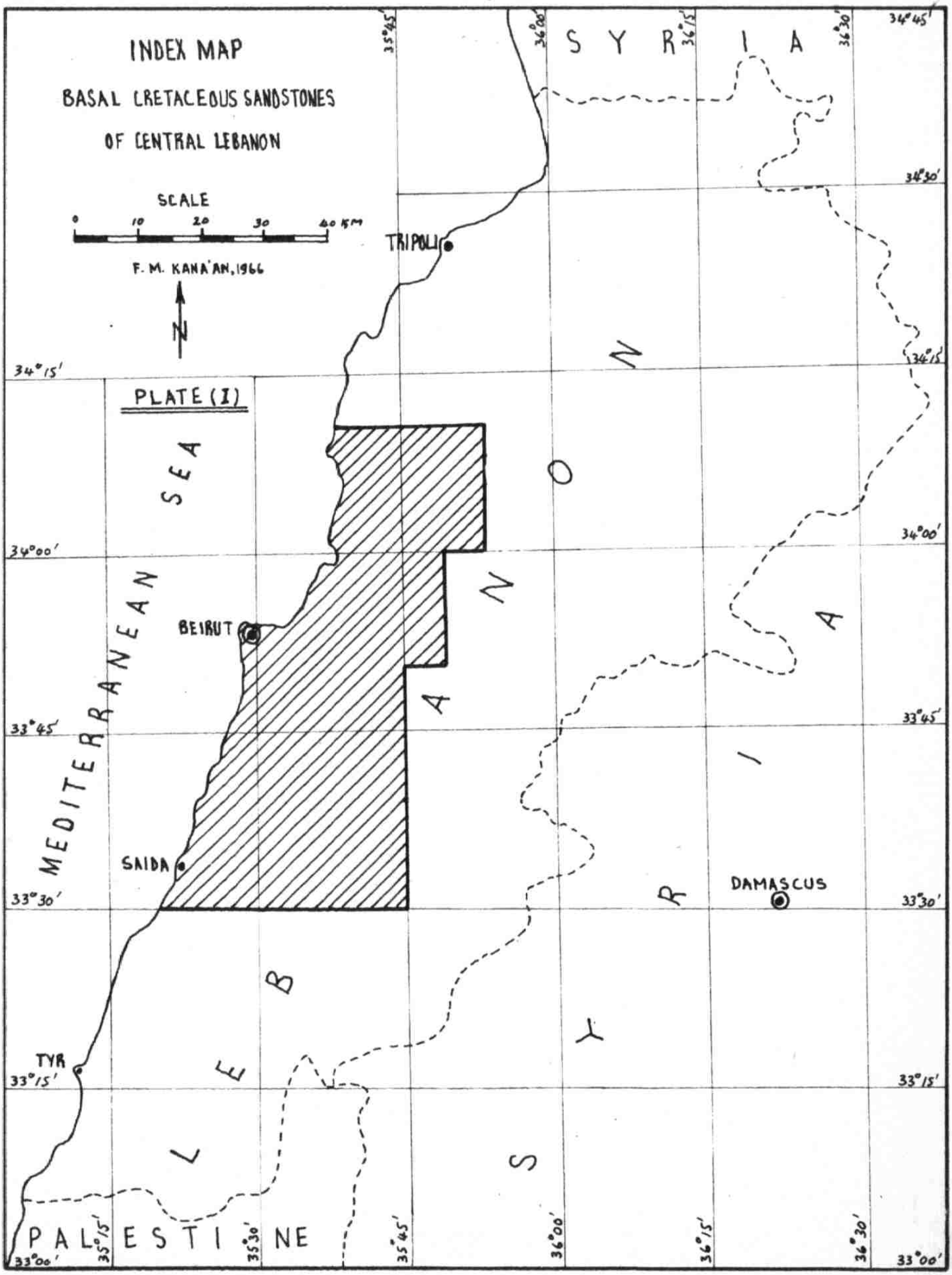
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Accessability

Lebanon is equipped with an extensive and dense network of good roads; linking practically all parts excepts for the high peaks, so that there is no place that is completely inaccessable though some have to be approached on foot.

Climate

Lebanon has a Mediterranean climate with generally mild wet winters, and warm dry summers. In winter snow falls on the mountains above 1000 meters, and temperatures range between -8°C and 10°C; while on the coastal plain temperatures vary between 8°C and 15°C. The area is characterized by much rain; average rainfall is about 893 mm per year, and this is mostly concentrated between the months of November and April. Sunny dry intervals of several days are often met with during the winter season. In summer the mountains above 800 meters elevation are renowned for their cool weather with temperatures varying between 18°C and 23°C; on the coastal plain, however, hot humid days characterise the months of July and August, when temperatures go up to 33°C. Accordingly, the period between the month of April and October of each calender year is most suitable for field work, when the weather can be relied upon.

Previous Work

Surface geological work has been carried out since the 1830's in the country and many publications on the general geology, stratigraphy, structure, and paleontology as well as a series of 1:50000 geological maps are available. Notable among the later works are those by Frass (1877), Blankenhorn (1890, 1927, 1931), Douville (1910), Zumoffen (1909, 1926), Kober (1915), Krenkel (1924), Day (1930), Dubertret (since 1930), Vautrin (1934), Heybrock (1946), de Vaumas (1948), Renouard (1955), Sabbagh (1961). Most of the work concerning the "Basal Cretaceous Sandstones" consisted mainly of general description of the lithology of the formation as a unit, with overall thicknesses at some localities; Sabbagh(1961) gives a detailed stratigraphic section of these sandstones in the Jezzine area, while Dubertret has briefly described several other sections in different parts of the country.

Different conclusions were arrived at, based on these obeservations. Some writers concluded that these sandstones were deposited along beaches and littoral zones of the continental shelf; others concluded that the sandstones were of fluvial continental to transitional type of deposition. Moreover, the sandstones are considered to be the result of the decomposition of granitic rocks in a region somewhere south of the Lebanon, probably the present area of the Arabian Shield. Lithological comparison and stratigraphic position equated these sandstones with the "Nubian facies Sandstones" in Jordan and Palestine, and they were, therefore, considered as an extension of the latter facies into Lebanon.

Objectives and Scope of the present work

The present work was undertaken with the following objectives:

i. To provide a better understanding of the mode of sedimentation and the environment of deposition of the "Basal Cretaceous Sandstones".

ii. To clarify the type and nature of the mediums of transportation of these sandstones.

iii. To arrive at clearer conclusions regarding the provenance and origin of these sandstones.

iv. To construct the paleogeography of "Basal Cretaceous Sandstones" times in the Lebanon, and in the Levant, (Lebanon, Syria, Palestine, and Jordon)

In order to properly carry out these objectives, the following studies were made, which are based primarily on field observations and interpretations:

i. Detailed study of the lithology of the sandstones at key sections.

ii. Detailed study of sedimentary structures, mainly stratification and cross-bedding, in these and subsidiary sections.

iii. Detailed analysis of vertical and lateral facies variation based on these sections.

iv. Construction of isopachyte maps for the Lebanon and the Levant.

v. Regional correlation of the Lebanon sandstones with similar facies sandstones in the Levant.

The term "Basal Cretaceous Sandstones" is used in reference to the sandstones that overly the Upper Jurassic (Portlandian and Kimmeridgian), and underly the carbonates of the Aptian of Lebanon. Several names have been used for this sandstone formation; viz: "Sandsteinformation", (Frass 1878), "Gres a Lignites", (Douville 1910), "Gres Lignitiferes" (Zumoffen 1926), "Gres du Liban", (Dubertret 1949), "Gres de Base", (Dubertret 1955).

The equivalent of the "Basal Cretaceous Sandstones" in Palestine and Jordon is the "Hathira Sandstone Formation". The Latter is considered to be of Upper Jurassic to high Lower Cretaceous (Albian, and perhaps may be even lowermost Cenomanian?). This formation (In Palestine and Jordon) is considered to be of continental, fluvial, deltaic, and occasionaly marine beach or shallow shore deposition. (Picard, 1959; Wetzel and Morton 1959).

The equivalent of the "Basal Cretaceous Sandstones" in Syria is the "Cherrife Shale Formation" which is taken to be of Upper Jurassic and Lower Cretaceous age. This formation (in Syria) is, presumably in part, the attenuated extension of the "Basal Cretaceous Sandstones" of Lebanon. No direct connection can be traced through from Syria to Jordon but there can be tittle doubt that it is likewise an extension of the Hathira Sandstone Formation (L.S.I. vol. III, fascicule 10 c I, p. 196.)

Methods and Extent of Work

1. Cross-Bedding

Eighteen sections were examined. These are divided into two categories: a) Those where complete stratigraphic sections were sampled and measured and where exposures are good; and b) incomplete stratigraphic sections, were studied because of the desirability to obtain a good density distribution of studied localities, but where complete sedimentary sequences were lacking. Table (I) page 7 gives the exact location of all these sections and the corresponding number of readings at each (see also, plate (II) page 8.)

The complete sections were systematically sampled, while random sampling only was made at the incomplete stratigraphic sections. In no case, however, were more than 4 readings (of cross-bedding foreset dip and azimuth) made at each outcrop, except in the locality of Rouaiset el-Ballout where 8 readings were taken; these readings were made in order to provide sufficient numbers for the construction of rose diagrams, and to provide better determinations of current directions. The number of readings at each section, however, was dependant on the variability of current directions; the more the variation the more the readings, and vice versa. In no

TABLE No. (I)

Localities of Cross-bedding Studies and

Corresponding Number of Readings.

No.	Localities	Long.	Lat.	Km G. x	Km G. y	N.R.
1	Qartaba	35°51'	34°05'	241	163	16
2	Hrajel	35°48'	34°01'	232	157	28
3	Beskinta	35°46'	33°56'	223	155	30
4	Majdal Tarchich	35°48'	33°53'	218	158	11
5	Kfar Selouan	35°46'	33°50'	212	153	16
6	Qoubai'	35°41'	33°48'	209	146	15
7	Aghmid	35°42'	33°45'	203	147	19
8	Maaser El Shouf	35°40'	33°39'	192	144	22
9	Jezzine	35°33'	33°33'	179	133	26
10	Col of Machgharah	35°37'	33°30'	175	139	20
11	Zahlta	35°32'	33°30'	175	132	20
12	Beisour	35°34'	33°45'	203	135	18
13	Roumieh	35°36'	33°52'	216	140	20
14	Douar	35°42'	33°54'	219	147	19
15	Bois de Bolongue	35°44'	33°54'	220	151	16
16	Salima	35°42'	33°51'	214	148	24
17	Aintoura	35°37'	33°56'	224	142	20
18	Rouaiset El Ballout	35°39'	33°49'	210	142	14

long. : Longtitude; Km G.x : Kilo meter grid, x-dirction
lat. : Latitude; Km G.y : Kilo meter grid, y-direction
N.R. : Number of readings;

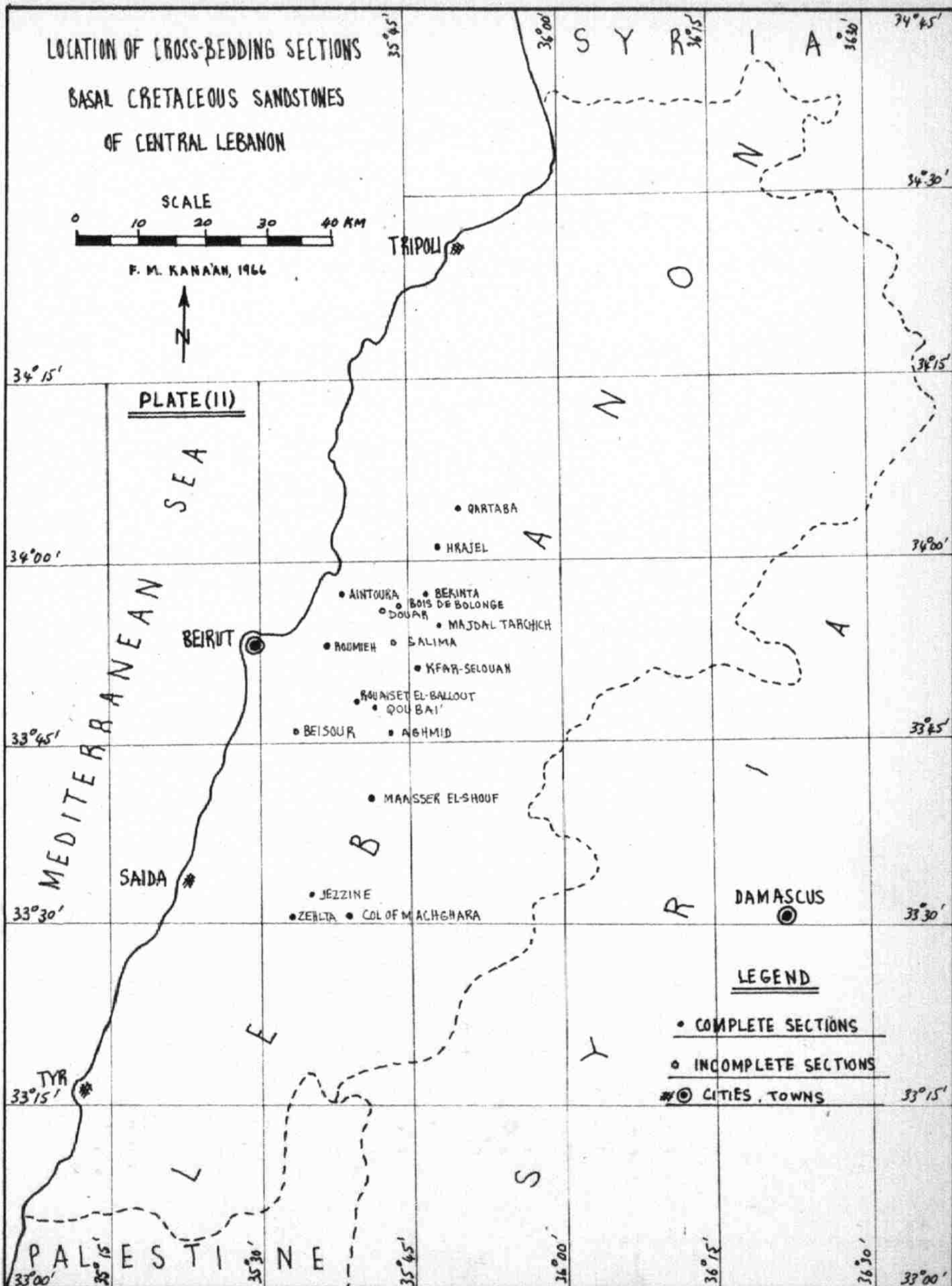
LOCATION OF CROSS-BEDDING SECTIONS
BASAL CRETACEOUS SANDSTONES
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PLATE (II)
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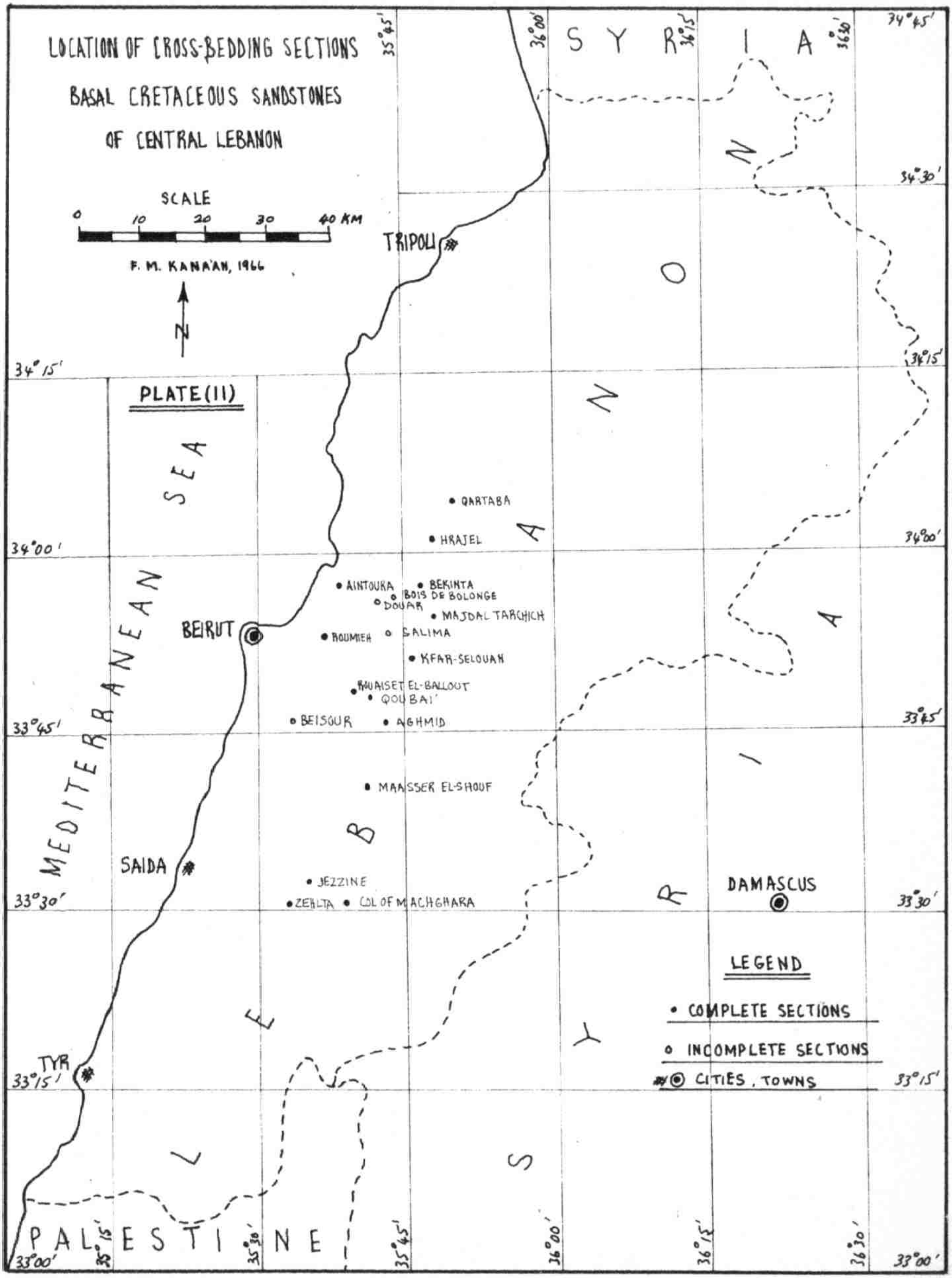
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case, however, were less than 11 readings taken at each locality.

The number of localities was a function of the variability within these localities, in that more areas of study were added in order to provide a reasonable concentration for the determination of the direction of transport. An average of 3 locality concentration was taken along a distance of 20 to 25 kilometers, (see plate II page 8).

A Brunton compass was used in the determination of azimuth direction of cross-bedding, and abney-levels for the determination of the angle of dip of the foresets of the cross-bedding. In order to determine the maximum amount of the angle of dip of foresets two components were measured at dihedral angles varying between 25^{o} and 90^{o}. Tectonic tilt was measured, whenever present, and a correction was applied for all corresponding readings; this varied between 0^{o} and 35^{o}.

Histograms were constructed in order to show the behaviour of the variation in the angle of dip of foresets in cross-bedding. The horizontal axis is divided into intervals of 6^{o} with the zero at the origin. The vertical axis is taken as the percentage occurence of angles of dip, with the zero at the origin. This analysis was carried out for each locality. These results are found on plate(IV) page 39.

Rose diagrams were constructed in order to determine general current directions. The mode of readings (the mid point of the interval that contains the highest numbers of readings, or in other words, intervals with largest percentage.) are taken as the general direction. These rose diagrams are divided into 9 intervals every 40^{o} degrees azimunths, and radial percentage of current directions. Results are found on plate (V) page 42.

The true direction and amount of dip of foresets of cross-bedding was computed by the use of stereographic nets with a twenty centimenters diameter and 2^{o} azimuth interval. These results are found on plate (VI) page 45.

A supplementary map showing the direction of individual readings at each locality was constructed in order assist in giving a better picture of the actual distribution of current directions, see plate (VII).

In order to arrive at clearer conclusions regarding the depositional environment responsible for the formation of cross-bedding, further analysis was carried out, embodied in the computation of the vector mean of the total number of observations, the sample variance, and the standard deviation of scatter at each locality. The following equations were used in the computation of these aspects of cross-bedding; they are taken from Potter and Pettijohn, (1963) pp. 255, and 264.

$$V = \sum_{i=1}^{n} n_i \cos x_i$$

$$W = \sum_{i=1}^{n} n_i \sin x_i$$

$$\bar{X} = \arctan W/V$$

$$R = (V^2 + W^2)^{\frac{1}{2}}$$

$$L = (R/n)\ 100$$

Where x_i is the mid-point azimuth of the i th class interval; $\bar{x}$ is the aximuth of the resultant vector (vector mean of readings); n_i the number of observations in each class, n the total number of observations; R the magnitude of the resultant vector; and L is the magnitude of the resultant vector in terms of percent.

$$S^2x = \sum_{i=1}^{n} (x_i - \overline{X})^2/(n-1)$$

where $S\overline{x}$ is the sample variance; x_i is the individual azimuth of reading; $\overline{x}$ is the resultant vector of total observations (mean of reading); n is the total number of observations.

$$S\overline{x}_n = \frac{Sx}{\sqrt{n}}$$

where $S\overline{x}_n$ is the standard deviation of scatter; S_x is the square root of the variance and n is the total number of observations.

The results of these analysis are given on table (5) page 38.

2. Stratigraphic sections

Nine stratigraphic sections were sampled and measured in detail in order to provide adequate data on vertical and lateral variation in facies, and on overall thickness variation of the "Basal Cretaceous Sandstones" in the Lebanon. These sections are fairly widely distributed, and generally reflect both the different lithologies and their corresponding thicknesses. The number, location, and total thicknesses are given on table (2) page 12; (see also plate (III) page 13). Appendices (page 82), gives the detailed description and individual thicknesses of beds within the formation at each of these sections.

Additional data were obtained from the literature concerning thicknesses and lithologies at other sectons, these are found on table (3) page 14 with their appropriate source. Data on Palestine, Jordon, and Syria were obtained from the literature, as shown on table (4) page 15.

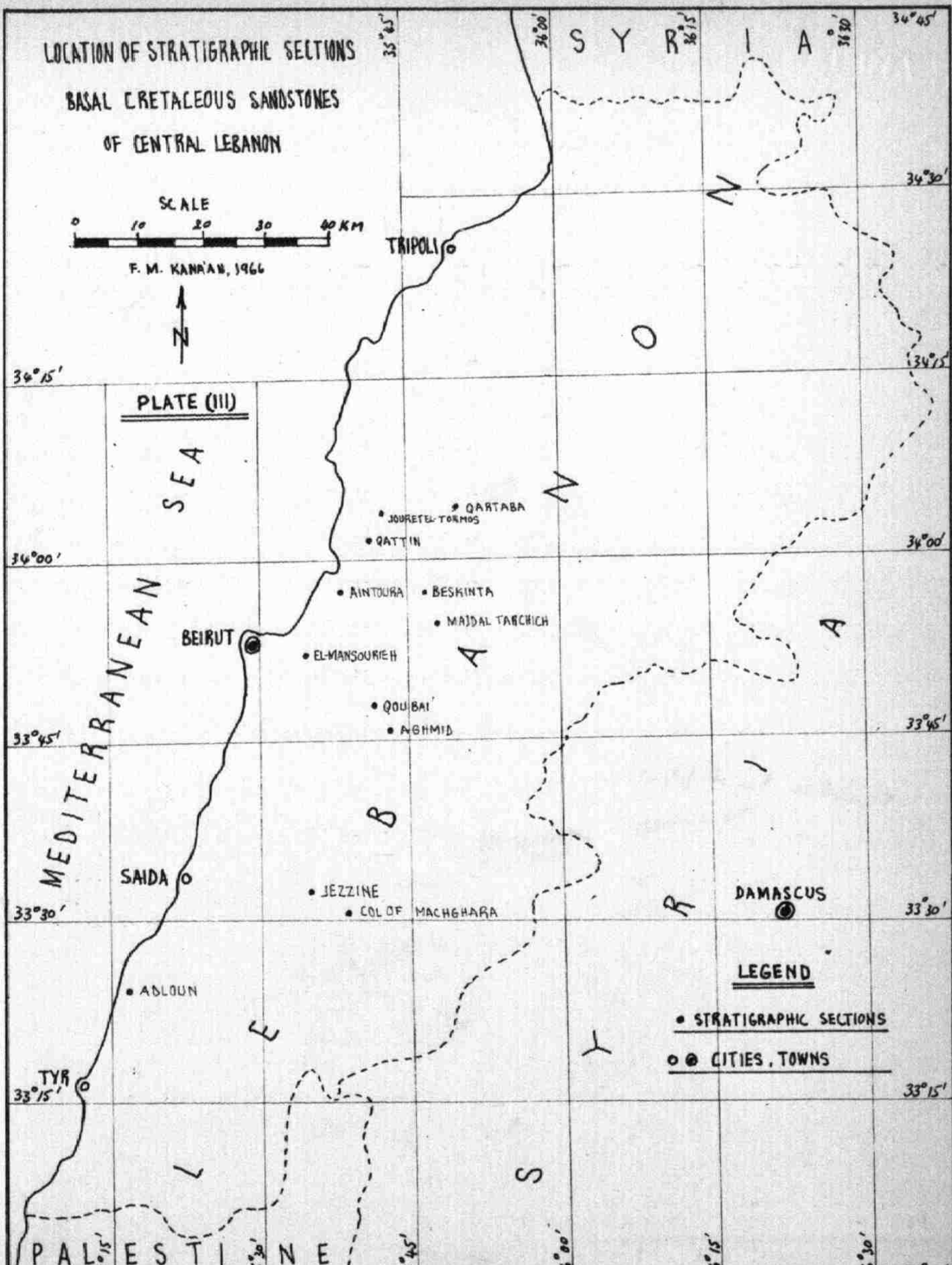
TABLE No. (2)

Number, Location, and total Thickness of

Stratigraphic Sections

No.	Locality	Long.	Lat.	Km G. x	Km G. y	T.T.	P.No.	APP.No.
1	Qartaba	35°51'	34°05'	241	163	96m	XVI	I
2	Jouret El Tormos	35°43'	34°03'	235	151	86.5m	XVII	II
3	Qattin	35°41'	34°00'	231	147	89m	XVIII	III
4	Aintoura	35°37'	33°56'	224	142	85m	XIX	IV
5	Beskinta	35°46'	33°56'	223	155	240m	XX	V
6	Majdal Tarchich	35°48'	33°53'	218	158	186m	XXI	VI
7	Qoubai'	35°41'	33°48'	209	146	259m	XXII	VII
8	Aghmid	35°42'	33°45'	203	147	187m	XXIII	VIII
9	Jezzine	35°33'	33°33'	179	133	388m	XXIV	IX

Long. : Longtitude
Lat. : Latitude
Km G.x : Kilometer grid, x-direction
Km G.y : Kilometer grid, y-direction
T.T. : Total Thickness
P.No. : Plate number
APP.No. : Appendix number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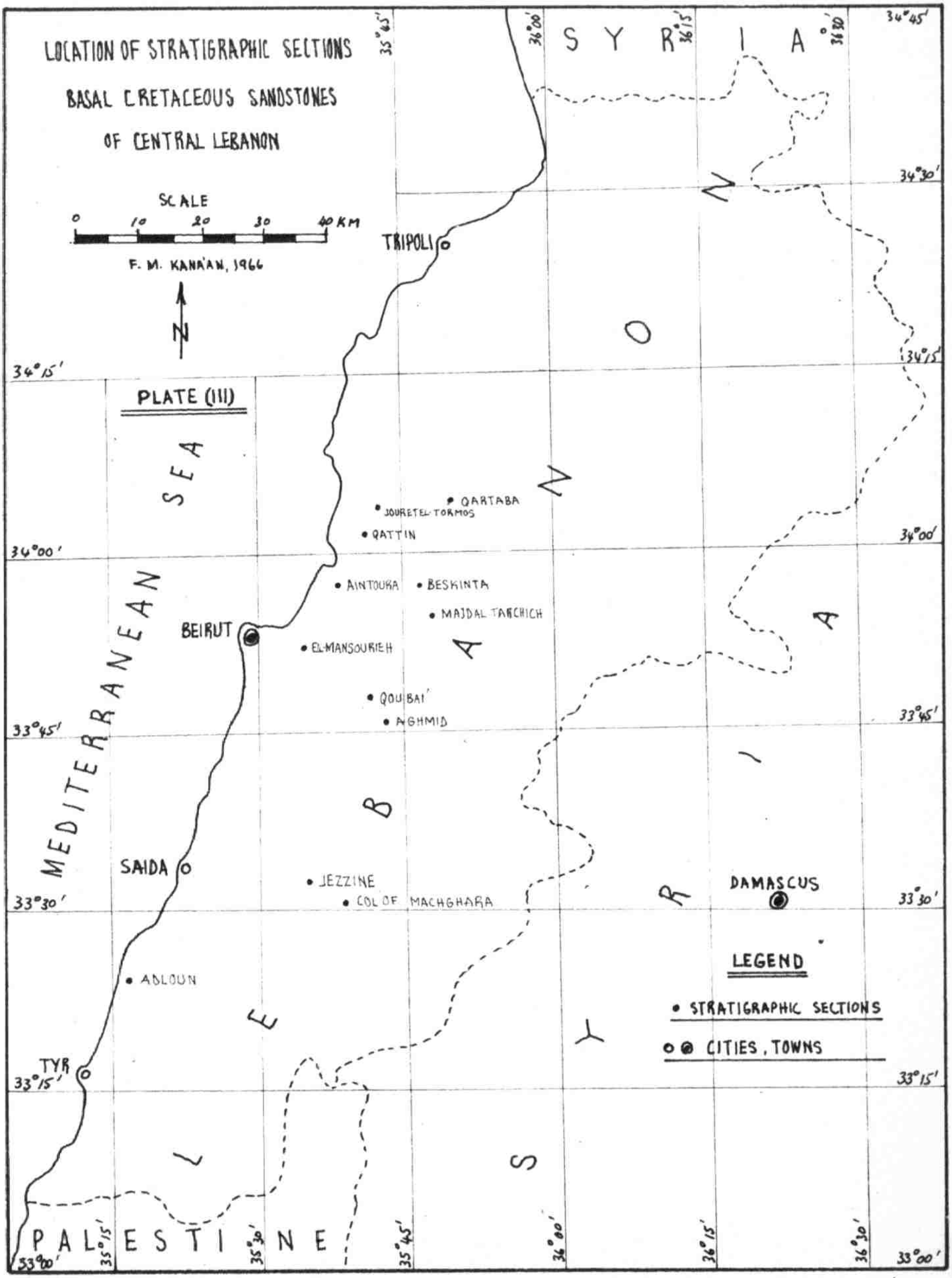
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TABLE No. (3)

Number, Location, Total Thickness of

Measured Stratigraphic sections

In Lebanon.

No.	Locality	Long.	Lat.	Km G. x	Km G. y	T.T.	Source
1	Sir ed Dannyie	36°02'	34°22'	272	180	6m	.R. Wetzel in Dubertret, 1951
2	Becharrie	35°59'	34°15'	256	176	20m	" " "
3	Bqaa Kafra	36°00'	34°13'	254	177	30m	" " "
4	Ma'azrat Beni Saab	35°54'	34°14'	256	165	28m	Dubertret, 1951
5	Ehmej	35°46'	34°06'	243	156	62m	" "
6	Broummana	35°37'	33°52'	216	141	150m	F.M.Kana'an, 1965
7	El Mansourieh	35°34'	33°51'	213	136	161m	B.Tixier, 1964
8	Kfar Niss	35°38'	33°44'	201	142	250m	Heybrock, in Dubertret, 1951
9	Abieh	35°30'	33°44'	201	130	205m	Karcz, 1965
10	Kneisseh	35°33'	33°43'	198	135	250m	" "
11	Maaser El Shouf	35°40'	33°39'	192	133	180m	F.M.Kana'an, S.Wakim, 1965
12	Col of Machgharah	35°36'	33°30'	175	139	233m	G. Geynaud, 1963
13	Mimms	35°43'	33°24'	163	148	125m	Renouard and Minassian, in Dubertret, 1956
14	Majdal Chemms (Hermon)	35°46'	33°16'	147	154	50m	Dubertret, in Wetzel and Morton, 1959
15	Adloun No.1 Well	35°16'	33°24'	164	107	170m	Co. Libanaise des Petroles, 1960

Long. : Longtitude; Km G.x : Kilometer grid, x-direction
Lat. : Latitude; Km G.y : Kilometer grid, y-direction
T.T. : Total Thickness

TABLE No. (4)

Number, Location, and Total Thickness of Measured Sections and Subsurface Data in the Levant.

No.	Locality	Long.	Lat.	T.T.	Country	Source
1	Qiryat Shemmona	35°38'	33°13'	180m	Palestine	Karcz, 1965
2	Debora	35°25'	32°40'	100m	"	" "
3	Ashier	35°11'	32°47'	30m	"	" "
4	Nahr Azarqa	35°57'	32°10'	214m	Jordon	Wetzel and Morton, 1959
5	Suweilleh No.1 Well	35°48'	32°02'	142m	Palestine	Bender, 1961
6	Safra No.1 Well	36°29'	31°53'	300m	Jordon	" "
7	Ramallah No.1 Well	35°07'	31°53'	310m	Palestine	" "
8	Jordon Valley No.1 Well	35°41'	31°46'	171m	Jordon	" "
9	Wadi Zarga Main	35°46'	31°43'	234m	"	Wetzel and Morton, 1959
10	Halhul No.1 Well	35°06'	31°36'	250m	Palestine	Bender, 1961
11	Massada No.1 Well	35°18'	31°27'	402m	Palestine	E. Aharoni, 1964
12	Zohar No.1 Well	35°16'	31°17'	406m	"	" "
13	ed Dhira	35°42'	31°13'	171m	Jordon	Wetzel and Morton, 1959
14	Makhtesh Hastera	35°09'	30°57'	513m	Palestine	Bentor and Vroman in L.S.I. v.III, Fas.10, C 1
15	" HatHira	34°56'	30°53'	450m	"	Bentor in Ball and Ball 1953
16	Wadi Musa	35°35'	30°16'	97m	Jordon	Nasr @ Morton in Wetzel and Morton, 1959
17	Neqeb Ashter	35°37'	30°02'	70m	"	Nasr @ Morton in Wetzel and Morton, 1959
18	Wadi Menéiaieh	34°57'	29°47'	150m	Palestine	Ball and Ball, 1953
19	El Quweira	35°19'	29°47'	135m	Jordon	Quennel, 1951 in L.S.I. v.III, Fas.10, C 1
20	Mudawara	36°04'	29°20'	150m	"	" " "
21	Wadi Raman	34°50'	30'31'	253m	Palestine	Shaw in Wetzel and Morton, 1959
22	Sinaf No.1 Well	34°52'	30°07'	200m	"	Picard, 1959

Thickness measurements were mostly made by tape, particularly in the thinly to thickly bedded rock units., of less than 5 meters thickness. Massive beds, however, were measured by the abney level, especially when such beds outcrop along roads, as is the case in the Jezzine area. Levelling was carried out in areas where dips were horizontal; and the difference in elevations, therefore, were taken as true thicknesses of the rock units. The Brunton compass was used in the measurement of the dip of strata and direction of the angle of dip, whenever required. Dip correction was introduced whenever present (Ma'aser el Shouf, Aghmid, Jouret el Tormous, Qattine, Aintoura, and Jezzine). Estimation of dip was made in some cases where actual measurement was virtually impossible.

Samples were taken at every change in Lithology; and one composite sample was collected from each lithologic unit, of less than 3 meters in thickness. Beds greater than 3 meters were sampled at random intervals adding up to three samples. No greater detailed collection of samples was carried out, as the present work is primarilly based upon field observations. Never the less some 250 samples were collected and these are include representative of all the lithologies encountered in the "Basal Cretaceous Sandstones".

AKNOWLEDGMENTS

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Lithologies

In order to obtain adequate control for facies variation within the "Basal Cretaceous Sandstones" formation, detailed field sampling and measuring of different stratigraphic sections was carried out, limited in density by the availability of good exposures, these measurements were supplemented from other sources, (see table (2) and (3) pp. 12 and 14). In the case of the measured sections both overall thicknesses of rock units, as well as thicknesses of individual beds within these rock units were measured. Grain size variation in the sandstones are recorded as fine, medium, and coarse. A detailed description of colour variations is recorded. The characters and mode of bedding planes are fully described for each lithologic rock unit within the extent of the outcrop. The carbonate content as measured in the field is given as strongly limey, slightly limey, and non-limey. Carbonaceous materials are noted and mentioned whenever present.

The following lithologies in the "Basal Cretaceous Sandstones" formation were recognised in the field:

1) sandstones
2) argillaceous sandstones
3) clays and shales
4) lignites and carbonaceous materials
5) limestones
6) marls

1) <u>Sandstones</u> constitute the bulk of the sedimentary sequence

in nearly all the stratigraphic sections; and in their overall areal distribution. These sandstones are composed of quartz grains, with traces of some heavy minerals. The cementing material, in most cases, is iron oxide (limonite and heamatite); calcite is generally a minor cementing material in a few exposures, in particular towards the lower and upper contacts of the formation with the Jurassic and the Aptian beds respectively. The hard and compact sandstones are often associated with haematitic cement; while the less consolidated and relatively soft sandstones are linked with a limonitic cement. Soft and friable sandstones are frequently encountered. According to grain size, these sandstones have been divided, into three divisions:

i. fine-grained sandstones

ii. medium-grained sandstones

iii. coarse-grained sandstones

The variability in grain size, however, makes it difficult to recognise and differentiate between these units.

The medium-grained sandstones are by far the most predominant, and are of wider areal distribution in contrast to the coarse-grained sandstones which are of a very limited occurrence, and of very short lateral extent (usually not more than a couple of meters); whenever found they grade into medium grain size sandstones. Most of the sand grains are subrounded in shape, particularly the fine and medium orders; the coarse grain sizes are more angular. These sandstones show an overall rapid changes in colour both vertically and laterally, although individual beds retain their own colours. The colours that were observed are white, and varying shades of yellow, brown,red, and violet. These sandstones are often found in bedded sedimentary units of thicknesses ranging from one centimeter to about one and a half meters. Generally they retain more or less constant thickness within the extent of the outcrops, namely as much as some hundreds of meters in many cases; this is particularly so with the massive and thick beds, which are often hard. Field observations, however, have shown that these beds can not be used as definite reliable stratigraphic markers for correlation because of non persistence over longer distances due to the rapid vertical and lateral variations that occur in the formation. Generally, lateral variation in these massive sandstones is accompanied by gradual thinning in opposite directions, to form large size troughs or lenses. This is best seen in the Beskinta and Zehlta areas (the latter about 5 to 6 kilometers south of Jezzine). Thin beds, however, are rather uniform in thickness but within rather short lateral distance of not more than few tens of meters; these thin beds are associated either with lignites or with clays and shales.

Cross-bedding structures are most predominant, and are only associated with sand-stones. Among other structure are mud cracks, ripple marks, trough bedding and nodular structures.

2) Argillaceous sandstons are the second most prominant lithologic rock unit in the "Basal Cretaceous Sandstones" formation. These are made of very fine to silty sandstones with an appreciable amount of clay that makes them some what sticky but friable. Usually they are rather soft, but sometimes quite hard beds are found; this hardness appears to be a result of loss of water content and is controlled by the amount of moisture with the clayey cementing material. The observed colour is mainly grey of various

tones; becoming blackish when associated with lignites and carbonaceous materials. They always occur in thinly bedded to laminated layers that are otherwise massive in character. These beds exhibit a variation in thickness and appear to follow the same trend as the sandstones but for shorter lateral distances. Pyrite grains are seen to be associated with these argillaceous sandstones in a good many exposures, particularly with the richly carbonaceous ones. Disseminated amber particles were occasionally observed in Jezzine, Qoubai, Beskinta and Aghmid areas.

No cross-bedding is observed. Among observed sedimentary structures are slump bedding, small scale faults, and disseminated nodular concretionary structures.

3) Clays and shales are of limited areal occurrence. They are always found in comparably much smaller lenticular dimensions ranging from a couple of meters in some cases to about forty meters in others. These clays and shales are found in laminated beds which are otherwise thick to massive in character. They are usually soft, and friable depending on the content of water. They are often found to be rich in carbonaceous materials and at times with associated lignite beds. The colour varies from blackish to greyish depending on the amount of carbonaceous material present. White colours are sometime seen, while red and chocolate coloured shales have been observed, many being rich in iron content. Chocalate coloured clays associated with the volcanic rocks, have been formed by the alteration of basalts and ashes and they are of sporadic occurence.

Contorted bedding, and minor small scale faults, are the main sedimentary structures that are associated with clays and shales.

4) Lignites were observed in several localities. Their thicknesses

vary from a few centimeters up to about 5 to 6 meters. They have a rather limited lateral extent not exceeding a couple of tens of meters although exceptional longer areal extents were found near Jezzine where a distance of about one hundred meters is not uncommon. These lignites are thinnly bedded to laminated in character within an overall massive to thick bed. They are soft and friable, with black colour. At times they are found interbedded with sandstones in an alternating manner of roughly equal thicknesses of about 5 to 7 centimeters, these beds extending for quite a long distance of some 70 meters. Carbonaceous materials, however, are always associated with fine sandstones, and occur in disseminated laminations.

5) Limestones are generally rare, except at the Jezzine and Adloun areas. In the Jessine area a sandy fossiliferous limestone bed 50 centimeters in thickness occurs in the middle of the section. In the Adloun No. I well a sequence of limestones and marls interbedded with shales and sandstones was encountered. These limestones are sometimes marly, and an oolitic limestone bed of about 4 meters thickness occurs towards the middle of the section. The thickness of the limestones vary between 3 and 19 meters; but no detailed description of individual beds is available.

No particular sedimentary structures were observed except for crossbedding in the Aptian limestones.

6) Marls are equally rare. They are, however, particularly developed in the Adloun No. 1 well where they are sometimes silty and sandy, grey and brown in colour. Their thickness vary between 4 and 5 meters; but no details of the individual beds are available.

Sedimentary Structures

Stratification and cross-bedding are the major sedimentary structures found in the "Basal Cretaceous Sandstones" formation. The study of stratification is based upon purely qualitative and descriptive methods. In addition the orientation of cross-bedded units is analized statistically in order to determine current directions. Other sedimentary structures of minor to rare occurrence were recognised and noted, but were not studied in any detail. These structures include ripple marks, and mud cracks, contorted bedding, nodular structures, small scale faults, trough bedding, and slump structures. Some of these structures could be very useful for the reconstruction of the paleogeography and details in the environment of deposition of "Basal Cretaceous Sandstone" times in the Lebanon and the Levant, and merit further work.

1. Stratification

Stratification, the most abundant sedimentary structure in the "Basal Cretaceous Sandstones" formation, has been carefully examined in all the key stratigraphic sectionsas well as in several other localities where only random studies were made due to the incomplete stratigraphic sequences. Four types of bedding are recognised:

a) laminated beds, Less than I cm

b) thin beds, I cm - 20 cm

c) thick beds, 20 cm - I m

d) massive beds, larger than I m

This classification is in close accordance with those of Payne (1943), and Mckee and Weir (1953). Most of the stratification is lithological in character, in that distinct bedding-planes are often developed between different sedimentary units, as definedby Otto (1938), such as between sandstones and clays, or argillaceous sandstones. Bedding-planes separating such lithological units are usually regular but occasionally wavy to hummocky surfaces indicate either erosion prior to deposition of the overlying unit or post-depositional diagenetic changes possibly coupled with differential compaction or slumping. No detailed examination of the bedding surfaces with regard to the overlying or underlying structures has been attempted. It would seem, however, that no sedimentary unit less than Im thick is laterally uniform in thickness, particularly so with clays which always appear in lenses of various dimensions. Massive bedding in contrast is laterally uniform in thickness at least within the extent of the outcrop; a few hundreds of meters in the case of sandstones, less than one hundred meters in the case of argillaceous sandstones, and of the order of twenty meters in the case of clays and shales. Clays, shales and lignites usually vary in thickness and are always lenticular. (Whether such wedging out and thining of sedimentary units is depositional or post-depositional in origin is not certain, because of the lack of erosional structures on top or bottom of the bedding planes.) Laminated bedding is associated either with cross-stratification of thicker sandstone units, as will be shown later, or with carbonaceous and lignitic materials. The latter are often interbedded with poorly consolidated sandstones which are otherwise massive in character.

Sandstones and argillaceous sandstones form non-rythmic and repeated alternations of clastic sequence. Thinly bedded clays and sandstones, however, exhibit an alternation of uniform bedding in an otherwise massive sedimentary unit, which by itself could be recognised as cyclic in behaviour. This is also developed by laminatedto thinly bedded lignites and carbonaceous materials interstratified with argillaceous sandstones. Thus the "Basal Cretaceous Sandstones" formation as a whole can be considered as a sequence of clastic sedimentary units consisting of interbedded sandstones and argillaceous sandstones, lacking a definite pattern of cyclic deposition, except that locally, repeated cyclic sedimentation of thinly bedded clays and sandstones, and laminated lignites does occur; (see plate XVII-XXVII). Sharp bedding planes are usually present, particularly in the more lithified sedimentary units. Argillaceous sandstones usually grade into sandstones without distinct bedding planes inbetween.

2. Discussion

The factors that could be responsible for the development of stratification include:

a) weather and seasonal changes

b) climatic changes

c) variation in the competency of fluvial currents

d) settling of suspended sediments

e) connection with rise and fall in sea level

f) organic activity

All these agents were contemporaneously operating in varying degrees and intensities.

a) seasonal changes of weather are partly reflected in the presence of laminated to thinly bedded sandstones and lignites, which appear in a repeatedalternating sequence as previously shown on page (24). The lignites possibly correspond to periods of quiet and rather stagnant conditions in the sites of deposition which allowed the settling of plant remains and their subsequent accumulation; these in time were transformed into peat and finally into lignites as they are presently found. These conditions, however, were rather limited in occurrence and were localized as evidenced by the areal distribution of the lignites which do not exceed 50 m in lateral extent. Such periods of local stagnation in the site of deposition were followed by relatively more turbulent conditions which put a stop to the accumulation of plants and gave way to the deposition of fine sandstones; these formed a cover on the lignites and possibly were responsible for their preservation. These conditions seems to have been repeated for some time reflected in the total thickness of the alternating sequence which in most cases are between 2 to 3 meteres thick. More massive lignites, however, were deposited during longer periods of stagnation, when the piling up of larger amounts of plant remains occured; these lignites are of wider areal extent and seem to correspond to local developements of stagnant pools of various dimensions, that were scattered over much of the area being covered by the "Basal Cretaceous Sandstones" in the Lebanon. Massive bedding, however, appears indicative of excessively rainy conditions, producing flooding and the movement of much sediment to the sites of deposition, ultimately resulting in thick and massive accummulation over rather widespread surfaces; these sites of deposition may have been large dimension troughs, or fluvial channels. Quieter time spans between floods, however, produced thin sediments of smaller grain size, and probably of different composition compared with the thicker units deposited by floods.

b) Massive bedding can also be attributed to general climatic changes.

Because such changes are rather of slow and gradual nature, they extend for longer periods of time during which fairly uniform conditions prevail with resulting little or no variation in the character of the bedding or stratification of the sediments moved. But it appears, from field observations that such widespread uniformity does not exist in the "Basal Cretaceous Sandstone" formation; and that these massive beds are really more lens like in form and with varying dimensions, and probably indicative of trough filling or river channel filling during floods.

c) The relationship between competency of fluvial currents and sedimentation appears to have been more effective in the development of stratification. Competency is defined as the maximum size particles of a given density which a stream will move at a given velocity. Currents greater than the critical value for the deposition of a certain grain size do not allow the deposition of finer grained sediments. Long uniform periods in the competency of currents seem to produce rather massive bedding, depending on the rate of sediment supply, in that the greater the supply the thicker the beds, and the less the supply the thinner the beds. With the same competency of current, it seems logical, that the greater the supply the thicker the bedding, and the more uniform the grain size. Current competency may change within an interval of time which will stop the deposition of a particular grain size, but without eroding what was previously laid down; and may give rise to the deposition of greater grain size, as fine sandstonesgive way to medium grained sandstones, or medium grained sandstones to coarse grained sandstones.

Sedimentary units with sharp boundaries seem to indicate an erosional period of rather uniform character in some of the bedding in the "Basal Cretaceous Sandstone" formation. Accordingly, two types of stratification may be deduced: one is connected with physical breaks (diastem), but without any apparent lithological changes (bedding within sandstones); and the second is connected with lithological changes, but without any apparent physical breaks. The latter corresponds to the gradational contacts between the sandstones and the argillaceous sandstones. Furthermore, low velocity currents may produce thicker accummulation of medium grain size and the development of massive bedding. The variability of the role played by the competency of currents is to be emphasised in relation to the gradational development of bedding which are the result of gradual changes in the velocity of current in the first place, and the abrupt changes that caused the partial erosion of the previously deposited unit, followed subsequently by the deposition of the coarser grains, and evidenced by the wavy to hummocky surface of some bedding planes.

d) The combined effect of competency of current and the rate of settling of suspended sediment seems to be the major factor in the development of stratification in the fine sandstones and clays and shales particularly, and the coarser sandstones in a more general way. This process seems to account for most of the thinly bedded to laminated beds in the "Basal Cretaceous Sandstones" formation. This is because most, if not all, of the bedding is lithological in character, reflected by variations in grain size, and clay content which largely determine the degree of cohesiveness and extent of lithification and the development of stratification or bedding. Clays appear as rather sharp units and form distinct boundaries with the overlying and underlying sandstone units often accompained by possible physical breaks as indicated by these sharp contacts. It would, therefore, seem that each bed reflects the conditions of its depositional history. Such conditions are certainly stable for each sedimentary unit (Otto, 1938; Twenhofel, 1953; Weller, 1960; and Allen, 1965). The degree and uniformity of such conditions is of periodic character as evidenced by the frequent alternation of different lithological units, like sandstones and argillaceous sandstones, clays, and carbonates. The thickness of the beds, however, seems to have no bearing on the rate of sedimentation or on time; for the dimensions of sedimentary units usually vary with the site of deposition (flood plane, river channel, or delta environments). This is coupled with the amount of load, character of composing sediments and type of supply, (Twenhofel, 1953). Coarser grained deposits, bigger loads, concentrated supplies, and favourable conditions for a rapid decrease in the competency of currents in sites of deposition seem to produce great variation in dimension and thickness of sedimentary units. Such variations are mostly controled by the environment of deposition, as each environment is characterised to a certain degree by some rather fairly definite sedimentary conditions (Weller 1960).

e) Rise or fall in sea level seems to have very slight effect on the development of stratification as reflected in the "Basal Cretaceous Sandstone" formation; except in the zones of littoral and shallow water sediments as evidenced by the subsurface section of Adloun No. 1 well. Each layer could corresponds to a particular horizon in changes of the level of the sea. A subsequent fall in sea level will give way to the partial erosion of what was previously deposited by means of waves and shore currents. Subsequent rise in sea level will lead to the deposition of a new layer. It seems probable that such fluctuation in sea level if it occured, was due to regional osscilations or to slight changes in the waters of the oceans which in effect caused this fluctuations. Tidal changes, however, appear to be too short to allow such development of stratifications to take place.

f) Organic activity seems to have played no effective role in the development of stratification; there seems to be a complete absence of any related structures like borrows, casts, reefs etc.

It may be concluded from the above discussion that, the "Basal Cretaceous Sandstones" were deposited in a fluvial-delatic environment, rather than in a littoral or other transitional environment of deposition; this is indicated by the character and areal distribution of the different lithologies which occur in, more or less, lens forms of various sizes and dimensions, and the particular development of stratification within these lithologies. Littoral environments usually show more uniform distribution of sediments and are of wider areal extent than in fluvial-deltaic environments (Twenhofel, 1953; Weller, 1960; and Pettijohn, 1957).

3. Cross-bedding structures

Cross-bedding is the second most prominant sedimentary structure in the "Basal Cretaceous Sandstones", and include the following three general types:

i. Tabular cross-bedding, (most prominant)

ii. Wedge-type cross-bedding, (of minor occurrence)

iii. Trough-type cross-bedding, (rare)

These types of cross-bedding are illustrated in figure (1) page 31.

The following is a general description of the cross-bedding as observed in the field:

DIFFERENT TYPES OF CROSS-BEDDING

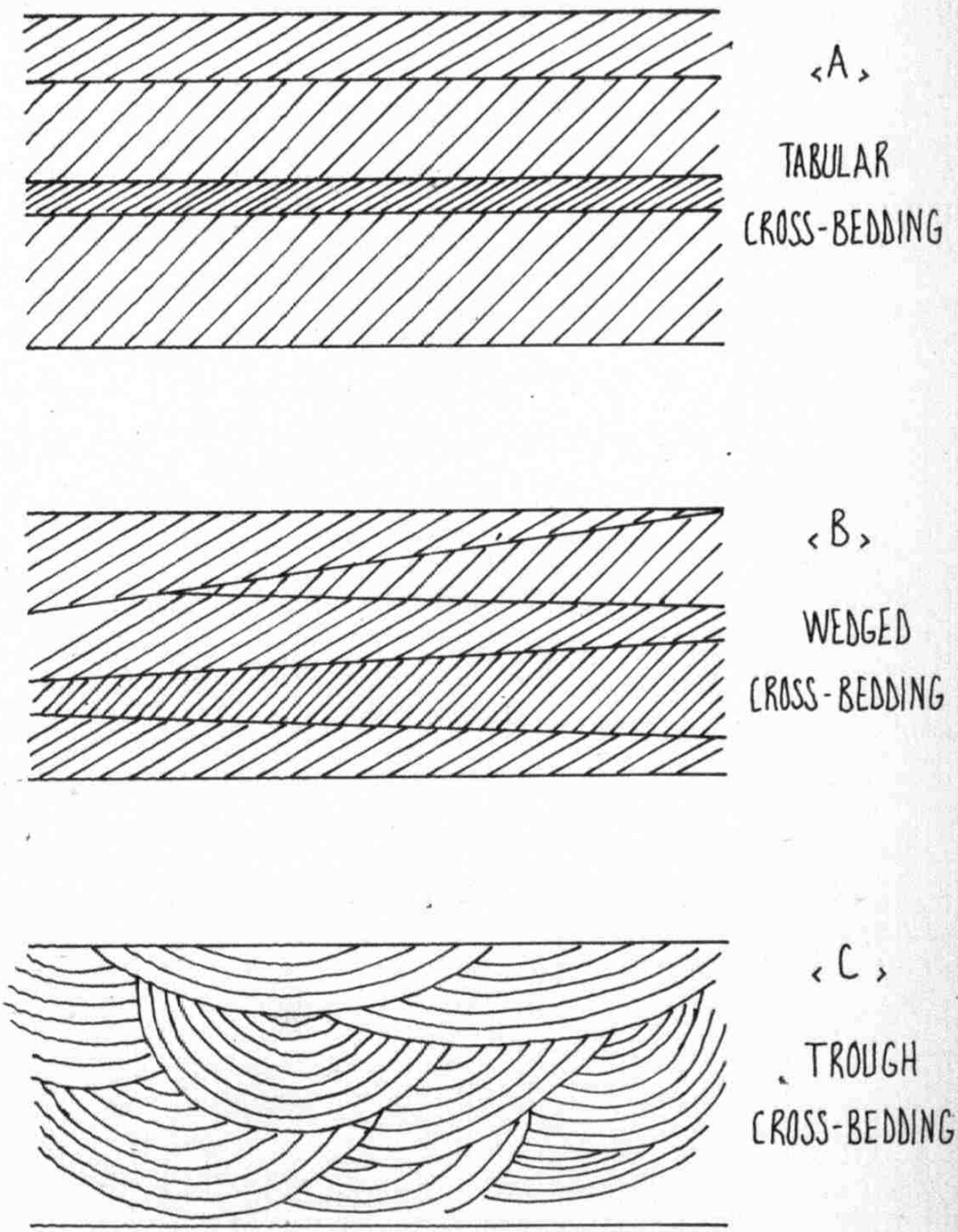
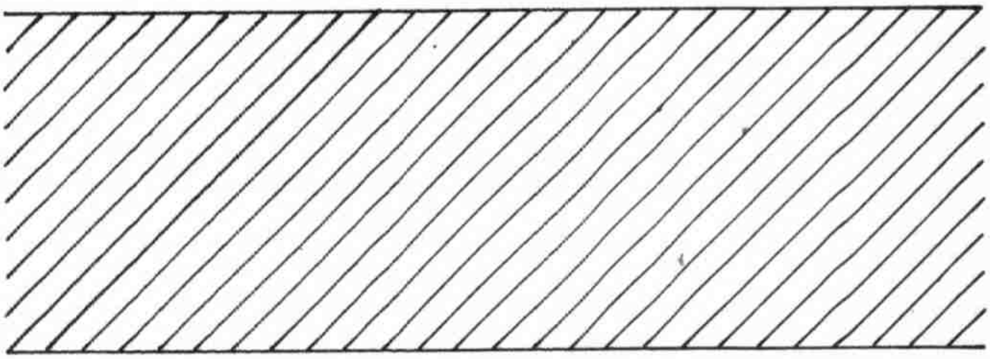


FIGURE (1)

FORESET RELATIONSHIP WITH OVERLYIING & UNDERLYING SURFACES

‹A›

Non-Tangential or Non-Asymptotic Foresets



‹B›

Tangential or Asymptotic Foresets

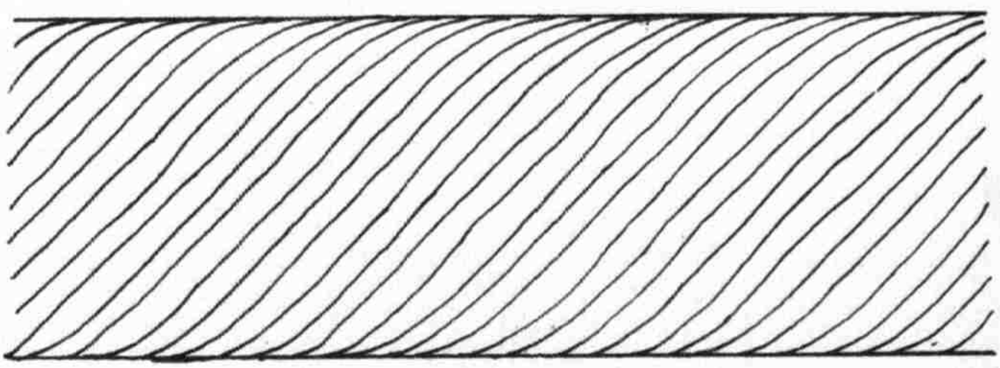


FIGURE (2)

a) Topsets are absent, except in very few exposures where tangential contacts with overlying units were observed. A uniform surface, otherwise, separates cross-bedded units. This plane is, generally, horizontal but in some cases it may be inclined up to 15° in the same direction as the foresets; occasionally, it is found to dip in an opposite direction to the foresets, but this seems to be due to tectonic tilt rather than to depositional effects.

b) Foresets usually have sharp boundaries with both the overlying and the underlying units, although asymptotic or tangential contacts (more frequently with lower units than with upper units) were also found; (see figur (2) page 32). Foresets generally show straight traces that are taken to be a diagnostic feature of planar tabular cross-bedding; in contrast, others show somewhat curved traces which are taken to be indicative of trough cross-bedding, (Potter and Pettijohn, 1963). After the removal of tectonic tilt most of foresets dip at between 20° and 30°; few have dips exceeding 30°, and a very few dips of less than 10°. These results, as obtained from each locality, are tabulated in plate (IV) page 39.

c) Bottomsets are generally absent, although asymptotic and tangential contacts are sometimes observed; (see figure (2) page 32). A sharp boundary, therefore, generally separates a cross-bedded unit from the underlying unit.

d) The thickness of cross-bedded units varies between a maximum of 100cm to a minimum of 2 to 5cm. Usually, cross-bedded units of 10 to 30cm thickness are most common. The thickness of the cross-bedding within cross-bedded units varies between 1 mm and 10 mm; as observed this is uniform in each cross-bedded unit, but can vary between one unit and another.

As a rule, thin cross-laminations are found in thin cross-bedded units, and thick cross-laminations in thick cross-bedded units; but no quantitative work has been done along this line.

e) Two distinct grain size distributions were generally observed within cross-bedding laminations:

i. uniform distribution (see fig. 3 B, p 35)

ii. graded distribution (see fig. 3 A, p 35)

The former consists of uniformly sorted fine to medium grain sizes. In the latter, coarse, somtimes pebbly, sand grain distribution grades into medium, then into fine grained levels in each successively built cross-lamination in a repeated rhythmic pattern.

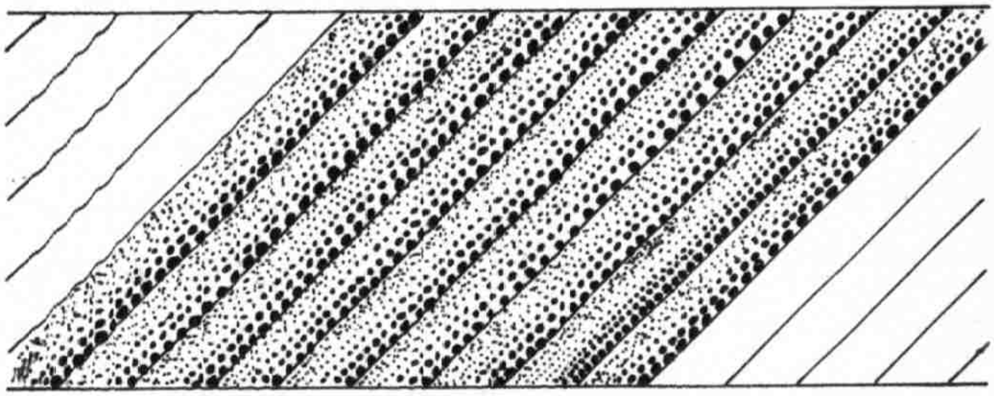
f) Cross-bedded units have similar colours to the bulk of the sandstones in the formation. Dark brownish colours are usually associated with coarser grains in each cross-lamination in a cross-bedded unit; these gradually grade into lighter brownish colours as the fine grained levels in the same cross-lamination are reached. This grading of colours occurs in a repeated rhythmic pattern in each cross-bedded unit. Sometimes, however, the reverse takes place, the coarser grains having the lighter colours, and the finer grains the darker colours.

g) The orientation of the laminations in the cross-bedded units has been studied statistically at several well scattered localities (see plate II). Measurements of dip and azimuth of foresets were taken in cross-bedded units along each stratigraphic section restricted in some cases, however, by the number of workable exposures. In each case two apparent foreset dip directions and the corresponding angle of dip were measured, and from this the actual direction of foresets and their asso-

GRAIN SIZE DISTRIBUTION IN CROSS-BEDDING

<A>

Graded distribution



<B>

Uniform distribution

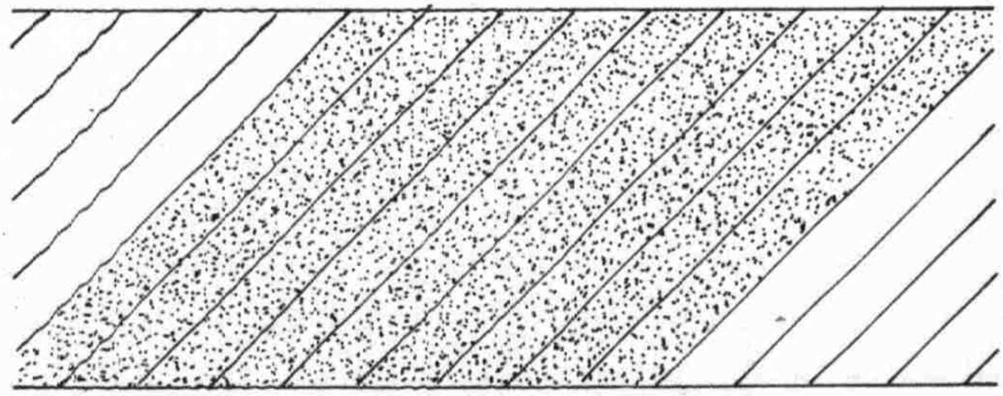


FIGURE (3)

ciated angle of dip were computed; corrections for tectonic tilt were carried out whenever this was present. The number of readings taken at each locality vary between 11 and 30; depending on the variability of current directions, less readings being required for less variability. The concentration and density of the localities chosen was governed by the general variation of current directions in the overall area comprising central Lebanon.

Two methods have been applied in the analysis of the data in an attempt to determine the actual current directions considered responsible for the formation of the cross-bedding, on the one hand, and the provenance and source of the sands, on the other hand. These methods are:

i) The first method was based upon the construction of rose diagrams with 9 azimuth intervals each of 40°, and radial percantage distribution of current directions in each interval. The results of these analyses are tabulated in plate (V) for each locality. After the removal of tectonic tilt the following results were obtained:

Azimuth	Percentage of total readings
0°-- 40°N	2%
40°-- 80°N	2.5%
80°--120°N	5.0%
120°--160°N	5.5%
160°--200°N	12.5%
200°--240°N	16.0%
240°--280°N	25.5%
280°--320°N	22.5%
320°--360°N	8.5%

It appears, therefore, that there is a general westerly azimuth direction, with a concentration between 160°N and 360°N, or in other words within a sector of 200°.

ii) The second method of analysis is presented in order to give both a three dimensional picture of the cross-bedding, and a supplimentation to the rose-diagram analysis; (see plate (VI)). After removal of tectonic tilt the following results were obtained:

a. general westerly concentration of azimuth directions.

b. almost 85°/o of the readings lie between azimuths of 160°N and 360°N, or in a sector of 200°.

In addition, the individual readings at each locality have been plotted on a map in order to give, perhaps, a clearer picture of the actual distribution of current directions. It shows the general westerly trend which was arrived at by means of the previous two statistical analyses. (see plate (VII)).

Further analysis was carried out based upon the computation of the sample variance and the standard deviation of scatter at each locality with respect to the corresponding mean directions at each locality. These results are found in table (5) page 38. It appears that both the mode of the readings(MR) and the vector mean of the readings (VMR) are closely conformable. The variance ranged from a minimum of 830 to, a maximum of 7900. The standard deviation of scatter ranged between 21° and 62°.

The regional analysis reveals the following results:

i. overall Mode of Readings (MR) is 260°N

ii. " Vector Mean of Readings (VMR) is 255°N

iii. " Variance 4573

iv. " Standard deviation of scatter (SDS) 2.45°

TABLE No. (5)

Cross-bedding analysis indicating Mode of Readings (MR), Vector Mean of Reading (VMR), Variance (V), and Standard Daviation of Scatter (SDS), at each studied locality

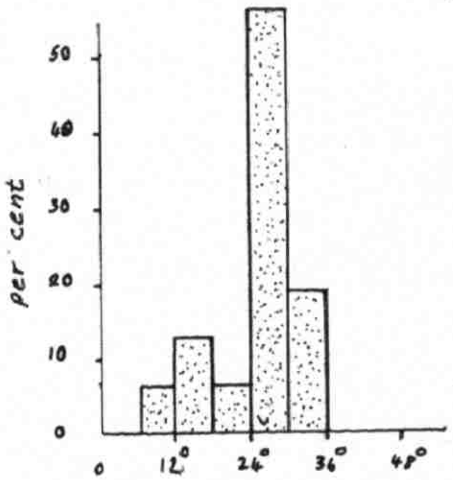
Locality	MR	VMR	V	SDS
Qartaba	300°N	310°N	6200	62°
Hrajel	180°N	225°N	6650	50°
Beskinta	300°N	277°N	6900	48°
Majdal Tarchich	180°N	190°N	3750	58°
Kfar Selouan	300°N	260°N	2500	39°
Qoubai	200°N	207°N	2950	45°
Aghmid	140°N	168°N	5650	54°
Maaser El Shouf	260°N	266°N	1820	28°
Jezzine	180°N	187°N	7900	55°
Col of Machgharah	260°N	254°N	875	21°
Zehlta	100°N	158°N	4400	47°
Beisour	300°N	282°N	1080	25°
Roumieh	260°N	245°N	3620	43°
Douar	260°N	276°N	1560	29°
Bois de Bolonge	340°N	315°N	850	23°
Salima	300°N	295°N	5000	35°
Aintoura	220°N	258°N	3620	43°
Rouaiset El Ballout	220°N	206°N	830	25°

CROSS-BEDDING FORESET DIPS

BASAL CRETACEOUS SANDSTONES OF CENTRAL LEBANON

HISTOGRAMS
PLATE (IV)

QARTABA



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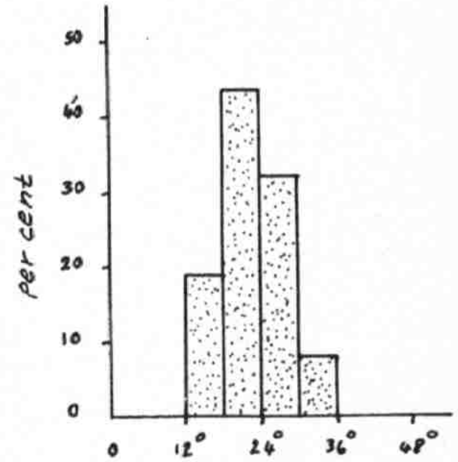

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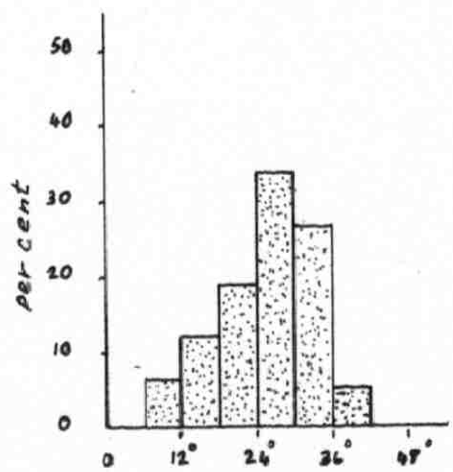
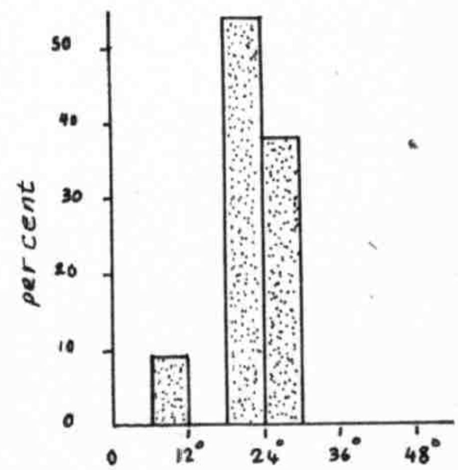


MAJDAL-TARCHICH



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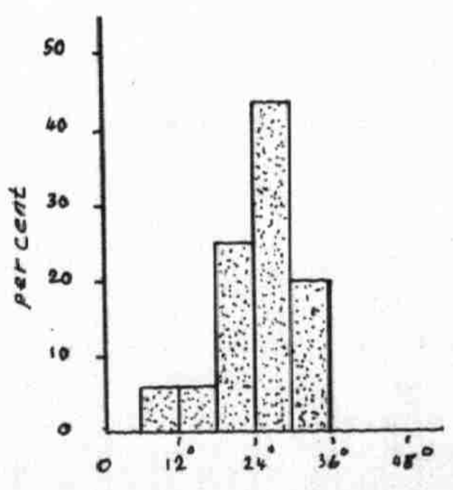
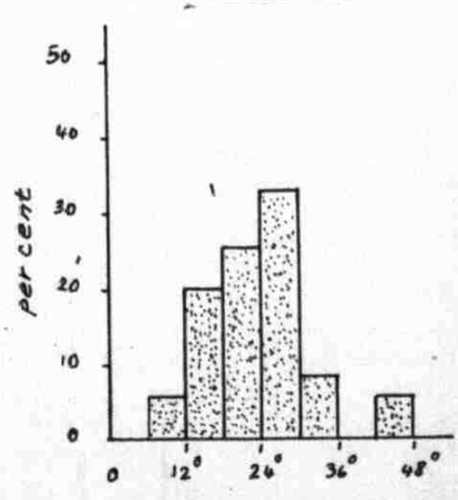


QOUBAI'



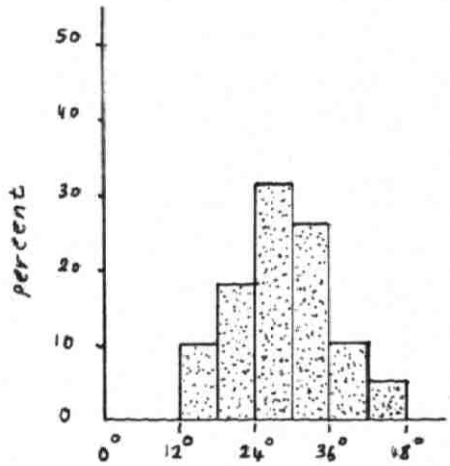
CROSS-BEDDING FORESET DIPS

BASAL CRETACEOUS SANDSTONES OF CENTRAL LEBANON

HISTOGRAMS

PLATE (IV)

AGHMID



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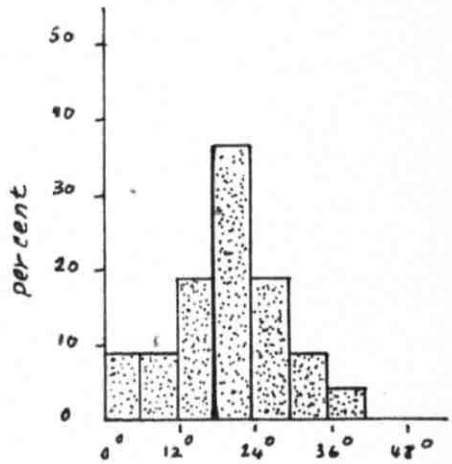

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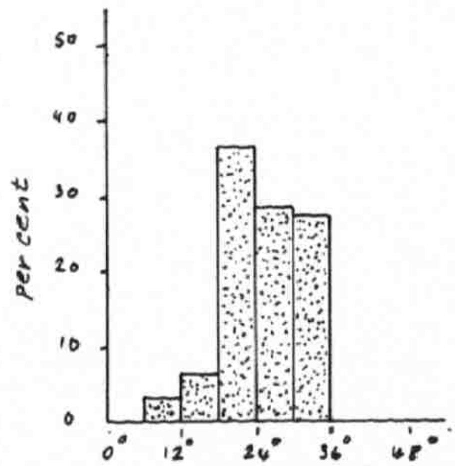

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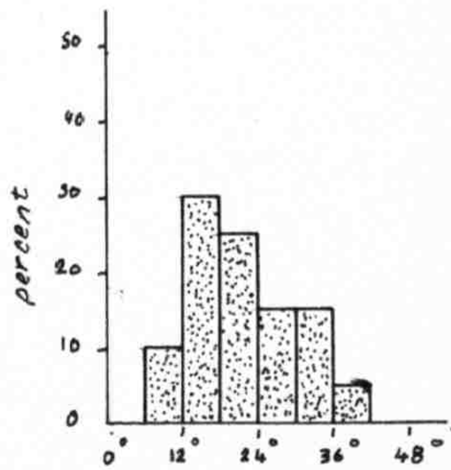
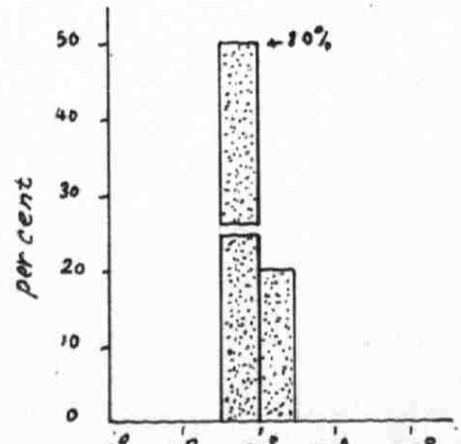


BEISOUR



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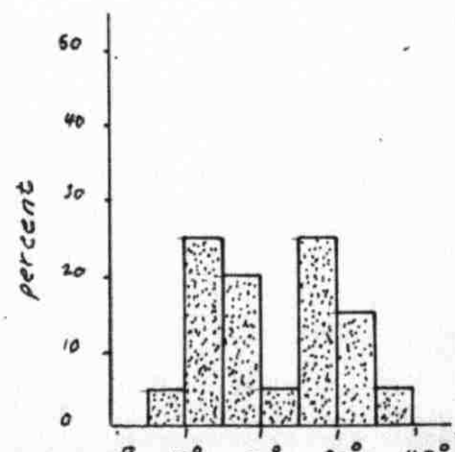
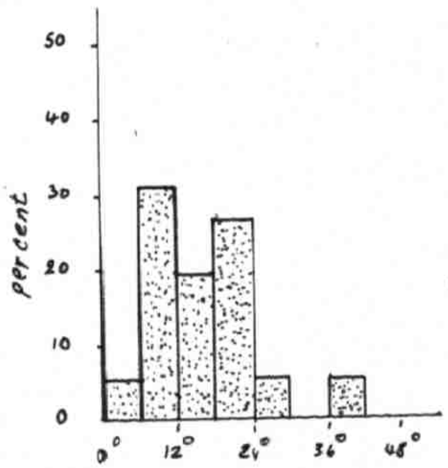


CROSS-BEDDING FORESET DIPS

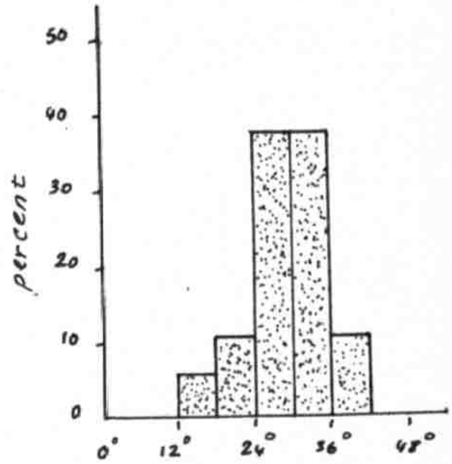
BASAL CRETACEOUS SANDSTONES OF CENTRAL LEBANON

HISTOGRAMS PLATE (IV)

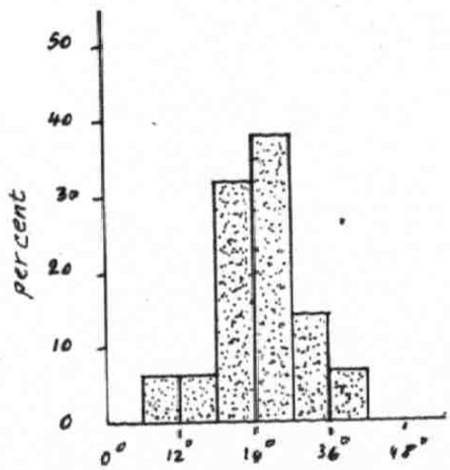
ROUMIEH



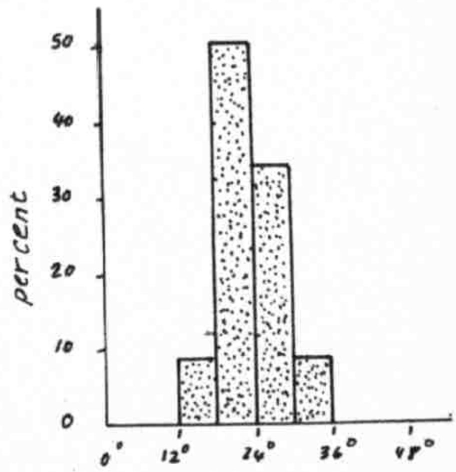
DOUAR



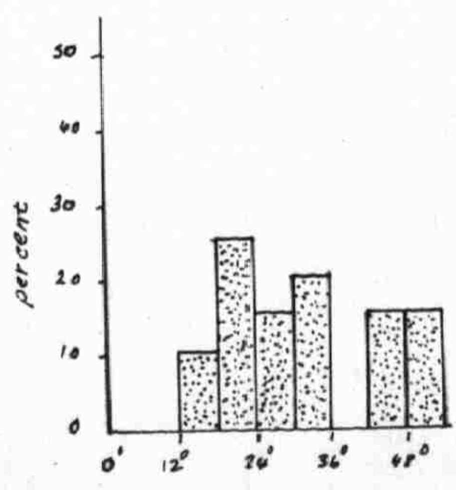
BOIS-DE-BOLONGE



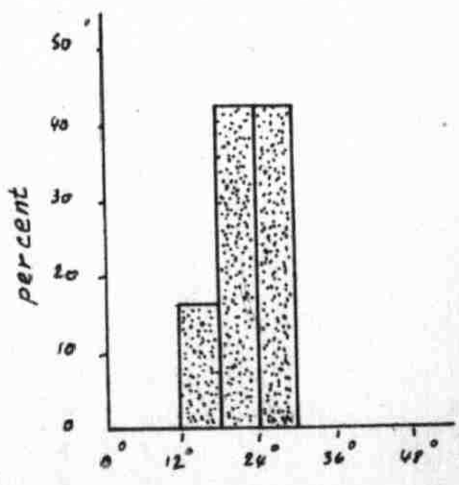
SALIMA



AINTOURA



ROUAISET AL-BALLOUT



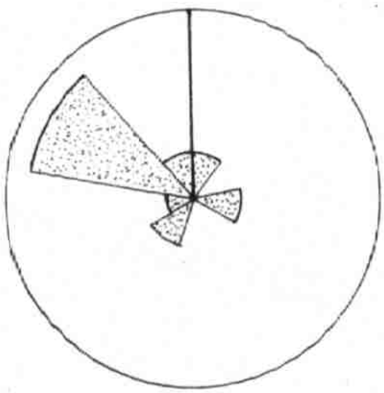
CROSS-BEDDING DIRECTION

BASAL CRETACEOUS SANDSTONES OF CENTRAL LEBANON

ROSE-DIAGRAMS

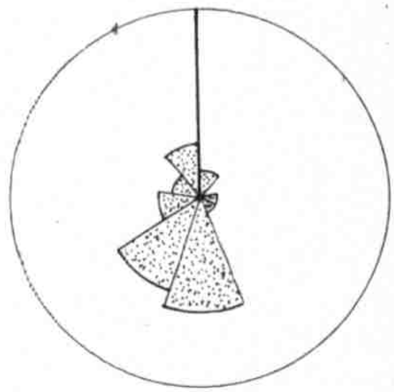
PLATE (V)

QARTABA



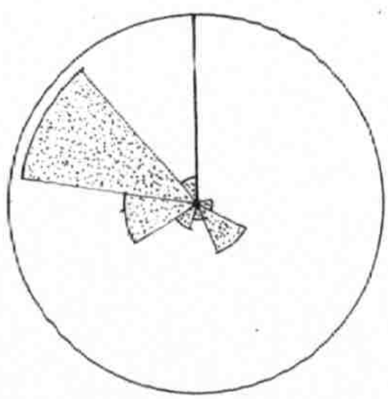
16 Observations

HRAJEL



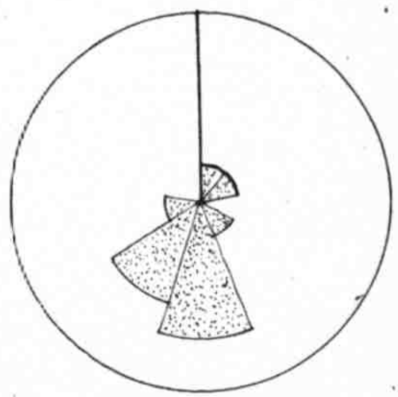
28 Observations

BESKINTA



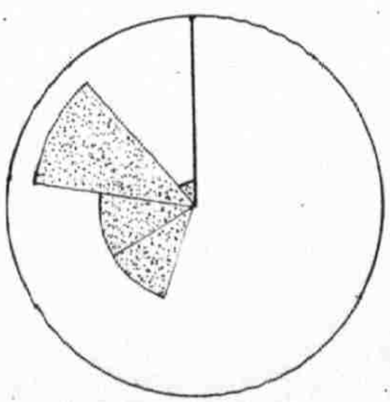
30 Observations

MAJDAL TARCHICH



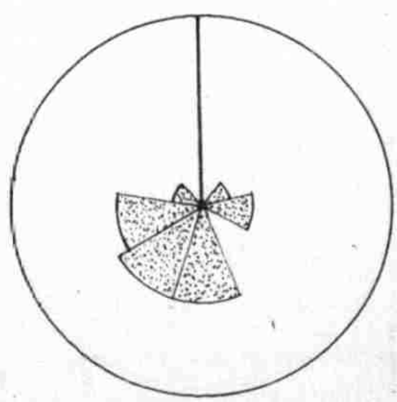
11 Observations

KFAR SELOUAN



16 Observations

QOUBAÍ



15 Observations

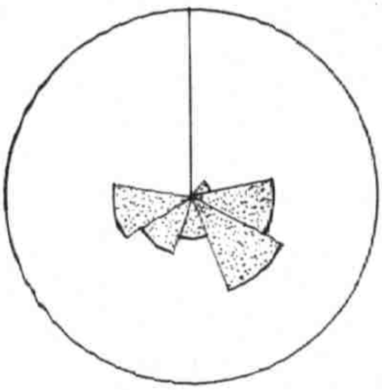
CROSS-BEDDING DIRECTION

BASAL CRETACEOUS SANDSTONES OF CENTRAL LEBANON

ROSE-DIAGRAMS

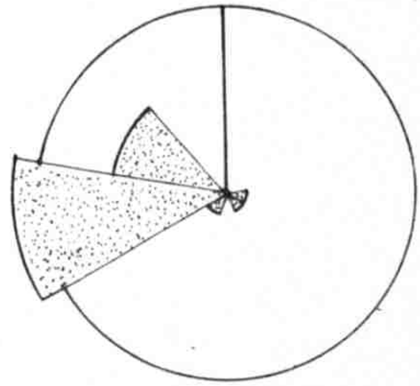
PLATE (V)

AGHMID



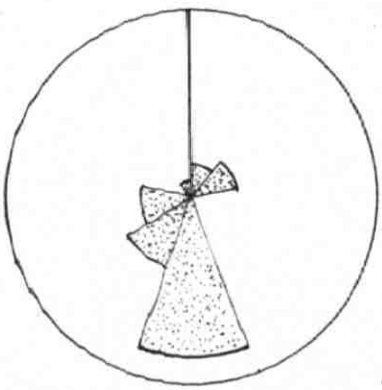
19 Observations

MAASER AL-SHOUF



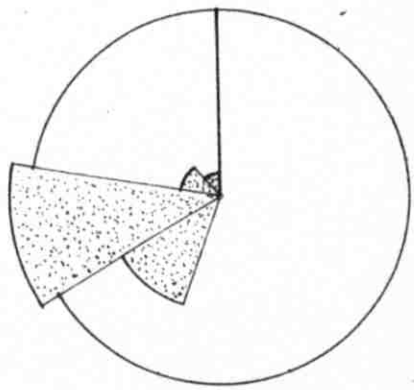
22 Observations

JEZZINE



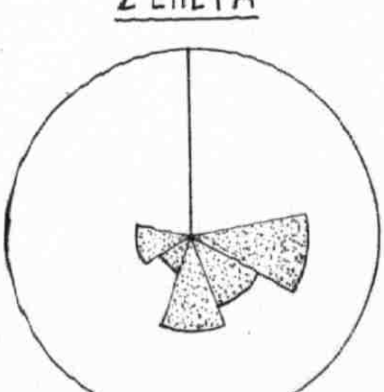
26 Observations

COL OF MACHGHARA



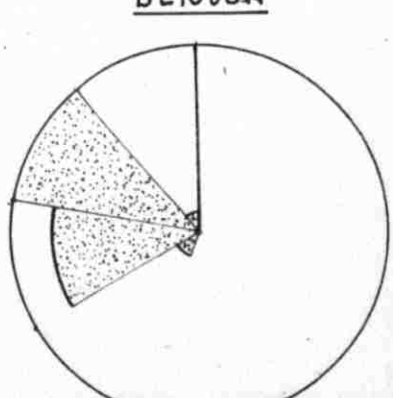
20 Observations

ZEHLTA



20 Observations

BEISOUR



18 Observations

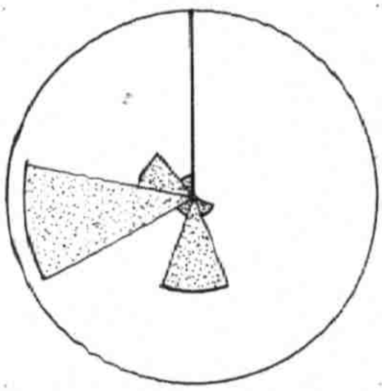
CROSS-BEDDING DIRECTION

BASAL CRETACEOUS SANDSTONES OF CENTRAL LEBANON

ROSE-DIAGRAMS

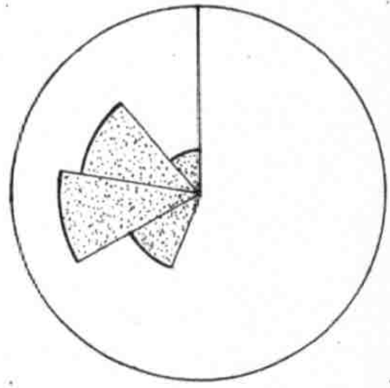
PLATE (V)

ROUMIEH



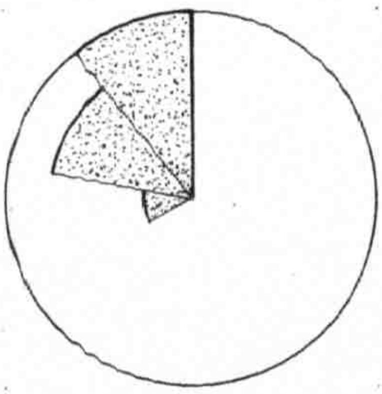
20 Observations

DOUAR



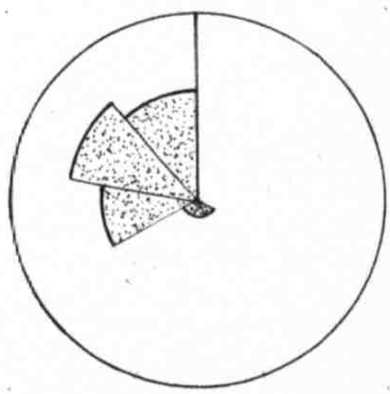
19 Observations

BOIS DE BOLONGE



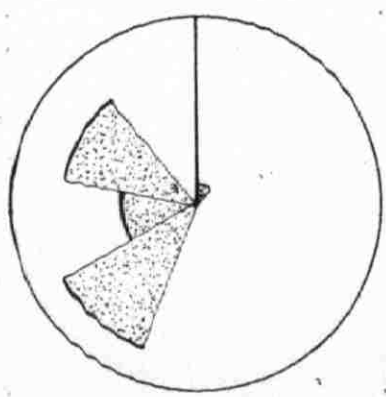
16 Observations

SALIMA



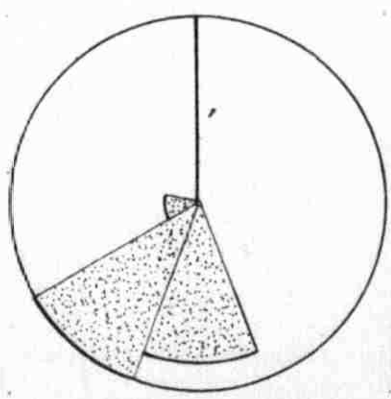
24 Observations

AINTOURA

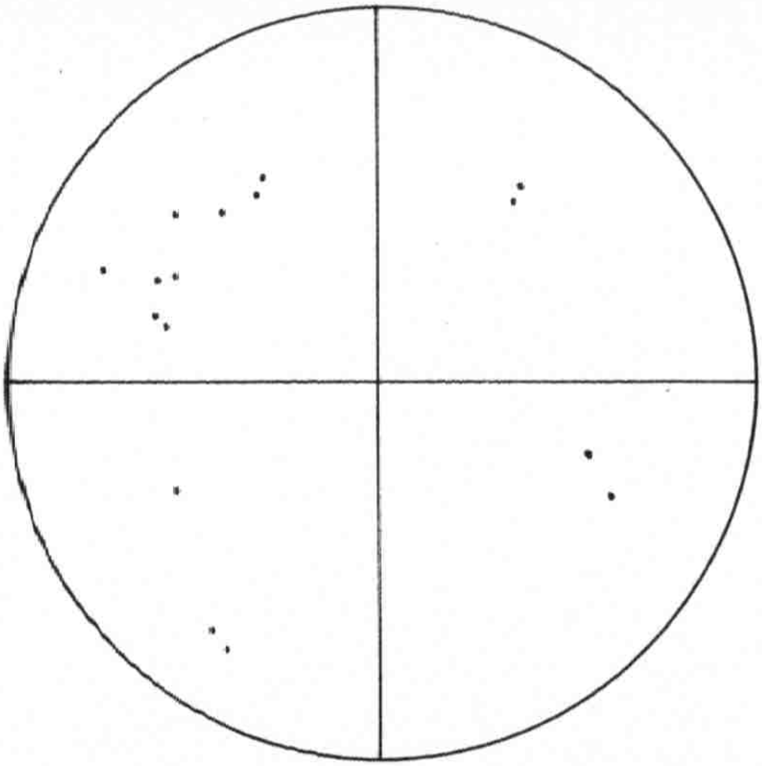


20 Observations

ROUAISET EL-BALLOUT



14 Observations



QARTABA

16 OBSERVATIONS

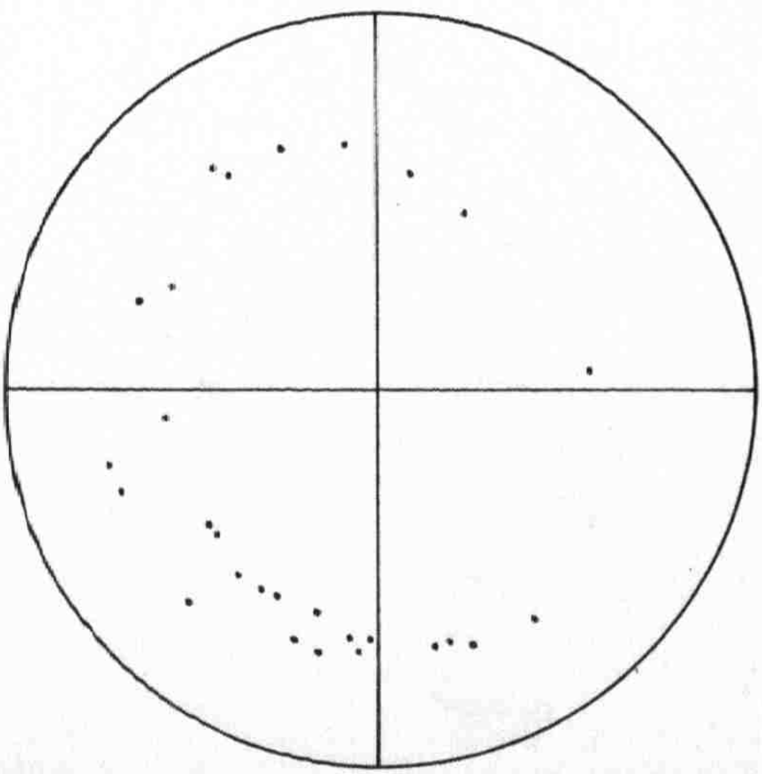
VECTOR MEAN OF READINGS 310° N

CROSS-BEDDING

BASAL CRETACEOUS SANDSTONES OF CENTRAL LEBANON

STEREOGRAPHIC POLE PROJECTION

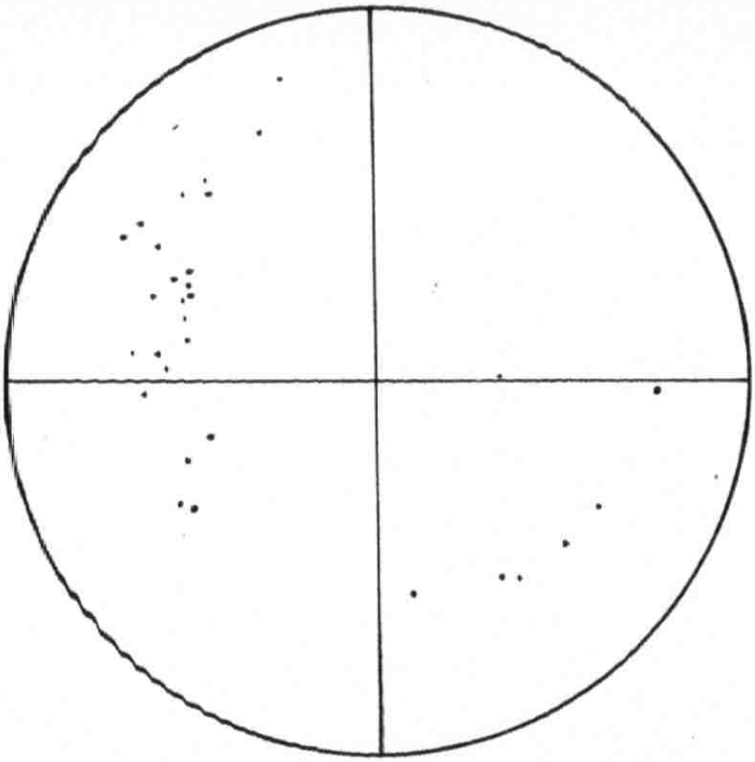
PLATE (VI)



HRAJEL

28 OBSERVATIONS

VECTOR M MEAN OF READINGS 223° N

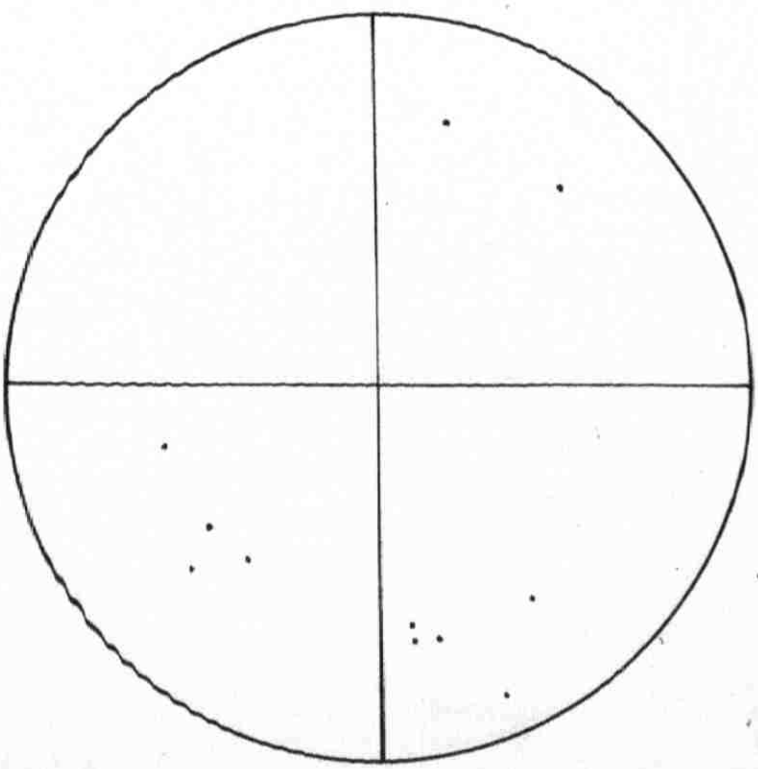


BESKINTA

30 OBSERVATIONS

VECTOR MEAN OF READINGS 277°N

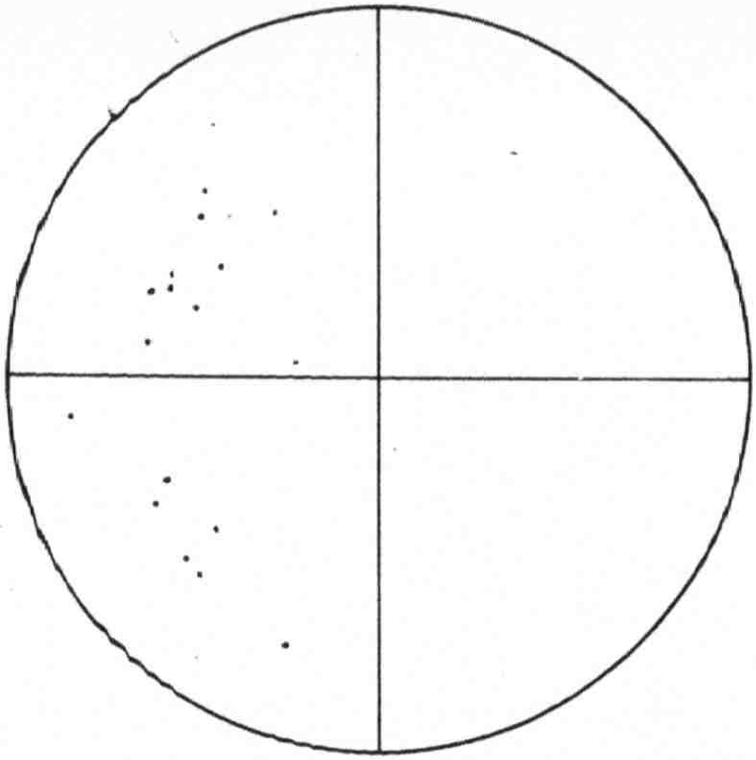
PLATE (VI)



MAJDAL TARCHICH

11 OBSERVATIONS

VECTOR MEAN OF READINGS 190°N

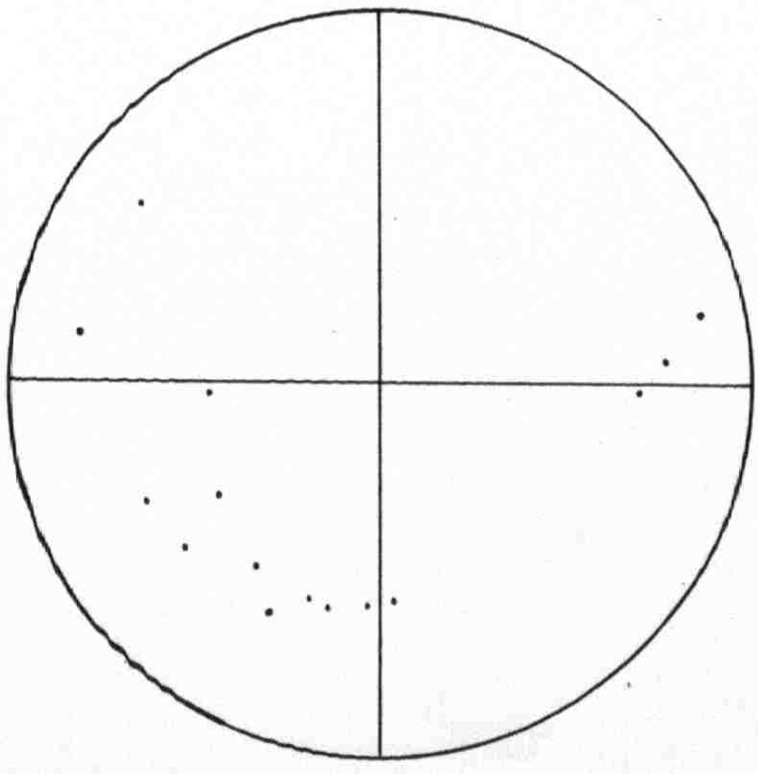


KFAR-SELOUAN

16 OBSERVATIONS

VECTOR MEAN OF READINGS 260°N

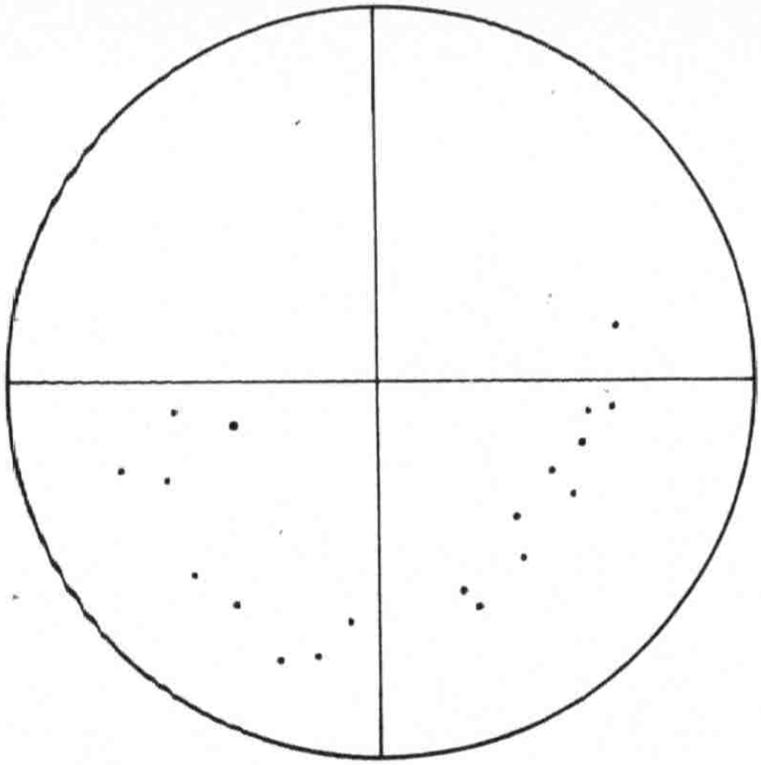
PLATE (VI)



QOUBAI'

15 OBSERVATIONS

VECTOR MEAN OF READINGS 207°N

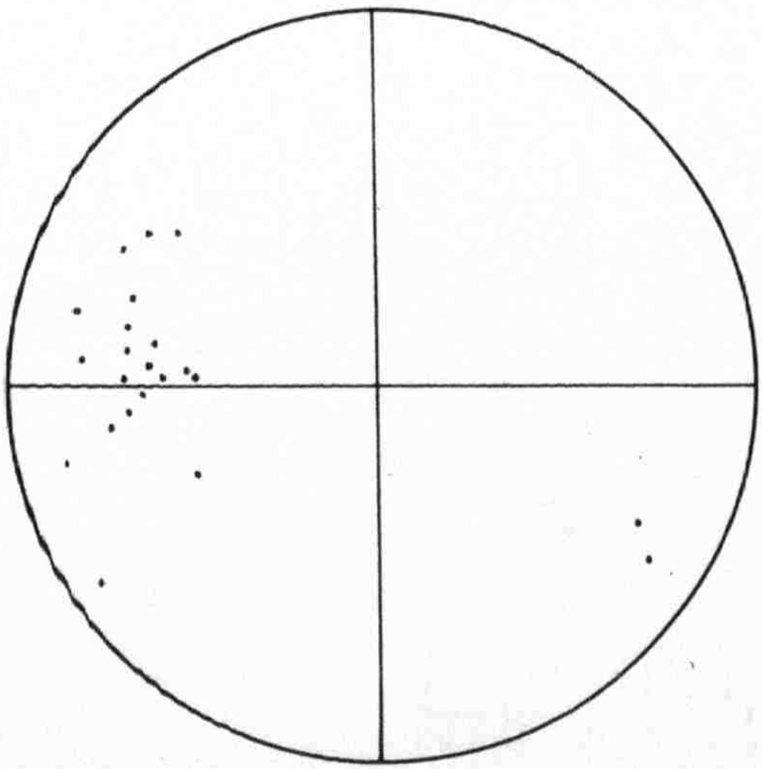


AGHMID

19 OBSERVATIONS

VECTOR MEAN OF READINGS 168°N

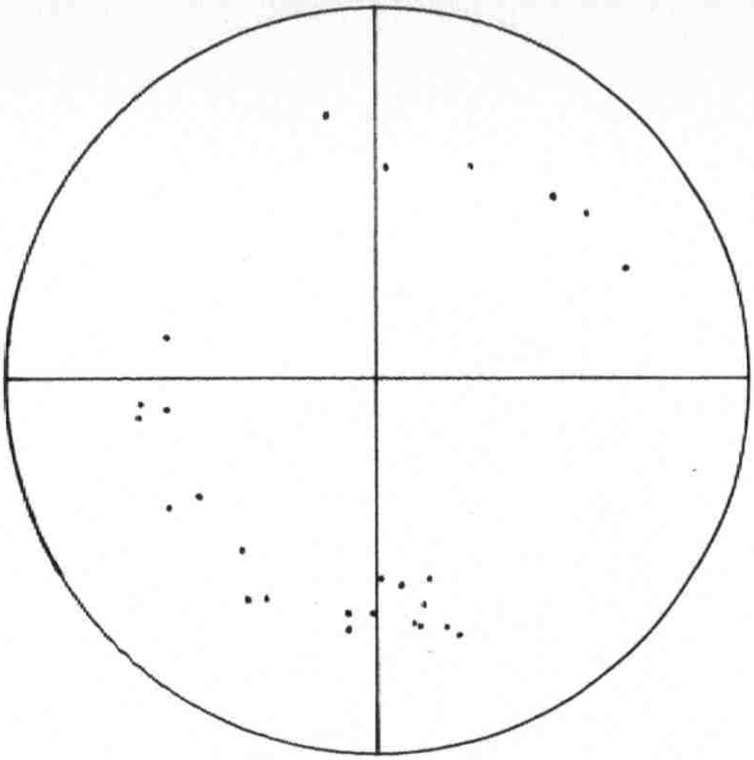
PLATE (VI)



MAASER EL-SHOUF

22 OBSERVATIONS

VECTOR MEAN OF READINGS 266°N

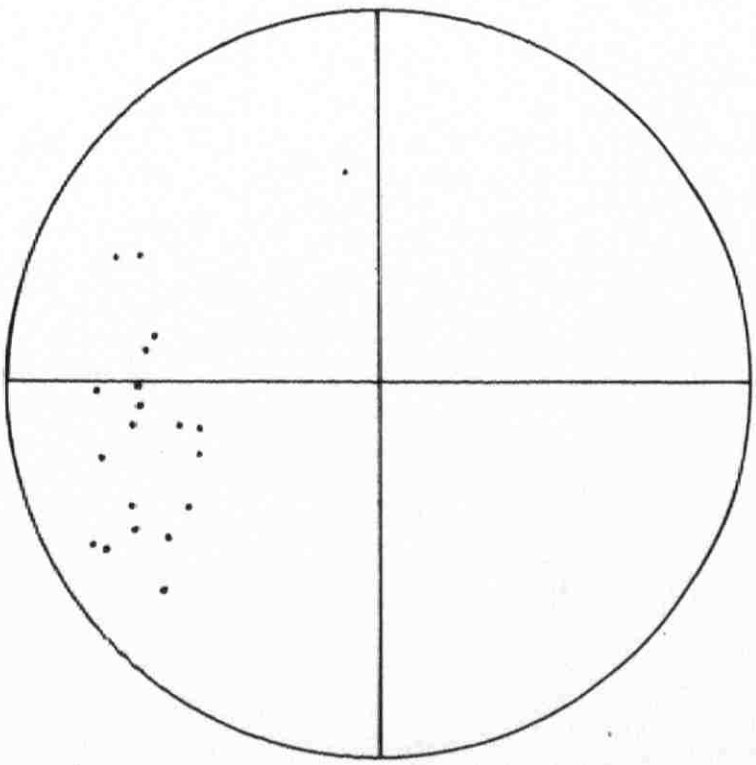


JEZZINE

26 OBSERVATIONS

VECTOR MEAN OF READINGS 187°N

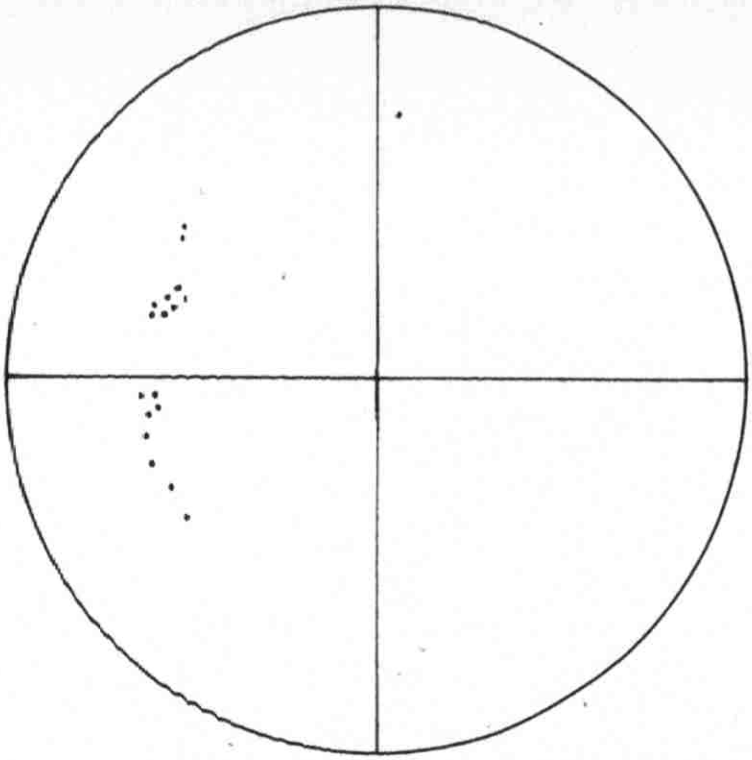
PLATE (VI)



COL OF MACHGHARA

20 OBSERVATIONS

VECTOR MEAN OF READINGS 260°N

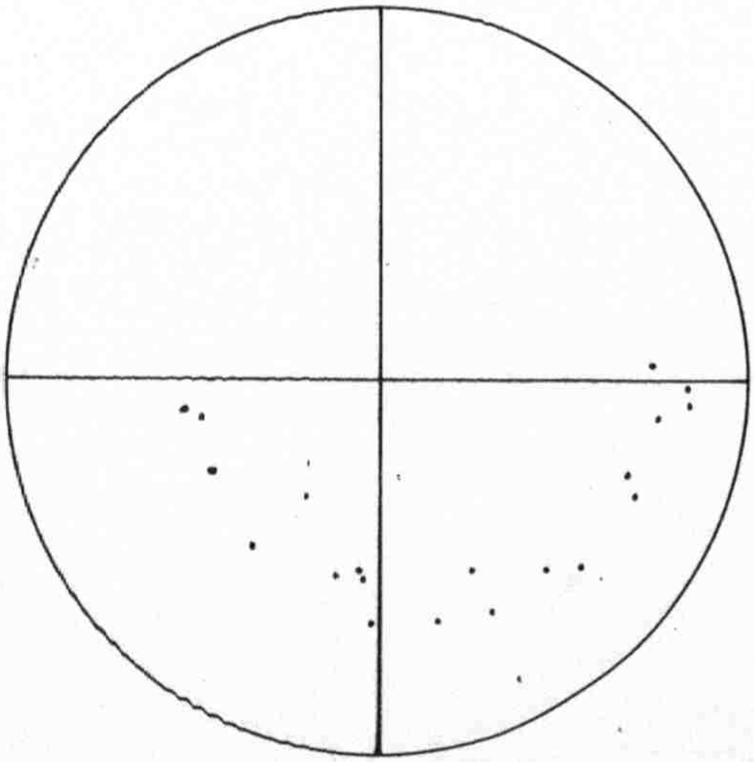


BEISOUR

18 OBSERVATIONS

VECTOR MEAN OF READINGS 282°N

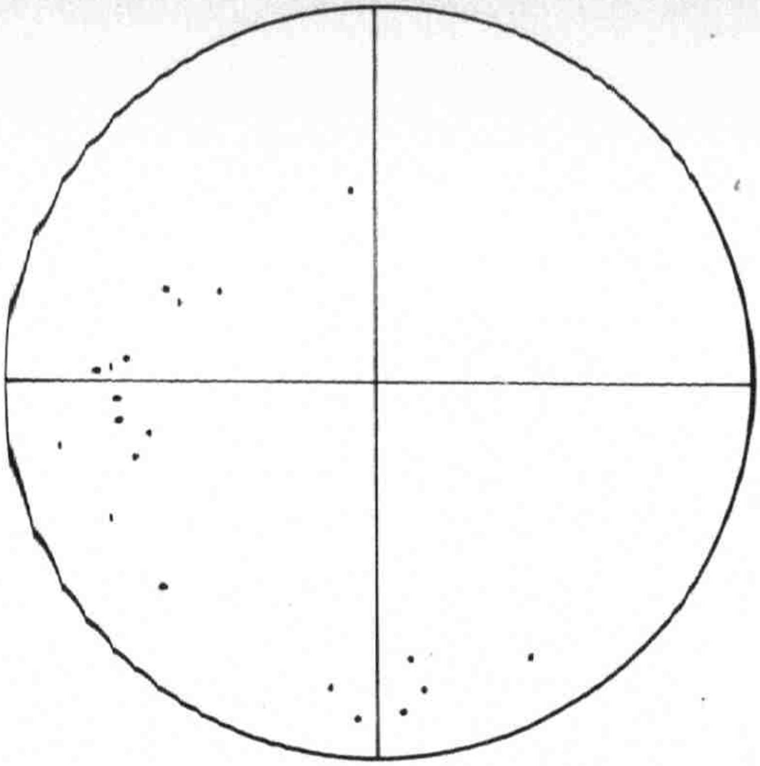
PLATE (VI)



ZEHLTA

20 OBSERVATIONS

VECTOR MEAN OF READINGS 158°N

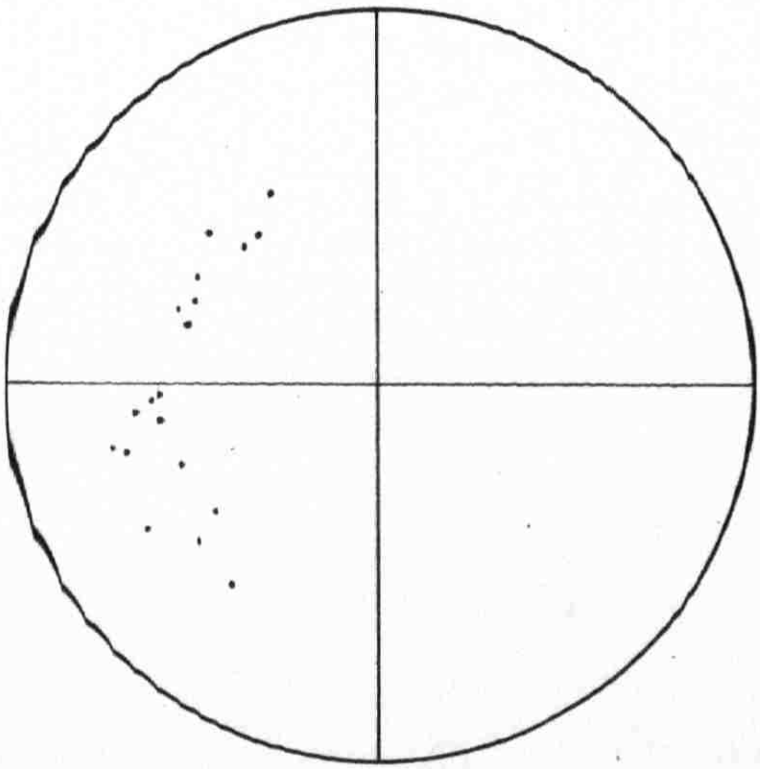


ROUMIEH

20 OBSERVATIONS

VECTOR MEAN OF READINGS 245°N

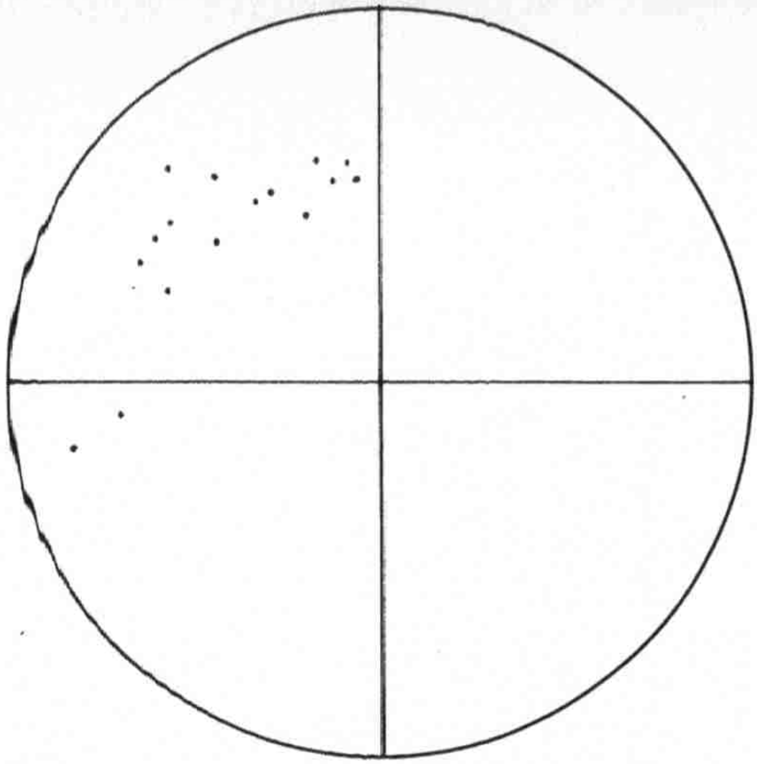
PLATE (VI)



DOUAR

19 OBSERVATIONS

VECTOR MEAN OF READINGS 276°N

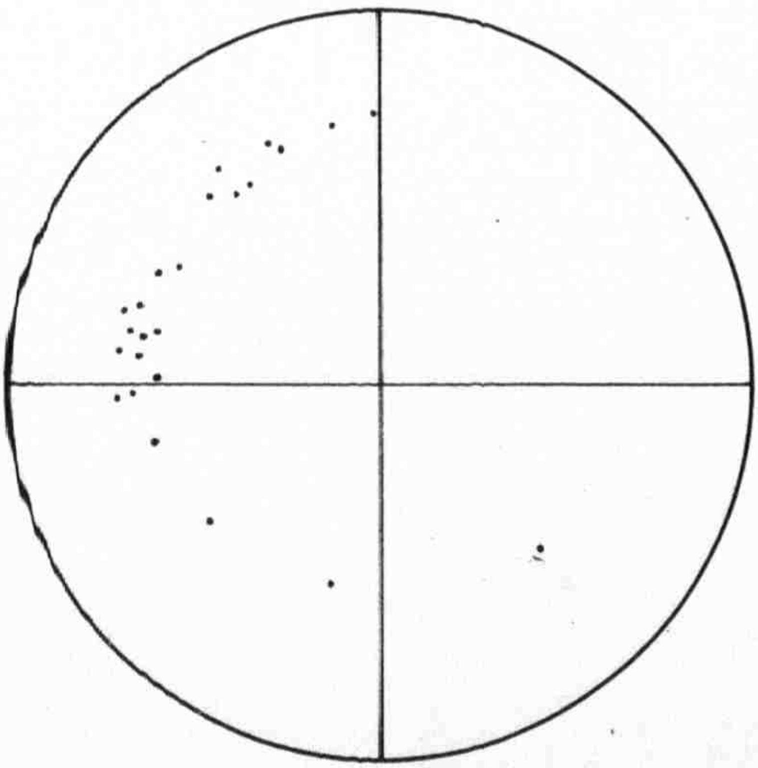


BOIS DE BOLONGE

16 OBSERVATIONS

VECTOR MEAN OF READINGS 315°N

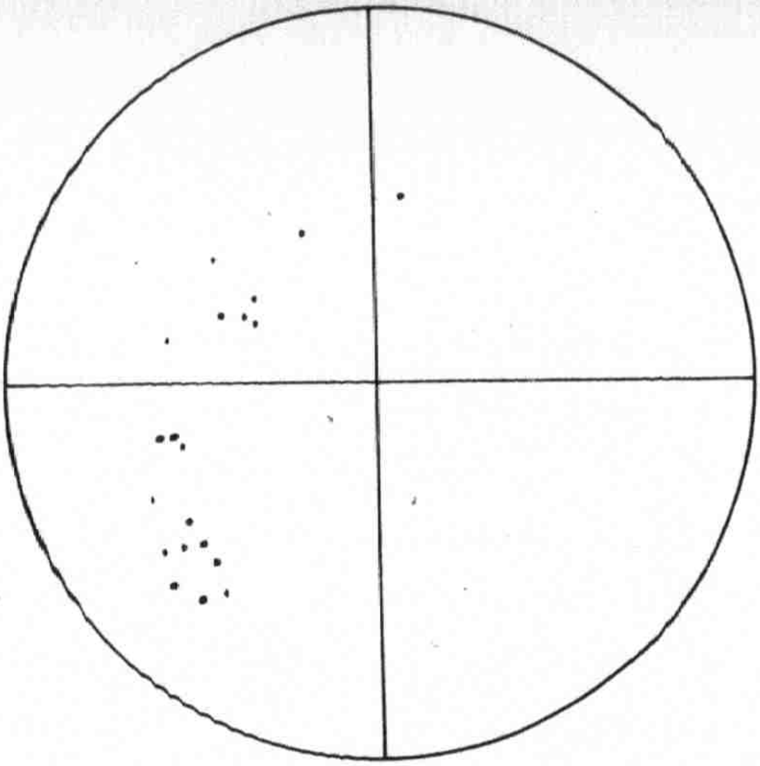
PLATE (VI)



SALIMA

24 OBSERVATIONS

VECTOR MEAN OF READINGS 295°N

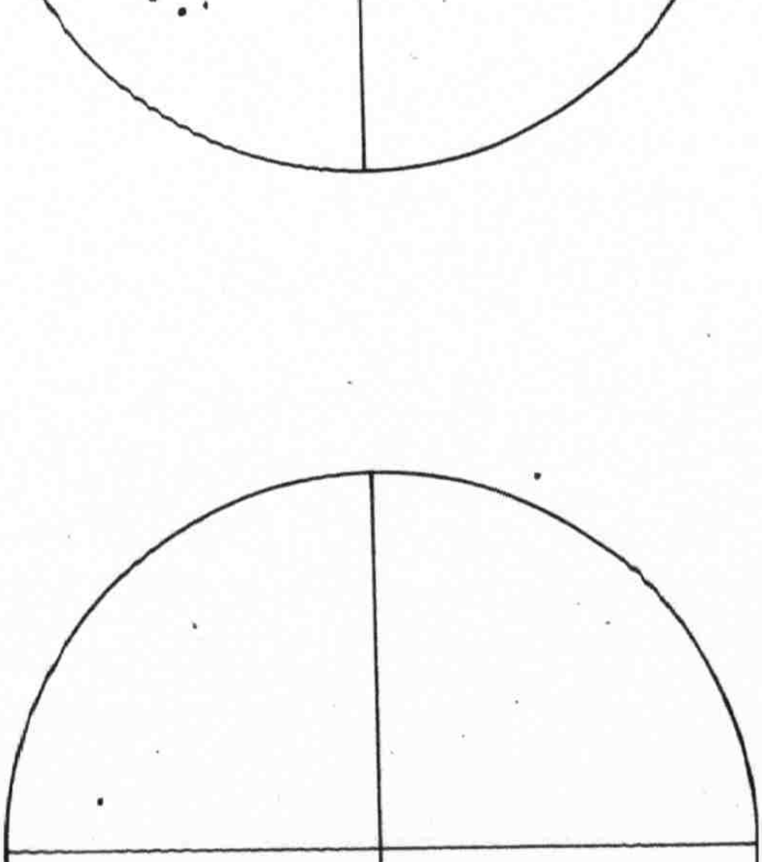


AINTOURA

20 OBSERVATIONS

VECTOR MEAN OF READINGS 258°N

PLATE (VI)



ROUAISET EL-BALLOUT

14 OBSERVATIONS

VECTOR MEAN OF READINGS 206°N

4. Discussion

The absence of topsets and the truncation of the foresets indicates erosion of the upper parts of each cross-bedded unit. Consequently, uniform surfaces or planes are generally developed. It is probable that current velocities increased beyond the depositional limit, and started eroding the previously deposited laminations. This erosional surfaces could either be contemporaneous with the deposition of the foresets laminations or post-depositional, i.e. the whole set of cross-lamination being deposited first and partly eroded later, prior to the deposition of the next unit. In any case, the velocity changes appear to have been uniform to enable plane surfaces of erosion to be developed. Subsequently, decrease in current velocities gave rise to the deposition of the overlying bed.

A sharp boundary occurs between foresets of one cross-bedded unit and the underlying unit; bottomsets, in other words, are generally absent. The reason for this is not understood. Usually, an asymptotic or tangential contact between foresets and the underlying layer in cross-bedded units is present. It has, however, been experimentaly shown that variations in current velocities are reposible for the formation of the different cross-bedded units, and the general morphological configuration of the cross-bedding, i.e. the development of tangential contact both with the overlying and the underlying units. Currents with velocities higher than 54 cm/sec., however, have been shown to produce large 'whale back' ripples with wave length of about 30 cm; although these are asymptotic at their crests, they abutt abruptly on to the floor of the underlying layer; exceptionally high velocities might, further, give rise to contradictory cross-bedding structures, (Boswell in Shrock 1948 page 243). With the subsequent truncation of the upper asymptotic contact layer the cross-bedding appears to be angular with the overlying and the underlying units. Potter and Pettijohn (1963) argue that the application of the terms "topsets", "foresets", and "bottomsets" to cross-bedding as used in the description of delta structures is rather ambiguous and is of little value, since such beds do not really exist in cross-bedding; this is especially so when an even bedded unit lies between two cross-bedded units. Accordingly, the term "bedding" seems to be more useful as reference to the main surface of deposition. Furthermore, although it is usually accepted that foresets must be asymptotic with both overlying and underlying units, non-tangential foresets are observed with equal frequency, (Potter and Pettijohn, 1963).

The thickness of cross-bedded units is a function of both the amount of sediment supply and periodicity in current velocity; thick units are associated with bigger loads and longer periods, and thinner units with smaller loads and shorter periods. Similarly the thickness of the cross-laminations within a cross-bedded unit is a function of the thickness of the cross-bedded unit, since thin cross-laminations are always associated with thinner cross-bedded units, and thicker cross-laminations with thicker cross-bedded units. But there is no quantitative data by which to determine whether this relationship is linear or parabolic in behaviour.

The phenomenon of grading in cross-bedding has a direct bearing on:

a) changes in current velocities

b) grain size and shape.

The coarser and more angular grains are closely associated with higher current velocities. As it is rhythmic in pattern, grading is more likely caused by periodic surges in current velocities. The changes in current velocities could be caused by seasonal fluctuations of water supply which in turn controle the amount of load that can be carried.

The colours of cross-laminations in cross-bedded units are of a secondary nature since original colours of sediments are usualy not preserved due to the diagenetic changes they undergo in the sites of deposition (Twenhofel, 1953). However, colours are somtimes valuable in establishing the environment of deposition and the paleogeography of a certain area; darker blackish colours are associated with anaerobic or rather stagnant waters, red colours with desert areas, and with oxidation in the zones of weathering, (Twenhofel, 1953; Weller, 1960). The cross-laminations have the same gradations in colour as previously discussed, with the association of darker colours with some zones and lighter colours with others; this association seems to have no relation to grain size since both coarse as well as fine grains show alternating dark and light brownish colours. However, this zoning in colour distribution could be due to seasonal grading of iron enrichment, as some beds show heamatitic (darker colours) grading upwards into limonite (lighter colours).

Although currents (wind, water, and possibly wave-action) are considered to be the cause of the formation of cross-bedding (Twenhofel, 1953; Schrock, 1948; Pettijohn, 1957; Lahee, 1959; Weller, 1960; Petter and Pettijohn, 1963; and Allen, 1965), a genetic relationship with environment is not well established, because of the great similarity of the morphological characters in nearly all environments. Generally, aeolian cross-bedding is marked by great irregularity of the units and their frequent truncation by later units. This is due to the variability of wind directions and to the continueous migration of dunes, (Lahee, 1959; Weller, 1960;). But this variability alone is not clear evidence of an aeolian origin since such variations in cross-bedding are also frequently encountered in fluvial-deltaic and, in some cases, marine environments. Furthermore, the dips of the foresets seem to have no genetic relationship to the environment of deposition; this is due to the fact that in all environments the foresets dip at angles from 10° to nearly 40°, depending on the grain size and the competency of the currents in the water environments, and on wind velocity in aeolian environments. Whether or not the contacts between cross-bedded units are diagnostic of the environment of deposition is still uncertain. Thus the geometry or morphology of the cross-bedded units seems to be too weak a character to be considered as criterion of the environment of deposition, (Pelletier, 1958; Frank, 1959; Pryon, 1960; and Potter and Pettijohn, 1963 in Potter and Pettijohn, 1963).

The degree of variability of current directions remains to be considered in an attempt to establish a possible genetic relationship between this aspect and the environment of deposition. It has been suggested that in most stream sediments cross-bedding lies with a sector 90° to 120°, and in delta and littoral sediments it is often more variable, usually lying within a 180° to 220° sector, (Junst, 1938 in Potter and Pettijohn, 1963). Others have come to the conclusion that the standard deviations of aeolian cross-bedding differed very little from those of deltaic and fluvial sediments, (Pelletier, 1958 in Potter. Pettijohn, 1963). Moreover, regional variability of cross-bedding has been suggested to be greater in marine environments than in deltaic fluvial sedimentary environments, and that sands considered to be aeolian have variability comparable to that of many deltaic and fluvial sands (Potter and Pettijohn, 1963).

It has been shown that the variance and the standard deviation of scatter in the "Basal Cretaceous Sandstones" ranged between 830 and 7900, and 21° and 62°, respectively. Comparing these results with those of sandstones which are considered to be of fluvial-deltaic environment, a close similarity can be observed, except that a lower standard deviation is encountered. This difference in standard deviation could be due to variability in the course of streams and corresponding gradiant; this is found in modern streams where the standard deviation varied between 20° and 83°, (Hamblin, 1958 in Potter and Pettijohn, 1963).

All these data and results add up to the consideration that the cross-bedding structures are formed by fluvial currents in a fluvial-deltaic environment of deposition.

Thickness and Facies Variation

I. General

This chapter deals with both thickness and facies variation in the "Basal Cretaceous Sandstones" of Lebanon in particular, and of the Levant (Lebanon, Syria, Jordon, and Palestine) in a more general manner. The study in Lebanon is based upon personal field observations embodied in the measurement of stratigraphic sections at well scattered localities (see table (2) page 12) and is supplemented by additional data obtained from different sources (see table (3) page 14); the regional study outside Lebanon, however, is based on data collected from the literature on Palestine, Jordon, and Syria (see table (4) page 15), and correlated to the Lebanon observations.

The first part deals with thickness variation both in Lebanon (in detail) and in the Levant region (in a more general way), while the second part deals with facies variation of the same areas. The final part discusses the causes contributing to the thickness variation and facies distribution during "Basal Cretaceous Sandstone" times, the environment of deposition of these sandstones in the Lebanon, and the medium of transportation and the provenance and origin of these sandstones as implied by thickness and facies variation.

Before going into the regional facies changes of the "Basal Cretaceous Sandstones" formation, it would not be out of place to stress the importance of clarifying the relationship between sedimentation on the one hand and geologic time on the other. The mode of sedimentation and type of sediment often transgress time boundaries. Many factors controle the distribution of facies; among these are time (in relation to vertical variation of facies), space (in relation to lateral variation of facies), and environmental conditions (in relation to type of sediments). The word facies, accordingly reflects the relationship between lithology, environment, and geologic time; i.e. lithofacies and lithostratigraphic divisions. The lithologic characters of facies correlation, therefore, can be considered (1) without regard to their relations to each other, (2) as variation in vertical sequence, and (3) as lateral variation. The word facies is, therefore, used here in reference to rock units that are independant of the rigid time boundaries. It is applied broadly to the formations regionally described and discussed as "Basal Cretaceous Sandstones" (Lebanon), "Hathira Sandstone Formation" (Jordon and Palestine). "Cherrife Shale Formation" (Syria), (L.S.I., vol. III, fascicule 10 cl and c2), all of which exhibit regional facies affinities but whose lower and upper limits transgress rigid time boundaries. In the main they are regarded as being of Basal Cretaceous (s.l.) age but undoubtedly are in part of Upper Jurassic and higher Lower Cretaceous ages in some regions.

2. <u>Thickness Variation</u>

a) <u>Lebanon</u>

The variation in thicknesses of the "Basal Cretaceous Sandstones" in Lebanon has been determined by:

i. the measurement of several stratigraphic sections in the field.

ii. the computation of additional thicknesses from 1/50000 geologic maps in areas where outcrops were poor but thickness data were considered useful.

iii. literature.

In central Lebanon the broad trends of thickness variations are best observed along ridge exposures. It is found that:

i. The "Basal Cretaceous Sandstones" die out towards the north where only about 5 to 10 meters occur in the locality of Sir ed Danyie and Becharre, (Dubertret, 1951, see plate VIII and IX).

ii. There are areas of relatively large thicknessess, located along the axis of Mount Lebanon, (Beskinta, 240m; Qoubai, 259m; Kfar Niss, 250m; and Jezzine 388m); see plate VIII and IX.

iii. The formation thins in an easterly direction; in the Anti-Lebanon its thickness varies from 50m to 150m, in southeast Lebanon at Mount Hermon the measured thickness is 125m (Dubertret, 1948, 1956); in the southeast part of Mount Lebanon at Mimms the measured thickness is 120m (Renouard, 1955).

iv. The formation thins and probably disappears in a westerly direction as is partly indicated by the smaller thicknesses along the exposures of the westerly flanks of Mount Lebanon (Jouret el-Tormos, 86m; Qattin, 89m; Aintoura, 85m; and Beit Mery, 150m) as shown on plate VIII and IX; but this requires further supplemantation and has to await possible future offshore drilling to show if the formation is absent seawards.

v. In south Lebanon the behaviour of thickness variation is not very clear; but it seems that there is a southerly thinning, as well as a westerly wedging and interfingering with more marine sediments as revealed by the staratigraphic section in the exploration well Adloun No. 1 (170m).

Compiling all these data a reasonably representative isopach map can be constructed which shows these general trands of variation, (plate IX).

Thickness variation also occurs within the members of the "Basal Cretaceous Sandstone" formation. Sandstones, as shown on page 20, thin in two directions within its outcrop area, reaching about two hundred meters in some cases. Often these sandstones show undulations in thickness within relatively short distances of the order of 50 meters; in a few cases they are found to vary within 10m. But such variation over short distances seems not to be as pronounced as is the case with longer distances. The argillaceous sandstones generally follow the same trend as that of the sandstones; although in some cases they are found to merge into sandstones and vice versa. Sometimes, however, these argillaceous sandstones show abrupt wedging within very short distances of not more than 5 to 10 meters. Clays are found to occur mainly in lenticular form; they usually wedge out within very short lateral intervals, in many cases this distance being not more than 30 to 40 meters but intervals of as little as 10 meters are not uncommon. These clays are found, nearly always, to occur between sandstones, although sometimes they are interbedded with argillaceous sandstones. In many outcrops a clay member with a thickness of nearly 50cm was found to gradually thin out, and then to completely disappear within a distance of 20 to 30 meters.

Lignites, are sometimes present, totalling no more than around 6 m in thickness, and they are found to be interbedded with white pale yellowish brown poorly consolidated sandstones. These lignites are lenticular in form, and consequently were found to wedge out within rather short distances, usually not more than 20 meters; although relatively longer outcrops of the order of hundreds of meters were observed particularly south of Jezzine on the way to Haitoura; here a thickness of nearly 5 to 10 meters of lignites were found to extend over a distance of about 150 meters. Volcanic material in the form of basalts and ashes together with chocolate coloured clays formed from the alteration of these rocks are of sporadic occurrence and add some 20 meters to the thickness of the sedimentary succession in different localities (Beskinta, Qoubai, and south of Jezzine near Zehlta);

b. The Levant

The equivalent of the "Basal Cretaceous Sandstone" formation in north Palestine is not exposed, except in some quaries in the Qiryat Shemona area near the Lebanese border. Subsurface data either are not available or if published are very generalised; thus there is a difficulty in relating variations in Lebanon to those in Palestine and Jordon. A subsurface borehole at Qiryat Shemona shows a thickness of 180 meters of clastics that are considered to be equivalent to the "Basal Cretaceous Sandstones" of the Lebanon (Karcz, 1965). This, may indicate very roughly, the southerly thining of the formation from Jezzine (in the Lebanon) down to Qiryat Shemona (in north Palestine). Further data supplements this trend of thinning from Lebanon to north Palestine; the subsurface thickness as obtained from a borehole at Debora near lake Tibarise is about 100 meters, while in the borehall at Ashier, east of Haifa, the thickness is only 30 meters.

In central and south Palestine, as well as in east Jordon, the variations in thickness are rather similar to those in the Lebanon. The "Hathira Sandstone Formation", which is taken as the equivalent of the "Basal Cretaceous Sandstones" in the Lebanon wedges out towards the west, where it interfingers with marine sediments of Lower Cretaceous age; in addition it thins eastwards and southwards. There is southerly relative thinning as evidenced by the measured sections of the "Hathira Sandstone Formation" at Nahr az-Zarqa (214m), Zarqa Ma'in (234m), ed Dhira (167m), (Wetzel and Morton, 1959), Wadi Musa near Petra (97m), Naqab Ashtar (71m) (Nasr and Morton, 1946, 1947, in L.S.I. vol. III, fascicule 10 c 1). Relatively large thicknesses are encountered at Makhtesh Hathira (450m), Makhtesh Hastera (313m), and in the subsurface wells at Messada No. 1 (402m), Zohar No. 1 (406m), (Bentor and Vroman, in L.S.I. vol. III fascicule 10 c 2); and Rammallah No. 1 (310m) Safra No. 1 (300m), (Bender, 1961). It appears that these large thicknesses are found along three concurrent directions centered at Makhtesh Hathira, Rammallah No. 1, and Safra No. 1, roughly at 120° to each other, (see plate X). Thicknesses, accordingly, decrease away from these three lines in a divergent manner. According to the available data this thinning is rather sharp on the western parts of the Ramallah and Makhtesh Hathira structures. Eastward, however, the thinning is more uniform, particularly in the area south of Amman.

Compiling all these data for Jordon, Palestine and Lebanon a general representatative isopach map has been constructed to help show the general picture of the thickness variation of the "Basal Cretaceous Sandstones" formation and its equivalents"Hathira Formation Sandstones", this is shown on plate (X).

3. Facies Variation

a. Lebanon

There are considerable local vertical and lateral variations in lithology of the "Basal Cretaceous Sandstones" in Lebanon. In most cases these do not show any evident pattern; close examination of the stratigraphic sections does, however, show simple rhythmic alternation of sandstones and argillaceous sandstones that are interbedded with lenses of clays and shales and lignites.

The sandstones constitute the bulk of the lithologies in all the studied stratigraphic sections, but are more predominant in some localities than in others. Relativly strong thicknesses of sandstones are found in the Qartaba (88°/o), Jouret el-Tormos (80°/o), Qattin (83°/o), Aintoura (84°/o), and el-Mansourieh (78°/o), localities in the nothern parts of Central Lebanon. Similar abundance is encountered along the strip of outcrops running from the Col of Machghara in the south up to el-Barouk northwards; at the Col of Machghara this is 70°/o. The axial zone of Mount Lebanon, however, shows a relative decrease in the overall thickness and content of sandstones; from 88°/o at Qartaba, it is 65°/o at Beskinta, 56°/o at Majdal Tarchich, 58°/o Qoubai, 55°/o at Aghmid and 46°/o at Jezzine. There is a corresponding increase in the content of argillaceous sandstones and clays in that order. Lignites and carbonaceous materials vary in content, it is about a maximum of 8°/o at Qoubai; in the areas south of Jezzine greater thicknesses where observed, but no statistacal data collection was carried out; the percentages of the different lithologies to the total section are shown in table (6)page 66.

Vertical variations at each studied stratigraphic section exhibit lack of any definite repeated cyclic sedimantation pattern; they show, however, simple altternation of sandstones interbedded with argillaceous sandstones, and with some lenses of clays, shales and lignites. No evident decreaseor increase in the sandstone content within each section is apparent in the vertical succession.

Most of the stratigraphic sections show no traces of limestones or marls, except for very slightly limey sandstones at the lower contact

TABLE No.(6)

Percentage occurence of the different Lithologies in terms of total Thickness at each Studied Stratigraphic section

Locality	S.S.°/o	A.S.S.°/o	C.S.°/o	L.C.°/o	L.S.°/o	M.
Qartaba	88	10	2	-	-	-
Beskinta	65	23	10	2	-	-
Majdal Tarchich	56	20	18	6	-	-
Qoubai	58	32	7	8	-	-
Aghmid	55	36	6	3	-	-
Jezzine	46	32	17	3	1	1
Col of Machgharah	70	12	18	-	-	-
Jouret el Tormos	80	16	2	2	-	-
Qattin	83	10	5	2	-	-
Aintoura	82	11	5	2	-	-
Al-Mansourieh	78	13	8	-	1	-

S.S.°/o : Sandstone

A.S.S. : Aggillaceous Sandstone

C.S. : Clay and Shale

L.C. : Lignites and Carbonaceous Material

L.S. : Limestone

M. : Marls

of the "Basal Cretaceous Sandstone" formation with the Upper Jurassic carbonates (e.g. Beskinta locality, see plate XXI and appendix V page 89), and the upper contacts with the Aptian sandy limestones (e.g. Beskinta and Jezzine localities; plates XXI, XXV and appendix V and IX pp. 89, 101, respectively). In the Jezzine neighbourhood the lowest 200 meters approximately are completely devoid of limestones, and only one meter thick bed of limey, slightly fossiliferous sandstone occurs at the 220 m level from the bottom of the section; whereas the upper 200 meters contain some thin beds (less than one meter thick) of sandy, fossiliferous limestones, and sandy marls especially at the very top towards the contact with the limestones of the Aptian "Falaise de Blanche". All other examined sections consist of an alternation of sandstones and argillaceous sandstones, with lenses of clays and lignites. Occasionally there is a sporadic occurrence of volcanics (basalts, tuffs, and choclate clays) within the formation; these were observed in the Beskinta (20m), and Qoubai (18m) areas, and south of Jezzine; at the first two localities these volcanics are found towards the bottom, while in the latter they are found towards the top.

The subsurface section of the exploration well Adloun No. 1, shows a marine sedimentary sequence of limestones and marls, interbedded with subordinate marine sandstones and clays. The thicknesses of these limestones vary between 3 and 19 meters and they appear to be massive in character, but no detailed description of the bedding is available. A dolomite bed occurs towards the middle of the section. No definite pattern of sedimentation is recognised in this section.

The "Basal Cretaceous Sandstones" laterally vary rapidly in details of lithology, that no particular bed can be followed for an appreciable distance, and generally only for very short distances; this is on the whole a few tens of meters in the case of clays and lignites, and slightly longer distances of the order of 60m to 70m in the case of argillaceous sandstones, and longer distances of more than two hundred meters in the cases of sandstones. Changes in the colours of these lithologies, particularly the sandstones, make correlation of one member with another very defficult, and in many cases, virtually impossible. Grain sizes are variable and no definite pattern of variation, either vertically or laterally, is observed in the field; the average grain size is however genarally of the medium order.

There is lateral variation in the degree of consolidation and induration of the sandstones; a hard thick bed, (2 meters in thickness) for instance, will often suddenly give way to a very soft bed; but some very hard massive sandstone beds could establish local stratigraphic levels. Clay members separating two sandstone members are often lenticular and can not be relied upon even as local markers. With such extensive variation definite correlation is virtually impossible.

Accordingly, two broad facies can be recognised in the "Basal Cretaceous Sandstones" of Lebanon, namely (I) a non-marine to transitional, deltaic, or terrestrial fluvial facies, consisting of sandstones, with argillaceous sandstones, clays, shales, lignites, amber, and occassionally volcanic material; and (2) a marine facies consisting of limestones, marls, clays, shales, and sandstones. The former appears to cover most of Lebanon, and the latter appears to extend in the southwest areas of the Lebanon. These two facies appear to interfinger with each other, as is partly indicated by the subsurface section in North Palestine, immediately adjoining

Lebanon at the Qirayat Shemona borehole (Karez, 1965) which shows a sequence that resembles that of the Adloun subsurface section, and partly by the lesser content of sandstone in the neighbourhood of Jezzine, and the occurences of sandy limestones within the sandstones at Jezzine; all these indicate a shifting of the strand line, and the interfingering of these two facies.

b. The Levant

The "Basal Cretaceous Sandstones" are attributed to the 'Neocomian' in most parts of the Lebanon, where they generally overly the Upper Jurassic carbonates (Portlandian, and Kimmeridgian), and generally underly the Aptian limestones, shales and sands; in the south, however, the upper parts probably includes the Aptian (Dubertret, 1955). This dating is, however, rather loose since fossils are generally absent. It would therefore be more appropriate to consider the whole formation in the Lebanon as Basal Cretaceous in age. See plate XI.

The equivalent of the "Basal Cretaceous Sandstone" formation in Palestine is the "Kurnub Sandstone", and in Jordon it is the "Hathira Sandstone Formation"; these two formations are stratigraphically equivalent. Since the word 'Kurnub' has also been used for some Tertiary formation (see L.S.I. vol. III, fascicule 10, c 1 and 2), the "Hathira Sandstone Formation" will be used in this text to refer to the Lower Cretaceous of both Palestine and Jordon. These two formations are taken to be of Upper Jurassic to Lower Cretaceous age. This loose dating is due to the lack of diagnostic fossils, except for some plant remains which were dated as Lower Cretaceous (Edwards, 1929 in Blake 1939 in L.S.I. vol. III, fascicule 10 c 1). See plate XI for regional correlation of these Lower Cretaceous sandstones.

The deposition of similar sands started in the Cambrian in Jordon and South Palestine (Quweira Sandstone and Conglomerate, Qunaya Sandstone, etc.) and intermittently continued through the Paleozoic (Ram Sandstone, Umm Sahm Sandstone, Raman Group), ending in the Lower Cretaceous by the Albian (Hathira Sandstone Formation, Kurnub Sandstone, Basal Cretaceous Sandstones) when it was followed by the widespread marine transgression of the Cenomanian (Judea Limestone, Cenomanian Limestones); see plate XIII. In north Palestine and Lebanon sand deposition may have started in the Uppermost Jurassic (post Portlandian?) or Lower Cretaceous (pre-Aptian) and ended up with the 'Aptian' ingression of the sea.

The "Basal Cretaceous Sandstones", "Kurnub Sandstone" and the "Hathira Sandstone Formation" are so similar in overall lithology that they constitute a major facies unit. In some areas this is continental-terrestrial (East and South Jordon) but it becomes progressively more marine in a westerly direction going into west Palestine and southwest Lebanon; the rest of the Lebanon appears to fall in the transitional, deltaic, to fluvial-terrestrial environment.

A good section of this group of sandstones in Jordon is found at Khuneizer, 5 kilometers wouth of Nahr az Zarqa, where a total thickness of 214 meters occurs, the lower parts are mainly variegated sandstones, interbedded with relatively thinly bedded sandy marls and shales, and marly shales sands; the middle is mainly sandstones, interbedded with marls and limestones; the upper part consists of limestones, calcareous sandstones and marls, including a yellow marly limestone with lamellibranches and gastropods, and thin layers of gypseous shales. Plant remains from the Nahr az Zarqa section indicate a Cretaceous age (Edwards, 1929 <u>in</u> Blake, 1939; in L.S.I. vol. III, fascicule 10 c 1); Knemiceras, sp. whenever found indicates more precisely an Albian age, particularly for the upper zones of the "Hathira Sandstones Formation."

In East Jordon the formation is mainly of continental deposition as indicated by (I) torrential cross-bedding (considered to originate under warm tropical conditions of heavy concentrated rainfall, and playa lake deposition (Lahee, 1959), (2) plant remains (fresh water) indicate lacustrine depositional environment and (3) some lateritic soil profiles which are taken to have developed under humid tropical to subtropical climates. In East Palestine, however, the formation has more of a transitional and marine character; this is observed in Wadi Faria near Nablus, where an intercalation of sandy limestones, sometimes oollitic and of established Albian age, occur. Below this succession there are basalt flows and ashes, which may correspond to either the Aptian or pre-Aptian volcanicity in the Lebanon; but the base of the section is not exposed, (Blake, 1936, in L.S.I., vol. IIIm fascicule 10 c 1 and 2; Blake and Goldschmidt, 1947). Although this volcanic activity occured during phases of sedimentation of the "Hathira Sandstones Formation" in the Neqeb (South Palestine), in Wadi Faria (North Palestine), and some parts of the Lebanon, none has been proved in Jordon.

In the southeast of the Neqeb (Palestine) the "Hathira Sandstone Formation" is mainly continental and possibly deltaic in origin, similar to the deposits of Jordon. Near the Gulf of Aqaba (Wadi Tima, and Wadi Manieiah) the formation is completely continental. A clear dividing line (strand line) between the continental and marine environment is rather well established between the more easterly locality of Makhtesh Hastera and the more westerly locality of Makhtesh Hathira; the former shows continental deposits, and the latter marine deposits. The continantal deposition in the area of Makhtesh Hastera is supported by (I) dark coloured, cellular limonite, with fingers of gypsum ("Limonite Layer"), (2) a sequence of rhythmic sediments which consists of black limonitic sandstones white silts, and kaolinitic clays, and some plant remains which indicate fresh water origin, ("Black Questa"). The marine deposits of the Makhtesh Hathira area, on the other hand, are supported by (I) a littoral sequence of sandy layers of haematite, limonite, and yellow marls which contain some Lower Cretaceous foraminifera ('First Iron Crust'), (2) a well bedded sequence composed of batryoidal clay ironstone, sandy concretionary limonite, and haematitic limonitic and argillaceous sandstones, and sandy clays, containing marine fossils, namely Protocardia judacia of Lower Cretaceous age, (L.S.I. vol. III, fascicule 10 c 1).

Further west in Palestine more marine sediments are encountered in the subsurface sections at Halutsa No. 1, Beer Sheba No. 1 (Aharoni 1964), and Ramallah No. 1, Halhul No. 1 (Bender, 1961), and Zohar No. 1, Massada No. 1 (Aharoni 1964), consisting of sands, marls and limestones; and along the costal plain south of Haifa and north of Jaffa, a pelagic sedimentary sequence is encountered in the subsurface well Gan Yavnne No. 1 (Aharoni 1964, Picard 1959), consisting of limestones and dolomites.

Accordingly, different facies were recognised by Picard (1959); These are: (1) Limey pelagic Carmel facies,

(2) Sandy-marly-limey shelf Shephela facies, (this turns to pelagic in the Albian)

(3) Rather marly Gallilean facies, (this is less sandy and less limy, littoral shelf facies of Gallilee, and becomes more pelagic in the Albian)

(4) Sandy semi-marine Neqeb facies; (this is sandy, less marly and less limy, semi-marine, facies of the Northern Neqeb; a littoral greensand subfaciescharacterizes the Albian)

(5) Continental Jordon facies (this is particularlty sandy, and is found in Jordon and the southernmost Neqeb in Palestine; and appears to be present in the lower pre-Aptian section of eastern Gallilee and eastern Samaria).

The extents of these facies are shown on the lithofacies map, (plate XIV).

4. Discussion.

Towards the close of the Jurassic period differential uplift took place over much of the Levant (Henson 1951; Picard and Eliezri, 1964). Erosion was contemporaneous at least in part, with further crustal disturbances, faulting, and locally, (e.g. Lebanon parts of Palestine) with vulcanicity. Local downwarping gave rise to an undulating but generally peneplained surfaces by the advent of the "Basal Cretaceous". The axial or central zones of such downwarpings within this peneplained surface would be favourable for thickest accumulations of sediments.

In order to attempt to delineate such possible basins of deposition, an isopachyte map was constructed, using all the available data. This map (plate X) does not show any overall axial basinal trend but indicates a somewhat irregular pattern of thickness distribution with two areas of thick accumulation indicated by the closure of the isopachytes in the locality of Jezzine in Lebanon (388m) and Makhtesh Hathira in Palestine (480m). It would therefore appear that the thickness variation of the "Basal Cretaceous Sandstones" and their equivalents in the Levant region are controled more by irregularities in the depositional surface rather than be pronounced regional basin developement; downwarpings, or subsidence on a local scale are suggested however by the focii of thicker accumulation, but these appear to have been shortlived and gave way to a more uniform, wider, and shallower depression dominating the Levant. Thicknesses decrease outward from the line connecting Jezzine and Makhtesh Hathira, and become more uniform in their areal extent over the rest of the Levant.

Subsidence is a major factor in providing space for sites of deposition while the rate of sedimentation controles how much the provided space is filled. The close relationship between subsidence and sedimentation surface is to be emphasised. As the Sandstones in the Levant show either continental evironment(East Jordon), or transitional possibly deltaic, or lagoonal, and partly fluvial (West Jordon, East Palestine, and most of Lebanon), or, in some cases, shallow water marine environments (Northwest Palestine, Southwest Lebanon, the rate of sedimentation would have compensated for that of subsidence; except for the marine ingressions when the rate of subsidence temporarelly was greater than that of sedimentation. This gave rise to the interfingering of facies as indicated in West Jordon and Palestine by interfingering of sandstones with marly, limestones and dolomites facies, as shown on plate XI; the same appears to be the case in south west Lebanon (see plate XI). Climatic changes are not of less importance in regard to thickness and facies variation. These controle both the transporting medium and the type of sediment to be carried and eventually deposited, and also the developement of weathering and erosion mechanisms producing the meterial that is later carried by steams and rivers to sites of deposition. The courses of the streams themselves, the size of the deltas, the presence of lagoons, or shelf marine environments are all influenced. A marked climatic change can greatly and within a short period alter the relationship of source and depositional areas. For example a desert type climate existing in the rigion in pre-Cretaceous times probably may have been responsible for a wide distribution of desert sand on the adjoining land. This became a ready pray to removal and redeposition when the climate became wet during the Basal Cretaceous. The source of the sands, thus need not have been far and could even have been partly local. Transportation of source material by a good drainage system from much further a field is not rejected but it need not be regarded as necessary.

The foregoing factors of sedimentation seem to explain the regional lateral and vertical variations in thickness and facies, and the areal distribution of the "Basal Cretaceous Sandstones" in Lebanon and their equivalent in the Lebant. Local variations however, appear to be due to the type of environment of deposition itself.

Such variations suggests, a more or less, fluvial-deltaic environment of deposition for the "Basal Cretaceous Sandstones" formation in most of Central Lebanon, this environment being in contact with an open sea (the Tethys) with the shore line located somewhere between the Jezzine and Adloun localities, running roughly NW-SE, see plate X V. The shore line was not stationary during "Basal Cretaceous" times, as indicated by the interfingering of fluvial and continental clastic sediments with carbonates, and marine clays shales and sandstones, both in Lebanon and the Levant.

Further south, more contintal sediments are encountered going eastwards from Palestine to Jordon, with a probable transitional zone between the of Makhtesh Hathira and Makhtesh Hastera localities running NE and then swinging N and then NW into Lebanon, see plate XIV.

Paleogeography

The following major paleogeographic divisions seem to have existed during "Basal Cretaceous" times, as revealed by both the regional distribution of facies, and the local vertical and lateral variations in lithologies within main facies units:

a. marine environment (shallow water, continental shelf)

b. transitional, littoral environment

c. deltaic-fluvial environment

d. continental environment (rivers, playas, and huge sands bodies)

These are disposed on the general regional paleogeographic map, (plate XV).

The strand line (shore line), however, was not stationary as evidenced by the interfingering and overlap of the different facies (pp. 69, 74). Most of the sediments in the marine environment, reflect shelf conditions where depths of water probably did not exceed 200m at the most. The littoral zone seems to have had variable areal extents controlled by the changing position of the strand line; at some places it was wide in extent in the southeast Neqeb in Palestine. This gradually disappears in a north west direction into northern Palestine and Lebanon. This environment seems to disappear along the Dead sea area where continental deposits are apparently in direct contact with the shallow marine sediments (Picard, 1959). Generally however, wide beaches and broad shore areas were probably common during "Basal Cretaceous" times in different parts of the Levant. In Lebanon slight beach deposits were encountered in the sedimentary successions near Jezzine (pp. 67, 68), but no evident littoral sediments were recognised in the northern parts of Palestine and Jordon, and the southern parts of Lebanon; (pp 68, 69); a shallow water marine zone seems more likely to have existed here as evidenced by some shallow water (about 10m depth) marine sediments in the subsurface section Qirayat Shemona No. 1 (Karez 1965), and Wadi Faria near Nablus, (pp 71, 72), and Adloun No. 1 (pp. 67, 68).

The deltaic-fluvial environment in Lebanon appears to have been in direct contact with the sea, possibly with local very narrow strips of beach and no littoral zone in the southwest part between the Jezzine and Adloun localities (pp. 68, 69). To the east in Syria this deltaic-fluvial environment is in contact with a littoral and neritic zone of the sea as evidenced by the wide uniform areal distribution to the east of the "Cherrife Shale Formation" (L.S.I. vol. III, Fascicule 10 C 1, p

In most of Jordon, continental and terrestrial environments seem to have been more predominant, with the possible prevallance of lakes, playas, and diverse river systems.

The extensive drainage systems appear to have played the major role in the transportation and subsequent distribution and deposition of the "Basal Cretaceous sandstones" in the Levant, particularly with the transitional and deltaic, and continantal environment; offshore currents took over distribution in the case of the littoral and marine environments. These river and stream networks appear to have reached maturity stage with the advent of "Basal Cretaceous" times as evidenced by the absence of conglomerates in the lower contact with the underlying Jurassic sediments, and the prevallance of level peneplained surfaces, (p 73). The rivers must have had the energy and power to transport huge amounts of sands of variable grain sizes along variable but probably often long distances; this indicates in part that the volume of water was considerable to allow for the great capacity. Deposition occured, however, whenever the equillibrium between the transporting power and the amount of load was disturbed, either by a decreas in the volume of water or by the increase in the amount of load, (i.e. this was dependent on the variability in the competency of the rivers).

This climate accordingly, was wet with heavy concentrated seasonal rainfall; this in turn controled the capacity and transporting power of the rivers and streams in carrying sediments and finally depositing them. Such heavy concentrated rainfall, certainly, caused seasonal flooding of rivers, and consequently it must have also given rise to the development of flood plains and meander fillings, in addition to channel fillings, as is the case in some parts of Jordon, and the Lebanon. The climate was also, warm, as evidenced by the presence of laterites within the sandstone sedimentary succession in Jordon, and lateritic alteration of basalts in Lebanon, as well as by the existence of some gypseous shales in Jordon indicative of quite strong evaporation. A tropical climate, therefore, seems to have, prevailed, and this is born out in part by the existence of lignites, particularly in the Lebanon.

The initial source area or provenance of the "Basal Cretaceous Sandstones", most probably, was located somewhere south of Jordon, or in other words with in the present Arabian Shield. Two possibilities regarding the parent material can be considered: one is that of a disintigrating a solid rock, and the second an original sand sheet body. The former could have been an upland of granitic rocks which under the action of physical and more predominant chemical weathering have disintigrated into quartz, feldspars and other mineral fragments which were later carried and transported by rivers to the present sites in which they are found. The second alternative, however, suggests that there could have been a great sand body (dunes and sand sheets), much nearer and even adjoining, like the present Great Nufud sand body in northern Saudi Arabia, which as a result of the change of climates, from dry into wet and accompanying development of wide strong drainage systems, was easy pray to water transportation which carried the sands from these great sand bodies to Jordon and Lebanon. More evidence is needed, however, regarding regional grain size analysis, grain shape and roundness, and degree of frosting, in addition to heavy mineral analysis and regional cross-bedding studies before one can come to a definite conclusion about the source area of the "Basal Cretaceous Sandstones"; this merits further future work.

Conclusions

The following conclusions can be reached from the foregoing observations and interpretations:

1. The "Basal Cretaceous Sandstone" formation, in most parts of the Lebanon, was deposited in a fluvial-deltaic environment, as revealed by the stratification, and cross-bedding, studies together with measurements, of local vertical and lateral variation in thicknesses and lithologies; the southwest part of the country, however, is characterized by more marine conditions, as revealed by the overall changes in facies in the Adloun No. 1 well.

Palestine, on the other hand, was more under shallow marine conditions at least for parts of the time; with a progressive facies change to a more continental type of environment eastwards and into Jordon.

2. The materials of the "Basal Cretaceous Sandstones" were fluvial transported along an extensive drainage net work, as indicated by the general variability in grain size, together with the graded pattern in cross-bedding, as well as by the broad variation in lithologies and regional facies. This drainage system most probably flowed in a westerly direction in Lebanon, as indicates by the cross-bedding measurements a northwesterly direction seems to have been dominant in northern Palestine; and presumably this is more northerly in southern Palestine and Jordon; this tentative conclusion, however, requires more evidence support from cross-bedding directions in Palestine and Jordon, and merits future work.

3. Two probable alternatives present themselves with regard to the provenance or source area and origin of the "Basal Cretaceous Sandstones" and their equivalents in the Levant. The first alternative is derivation from granitic parent rocks to the south, and the second is derivation from a great sand body probably nearer at hand. No definite conclusions are arrived at in this respect, as considerably more work on a regional basis to include analysis of grain distribution, and general fabric of the sandstones, accompanied by detailed analyses for heavy minerals occurence before weight can be given to one in preference to the other.

4. Land and sea are the broad paleogeographic divisions. The former covered most parts of Lebanon and Jordon, and the latter was predominant in most parts of western Palestine. The divide line (shore line) runs NNE from the southern parts of Palestine near the Gulf of Aqaba, up to the Dead sea, then N into northern Palestine, and thence NW into southwest Lebanon. Shallow water not exceeding 200 meters appears to have dominated the marine environment with a rather narrow littoral zone fringing its eastern limit which is most pronounced in southeast Palestine, and possibly in northeast Palestine and southeast Lebanon. Continental conditions were dominant in Jordon; these are characterized by diverse river systems, together with local developments of lakes and playas. Deltaic and fluvial conditions seem to have prevailed in the remaining parts of the Lebanon. The climate, accordingly was wet, rather warm, and with heavy concentrated seasonal rainfall.

Appendix No. I

STRATIGRAPHIC SECTION

"Basal Cretaceous Sandstones" of Central Lebanon
Qartaba Locality
Detailed Description to accompany Plate No.XVII
Total Thickness 96 m

Interval Number	Rock unit	Thickness	Description
Top I	sandstone	10.5m	hard; fine to medium grained; massive to thickly bedded (50 to 100cms and more); compact; slightly limey; pale brownish; iron stainning on surface; current bedded.
2	sandstone	53.0m	mostly obscured; hard and soft alternating layers; fine to medium grained, with some disseminated coarse grains in one outcrop; slightly limey; slightly limonitic; massive to thickly bedded (greater than 100cm); yellowish to brownish.
3	sandstone	7.0m	rather hard; fine to medium grained; in places coarse; massive to thickly bedded; laminations of iron in between bedding planes; interbedded with slightly carbonaceous and argillaceous sands; poorly current bedded; yellowish brownish.
4	sandstone	2.5m	soft; coarsed grained; limonitic; massive; yellowish; gets hard towards the bottom; current bedded.
5	sandstone	7.5m	relatively soft; variably grained medium to coarse; massive bedding; compact; yellowish brownish; bands of argillaceous sands; current bedded.
6	sandstone	5.5m	hard; fine grained at top; pale yellowish colour; current bedded; gets coarser grained at bottom with argillaceous sand, and carbonaceous material.
7	sandstone	9.5m	alternation of current bedded sandstones, and argillaceous sandstones; current bedded sandstones white to yellowish; fine to medium grained; 1 limonitic, massive bedding; argillaceous sandstones soft, greyish, friable, slightly clayey at bottom.

Interval Number	Rock unit	Thickness	Description
8	sandstone	15.0m	hard; variably grained fine to medium; massive to thickly bedded (greater than 100cm); yellowish brown; current bedded; iron concentration in hard beds that alternate with softer beds.
9	sandstone	5.0m	hard; fine to medium grained; massive.
10	sandstone	2.0m	soft; friable; massive, no beeding; fine grained.
base			

Appendix No. II

"Basal Cretaceous Sandstones" of Central Lebanon
Jouret el-Tormos Locality
Detailed Description to Accompany Plate No.XVIII
Total Thickness 86.5m

Interval Number	Rock Unit	Thickness	Description
Top I	sandstone	23.5m	alternation of sandstones and argillaceous sandstones, (2m and 25 to 50cm thick respectively; sandstones: white to yellowish; variably medium grained; slightly current bedded; hard sandy bands of iron in between beding planes; argillaceous sandstones: soft; grayish; laminated; friable.
2	sandstone	14.5m	hard to soft sandstones alternating with some argillaceous sands (40cm thick); thinly to thickly bedded; fine grained; friable towards to top iron bands (5 to 10cm) in between bedding planes; yellowish brownish to grayish.
3	sandstone	12.5m	alternation of limonitic sands (soft), and white yellowish sandstones (hard); fine to medium grained, with variable disseminated coarse grains; massive to thickly bedded (greater than 100cm).
4	sandstone	3.5m	soft; not very well consolidated; very fine grained; friable; ochre to yellowish; thickly bedded (50cm) to massive; limey at bottom.
5	argillaceous sandstone	2.5m	friable; thinly bedded to laminated; grayish; slightly carbonaceous; intercalations of limonitic sands.
6	sandstone	1.5m	hard; fine grained; ochre yellow; limonitic; slightly limey.
7	sandstone	7.0m	alternation of white and limonitic sands; soft; friable; variably grained fine to medium; thickly bedded; laminations of carbonaceous and argillaceous sands.

Interval Number	Rock Unit	Thickness	Description
8	argillaceous sandstone	3.0m	soft; friable; gray to yellowish; carbonaceous alternation of thin beds of soft sands.
9	sandstone	1.5m	rather soft; not well consolidated; variably grained fine to medium; white to yellowish to reddish; thickly bedded; slightly pisolitic towards the bottom; iron rich layer at bottom (15cm).
10	argillaceous sandstone	3.0m	friable; slightly clayey; grayish; thinnly bedded (less than 10 cm).
11	sandstone	1.5m	hard to soft; fine grained; yellowish brownish; thinnly bedded.
12	argillaceous sandstone	11.5m	soft; friable; clayey at top; very fine grained; iron rich; obscure bedding, massive.
Base			

Appendix No. III

"Basal Cretaceous Sandstones" of Central Lebanon
Qattin Locality
Detailed Description to Accompany Plate No.XIX
Total Thickness 89m

Interval Number	Rock Unit	Thickness	Description
Top 1	sandstone	7.0m	soft; fine to medium grained; alternating white and brown colours; massive to no bedding; argillaceous laminations towards the bottom;
2	sandstone	3.0m	hard; massive to no bedding; variably fine grained; brownish; iron enrichment on the surface.
3	sandstone	10.0m	soft; variably fine to medium grained; massive bedding; yellowish to white; laminated argillaceous sandstones interbedded in intervals of (50 cm); slightly carbonaceous laminations.
4	sandstone	5.5m	soft; alternation of limonitic sands and argillaceous sands; massive (greater than 100cm); fine grained; reddish brown (Limonite layers), gray (argillaceous sands); some coarse grained at bottom.
5	sandstone	17.0m	soft; alternation of massive white sands fine to medium grained; and limonitic sand layers (30cm), fine grained; unconsolidated laminated carbonaceous material and argillaceous sands within the white sands.
6	sandstone	9.5m	alternation of argillaceous sandstones (and sandstones of 30 to 80cm thickness; sands are white and limonitic, in alternation; separated by argillaceous sands; soft, greyish; friable; laminated bedding; sandstone show no bedding with units; limonitic layer gets thicker at bottom (300cm).
7	sandstone	8.0m	hard; compact, consolidated; variably grained; thinnly bedded (10 to 25 cm); to thickly bedded; white reddish; current bedded.

Interval Number	Rock Unit	Thickness	Description
8	clay	4.5m	sandy; friable, flakey; iron rich;
9	sandstone	3.5m	hard; fine to coarse grained; massive; brown.
10	sandstone	21.0m	soft; fine to medium grained; yellowish brownish; obscured by sandy soil.
Base			

Appendix No. IV

"Basal Cretaceous Sandstones" of Central Lebanon
Aintoura Locality
Detailed Description to Accompany Plate No. XX
Total Thickness 85m

Interval Number	Rock Unit	Thickness	Description
Top 1	sandstone	7.0m	hard; yellowish brownish; fine to medium grained; compact; slightly limey; thickly bedded (50 to 100cm).
2	sandstone	26.0m	rather soft, not well consolidated; fine to medium grained; thickly to thinly bedded (10 to 50cm); strongly current bedded; limonitic; reddish to yellowish brown.
3	sandstone	11.5m	soft; reddish brown; variably grained, fine to coarse; thickly to thinly bedded (10 to 50cm); strongly current bedded.
4	sandstone	10.0m	hard; yellowish reddish brown; variably grained fine to course; thickly bedded to thinly bedded (10 to 50cm); current bedded; becomes poorly consolidated towards bottom; interbedded with argillaceous sandstones and laminations of clays.
5	sandstones	7.5m	hard and soft layers alternating; thickly bedded; hard layers: rich in iron; yellowish, sometimes grayish due to argillaceous inclusions, consolidated, compact, medium to fine grained; soft layers: yellowish to brownish, sometimes grayish to whitish due to argillaceous matter, and bands of lignites; thickly bedded; medium to coarse grained; limonitic.
6	sandstone	2.5m	consolidated but not very compact; thinly to thickly bedded (10 to 60cm); yellowish brown; variably grained, coarse to fine; current bedded.
7	sandstone	8.0m	hard, becomes softer towards bottom; variably grained, medium to fine; compact; iron rich; yellowish brownish; current bedded; with laminated argillaceous sands.
8	sandstone	4.5m	alternation of hard and soft layers; at top clay bed(50cm); reddish; variably grained.
9 Base	sandstone	8.0m	hard, becomes softer towards bottom; thickly bedded (80 to 100cm) to massive; iron rich; yellowish brown; medium grained.

Appendix No. V

"Basal Cretaceous Sandstones" of Central Lebanon
Beskinta Locality
Detailed Description to Accompany Plate No.XXI
Total Thickness 240m

Interval Number	Rock Unit	Thickness	Description
Top 1	sandstone	23.0m	massive to thickly bedded; interbedded with argillaceous sandstones (50 to 100cm); yellowish brown; fine to coarse grained; alternation of hard and soft beds; becomes argillaceous towards the top.
2	sandstone	5.5m	hard; feature forming; medium to fine grained, sometimes coarse; variegated, white, yellow; violet, brown, massive to thickly bedded; strongly current bedded.
3	sandstone	4.5m	hard; feature forming; fine to coarse grained; variegated, white, yellowish brown; massive bedded; current bedded; iron concretions with pyrite cores.
4	sandstone	15.0m	hard; coarse to medium grained; some alternation; white to yellowish; massive to thickly bedded; current bedded; patches of iron staining on surface.
5	sandstone	6.5m	alternation of argillaceous sandstones and sandstones; the former: soft, no bedding; variably grained, iron rich band (5cm); the latter: massive to indistinct bedding; variably grained; yellowish brown; iron rich layer in the middle (20 to 30cm).
6	sandstone	7.0m	alternation of hard and soft beds; thickly bedded (50 to 100 cm); variably grained; yellowish brown; iron surface staining; poorly current bedded.
7	argillaceous sandstone	1.5m	soft; friable; grayish; no bedding; slightly carbonaceous.

Interval Number	Rock Unit	Thickness	Description
8	sandstone	1.5m	soft; friable; fine grained; variegated, white, yellow, brown; thinly bedded.
9	argillaceous sandstone	9.5m	soft to hard (when iron rich); thickly to thinly bedded (20 to 60cm); grayish; iron nodules; interbedded with thinly bedded sands (10cm); yellowish to white; variable grained.
10	sandstone	2.0m	hard; thickly bedded; variably grained; yellowish brown.
11	clay	2.5m	slightly sandy; friable; sticky; thinly to laminated bedded; soft; yellowish grayish.
12	sandstone	12.5m	alternation of argillaceous sandstones and sandstone; the former: friable, soft, thinly bedded (10cm), grayish yellowish; the latter: soft; fine to medium grained; thinly to thickly bedded (20 to 50cm); white yellowish brown; a clay bed (15cm) at bottom.
13	sandstone	5.0m	hard; fine to medium grained; massive bedding; white, yellowish brown; slightly current bedded; with alternation of some argillaceous sandstones.
14	clay	3.0m	soft; friable; slightly sandy; with thin layers of sands, and thins beds of lignites.
15	sandstone	1.5m	soft; variably grained; thinly bedded; yellowish brown.
16	clay	3.0m	soft; friable; thinly to laminated bedding; interbedded with thin beds of sands (10 cm); thin beds of lignites.
17	sandstone	3.0m	soft; fine grained; slightly argillaceous and clayey; bands and thin beds of lignites; slightly limonitic.

Interval Number	Rock Unit	Thickness	Description
18	sandstone	5.5m	alternation of soft and hard beds; thinly to thickly bedded (10 to 50 cm); fine to medium grained; yellowish brown.
19	sandstone	14.5m	alternation of argillaceous sandstones and sands; the former: soft; fraible; thinly to laminated bedding (less than 10cm); greyish; carbonaceous; with some iron laminations; the latter; alternation of hard and soft bads; variable grain size; thinly bedded (10 to 25cm); yellowish whitish; sometimes friable.
20	sandstone	3.0m	hard; feature forming; massive to thickly bedded; fine to medium grained; some argillaceous sands interbedded in lenses.
21	sandstone	8.5m	alternation of argillaceous sandstones and sandstones; argillaceous sandstone: soft, friable; thinly bedded (less than 10cms.) grayish to yellow; limonitic; carbonaceous; a lignite bed (30 cms.); sandstone: hard; thinly to thickly bedded (10 to 30 cms); variably grained; iron staining on surface; yellowish to brown.
22	sandstone	11.5m	massive to thickly bedded (greater than 50 cms); variegated, yellow, white; variably grained fine to medium; current bedded; iron staining on surface.
23	argillaceous sandstone	4.5m	soft; thinly bedded (10 to 20cms); grayish interbedded with thin beds of fine sands; yellowish.
24	sandstone	3.0m	massive to thickly bedded; variably grained, fine to coarse; hard; yellowish; current bedded; iron staining on surface.

Interval Number	Rock Unit	Thickness	Description
25	sandstone	8.5m	alternation of argillaceous sandstone and sandstone; the former: soft, friable, thinly bedded to thickly bedded(IO to 50 cm), grayish; the latter:hard, thickly bedded(25 to 50cm), to massive, variably grained, yellowish grayish, jointed.
26	sandstone	I5.0m	massive to thickly bedded(greater than 50cm), interbedded with argillaceous sandstone(IO to 20cm), variably grained, yellowish to whitish, current bedded,thin iron layers in between bedding planes.
27	clay	6.5m	sandy, friable, chocolate to blackish, iron rich, thinly to laminated bedding.
28	sandstone	7.0m	hard, massive to thickly bedded(greater than 50cm), variably grained fine to coarse, yellowish brown, current bedded.
29	"volcanic complex"	11.0m	chocolate clays and marls?; reddish brown to blackish, with some volcanic material (Olivine?), friable, thinly to laminated bedding otherwise massive.
30	basalts	7.5m	soft to hard, sometimes friable; greenish to dirty grayish white; altered slightly to marls; rich in olivine; appear to be agglomratic in texture.
31	sandstone	9.0m	hard, massive to thickly bedded(greater than I00cm), variably grained fine to medium; yellowish to brown, current bedded.
32	basalt	2.0m	very hard; dark blackish, columnar structure, jointed, olivine rich, calcite veins.
33	sandstone	5.5m	hard, thickly bedded(greater than 50cm), fine grained; white to yellowish,current bedded.
34	sandstone	4.5m	soft, fine grained to variable, thickly bedded to massive, yellowish brown.
35	sandstone	7.5m	hard, fine grained, thinly to thickly bedded(IO to 40cm), yellowish brown, gets limey towards bottom, in contact with Upper Jurassic limestones.
Base			

Appendix No. VI

"Basal Cretaceous Sandstone" of Central Lebanon
Majdal Tarchich Locality
Detailed Description to Accompany Plate No. XXII
Toatl Thickness I86m

Interval Number	Rock Unit	Thickness	Description
Top 1	sandstone	36.0m	mostly obscured, soft, with argillaceous sands; yellowish brown; sandy soil.
2	sandstone	1.5m	hard; thickly bedded(50cm); with thin clay bed in the middle; fine to medium grained; yellowish brown.
3	clay	12.0m	slightly sandy; friable and sticky; grayish to greenish; thinly bedded.
4	sandstone	7.5m	hard; massive to thickly bedded(greater than 50cm); yellowish brown; variably grained fine to medium; current bedded.
5	sandstone	9.0m	alternation of sandstones and argillaceous sandstones; the former: at top current bedded; thickly bedded(greater than 50cm), yellowish brown; variably grained medium to coarse; the latter: soft, friable, thinly bedded; grayish.
6	sandstone	8.0m	hard; massive to thickly bedded; yellowish to whitish; variably grained fine to medium; strongly current bedded.
7	sandstone	8.5m	alternation of argillaceous sandstones and sandstones; the former: soft, grayish, friable, laminated to thinly bedded, the latter: current bedded, variably grained fine to medium, thinly bedded.
8	sandstone	8.0m	hard; variably grained, massive bedding, current bedded, some bands of argillaceous sands in thin beds (IOcm).
9	sandstone	9.5m	alternation of argillaceous sandstone and sandstone; the former: soft, friable thick units(20cm), grayish; the latter: thinly bedded, variably grained, with some pyrite nodules.

Interval Number	Rock Unit	Thickness	Description
10	sandstone	12.0m	thickly bedded; vatiably grained fine to medium; yellowish brown; hard; argillace-sands in thin layers(50cm) soft, grayish.
11	sandstone	4.0m	soft, slightly coarse grained, mainly medium, yellowish, massive bedding, curr-ent bedded.
12	sandstone	4.0m	hard; massive bedding, jointed; medium to fine grained; brownish reddish; iron rich; thin bands of ferrugineous layers and crusts along bedding planes.
13	argillaceous sandstone	2.0m	soft, friable, grayish to whitish, no apparent bedding.
14	sandstone	10.0m	soft; thickly bedded to massive; medium grained; light yellowish brown; current bedded.
15	sandstone	40.0m	soft; yellowish brown; forming gentle slope mostly obscured; mainly fine grained, slightly argillaceous at some levels; with clay lenses; no bedding is observed.
16	sandstone	5.0m	hard; massive bedding; jointed; variably grained medium to fine; brownish.
17	argillaceous sandstone	2.0m	soft; friable, thinly bedded, grayish to greenish.
18	sandstone	7.om	hard; massive bedding; variably grained medium to fine; brownish
Base			

Appendix No. V11

"Basal Cretaceous Sandstone" of Central Lebanon
Qoubai Locality
Detailed Description to Accompany Plate No.XX111L
Total Thickness 259m

Interval Number	Rock Unit	Thickness	Description
Top 1	sandstone	27.0m	mostly obscured, at top very hard sandstone, variably medium grained; yellowish, slightly limey; clayey and argillaceous at different levels; exposed part thinly to thickly bedded(20 to70cm).
2	argillaceous sandstone	18.0m	soft; friable; grayish greenish at top and grayish at bottom, mainly fine grained, sometimes medium, thinly bedded, with ferrugineous pisolitic concretions towards the top, becomes clayey towards the bottom.
3	sandstone	5.0m	massive to obscure bedding; variably grained fine to medium; yellowish, limonitic, calcitic veins, with carbonaceous bands.
4	clay	9.5m	slightly sandy, and carbonaceous, grayish, becomes more sandy towards bottom; with a bed of sandstone (50cm) thick, yellowish, medium grained.
5	sandstone	20.0m	alternation of sandstones and argillaceous sandstones; the former: thickly bedded (1 to 2m), current bedded; variably grained medium to coarse, yellowish with some limonitic layers; the latter: soft, thickly bedded (50 to I00cm), otherwise laminated, friable, grayish.
6	sandstone	16.0m	top:part: soft(6m) thick, yellowish to graysih, slightly argillaceous, medium grained, limonitic, massive bedding. middle part: (5m) thick, hard, massive to thick bedding(50 to I00cm), medium grained in places coarse, yellowish, limonitic, argillaceous in places. bottom part: (5m) thick, soft, slightly argillaceous, yellowish to grayish, variably grained, mainly medium; obscure to massive bedding.

Interval Number	Rock Unit	Thickness	Description
7	sandstone	6.5m	alternation of hard and soft sandstones; hard: fine to medium grained, reddish brownish, thickly bedded(50cm), current bedded, iron surface crust; soft: slightly argillaceous, and carbonaceous, grayish, fine grained.
8	argillaceous sandstone	3.5m	soft; friable; thinly bedded; clayey; with fossil plant remains.
9	sandstone	14.5m	hard; massive to thickly bedded (50 to IOO cm), jointed; current bedded; reddish in places, generally brownish; variably grained medium to coarse.
10	sandstone	4.5m	argillaceous at top; and clayey at bottom; thinly bedded, yellowish to grayish.
11	sandstone	5.5m	soft, medium grained, slightly argillaceous; yellowish, limonitic.
12	sandstone	11.0m	topppart: hard; current bedded; medium grained; massive bedding, yellowish; becomes softer towards down,(4m) thick. middle part: argillaceous; thinly bedded, alternating with white soft sands, grayish, medium grained, (3m) thick. bottom part: soft, not compact, friable, coarse to medium grained; current bedded, yellowish; thinly to thickly bedded(20 to 50 cm), (4m) thick.
13	sandstone	6.5m	alternation of sandstones and argillaceous sandstones; the former: hard, thinly bedded, fine grained, yellowish; the Latter: soft, friable, grayish, thinly bedded (less than 20 cm).
14	sandstone	5.5m	hard; current bedded, jointed, fine to medium grained, yellowish to slightly reddish, slightly argillaceous in middle.
15	argillaceous sandstone	5.5m	soft; thinly bedded(Io to 15cm); which are laminated from within, friable; grayish; fine grained; clayey in middle; with alternation of some sands at bottom(3 to 5cm).

Interval Number	Rock Unit	Thickness	Description
16	sandstone	9.0m	massive to thickly bedded(greater than 50 cm), medium grained; hard; with bands of clay in laminated form less than 1m thick; yellowish current bedded.
17	sandstone	4.0m	alternation of hard and soft sanddtones, (5 to 20cm thick); medium grained, yellowish; current bedded.
18	sandstone	3.0m	alternation of sandstones and argillaceous sandstones; the former: thinly beded, fine grained; harder. the Latter: friable, soft; grayish.
19	sandstone	5.0m	hard; massive bedding (greater than 50cm), variably grained medium to fine; yellowish; current bedded.
20	sandstone	12.5m	alternation of sandstones and argillaceous sandstones; the former: hard, massive to thickly bedded(30 to 50cm), medium grained, yellowish brown, with bands of clay(2cm); the latter: friable, soft, laminated to thinly bedded, grayish, with some lignite seams(1 to 3 cm), slightly contorted, becomes more sandy towards bottom, where bedding is obscure, and becomes more compact.
21	sandstone	12.0m	alternation of current bedded sandstones and argillaceous sandstones; the former: hard, massive to thickly bedded(0.5 to 2m), medium to fine grained, yellowish brown, the latter: friable, soft, laminated to thinly bedded, grayish.
22	sandstone	20.0m	hard, massive to thickly bedded(1to1.5m), with alternation of argillaceous sands (1 to 1.5m), which are soft, friable, thinly bedded, grayish; the sandstones: current bedded, yellowish brown, variably grained mainly medium, jointed.
23	"volcanic complex "	15.0m	chocolate coloured clays, crumbly, fraible, thinly bedded otherwise massive, alteration product of underlying basalts.
24	basalt	5.0m	olivine rich, greenish to olive colour, hard, weathered, exfoliation.
25	sandstone	15.0m	hard, massive to thickly bedded(1 to 2m), variably grained, mainly medium, yellowish, current bedded, with some argillaceous interbedded with sandstone.
Base			

Appendix No. V111

"Basal Creraceous Sandstones" of Central Lebanon
Aghmid Locality
Detailed Description to Accompany Plate No.XX1V
Toatal Thickness 187m

Interval Number	Rock Unit	Thickness	Description
Top 1	marly sandstone	16.0m	soft; obscure bedding; limey; sandy, pisolitic nodules; pale greenish, white.
2	sandstone	13.5m	alternation of sandstones and argillaceous sands; soft , sands yellowiah brown, massive to thickly bedded, fine to medium grained; the latter: soft, grayish, slightly limey, pidolitic; lignitic at bottom, some iron concretions, and laminations.
3	argillaceous sandstone	7.0m	soft, grayish to ochre; variably grained fine to medium, slightly limey, many disseminated iron laminations, no bedding massive appearnce.
4	sandstone	8.5m	alternation of sandstones and argillaceous sandstones; the former: fine to medium grained, yellowish brown, thinly bedded(I0 to 20cm); the latter: soft to flakey, limey towards bottom, carbonaceous, some contorted clayey beds.
5	argillaceous sandstone	30.0m	massive bedding; medium to coarse grained; grayish to white in places yellowish; soft to flakey, laminated; iron enrichment in form of cement; iron concretions; limonitic in places, with some caly bed at bottom(5 to 10cm).
6	sandstone	6.0m	alternation of sandstones and argillaceous sandstones; the former: fine to medium grianed, obscure bedding, hard, yellowish brown; the Latter: soft, flakey, laminated, friable, grayish.
7	sandstone	66.0m	soft, yellowish brown; fine to medium grained, thinly to thickly bedded, current bedded, slightly carbonaceous.

Interval Number	Rock Unit	Thickness	Description
8	sandstone	13.0m	very hard, with alternation of softer beds; medium to coarse grained, iron sufrace staining; yellowish to grayish; thinly to thickly bedded(15 to 50 cm); current bedded; fossil wood traces.
9	argillaceous sandstone	3.0m	soft; laminated to thinly bedded; fine grained; with some disseminated coarse grains; carbonaceous; fossil wood traces.
10	sandstone	12.0m	very ahrd; with alternation of softer beds; massive to thickly bedded(greater than 50cm); yellowish brown, sometimes grayish, current bedded; argillaceous at some intebvals.
11	sandstone	2.0m	soft; coarse grained; yellowish brown.
12	sandstone	14.5m	hard; massive to thickly bedded(greater than 50cm); variably grained; yellowish to brownish; alternation with carbonaceous and argillaceous sands that are soft, friable, grayish, thick beds (I00 to150cm), laminated in form, with some amber; lignitic material towards bottom; current bedded sands, mainly towards bottom; rich iron laminations between bedding planes and iron crust on surface.
13	sandstone	8.5m	alternation of hard and soft beds; thinly to thickly bedded(5 to 40cm); current bedded; fine to medium grained, yellowish brown; iron rich on surface.
14	sandstone	13.5m	alternation of sandstones and argillaceous sandstones; former: fine to medium grained; thinly to thickly bedded (20 to 50cm), yellowish brown; Latter: soft, friable, grayish, with some limonite, laminated bedding, slightly carbonaceous.
15	clay	7.0m	sandy, very fine grained, soft, friable, laminated bedding, grayish to violet, slightly carbonaceous.

Interval Number	Rock Unit	Thickness	Description
16	sandstone	5.5m	hard to soft, variably grained, at top fine, becomes coarser towards the bottom, reddish brownaat middle, yellowish brown towards bottom, massive to thickly bedded (gretaer than 50cm), current bedded.
17	argillaceous sandstone	4.0m	soft, friable, flakey, laminated bedding (less than 2 cm), violet to grayish; iron rich, slightly clayey.
18	sandstone	16.0m	hard to soft; mainly fine grained, yellowish; massive bedding; with carbonaceous laminations, current bedded; some calcareous veins, slightly argillaceous towards the bottom.
Base			

Appendix No. IX

"Basal Cretaceous Sandstone" of Central Lebanon
Jezzine Locality
Detailed Description to Accompany Plate No. XXV
Total Thickness 388m

Interval Number	Rock Unit	Thickness	Description
Top 1	pisolitic sandstone	10.0m	compact, hard, brownish grayish; pisolites rounded of variable size 1 to 3cm in diameter.
2	sandstone	27.0m	alternation of argillaceous sandstone, and sandstone; former: soft, friable fine grianed, grayish, thick beds of about 4m in thickness, with lignite seams; latter: hard, thinly to thickly bedded(50 to 80cm), variably grained fine to medium, iron staining on surface, yellowish brown; becomes whitish towards bottom, limonitic.
3	argillaceous sandstone	25.0m	soft, friable, clayey, obscure bedding, appears as a massive unit, yellowish, grayish to reddish, variably grained mainly fine; soft at top, becomes harder towards bottom.
4	sandstone	10.0m	alternation of sands and clays; former: soft to hard, yellowish brown, thickly bedded (1m), variably grained fine to medium; latter: 50 to 100cm thick, soft, crumbly, laminated to thinly bedded, grayish, violet, chocolate.
5	sandstone	3.5m	alternation of laminated sands and argillaceous sands(2 to 5cm in thickness), yellowish to grayish, variably grained, fine to medium.
6	clay	1.5m	shaley, friable, laminated, grayish violet, slightly yellowish, traces of plant remains.
7	sandstone	6.0m	alternation of sandstones and argillaceous sandstones; former: 2 to 7cm in thickness, soft, yellowish; latter: soft grayish thinly bedded, with clays along bedding planes.

Interval Number	Rock Unit	Thickness	Description
8	clay	2.5m	shaley, soft, friable, yellowish to grayish, laminated.
9	sandstone	1.0m	soft, firable, fine grained, yellowish.
10	clay	2.5m	shaley, slightly sandy, friable, laminated, yellowish to grayish.
11	sandstone	6.0m	sands(white to reddish) interbedded with clays (friable, soft, grayish to violet); sands are fien grained, obscure bedding to massive.
12	sandstone	3.0m	hard, thinly bedded (2to 5cm), fine grained, yellowish brownish, iron surface staining, compact, with laminations of carbonaceous material, .
13	argillaceous sandstone	2.0m	soft, friable, slightly carbonaceous, thinly bedded to laminated, grayish to violet to yellowish, medium to fine grained.
14	sandstone	3.0m	soft, massive to obscure bedding, variably grained mainly medium, yellowish, brownish, current bedded.
15	sandstone	7.0m	hard, thick to massive bedding, yellowish brown, variably grained fine to coarse, current bedded.
16	clay	1.0m	friable, crumbly, laminated, blackish.
17	argillaceous sandstone	2.5m	soft, thinly bedded (2 to 5cm), white to grayish, limonitic in parts.
18	argillaceous sandstone	1.5m	soft, slightly clayey, laminated, carbonaceous, with fine grained sand lamination, grayish.
19	sandstone	10.0m	soft, massive unit, with laminated carbonaceous matreails and argillaeous sands, yellowish brwon, variably grained fine to medium.
20	clay	1.0m	chocolate, with interbedded white sands, current bedded.

Interval Number	Rock Unit	Thickness	Description
21	sandstone	1.0m	soft, alminated, with clayey and carbonaceous bands, yellowish to brownish, variably grained fine to medium, current bedded.
22	clay	1.8m	crumbly, sticky, laminated, chocolate to balckish due to carbonaceous matter.
23	sandstone	7.0m	current bedded units, interbedded with clays, variably grained fine to medium, becomes coarser towards bottom.
24	sandstone	3.5m	calcareous sand with intercalations of clays and marls, white sands, no bedding, fine grained.
25	clay	3.5m	black to greenish, laminated, interbedded with bands of sand 50cm thick, friable, with lignite seams.
26	sandstone	8.5m	soft, variably grained fine to medium, yellowish; a clay bed 1.5m thick occur in the middle; becomes clayey towards bottom.
27	sandstone	3.5m	hard, massive bedding, yellowish brown, variably grained mainly medium, current bedded.
28	clay	7.0m	alternation of clays and argillaceous sandstone; at top clay bed 1.5m thick friable soft, middle 3m thick argillaceous sands grayish, soft, at bottom clay bed 2.5m thick, soft, friable, greenish grayish.
29	sandstone	6.5m	massive bedding except for current bedding, variably grained fine to medium yellowish brownish, carbonaceous laminations, becomes richer towards bottom, with grayish colour.
30	sandy limestone	1.0m	thick bed, fossilifireous, with sand matrix.

Interval Number	Rock Unit	Thickness	Description
31	argillaceous sandstone	5.5m	clayey, friable and sticky, with carbonaceous material and lignites interbedded in the sands; soft, grayish to whitish.
32	sandstone	4.5m	hard, becomes soft towards bottom, thickly bedded, variably grained fine to coarse, slightly argillaceous, yellowish to whitish.
33	argillaceous sandstone	28.0m	massive unit, consists of argillaceous sands and clays, lignites, and carbonaceous materials in thin beds (2 to 10cm), grayish yellowish to blackish when associated with lignite.
34	sandstone	5.5m	hard, massive bedding, yellowish brown, variably grained medium to coarse, current bedded.
35	clay	4.0m	soft, friable, sandy, laminated, grayish, with intercalations of thin bands of sand.
36	sandstone	5.0m	hard, massive bedding, variably grained medium to coarse, yellowish brown, current bedded, iron stainind on surface.
37	clay	3.0m	slightly sandy, laminated, fraible, reddish to grayish.
38	sandstone	3.0m	soft, massive bedding, yellowish brown, variably grained medium to coarse, current bedded, ferrugineous concretions.
39	sandstone	4.5m	alternation of sandstones and sandy clays, thin to thick bedded sands (10 to 100cm) and thicker clays (50 to 100cm), yellowish sands; grayish to whitish clays.
40	argillaceous sandstone	2.0m	friable, slightly clayey, laminated, grayish reddish.
41	sandstone	12.0m	massive, current bedded, yellowish brown reddish, whitish, variably grained fine to coarse, not very compact, thick bedding(50 to 100cm); clayey and argillaceous (2 to15cm) separate cross-bedded units.

Interval Number	Rock Unit	Thickness	Description
42	argillaceous sandstone	3.0m	friable, slightly clayey, laminated, reddish to violet, to grayish, fine grained; becomes clayey towards top.
43	sandstone	4.0m	massive except at top where it is t thinly bedded, with laminated clays yellowish brownish, sometimes whitish, coarsed grained, becomes finer towards the bottom.
44	clay	10.0m	alternation of clays and sandstones; foremr: 3m thick units, laminated, fraible, sticky, grayish reddish violet to blackish towards bottom with presence of lignites and carbonaceous materials; latter: thinly bedded(15to 20cm), hard, violet to brown, variably grained medium to fine.
45	sandstone	5.0m	massive to thickly bedded, yellowish reddish to whitish, variably grained medium to fine, limonitic to haematitic at top, thin bedding in the middle with clay and argillaeous layer; current bedded.
46	clay	3.5m	top layer friable, laminated, reddish to violet, soft; becomes harder and more compact towards bottom where thinly bedded and more sandy, slightly carbonacous.
47	sandstone	9.5m	massive, thinly to thickly bedded towards top, yellowish brownish, variably grained fine to medium, current bedded, jointed, compact; becomes softer towards bottom; carbonaceous laminations separate current bedded units.
48	clay	4.0m	slightly sandy, laminated, grayish to blackish, rich in lignite seams.
49	sandstone	7.5m	massive, yellowish, variably grained medium to coarse, current bedded, with slightly carbonaceous laminations.
50	lignite	3.0m	black; laminated, thick unit, friable.

Interval Number	Rock Unit	Thickness	Description
51	sandstone	15.0m	massive, yellowish brown, variably grained mainly medium, current bedded, carbonaceous lamination along beddin planes of cross-bedded units.
52	clay	10,0m	alternation of clays and argillaceous sands; former: friable, sticky, reddish violet, grayish; latter: fine grained, thinly bedded (10cm), within a unit of 1 to 1.5m thick.
53	sandstone	9.0m	alternation of sandstone and argillacous sandstone; former: reddish to brownish, thinly to thickly bedded(15 to 50cm), fine grained; latter: soft, friable, thinly bedded, grayish.
54	sandstone	3.0m	massive to thickly bedded, yellowish reddish brownish, variably grained fine to medium, soft to hard, current bedded.
55	clay	7.0m	alternation of thinly bedded sands and clays(2 to15cm) thickness, red violet colour at top, yellowish to white gray to brownish towards bottom.
56	sandstone	25.0m	massive to thickly bedded, yellowish to reddish and brownish, variably grained fine to medium,; alternation of hard and soft beds; current bedded, iron surface staining tpwards the top; argillaceous sandy clayey laminations and bands.
57	argillaceous sandstone	22.5m	soft, massive to obscure bedding, sometimes thickly bedded, reddish, violet, yellow brown and grayish, friable, fine grained to medium; with contorted bedding.
Base			

BIBLIOGRAPHY

AHARONI, E., 1964, "Litho-electric Correlation of the Kurnub Group (Lower Cretaceous) in the Northern Neqev", Isreal Journal of Earth Sciences, v. 13, No. 2.

ALLEN, J.R.L. and NARAYAN, J., 1964, "Cross-stratified Units, Some With Silt Bands in the Folkestone Beds (Lower Greensand) of Southwest England", Geologie en Mijnbouw, No. 10, Oct. pp. 421-466.

_____ , J. R.L., 1965, "Review of the Origin and Characteristics of Recent Alluvial Sediments" Sedimentology, v. 5, No. 2.

BAKER, N.E. and HENSON, F.R.S., 1952 "Geological Conditions of Oil Occurrences in the Middle East", Bull. A.A.P.G., v. 29, No. II.

BALL, P.G. and BALL, D., 1953, "Oil Prospects of Isreal", Bull. A.A.P.G., v. 38, No. I.

BENDER, F., 1961, "Stand der Exploration and Erdolaussichten in Jordanien", Erdol und Kohle-Erdgas-Petrochemie, 14 Jahrs, No. 10.

_____ , F., 1963, co-author, "Lexique Stratigra International, v. III, ASIE, Fascicule 10 C1", Centre National De La Recherch Scientifique, Paris.

BENTOR, Y.K., 1959, ed., "Lexique Stratigraphic International, v. III, ASIE, Fascicule 10 C2, Israel", Centre National De La Recherche Scientifique, Paris.

BEYDOUN, Z.R., 1965, "A Review of the Oil Prospects of Lebanon", 5th Arab Petroleum Congress, Cairo, serial No. 29 (B-3).

BELOUSSOV, V.V., "Basic Problems in Geotectonics", McGraw-Hill Book Company, Inc., New York, Toronto, London, San Francisco, pp. 233-269.

BLAKE, G.S. and GOLDSCHMIDT, M.J., 1947, "Geology and Water Resources of Palestine", Government of Palestine, printer, Jerusallem.

BOUMA, A.H., 1962, "Sedimentology of Some Flysch Deposits", Elsevier Publishing Company, Amsterdam and New York.

BURDON, D.J., 1959, "Handbook of the Geology of Jordon", published by the Government of the Hashemite Kingdom of Jordan.

COATS, J.; GOTTESMAN, E.; JACOBS, M.; ROSENBERG, 1963, "Gas Discoveries in Western Dead Sea Region", 6th World Petroleum Congress, Frankfurt, section I, paper I.

CUMMINGS, W.A., 1957, "The Dunhigh Grit; Wenlock Greywackes in Wales", Geological Magazine, v. XCIV, No. 6, pp. 433-451.

DAY, A.E., 1930, "Geology of Lebanon and Syria, Palestine and Neighbouring Countries", printed at the American Press, Beirut, Syria.

DANIEL, E.J., 1963, co-author, "Lexique Stratigraphic International, v. III, ASIE, Fascicule 10 cl, LIBAN, SYRIE, JORDANIE", Centre National De La Recharche Scientifique, Paris.

DUBERTRET, L., 1949, "Carte Geologique au 50000, Feuille de Zebdani" Republique Syrienne, Ministere des Travaux Publics, Damas.

________, L., 1949, "Carte Geologique au 50000, Feuille de Saida" Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

________, 1950, "Carte Geologique au 50000, Feuille de Djezzine", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

________, 1950, "Carte Geologique au 50000, Feuille de Baalbedk", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

________, 1951, "Carte Geologique au 50000, Feuille de Sir ed Danniye," Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

________, 1951, "Carte Geologique au 50000, Feuille de Beyrouth", Republique Libanaise, Ministere des travaux Publics.

________, 1951, "Carte Geologique au 50000, Feuille de Tripoli", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

________, 1951, "Carte Geologique au 50000, Feuille de Qartaba", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

________, 1951, "Carte Geologique au 50000, Feuille de Mardjayoun", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

________, 1953, "Carte Geologique au 50000, Feuille de Zahle", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

________, 1955, "Carte Geologique au 50000, Feuille du Liban", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

DUBERTRET, L., 1956, "Carte Geologique au 50000, Feuille de Jbail", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

———, 1956, "Carte Geologique au 50000, Feuille de Tyr-Nabatiye", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

———, 1956, "Carte Geologique au 50000, Feuille de Rechaya Nord", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

———, 1956, "Carte Geologique au 50000, Feuille de L'Hermon", Republique Libanaise, Ministere des Travaux Publics, Beyrouth.

———, ed., 1963, "Lexique Stratigraphic International, vol. III, Fascicule 10, cI", Centre National de la Recherche Scientifique.

ELLIOT, R.E., 1965, "A Classification of Subaqueous Structures Based on Rheological and Kinematical Parameters", Sedimentology, v 5, No. 3.

HENSON, F.R.S., 1951, "Observationson the Geology and Petroleum Occurrences of the Middle East", Proc. 3rd. World Petroleum Congress, the Hague, section I.

KARCZ, I., 1965, "Lower Cretaceous Fluviatites in the Levant", Nature, vol. 207, No. 5002, pp. 1145-1146.

KEUNEN, Ph. H. 1963, "Marine Geology", John Wiley and Son, Inc., New York, London.

KLEMME, H.D., 1958, "Regional Geology of Circum-Mediterranean Region", Bull. A.A.P.G., vol. 42, No. 3.

LAHEE, F.H., 1959, "Field Geology", McGraw-Hill Book Company, Inc., New York, Toronto, London, Kogakusha Company, Lit., Tokyo.

LEES, G.M., 1948, "Some Structural and Stratigraphical Aspects of the Oil Fields of the Middle East", International Geological Congress, Great Britain.

LEXIQUE STRATIGRAPHIC INTERNATIONAL (L.S.I.), 1963, v III, ASIE, Fascicule 10 cl, Liban Syrie, Jordanie, authors, DUBERTRET, L; DANIEL, E.J; BENDER, F; publishers, Centre National De La Recherche Scientifique, Paris.

LEXIQUE STRATIGRAPHIC INTERNATIONAL (L.S.I.), 1959, v III, ASIE, Fascicule 10 c2, Israel, author Bentor, Y.K. publishers, Centre National De La Recherche Scientifique, Paris.

LONGWELL, C.R., 1949, Chairman, "Sedimentary Facies in Geologic History" Geological Society of America, Memoire, , New York.

MCKEE, E.D., 1962, "Origin of the Nubian and Similar Sandstones", Geologische Rundschau, Bd. 52, pp. 551-587.

MITCHEL, R.C., 1957, "Notes on the Geology of Western Irak and Northern Saudi Arabia", Geologische Rundschau, Bd. 46, No. 2, pp. 476-493.

NAGTEGAAL, P.J.C., 1965, "An Approximation to the Genetic Classification of Non-Organic Sedimentary Structures", Geologie en Mijnbouw No. 10, Oct., pp. 337-372.

PAYNE, Th.G., 1942, "Stratigraphical and Environmental Reconstruction", Bull. A.A.P.G., v. 26, No. 11.

PETTIJOHN, F.J., 1957, "Sedimentary Rocks", Harper and Brothers, New York.

PICARD, L., 1943, "Structure and Evolution of Palestine", published by the Geological Department, Hebrew University, Jerusalem.

________, 1959, "Geology and Oil Exploration of Israel", 5th World Petroleum Congress, Proc., section 1.

PICARD,L. and ELIEZRI,I., 1964, "Oil Exploration of Israel", published by Petroleum Science and Publications Ltd., DELEK, the Israel Feul Corporation Ltd.

POTTER,P. and PETTILHON,F.J., 1963,"Paleocurrents and Basin Analysis", 5, Springer-Verlag, Berlin, Gottingen, Heidelberg, Germany.

QUENNELL, A.M., 1951, "The Geology and Mineral Resources of (former) Trans-Jordon", Colon. Geology and Mineral Resources, v. 2.

RENOUARD, G., 1955, "Oil Prospects of Lebanon", Bull. A.A.P.G.,v.29, No. 11.

SABBAGH, G.N., 1961, "Stratigraphie & Tectonique du Liban", Faculte de Science de Grenoble, published by Industry Institute, Beirut.

SHAW, A.B., 1964, "Time in Stratigraphy", McGraw-Hill Co., New York, San Francisco, Toronto, London.

SCHROCK, R.R., 1948, "Sequence in Layered Rocks", McGraw-Hill Book Co., Inc., New York, Toronto, London.

TWENHOFEL, W.H. and TYLER, S.A., 1941,"Methods of Study of Sediments", McGraw-Hill Book Co., Inc., New York and London.

________, W.H., 1950, "Principles of Sedimentation", McGraw-Hill Book Co., Inc., New York, Toronto, London.

STRAATEN, L.M.J.U. van, ed., 1964, "Deltaic and Shallow Marine Deposits", 6th International Sedimentological Congress, Proc., Elsevier publishing company.

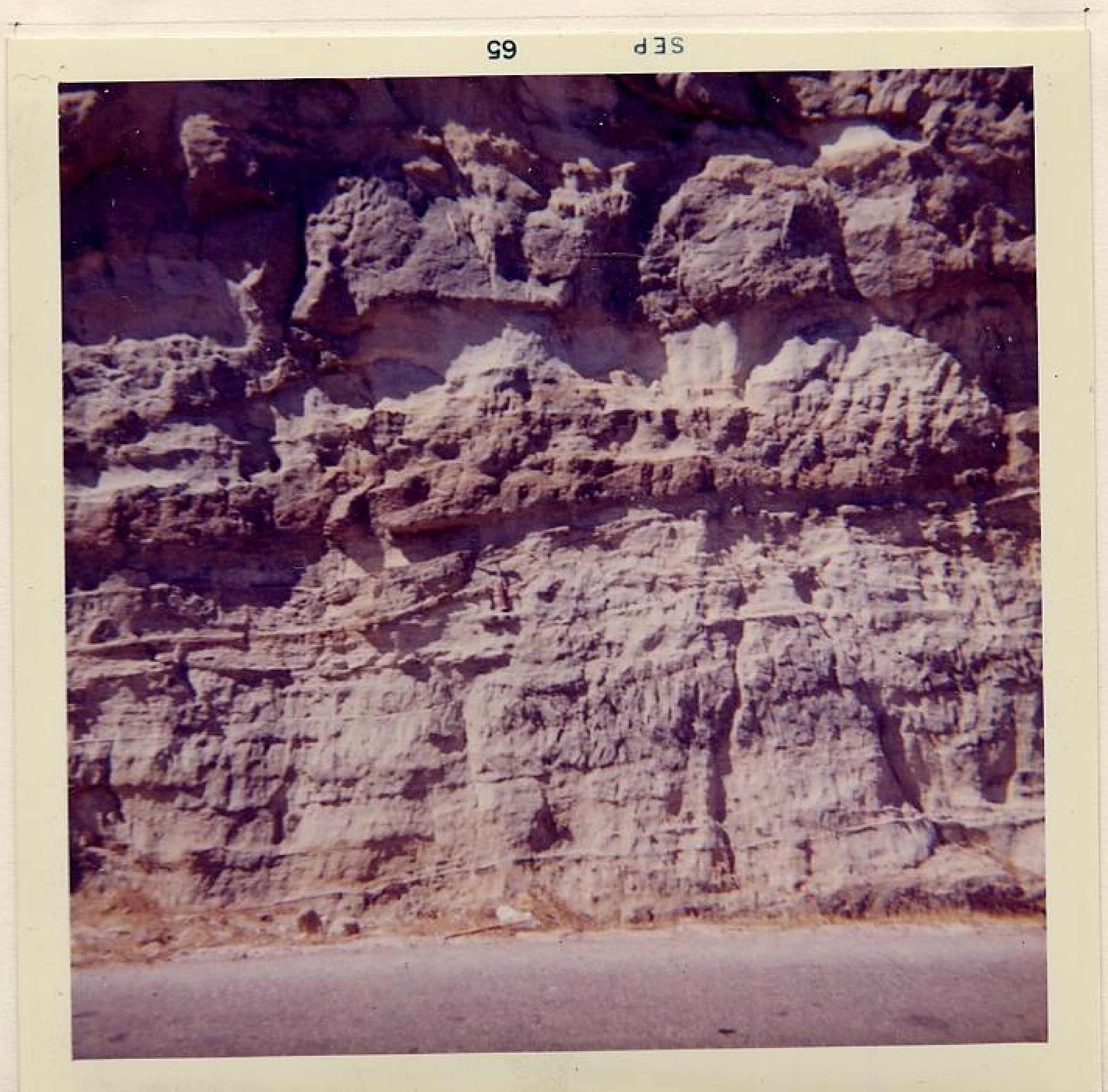
WELLER, J.M., 1960, "Stratigraphic Principles and Practice", Harper and Row, Publisher, New York, Evanston, and London.

WETZEL, R., and MORTON, D.M., 1959, "Contribution a la Geologie de la Trans-Jordanie", Notes et Memoires sur le Moyen Orient, Tome Vll.

ZUMMOFFEN, G.S.J., 1926, "Geologie du Liban", Henry Barrere, E'Ditem, 21, Rue du Bac, 21, Paris.

VAN DER LINDEN, W.J.M., 1963, "Sedimentary Structures and Facies Interpretation of Some Molasse Deposits", Book en Offsetdrukkerij de Werled, Eindhoven.

Photograph (1); Qoubai Locality; Thin fine grained sandstone interbedded with laminated clays.



Photograph (2); Aghmid locality; Thinly to thickly bedded alternating soft and hard sandstones, scour-and-fill structure along the middle of picture (hammer).

Photograph (3); Qoubai locality; Thick to massive, cross-bedded sandstones.

Photograph (4); Beskinta locality; argillaceous sandstone(lowest), overlain by sandstone, with a uniform bedding surface, a scour-fill structure at top.

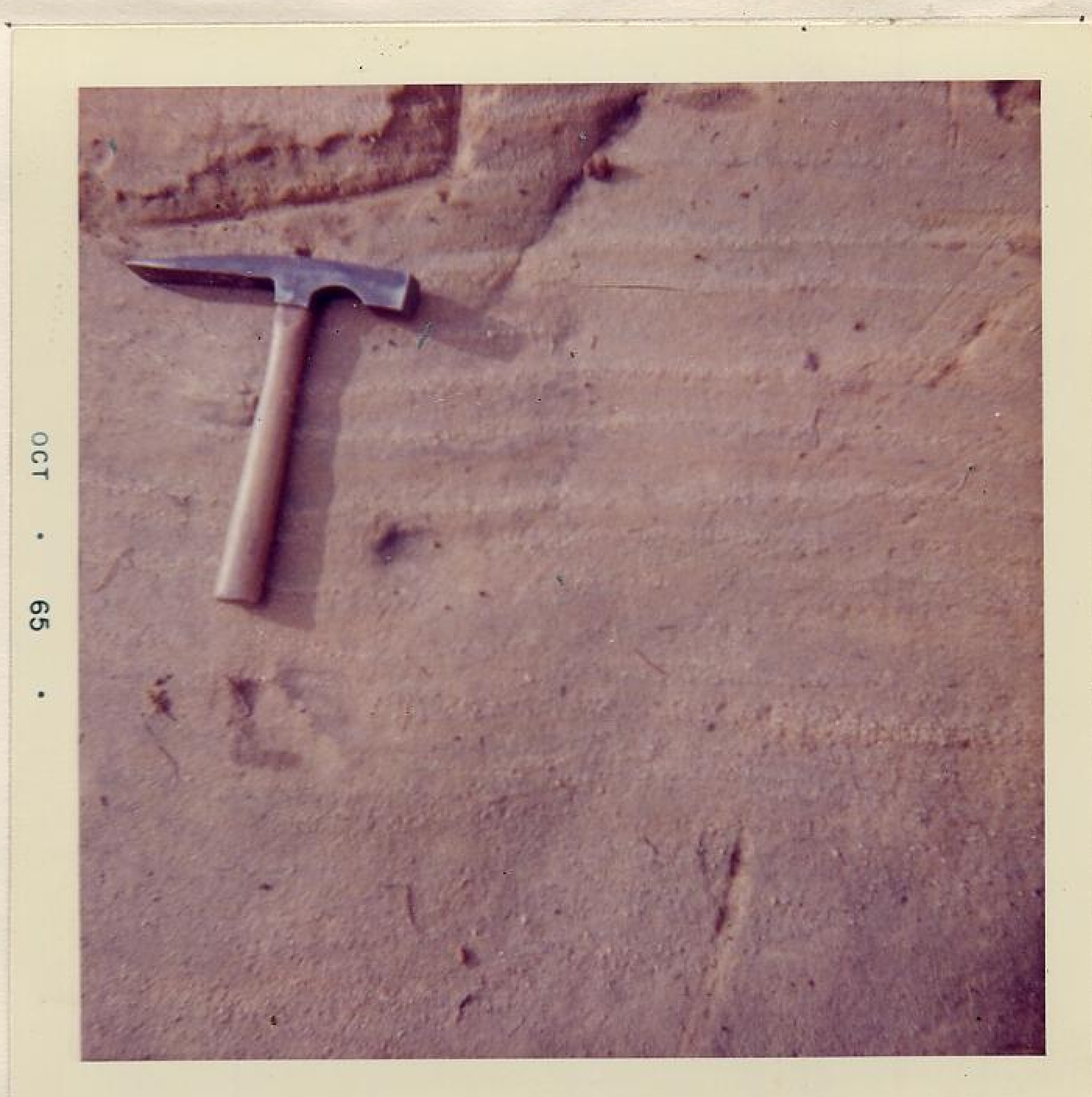
Photograph (5); Aghmid locality; Thinly bedded sandstone, interbedd with laminated to thin beds of lignite and carbonaceous matter.

Photograph (6); Jezzine locality; Thin to thick bedding, cross-bedded, sandstone, interbedd with thin to laminated beds of lignites.

Photograph (7); Douar locality; Tabular, non-tangential cross-bedding in sandstones.

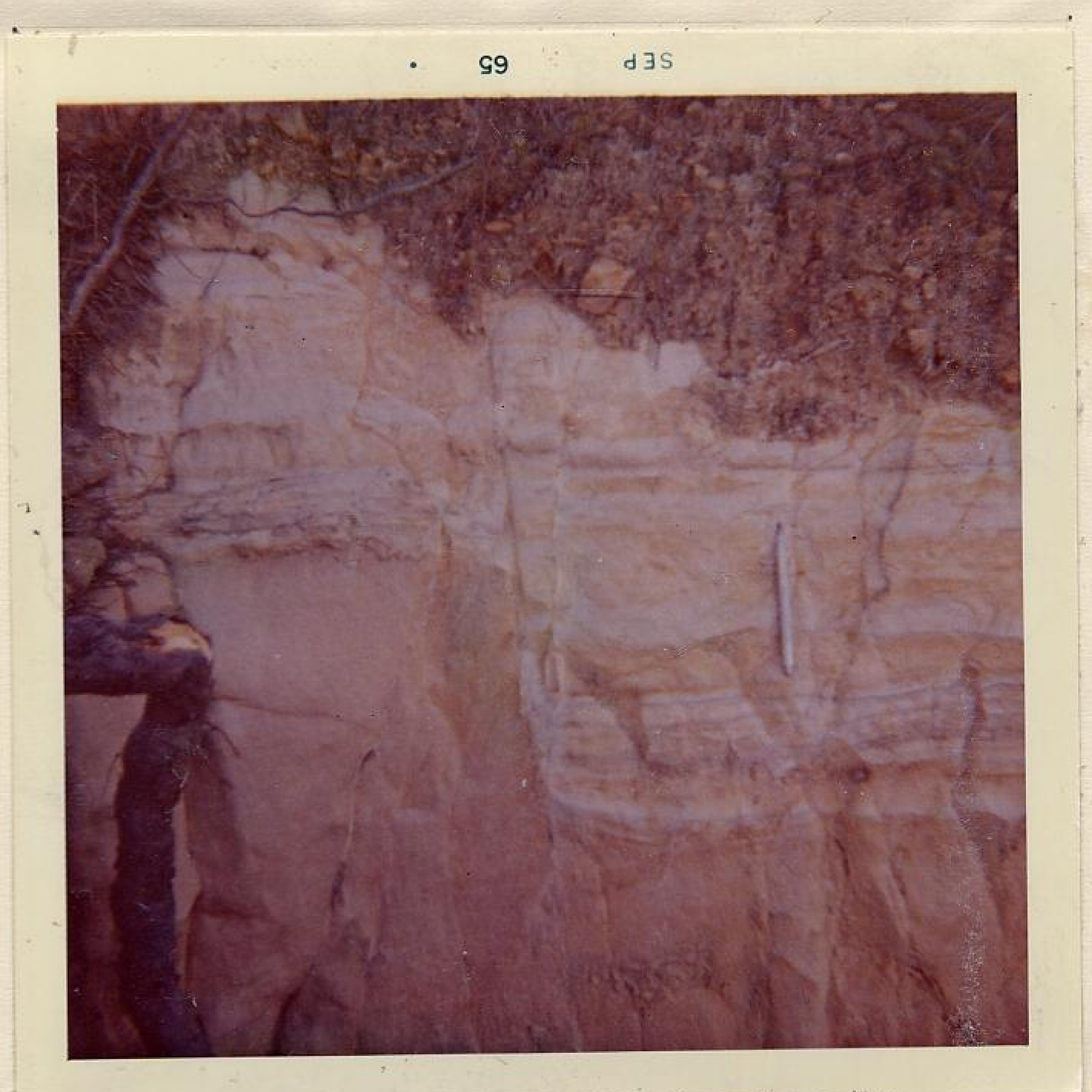
Photograph (8); Jezzine locality; Wedge, tangential cross-bedding in sandstones.

Photograph (9); Jezzine locality; Trough, tangential cross-bedded units in sandstone.



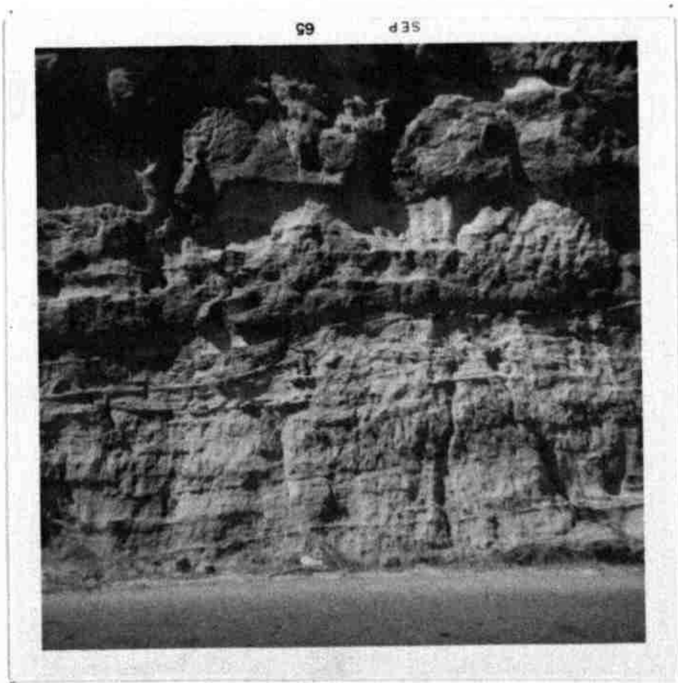
Phtograph (10); Douar locality; Cross-bedding laminations(along strike) showing graded distribution of sand grains within every consecutive cross-lamination.

Photograph (11); Beskinta locality; contorted bedding of clays in sandstones.



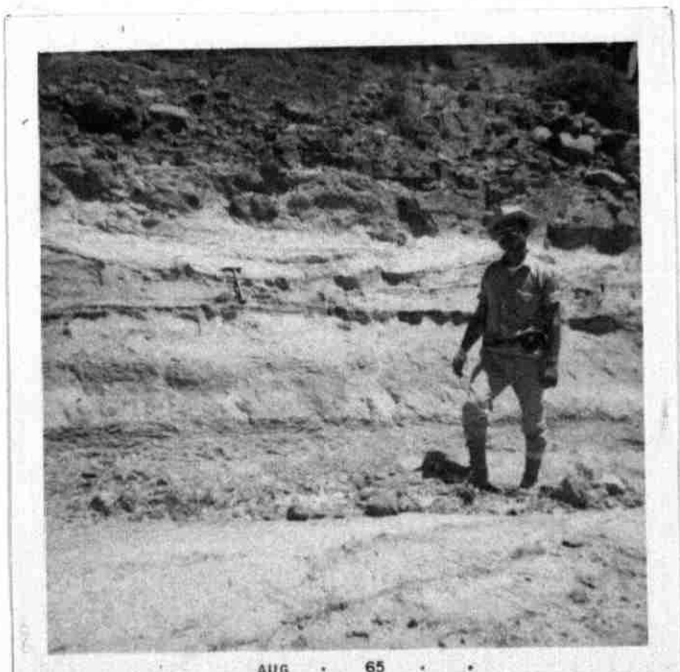
Photograph (12); Aghmid locality; Small scale fault structure associated with laminated to thinly bedded clays and argillaceous sandstones.

Photograph (1); Qoubai Locality; Thin fine grained sandstone interbedded with laminated clays.

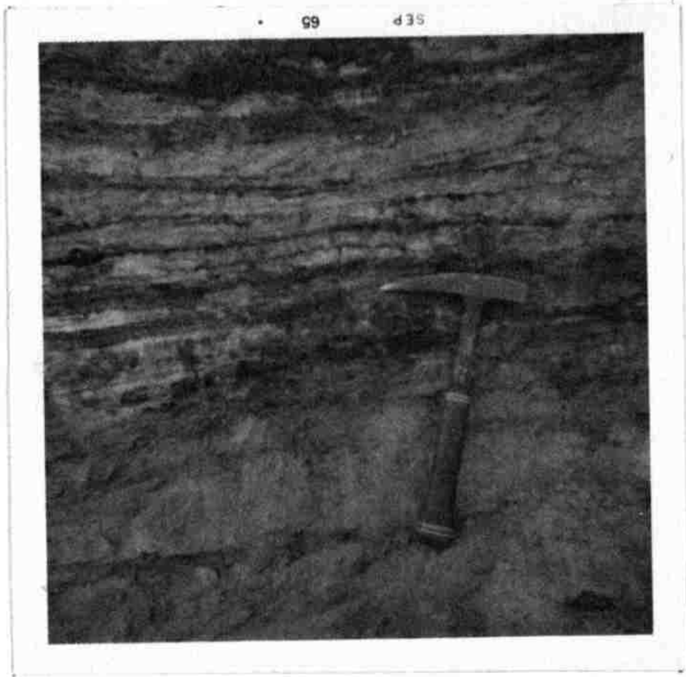


Photograph (2); Aghmid locality; Thinly to thickly bedded alternating soft and hard sandstones, scour-and-fill structure along the middle of picture (hammer).

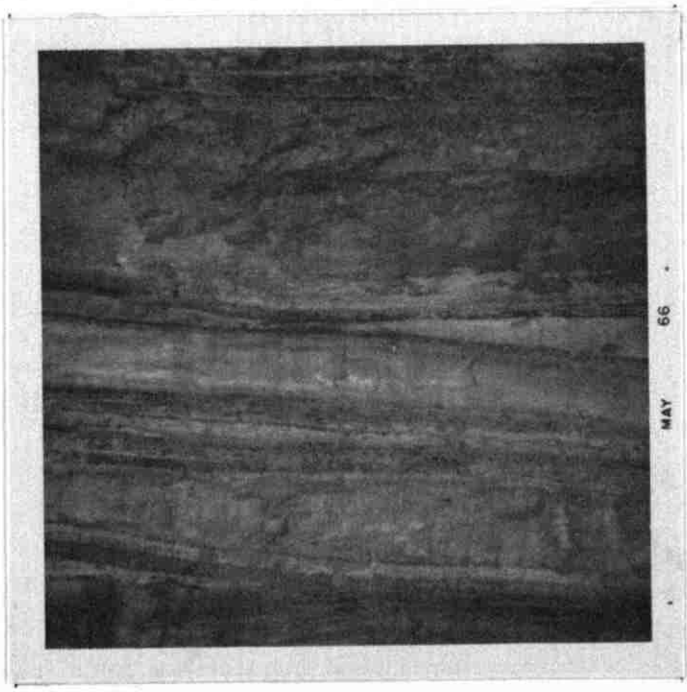
Photograph (3); Qoubai locality; Thick to massive, cross-bedded sandstones.



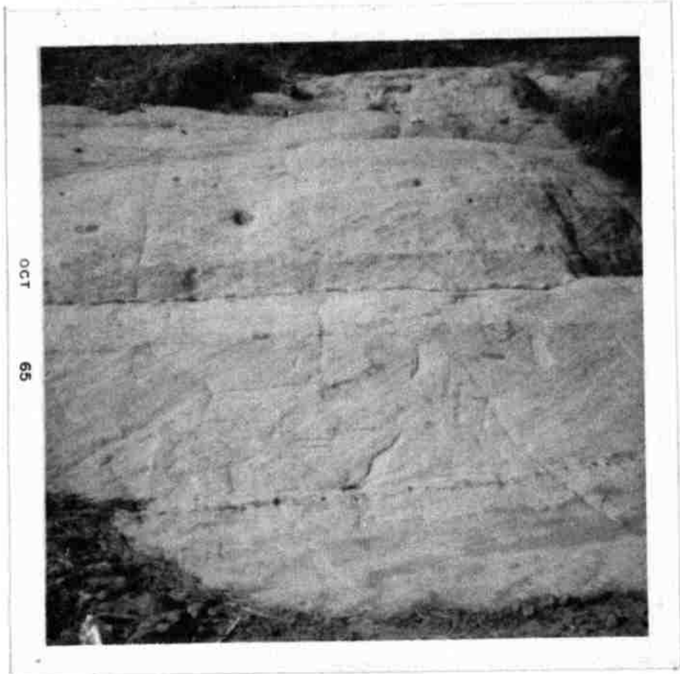
Photograph (4); Beskinta locality; argillaceous sandstone(lowest), overlain by sandstone, with a uniform bedding surface, a scour-fill structure at top.



Photograph (5); Aghmid locality; Thinly bedded sandstone, interbedd with laminated to thin beds of lignite and carbonaceous matter.

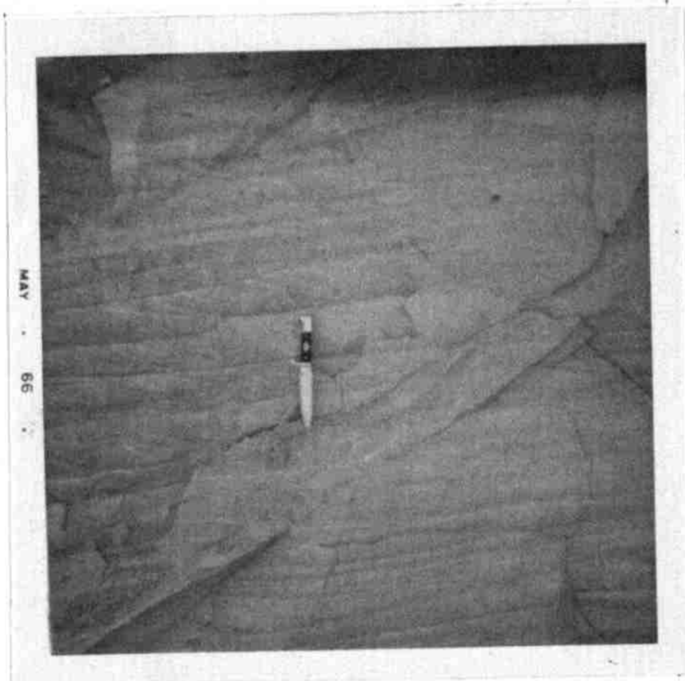


Photograph (6); Jezzine locality; Thin to thick bedding, cross-bedded, sandstone, interbedd with thin to laminated beds of lignites.

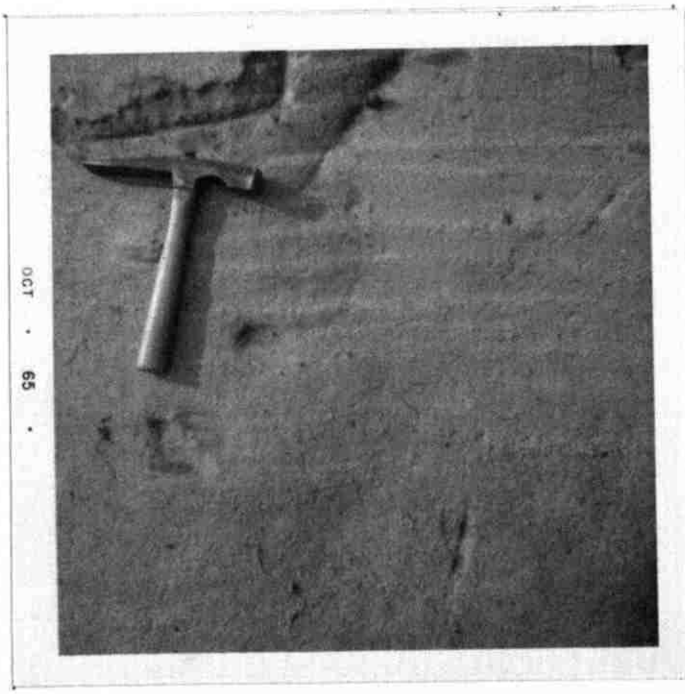


Photograph (7); Douar locality; Tabular, non-tangential cross-bedding in sandstones.

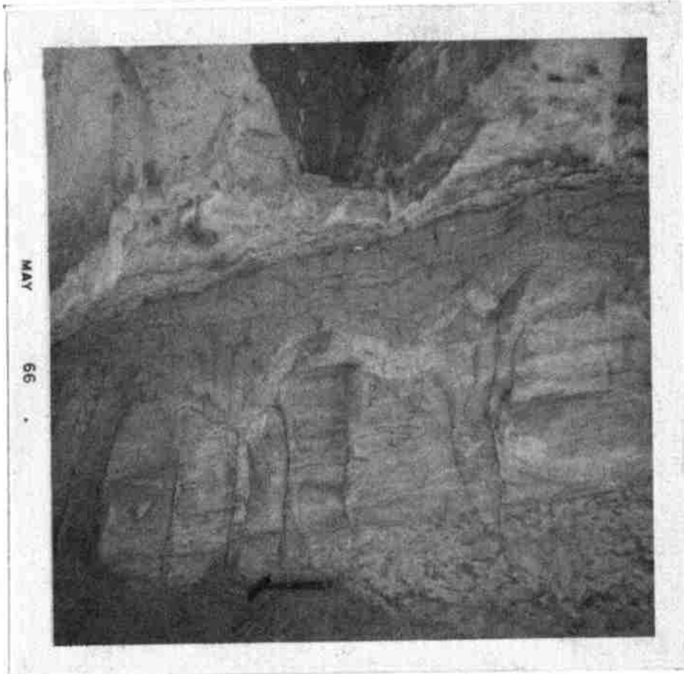
Photograph (8); Jezzine locality; Wedge, tangential cross-bedding in sandstones.



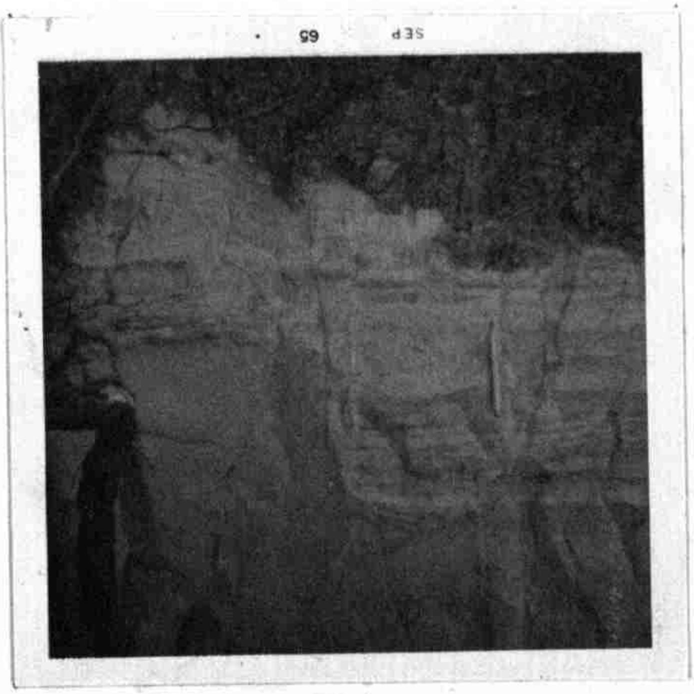
Photograph (9}; Jezzine locality; Trough, tangential cross-bedded units in sandstone.



Phtograph (10); Douar locality; Cross-bedding laminations(along strike) showing graded distribution of sand grains within every consecutive cross-lamination.

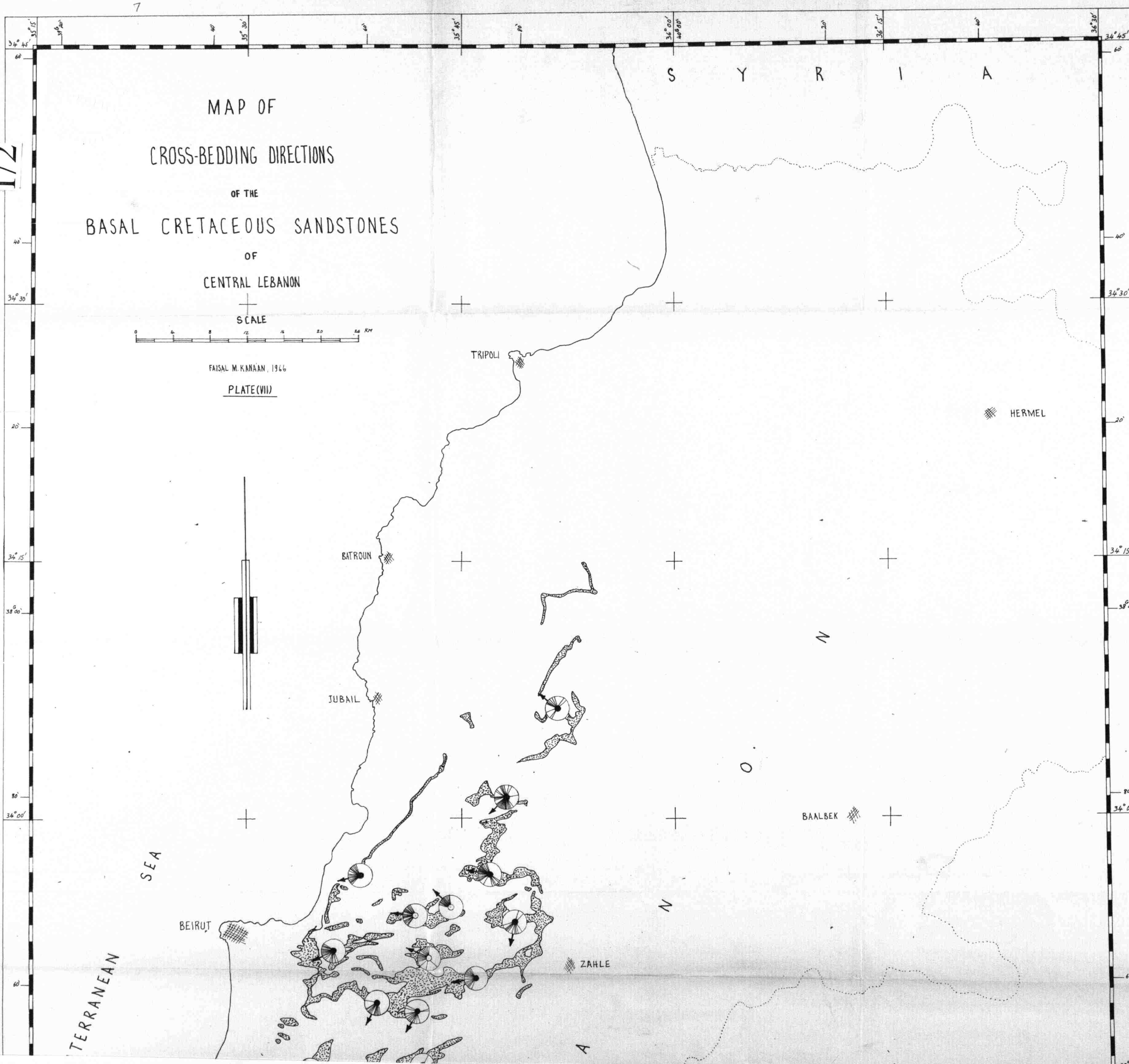


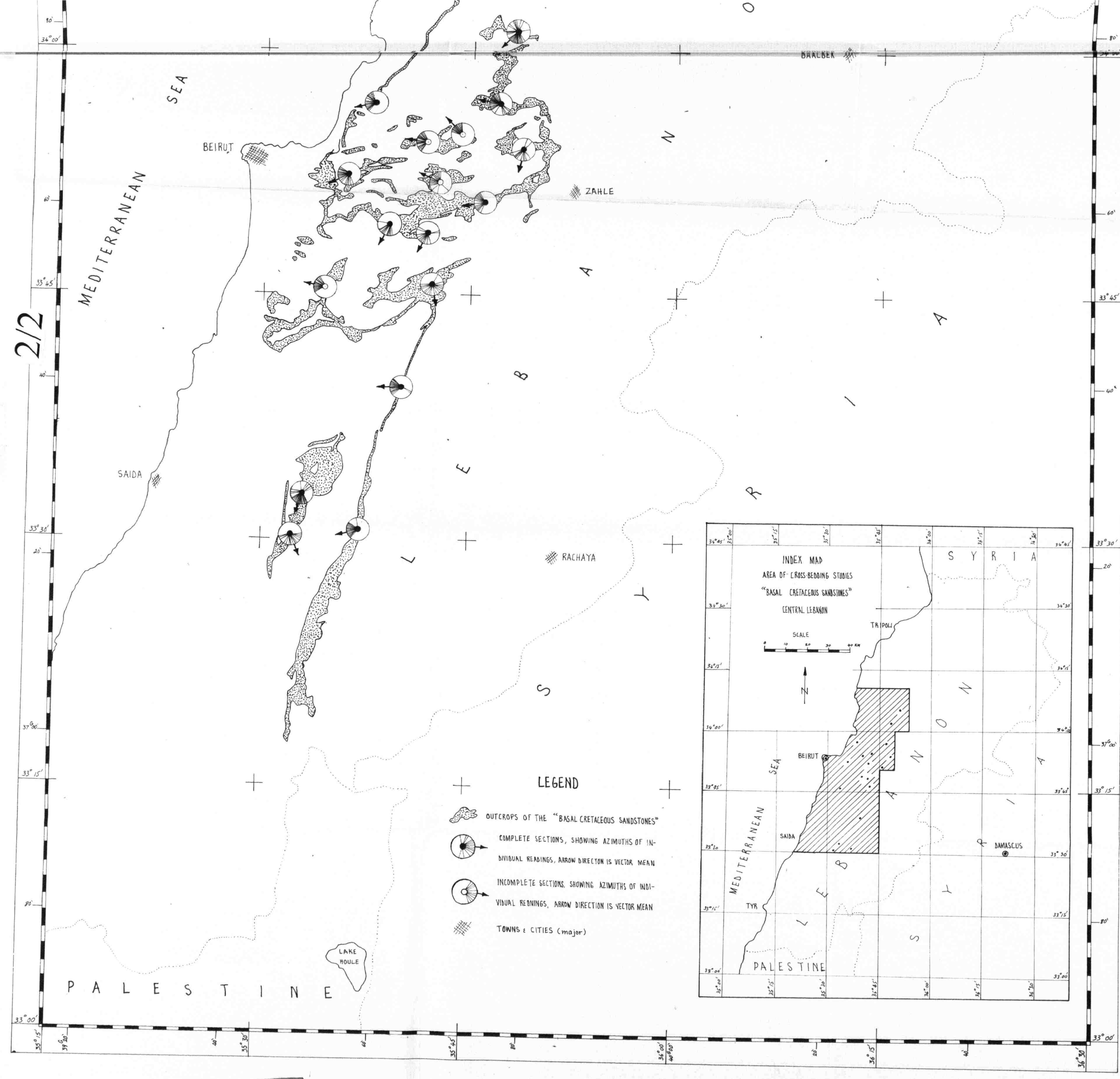
Photograph (11); Beskinta locality; contorted bedding of clays in sandstones.

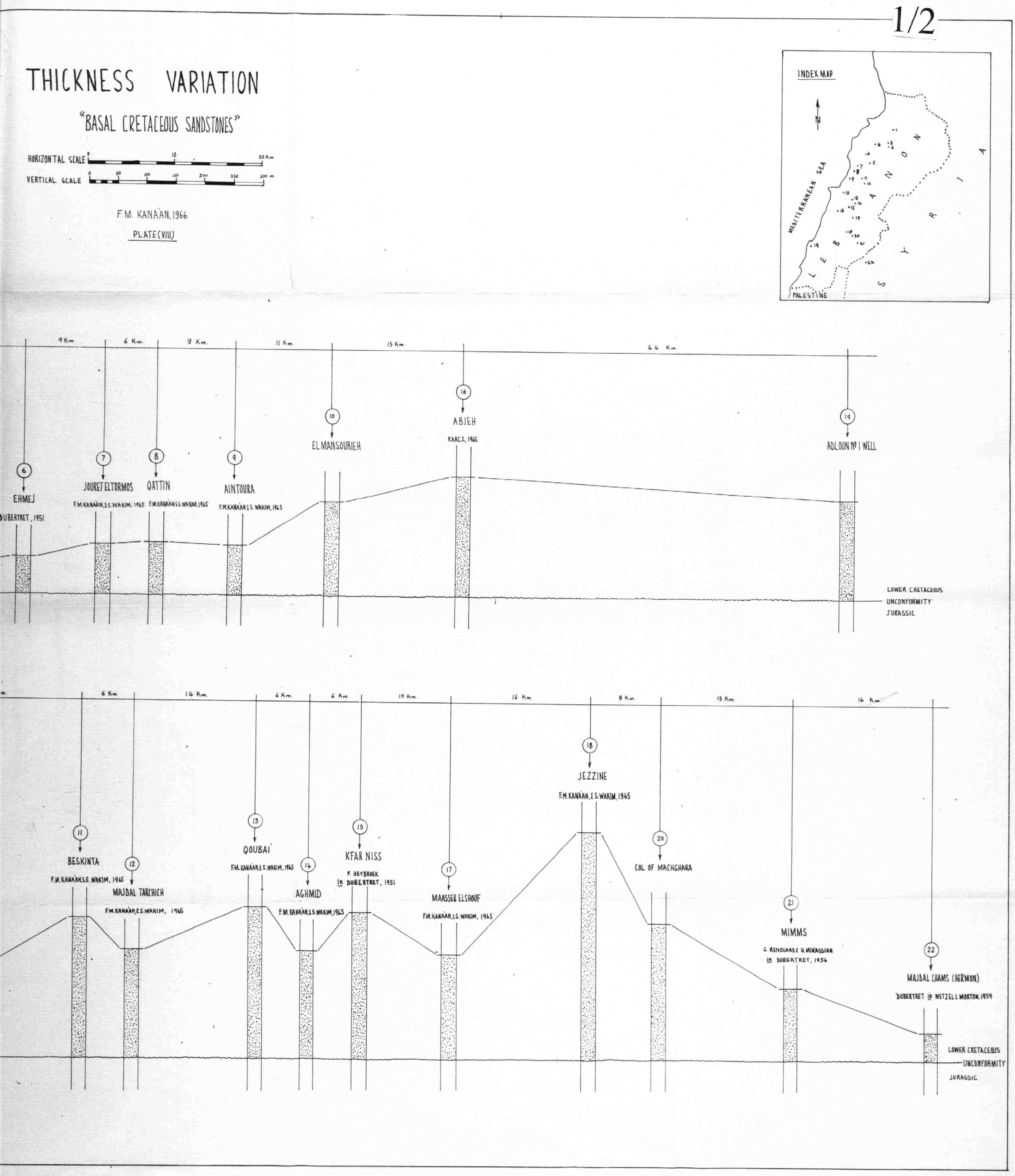


Photograph (12); Aghmid locality; Small scale fault structure associated with laminated to thinly bedded clays and argillaceous sandstones.

1/2


MAP OF
CROSS-BEDDING DIRECTIONS
OF THE
BASAL CRETACEOUS SANDSTONES
OF
CENTRAL LEBANON
SCALE
FAISAL M. KANAAN, 1966
PLATE (VII)
S Y R I A
TRIPOLI
HERMEL
BATROUN
JUBAIL
BAALBEK
BEIRUT
ZAHLE
SEA
TERRANEAN
N O N
A
34°45'
35°15'
35°30'
35°45'
36°00'
36°15'
36°30'
34°30'
34°15'
34°00'
33°45'


2/2
MEDITERRANEAN SEA
BEIRUT
ZAHLE
BAALBEK
SAIDA
RACHAYA
LEBANON
SYRIA
PALESTINE
LAKE HOULE
LEGEND
OUTCROPS OF THE "BASAL CRETACEOUS SANDSTONES"
COMPLETE SECTIONS, SHOWING AZIMUTHS OF INDIVIDUAL READINGS, ARROW DIRECTON IS VECTOR MEAN
INCOMPLETE SECTIONS, SHOWING AZIMUTHS OF INDIVIDUAL READINGS, ARROW DIRECTION IS VECTOR MEAN
TOWNS & CITIES (major)
INDEX MAP
AREA OF CROSS-BEDDING STUDIES
"BASAL CRETACEOUS SANDSTONES"
CENTRAL LEBANON
SCALE
TRIPOLI
BEIRUT
SAIDA
TYR
DAMASCUS
MEDITERRANEAN SEA
LEBANON
SYRIA
PALESTINE
34°00'
33°45'
33°30'
33°15'
33°00'
35°15'
35°30'
35°45'
36°00'
36°15'
36°30'



1/2
THICKNESS VARIATION
"BASAL CRETACEOUS SANDSTONES"
HORIZONTAL SCALE 0 10 20 Km.
VERTICAL SCALE 0 50 100 150 200 250 300 m
F.M. KANA'AN, 1966
PLATE (VIII)
INDEX MAP
N
MEDITERRANEAN SEA
LEBANON
SYRIA
PALESTINE
9 Km. 6 Km. 9 Km. 11 Km. 15 Km. 44 Km.
6 EHMEJ
DUBERTRET, 1951
7 JOURET ELTORMOS
F.M. KANA'AN, E.S. WAKIM, 1965
8 QATTIN
F.M. KANA'AN, E.S. WAKIM, 1965
9 AINTOURA
F.M. KANA'AN, E.S. WAKIM, 1965
10 EL MANSOURIEH
16 ABIEH
KARCZ, 1965
19 ADLOUN Nº 1 WELL
LOWER CRETACEOUS
UNCONFORMITY
JURASSIC
6 Km 14 Km. 6 Km. 6 Km. 10 Km. 16 Km. 8 Km. 15 Km. 16 Km.
11 BESKINTA
F.M. KANA'AN, S.S. WAKIM, 1965
12 MAJDAL TARCHICH
F.M. KANA'AN, E.S. WAKIM, 1965
13 QOUBAI
F.M. KANA'AN, E.S. WAKIM, 1965
14 AGHMID
F.M. KANA'AN, E.S. WAKIM, 1965
15 KFAR NISS
F. HEYBROEK in DUBERTRET, 1951
17 MAASSER ELSHOUF
F.M. KANA'AN, E.S. WAKIM, 1965
18 JEZZINE
F.M. KANA'AN, E.S. WAKIM, 1965
20 COL OF MACHGHARA
21 MIMMS
G. RENOUARD & H. MINASSIAN in DUBERTRET, 1956
22 MAJDAL CHAMS (HERMON)
DUBERTRET in WETZEL & MORTON, 1959
LOWER CRETACEOUS
UNCONFORMITY
JURASSIC

2/2

THICKNESS VARIATION

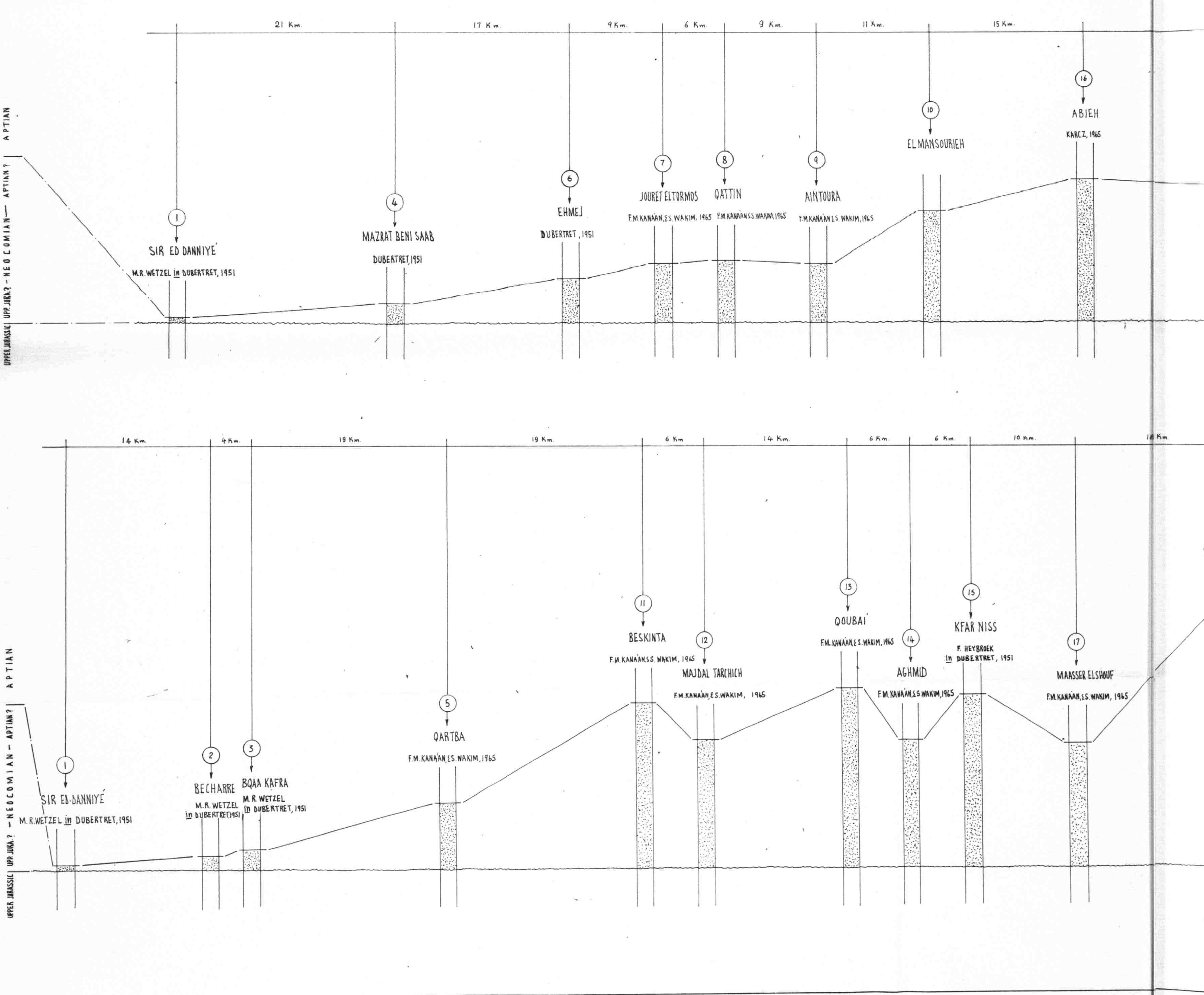
"BASAL CRETACEOUS SANDSTONES"

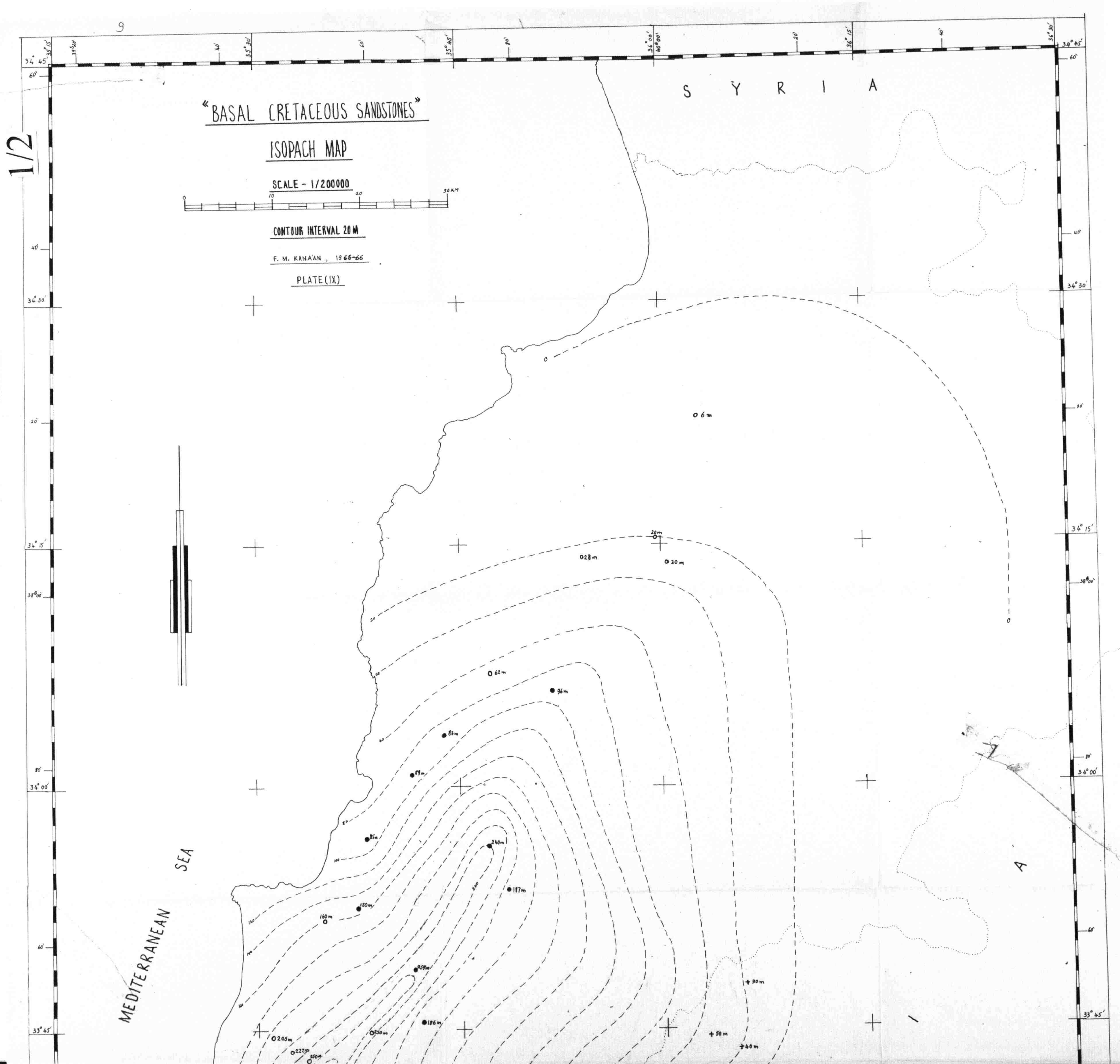
HORIZONTAL SCALE 0 10 20 Km.

VERTICAL SCALE 0 50 100 150 200 250 300 m

F.M. KANA'AN, 1966

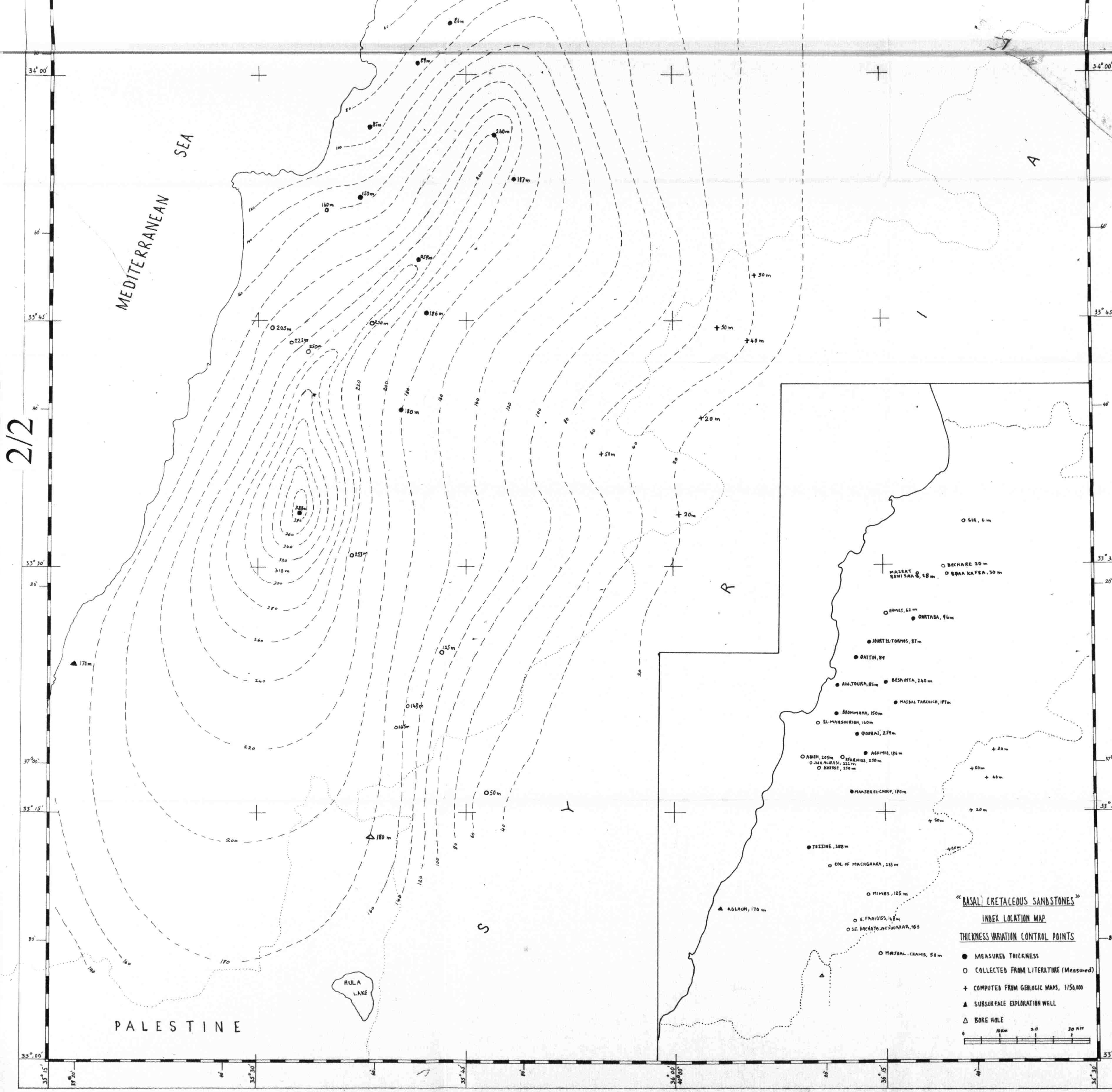
PLATE (VIII)





"BASAL CRETACEOUS SANDSTONES"
ISOPACH MAP
SCALE - 1/200000
CONTOUR INTERVAL 20 M
F. M. KANA'AN , 1965-66
PLATE (IX)
S Y R I A
MEDITERRANEAN SEA

2/2

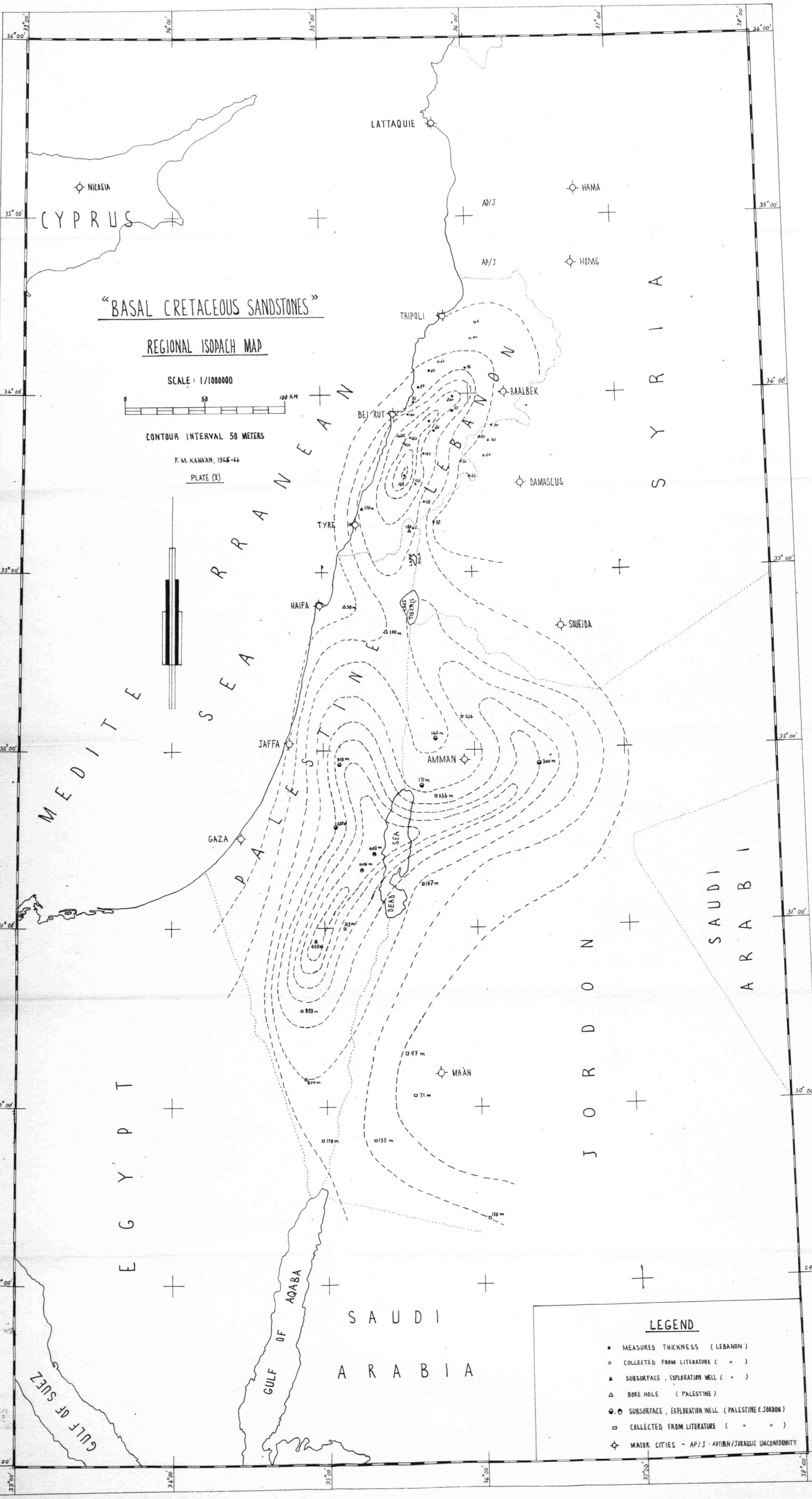


"BASAL CRETACEOUS SANDSTONES"
INDEX LOCATION MAP
THICKNESS VARIATION CONTROL POINTS
MEASURED THICKNESS
COLLECTED FROM LITERATURE (Measured)
COMPUTED FROM GEOLOGIC MAPS, 1/50.000
SUBSURFACE EXPLORATION WELL
BORE HOLE
0
10 Km
20
30 KM
MEDITERRANEAN
SEA
PALESTINE
HULA
LAKE
S
Y
R
I
A
34°00'
33°45'
33°30'
33°15'
33°00'
35°15'
35°30'
35°45'
36°00'
36°15'
36°30'


"BASAL CRETACEOUS SANDSTONES"
REGIONAL ISOPACH MAP
SCALE : 1/1000000
0 50 100 KM
CONTOUR INTERVAL 50 METERS
F. M. KANA'AN, 1965-66
PLATE (X)
LEGEND
MEASURED THICKNESS (LEBANON)
COLLECTED FROM LITERATURE (")
SUBSURFACE, EXPLORATION WELL (")
BORE HOLE (PALESTINE)
SUBSURFACE, EXPLORATION WELL (PALESTINE & JORDON)
COLLECTED FROM LITERATURE (" ")
MAJOR CITIES - AP/J : APTIAN/JURASSIC UNCONFORMITY
CYPRUS
NICOSIA
LATTAQUIE
HAMA
HOMS
AP/J
TRIPOLI
BAALBEK
BEIRUT
DAMASCUS
TYRE
HAIFA
SOUEIDA
JAFFA
AMMAN
GAZA
DEAD SEA
LAKE TIBERIAS
MA'AN
MEDITERRANEAN SEA
LEBANON
SYRIA
PALESTINE
JORDON
SAUDI ARABIA
EGYPT
GULF OF AQABA
GULF OF SUEZ
162 m
171 m
236 m
300 m
310 m
320 m
167 m
450 m
853 m
97 m
71 m
200 m
170 m
135 m
150 m
100 m
130 m
35° 00'
34° 00'
33° 00'
32° 00'
31° 00'
30° 00'
29° 00'
28° 00'
36° 00'
37° 00'
38° 00'

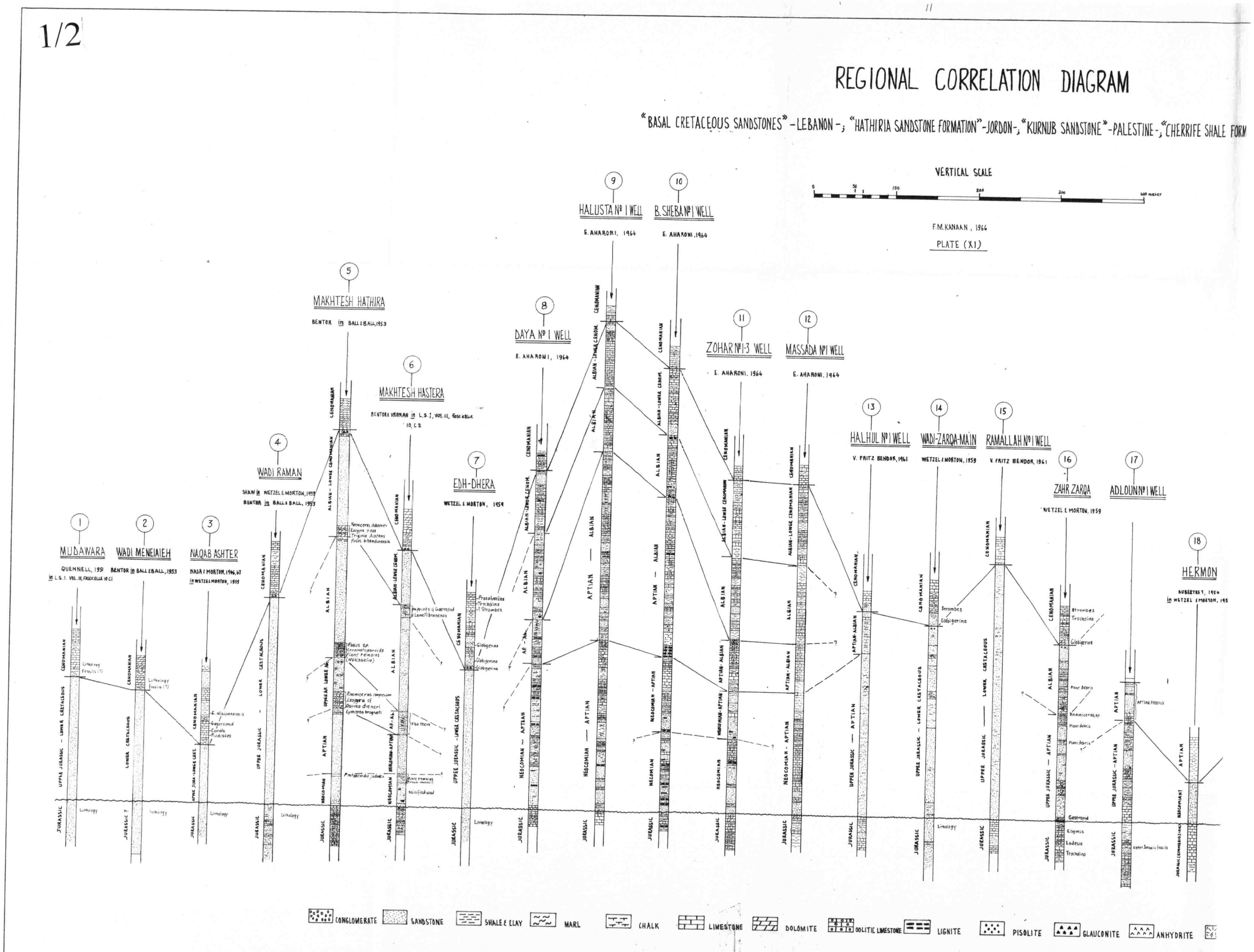
10


"BASAL CRETACEOUS SANDSTONES"
REGIONAL ISOPACH MAP
SCALE : 1/1000000
0
50
100 KM
CONTOUR INTERVAL 50 METERS
F. M. KANA'AN, 1965-66
PLATE (X)
LEGEND
MEASURED THICKNESS (LEBANON)
COLLECTED FROM LITERATURE (")
SUBSURFACE, EXPLORATION WELL (")
BORE HOLE (PALESTINE)
SUBSURFACE, EXPLORATION WELL (PALESTINE & JORDON)
COLLECTED FROM LITERATURE (" ")
MAJOR CITIES - AP/J - APTIAN/JURASSIC UNCONFORMITY
CYPRUS
NICOSIA
LATTAQUIE
HAMA
HOMS
AP/J
AP/J
TRIPOLI
BAALBEK
BEIRUT
DAMASCUS
TYRE
HAIFA
SOUEIDA
JAFFA
AMMAN
GAZA
MA'AN
LAKE TIBERIAS
DEAD SEA
MEDITERRANEAN SEA
LEBANON
SYRIA
PALESTINE
JORDON
SAUDI ARABIA
SAUDI ARABIA
EGYPT
GULF OF AQABA
GULF OF SUEZ
36° 00'
35° 00'
34° 00'
33° 00'
32° 00'
31° 00'
30° 00'
29° 00'
28° 00'
37° 00'
38° 00'
214
162 m
300 m
171 m
236 m
318 m
402 m
406 m
167 m
313 m
450 m
853 m
97 m
71 m
200 m
170 m
135 m
150 m
170 m
34 m
100 m


"BASAL CRETACEOUS SANDSTONES"
REGIONAL ISOPACH MAP
SCALE : 1/1000000
0 50 100 KM
CONTOUR INTERVAL 50 METERS
F. M. KANA'AN, 1965-66
PLATE (X)
CYPRUS
NICOSIA
LATTAQUIE
TRIPOLI
BEI RUT
TYRE
HAIFA
JAFFA
GAZA
HAMA
HOMS
BAALBEK
DAMASCUS
SOUEIDA
AMMAN
MA'AN
AP/J
LAKE TIBERIAS
DEAD SEA
MEDITERRANEAN SEA
LEBANON
PALESTINE
SYRIA
JORDON
SAUDI ARABIA
EGYPT
GULF OF AQABA
GULF OF SUEZ
LEGEND
MEASURED THICKNESS (LEBANON)
COLLECTED FROM LITERATURE (")
SUBSURFACE, EXPLORATION WELL (")
BORE HOLE (PALESTINE)
SUBSURFACE, EXPLORATION WELL (PALESTINE & JORDON)
COLLECTED FROM LITERATURE (" ")
MAJOR CITIES - AP/J - APTIAN/JURASSIC UNCONFORMITY

10

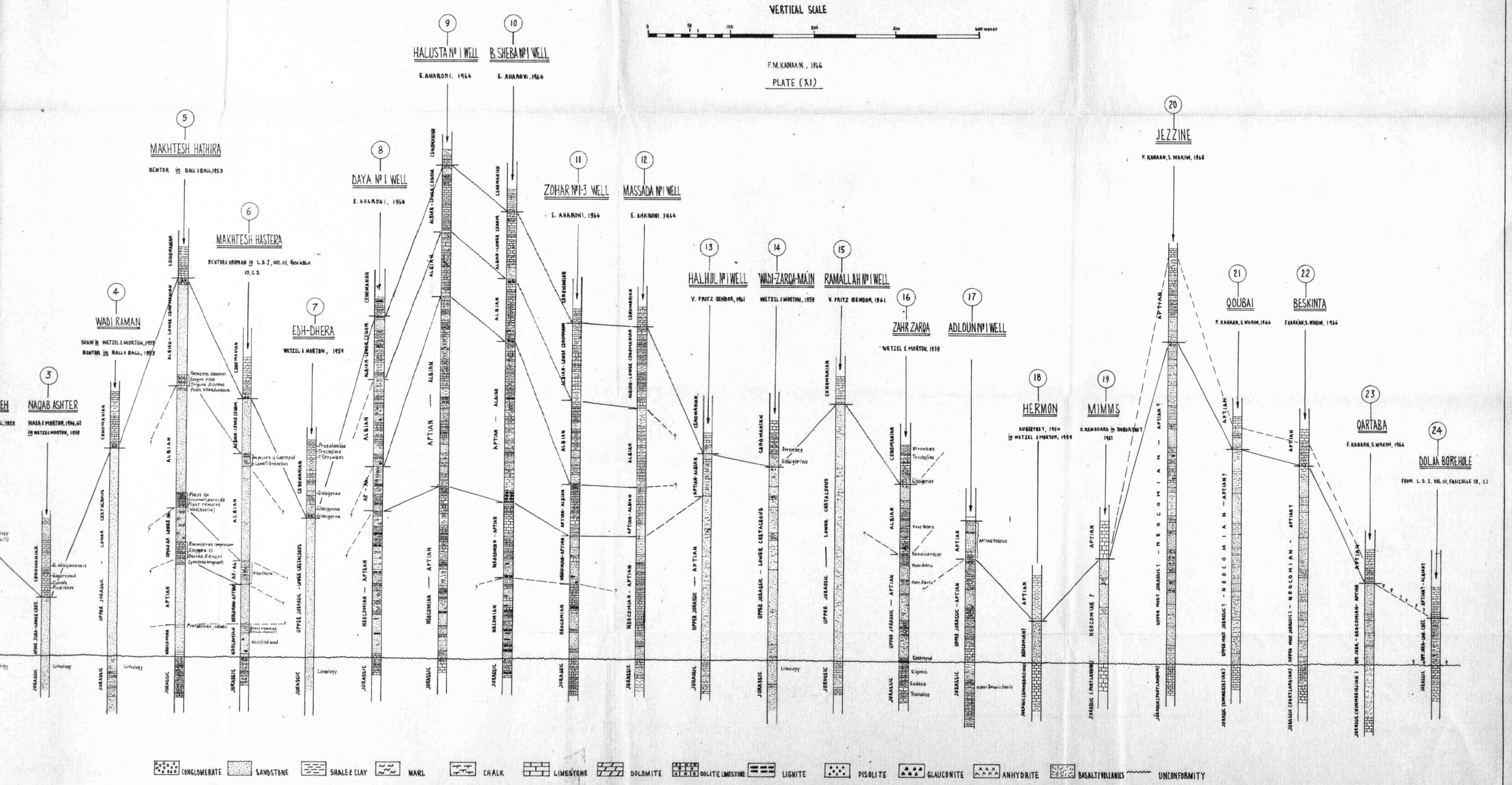
1/2



REGIONAL CORRELATION DIAGRAM
"BASAL CRETACEOUS SANDSTONES"-LEBANON-; "HATHIRIA SANDSTONE FORMATION"-JORDON-; "KURNUB SANDSTONE"-PALESTINE-; "CHERRIFE SHALE FORM
VERTICAL SCALE
F.M. KANAAN, 1966
PLATE (XI)
1 MUDAWARA
QUENNELL, 1951
2 WADI MENEIAIEH
3 NAQAB ASHTER
4 WADI RAMAN
5 MAKHTESH HATHIRA
6 MAKHTESH HASTERA
7 EDH-DHERA
WETZEL & MORTON, 1959
8 DAYA No 1 WELL
E. AHARONI, 1964
9 HALUSTA No 1 WELL
E. AHARONI, 1964
10 B. SHEBA No 1 WELL
E. AHARONI, 1964
11 ZOHAR No 1-3 WELL
E. AHARONI, 1964
12 MASSADA No 1 WELL
E. AHARONI, 1964
13 HALHUL No 1 WELL
V. FRITZ BENDOR, 1961
14 WADI-ZARQA-MAIN
WETZEL & MORTON, 1959
15 RAMALLAH No 1 WELL
V. FRITZ BENDOR, 1961
16 ZAHR ZARQA
WETZEL & MORTON, 1959
17 ADLOUN No 1 WELL
18 HERMON
CENOMANIAN
ALBIAN
APTIAN
NEOCOMIAN
JURASSIC
UPPER JURASSIC - LOWER CRETACEOUS
LOWER CRETACEOUS
CONGLOMERATE
SANDSTONE
SHALE & CLAY
MARL
CHALK
LIMESTONE
DOLOMITE
OOLITIC LIMESTONE
LIGNITE
PISOLITE
GLAUCONITE
ANHYDRITE

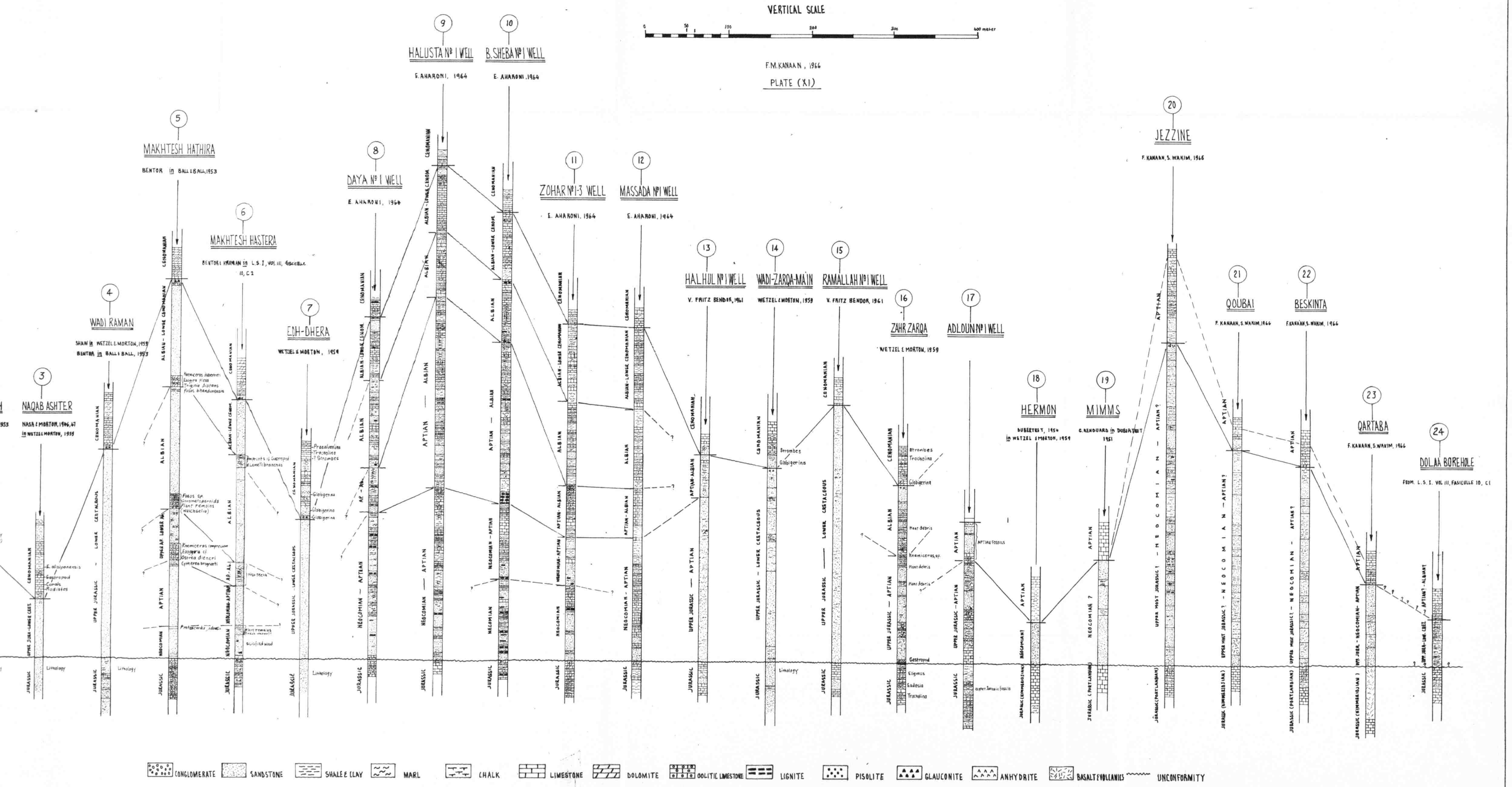
REGIONAL CORRELATION DIAGRAM

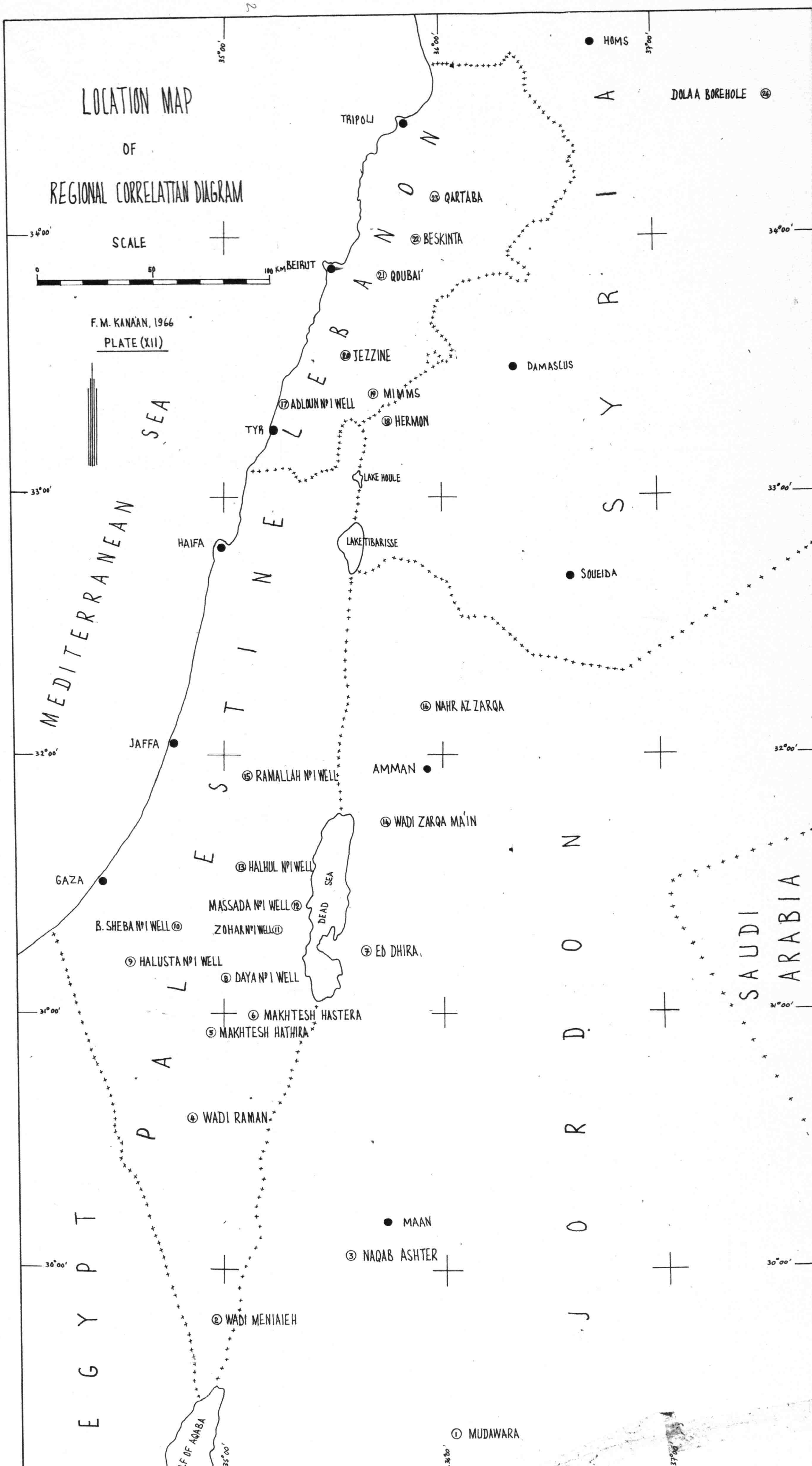
"BASAL CRETACEOUS SANDSTONES" -LEBANON-; "HATHIRIA SANDSTONE FORMATION" -JORDON-; "KURNUB SANDSTONE" -PALESTINE-; "CHERRIFE SHALE FORMATION" -SYRIA-



REGIONAL CORRELATION DIAGRAM

"BASAL CRETACEOUS SANDSTONES" -LEBANON-; "HATHIRIA SANDSTONE FORMATION"-JORDON-; "KURNUB SANDSTONE"-PALESTINE-; "CHERRIFE SHALE FORMATION"-SYRIA-




LOCATION MAP
OF
REGIONAL CORRELATIAN DIAGRAM
SCALE
0
50
100 KM
F. M. KANA'AN, 1966
PLATE (XII)
MEDITERRANEAN SEA
LEBANON
PALESTINE
SYRIA
JORDON
EGYPT
SAUDI ARABIA
TRIPOLI
BEIRUT
TYR
HAIFA
JAFFA
GAZA
HOMS
DAMASCUS
SOUEIDA
AMMAN
MAAN
LAKE HOULE
LAKE TIBARISSE
DEAD SEA
GULF OF AQABA
① MUDAWARA
② WADI MENIAIEH
③ NAQAB ASHTER
④ WADI RAMAN
⑤ MAKHTESH HATHIRA
⑥ MAKHTESH HASTERA
⑦ ED DHIRA
⑧ DAYA Nº1 WELL
⑨ HALUSTA Nº1 WELL
B. SHEBA Nº1 WELL ⑩
ZOHAR Nº1 WELL ⑪
MASSADA Nº1 WELL ⑫
⑬ HALHUL Nº1 WELL
⑭ WADI ZARQA MA'IN
⑮ RAMALLAH Nº1 WELL
⑯ NAHR AZ ZARQA
⑰ ADLOUN Nº1 WELL
⑱ HERMON
⑲ MIMMS
⑳ JEZZINE
㉑ QOUBAI'
㉒ BESKINTA
㉓ QARTABA
DOLAA BOREHOLE ㉔
35°00'
36°00'
37°00'
34°00'
33°00'
32°00'
31°00'
30°00'

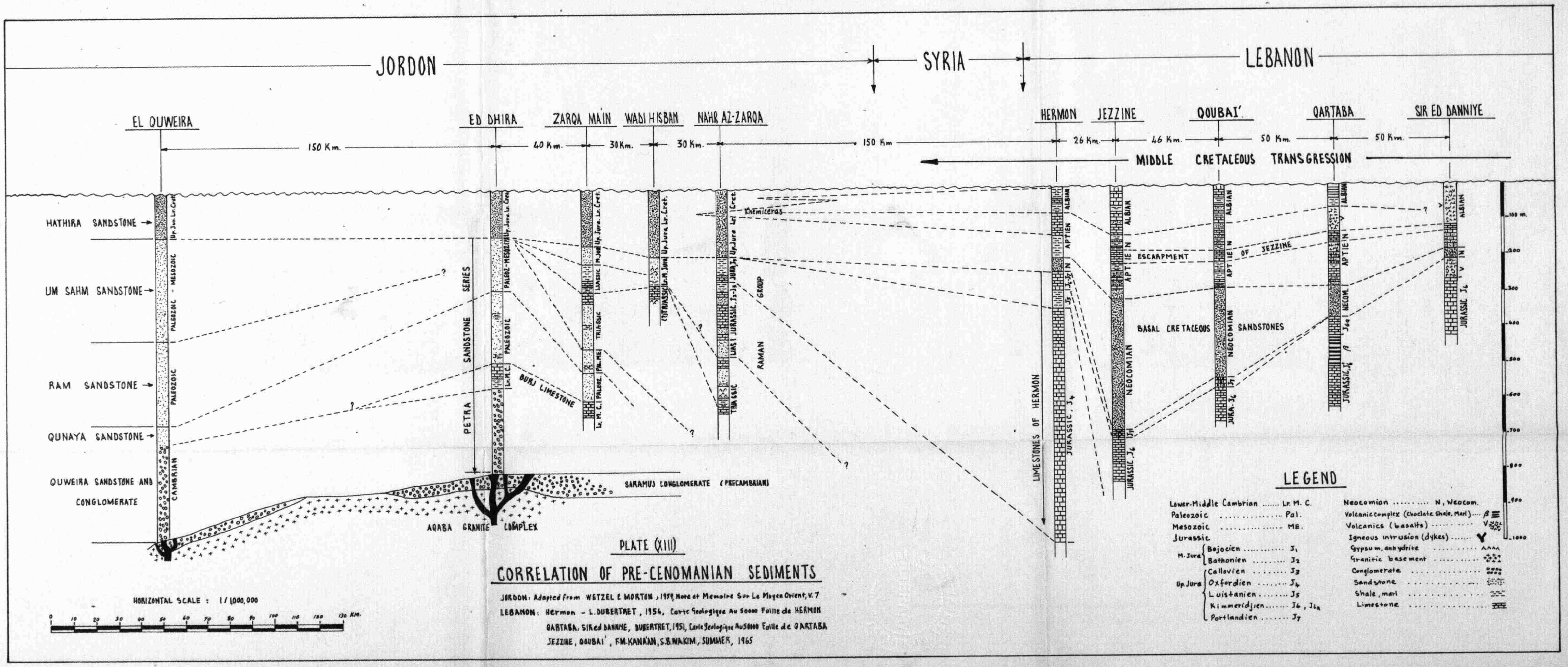


PLATE (XIII)

CORRELATION OF PRE-CENOMANIAN SEDIMENTS

JORDON: Adapted from WETZEL & MORTON, 1959, Note et Memoire Sur Le Moyen Orient, V. 7

LEBANON: Hermon - L. DUBERTRET, 1954, Carte Geologique Au 50000 Fuille de HERMON

QARTABA, SIR ed DANNIYE, DUBERTRET, 1951, Carte Geologique Au 50000 Fuille de QARTABA

JEZZINE, QOUBAI', F.M. KANA'AN, S.B. WAKIM, SUMMER, 1965

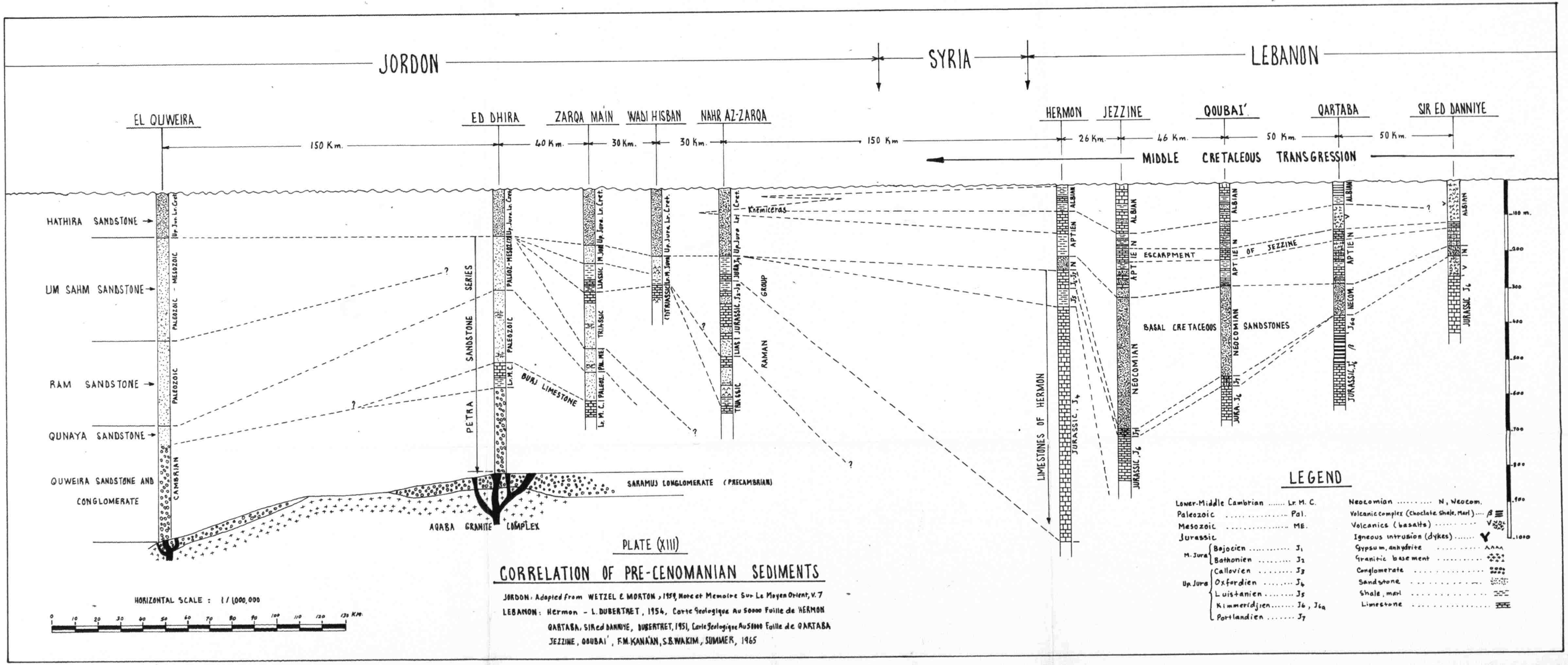
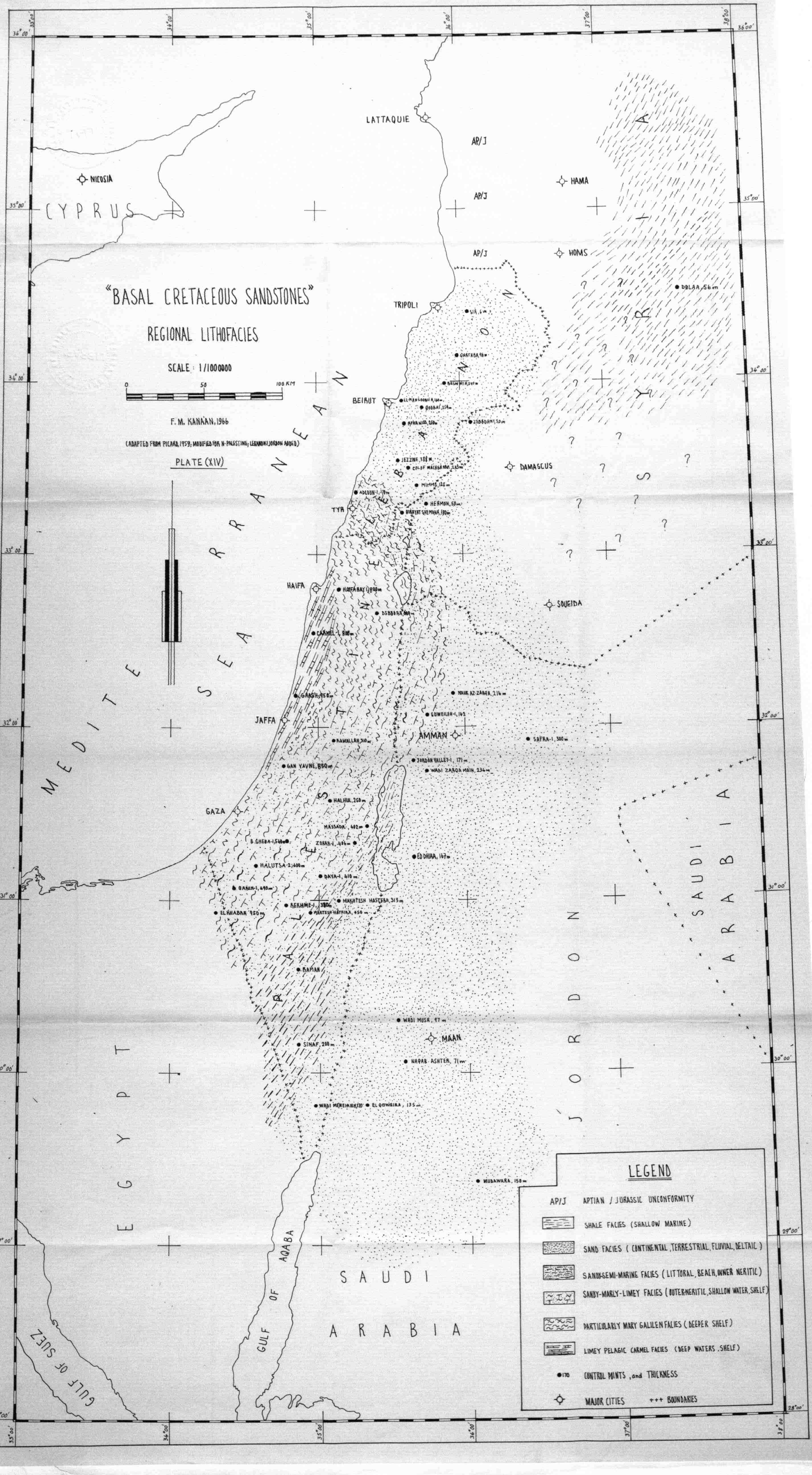
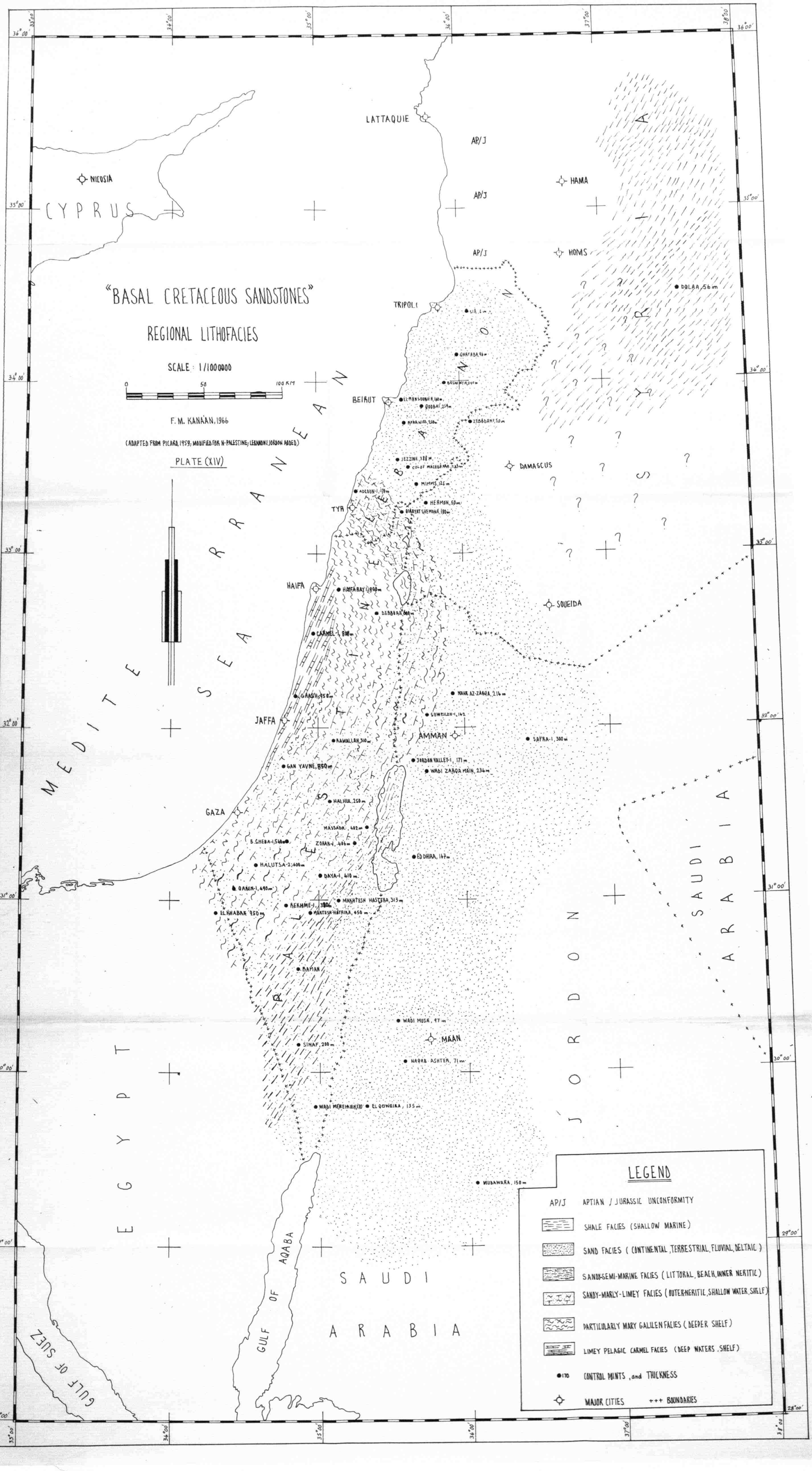


PLATE (XIII)

CORRELATION OF PRE-CENOMANIAN SEDIMENTS

JORDON: Adapted from WETZEL & MORTON, 1959, Note et Memoire Sur Le Moyen Orient, V. 7
LEBANON: Hermon - L. DUBERTRET, 1954, Carte Geologique Au 50000 Fuille de HERMON
QARTABA, SIRed DANNIYE, DUBERTRET, 1951, Carte Geologique Au 50000 Fuille de QARTABA
JEZZINE, QOUBAI', F.M. KANA'AN, S.B. WAKIM, SUMMER, 1965


"BASAL CRETACEOUS SANDSTONES"
REGIONAL LITHOFACIES
SCALE : 1/1000000
0
50
100 KM
F. M. KANAAN, 1966
(ADAPTED FROM PICARD, 1959; MODIFIED FOR N-PALESTINE; LEBANON, JORDAN ADDED)
PLATE (XIV)
LEGEND
AP/J APTIAN / JURASSIC UNCONFORMITY
SHALE FACIES (SHALLOW MARINE)
SAND FACIES (CONTINENTAL, TERRESTRIAL, FLUVIAL, DELTAIC)
SANDY-SEMI-MARINE FACIES (LITTORAL, BEACH, INNER NERITIC)
SANDY-MARLY-LIMEY FACIES (OUTER-NERITIC, SHALLOW WATER, SHELF)
PARTICULARLY MARY GALILEN FACIES (DEEPER SHELF)
LIMEY PELAGIC CARMEL FACIES (DEEP WATERS, SHELF)
CONTROL POINTS, and THICKNESS
MAJOR CITIES
+++ BOUNDARIES
CYPRUS
NICOSIA
LATTAQUIE
TRIPOLI
BEIRUT
TYR
HAIFA
JAFFA
GAZA
HAMA
HOMS
DAMASCUS
SOUEIDA
AMMAN
MAAN
AP/J
MEDITERRANEAN SEA
LEBANON
SYRIA
PALESTINE
JORDON
SAUDI ARABIA
EGYPT
GULF OF AQABA
GULF OF SUEZ
DOLAA, 56 m
JEZZINE, 388 m
HERMON, 50 m
CARMEL-1, 800 m
GAN YAVNE, 850 m
HALHUL, 250 m
MASSADA, 402 m
ZOHAR-1, 486 m
HALUTSA-2, 400 m
DAYA-1, 410 m
MAKHTESH HASTERA, 315 m
MAKTESH HATRIRA, 450 m
EL KHABRA 350 m
RAMAN
SINAF, 200 m
WADI MUSA, 47 m
NAQAB ASHTER, 71 m
EL QOWEIRA, 135 m
MUDAWARA, 150 m
ED DHIRA, 147 m
JORDAN VALLEY-1, 171 m
WADI ZARQA MAIN, 234 m
SUWEILEH-1, 162
NAUR AZ-ZARQA, 216 m
SAFRA-1, 380 m
RAMALLAH, 310 m
36°00'
35°00'
34°00'
33°00'
32°00'
31°00'
30°00'
29°00'
28°00'
37°00'
38°00'



"BASAL CRETACEOUS SANDSTONES"
REGIONAL LITHOFACIES
SCALE : 1/1000000
0 50 100 KM
F. M. KANAAN, 1966
(ADAPTED FROM PICARD, 1959; MODIFIED FOR N-PALESTINE; LEBANON, JORDON ADDED)
PLATE (XIV)
LEGEND
AP/J APTIAN / JURASSIC UNCONFORMITY
SHALE FACIES (SHALLOW MARINE)
SAND FACIES (CONTINENTAL, TERRESTRIAL, FLUVIAL, DELTAIC)
SANDY-SEMI-MARINE FACIES (LITTORAL, BEACH, INNER NERITIC)
SANDY-MARLY-LIMEY FACIES (OUTER-NERITIC, SHALLOW WATER, SHELF)
PARTICULARLY MARY GALILEN FACIES (DEEPER SHELF)
LIMEY PELAGIC CARMEL FACIES (DEEP WATERS, SHELF)
CONTROL POINTS, and THICKNESS
MAJOR CITIES +++ BOUNDARIES
CYPRUS
NICOSIA
LATTAQUIE
HAMA
HOMS
TRIPOLI
BEIRUT
DAMASCUS
TYR
HAIFA
SOUEIDA
JAFFA
AMMAN
GAZA
MAAN
MEDITERRANEAN SEA
LEBANON
SYRIA
PALESTINE
JORDON
SAUDI ARABIA
EGYPT
GULF OF AQABA
GULF OF SUEZ
AP/J
DOLAA, 56 m
HERMON, 60 m
JEZZINE, 388 m
HAIFA BAY, 800 m
CARMEL-1, 800 m
GAASH, 950 m
RAMALLAH, 310 m
GAN YAVNE, 850 m
HALHUL, 250 m
MASSADA, 402 m
ZOHAR-1, 486 m
HALUTSA-2, 400 m
DAYA-1, 410 m
MAKHTESH HASTERA, 313 m
MAKTESH HATRIRA, 450 m
EL KHABAR, 850 m
RAMAN
NAHR AZ-ZARQA, 216 m
SUWEILEH-1, 142
SAFRA-1, 300 m
JORDAN VALLEY-1, 171 m
WADI ZARQA MAIN, 234 m
ED DHIRA, 147 m
WADI MUSA, 47 m
NAQAB ASHTER, 71 m
SINAF, 200 m
EL QUWEIRA, 135 m
MUDAWARA, 150 m

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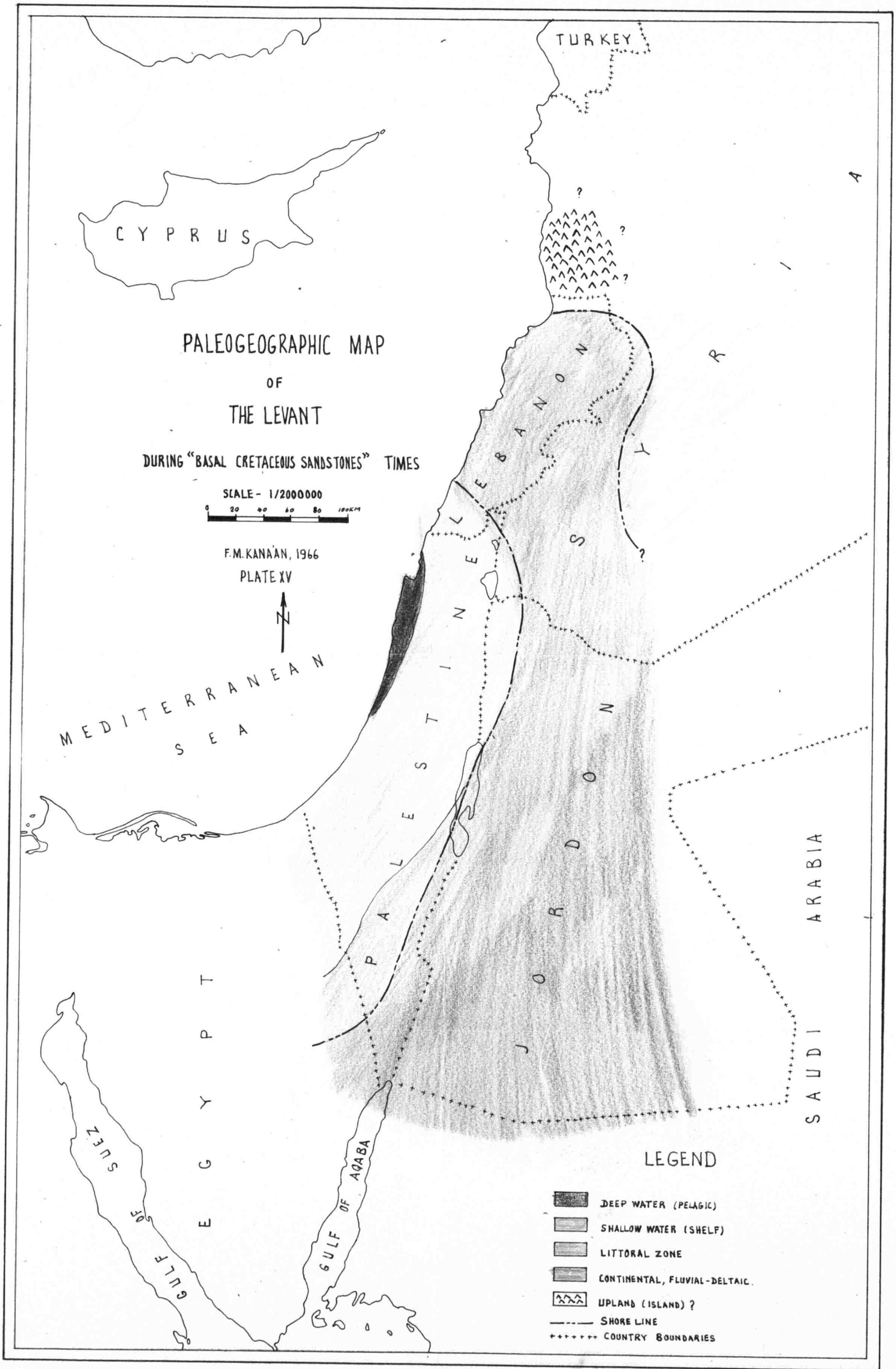
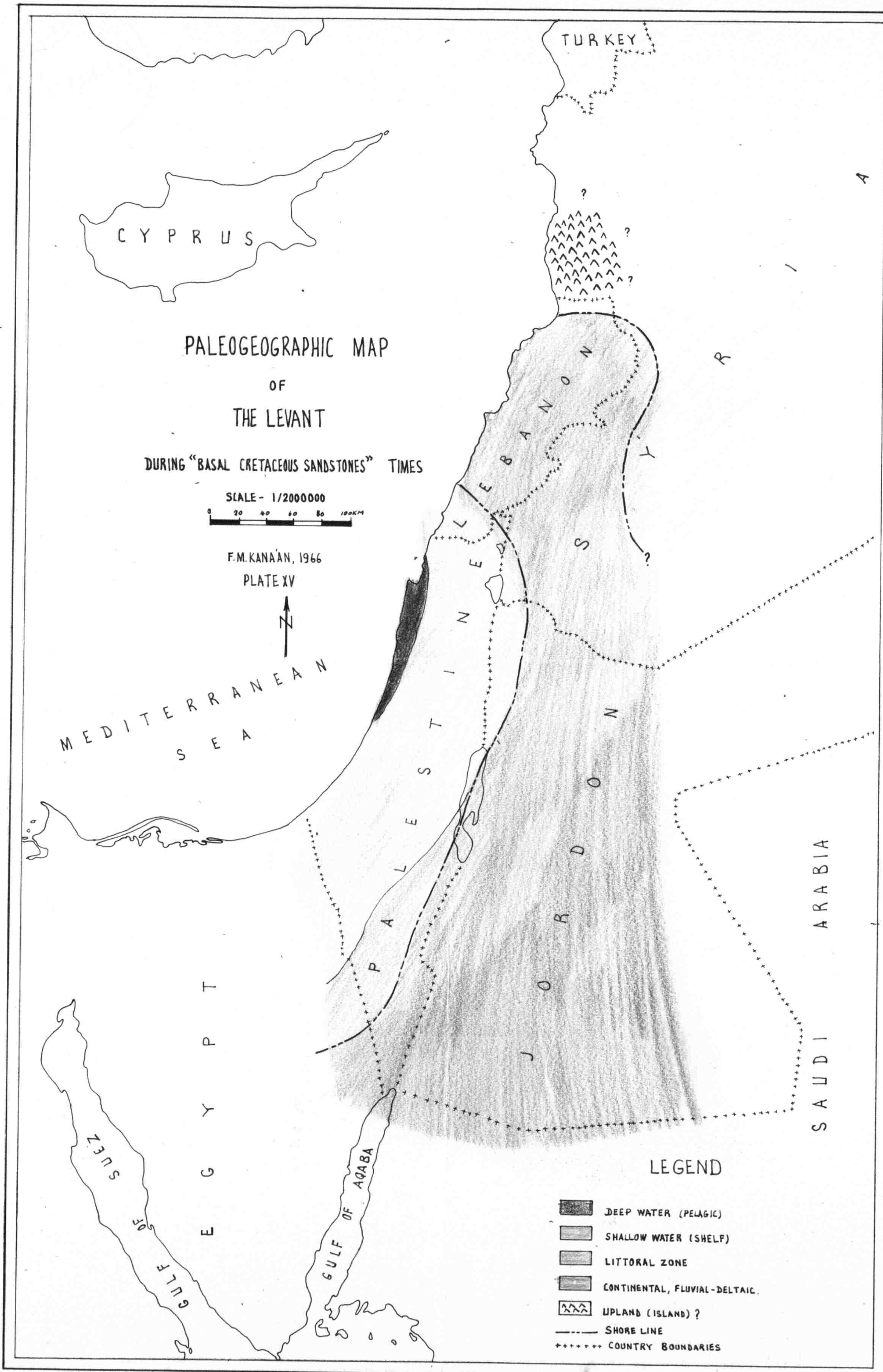

PALEOGEOGRAPHIC MAP
OF
THE LEVANT
DURING "BASAL CRETACEOUS SANDSTONES" TIMES
SCALE - 1/2000000
0 20 40 60 80 100KM
F.M. KANA'AN, 1966
PLATE XV
N
TURKEY
CYPRUS
SYRIA
LEBANON
PALESTINE
JORDON
MEDITERRANEAN SEA
EGYPT
SAUDI ARABIA
GULF OF SUEZ
GULF OF AQABA
LEGEND
DEEP WATER (PELAGIC)
SHALLOW WATER (SHELF)
LITTORAL ZONE
CONTINENTAL, FLUVIAL-DELTAIC.
UPLAND (ISLAND) ?
SHORE LINE
COUNTRY BOUNDARIES

15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CYPRUS
MEDITERRANEAN
SEA
LEBANON
SYRIA
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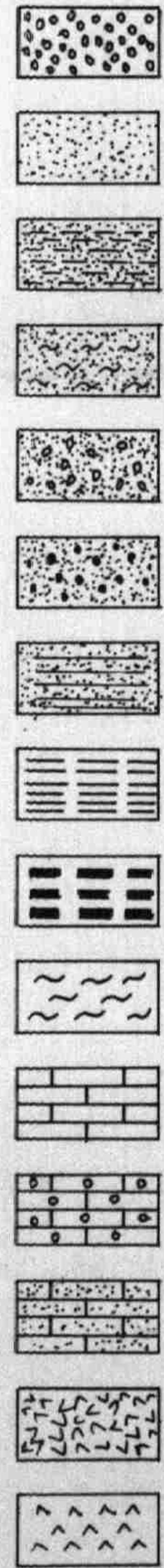
DEEP WATER (PELAGIC)
SHALLOW WATER (SHELF)
LITTORAL ZONE
CONTINENTAL, FLUVIAL-DELTAIC.
UPLAND (ISLAND) ?
SHORE LINE
COUNTRY BOUNDARIES

LEGEND

FOR ALL STRATIGRAPHIC SECTIONS IN TEXT

PLATE (XVI)



CONGLOMERATE

SANDSTONE

ARGILLACEOUS SANDSTONE

MARLY SANDSTONE

PISOLITIC SANDSTONE

SANDSTONE WITH PYRITE NODULES

SANDSTONE WITH CARBONOCEOUS MATERIAL

CLAY AND SHALES

LIGNITES

MARLS

LIMESTONES

OOLITIC LIMESTONE

SANDY LIMESTONES

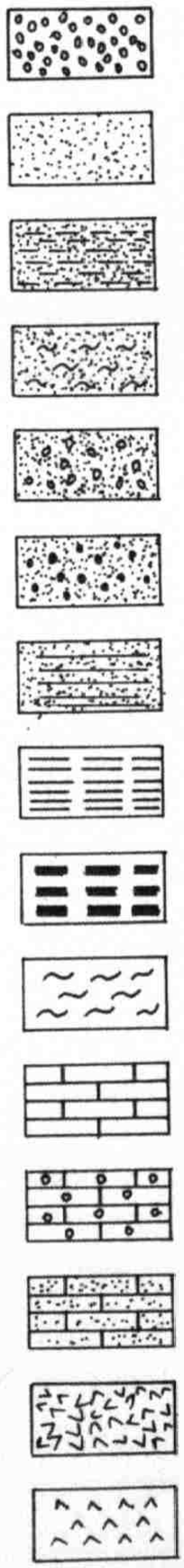
VOLCANICS - BASALT, TUFF, CHOCLATE CLAYS

ANHYDRITE & GYPSUM

LEGEND

FOR ALL STRATIGRAPHIC SECTIONS IN TEXT

PLATE (XVI)

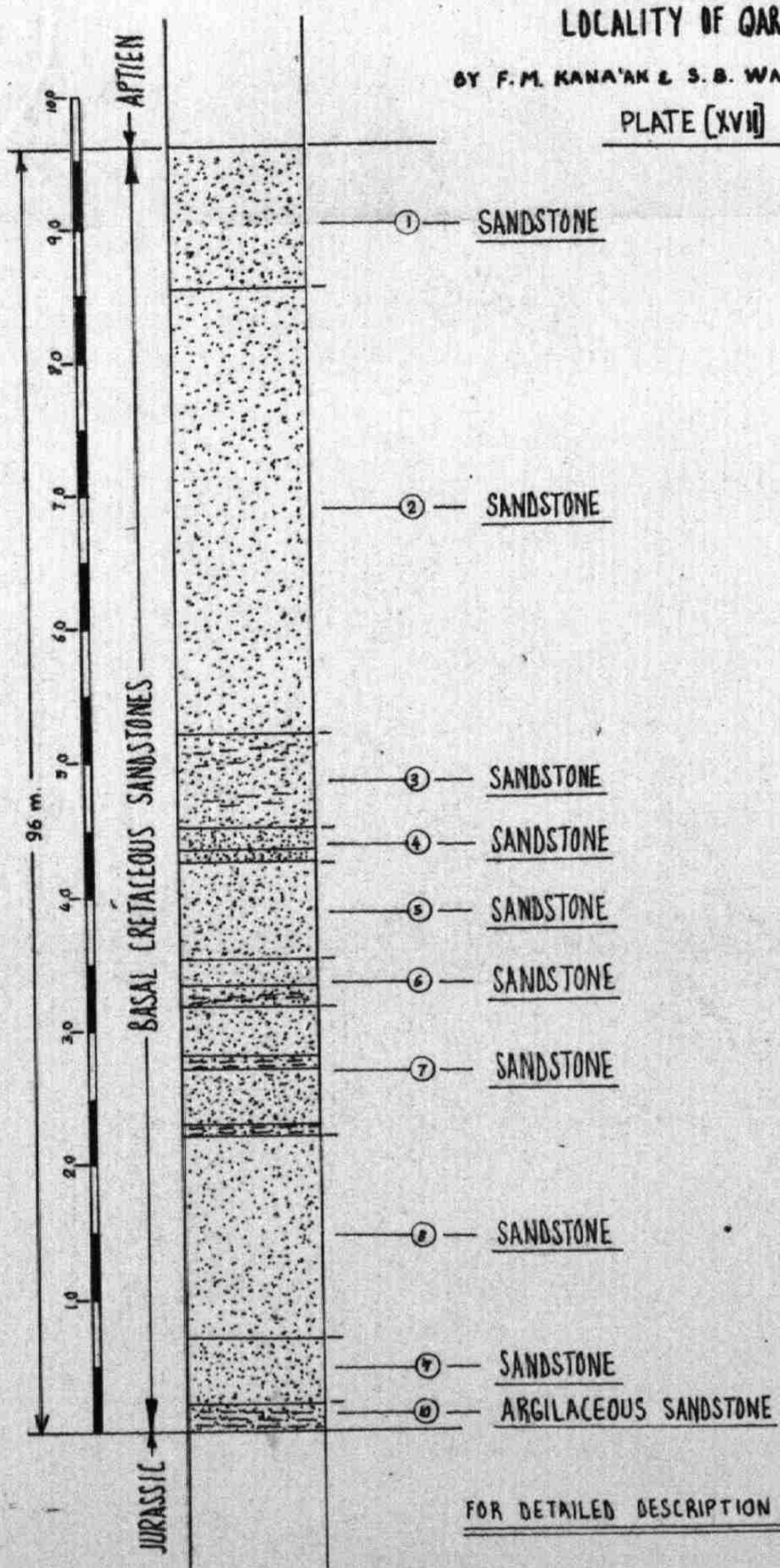


- CONGLOMERATE
- SANDSTONE
- ARGILLACEOUS SANDSTONE
- MARLY SANDSTONE
- PISOLITIC SANDSTONE
- SANDSTONE WITH PYRITE NODULES
- SANDSTONE WITH CARBONOCEOUS MATERIAL
- CLAY AND SHALES
- LIGNITES
- MARLS
- LIMESTONES
- OOLITIC LIMESTONE
- SANDY LIMESTONES
- VOLCANICS - BASALT, TUFF, CHOCLATE CLAYS
- ANHYDRITE & GYPSUM

STRATIGRAPHIC SECTION
«BASAL CRETACEOUS SANDSTONES» OF CENTRAL LEBANON
LOCALITY OF QARTABA

BY F.M. KANA'AK & S.B. WAKIM, SUMMER 1965

PLATE [XVII]

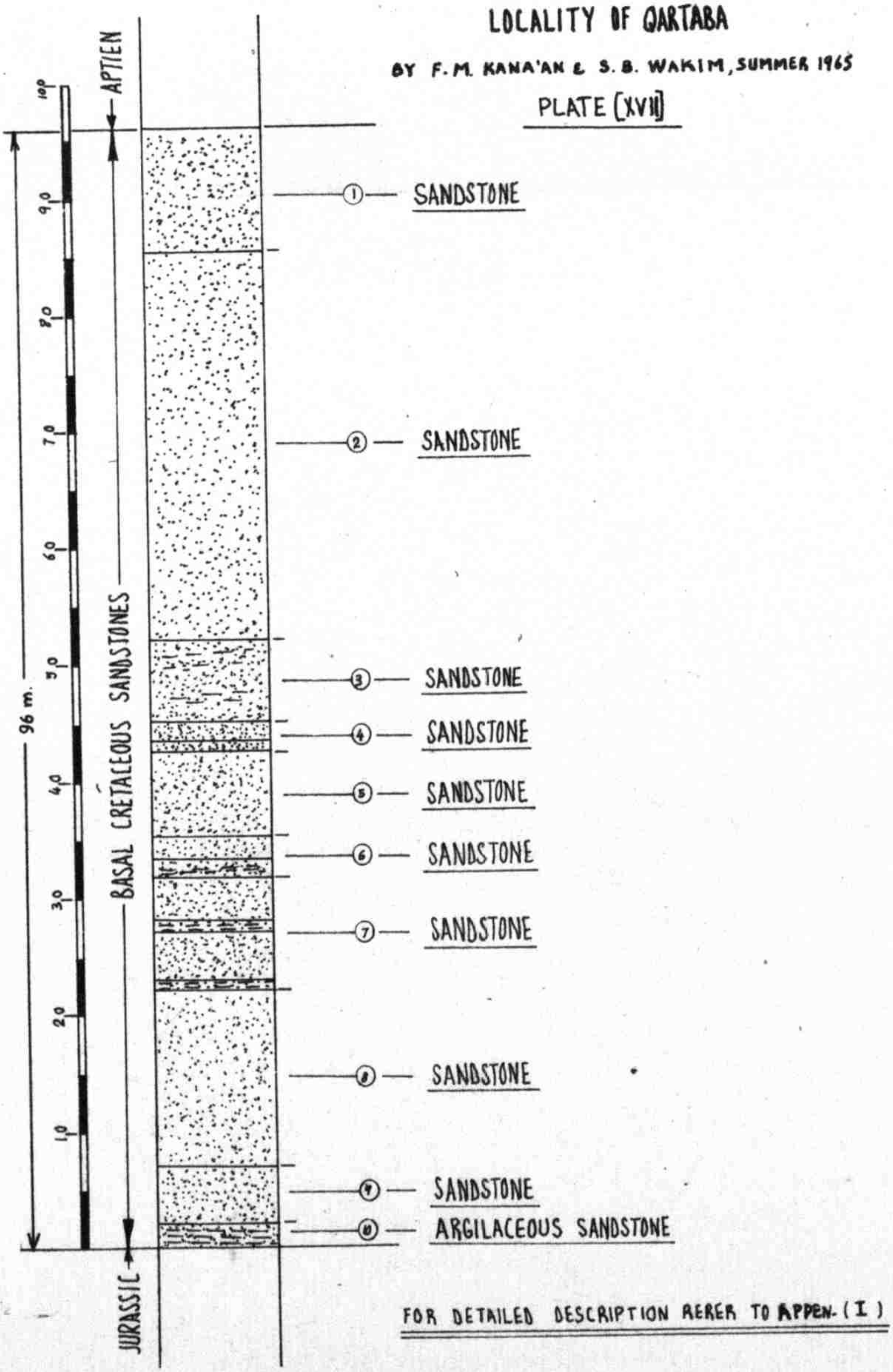


FOR DETAILED DESCRIPTION REFER TO APPEN. (I)

STRATIGRAPHIC SECTION
«BASAL CRETACEOUS SANDSTONES» OF CENTRAL LEBANON
LOCALITY OF QARTABA

BY F. M. KANA'AN & S. B. WAKIM, SUMMER 1965

PLATE [XVII]



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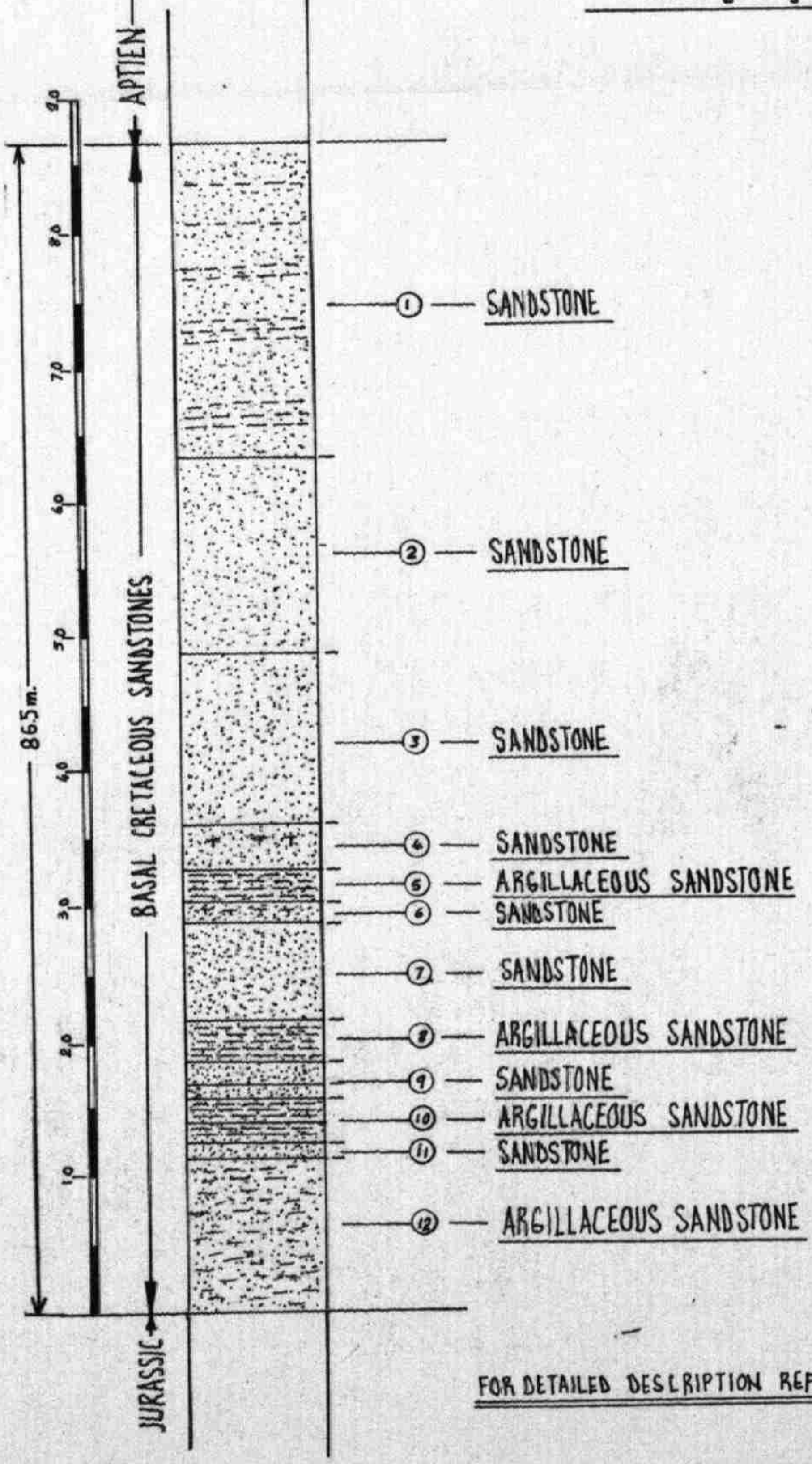
STRATIGRAPHIC SECTION

«BASAL CRETACEOUS SANDSTONES» OF CENTRAL LEBANON

LOCALITY OF JOURET EL-TORMOS

BY F. M. KANA'AN & S. B. WAKIM, SUMMER, 1965

PLATE [XVIII]



FOR DETAILED DESCRIPTION REFER TO APPEN. (II)

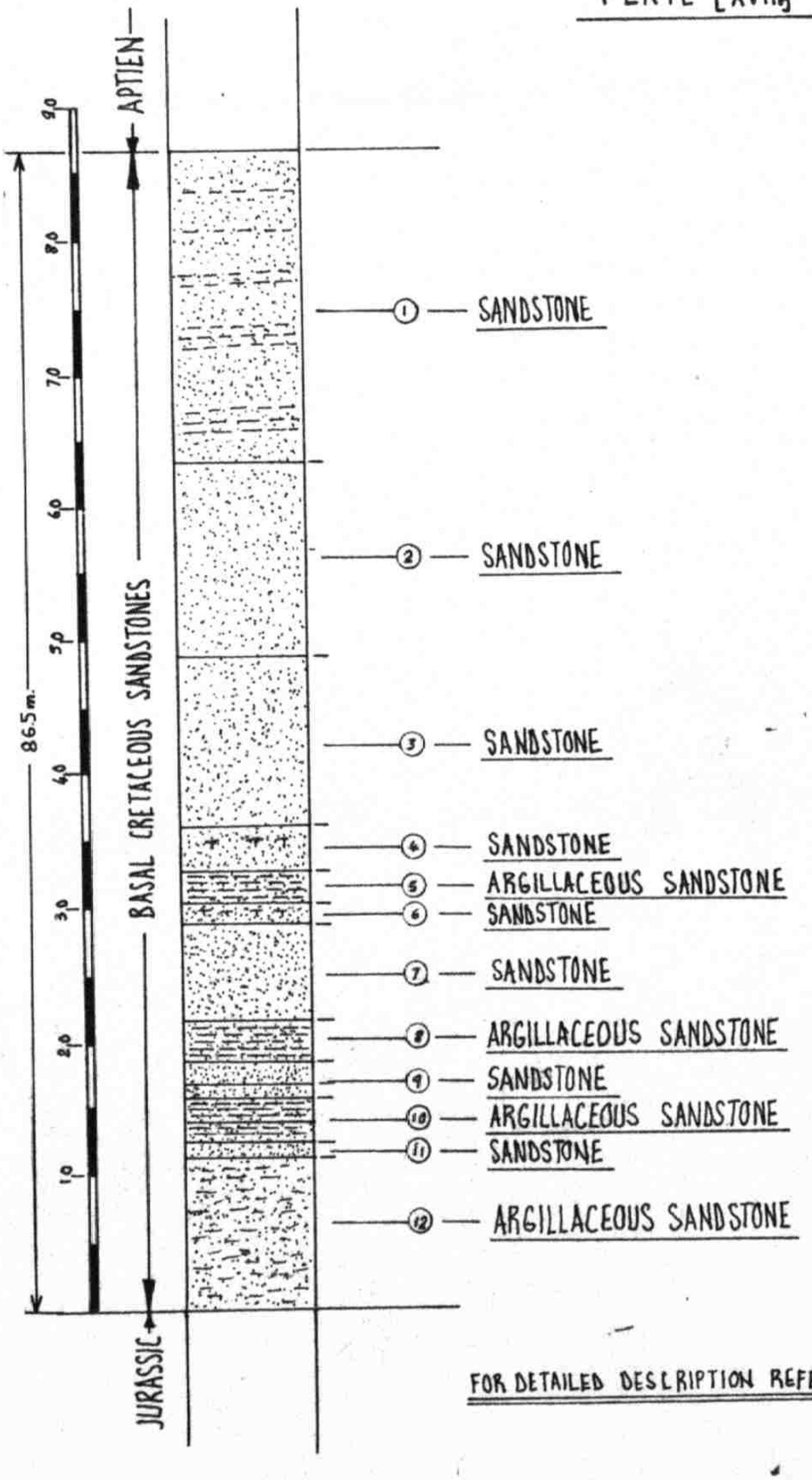
STRATIGRAPHIC SECTION

«BASAL CRETACEOUS SANDSTONES» OF CENTRAL LEBANON

LOCALITY OF JOURET EL-TORMOS

BY F. M. KANA'AN & S. B. WAKIM , SUMMER, 1965

PLATE [XVIII]



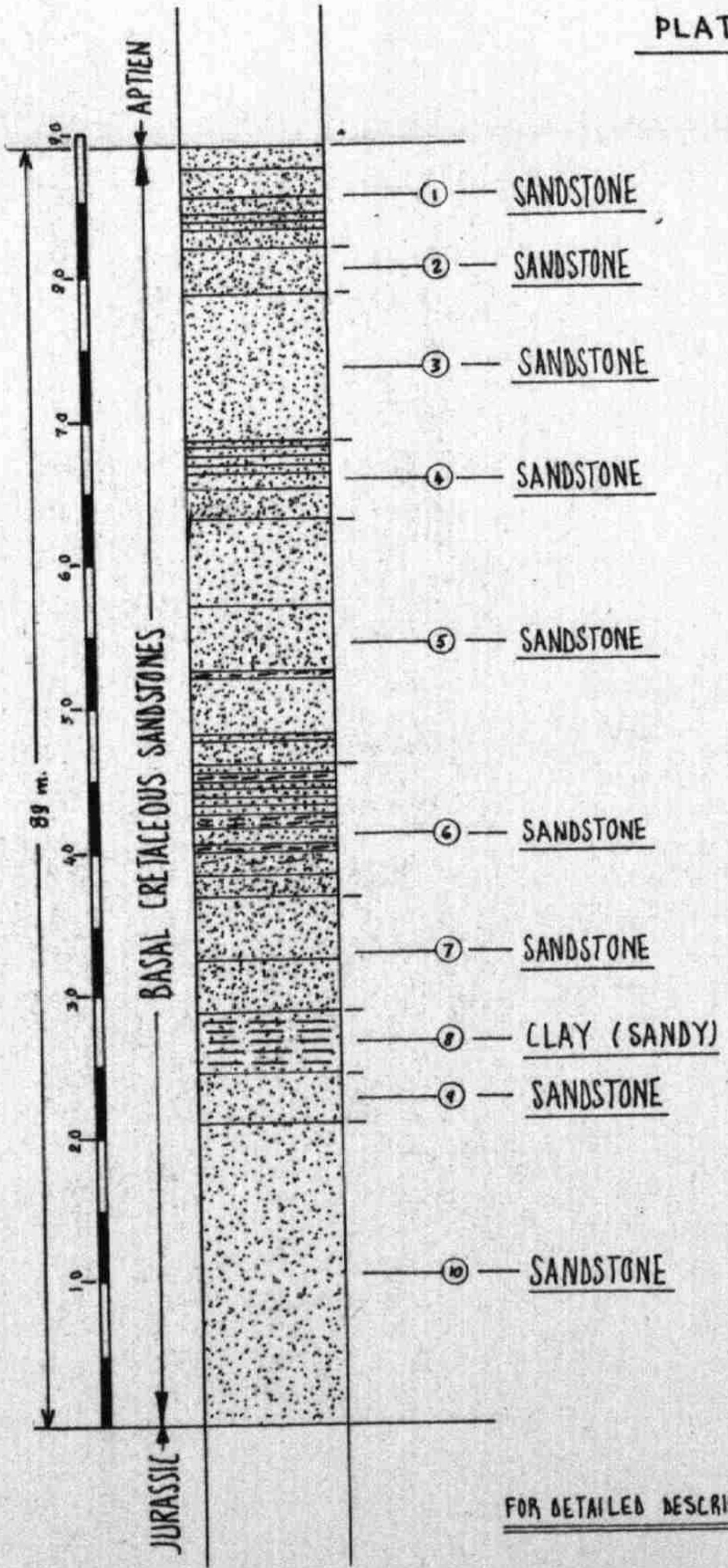
FOR DETAILED DESCRIPTION REFER TO APPEN. (II)

19.

STRATIGRAPHIC SECTION
« BASAL CRETACEOUS SANDSTONES » OF CENTRAL LEBANON
LOCALITY OF QATTIN

BY F.M. KANA'AN & S.B. WAKIM, SUMMER 1965

PLATE [XIX]



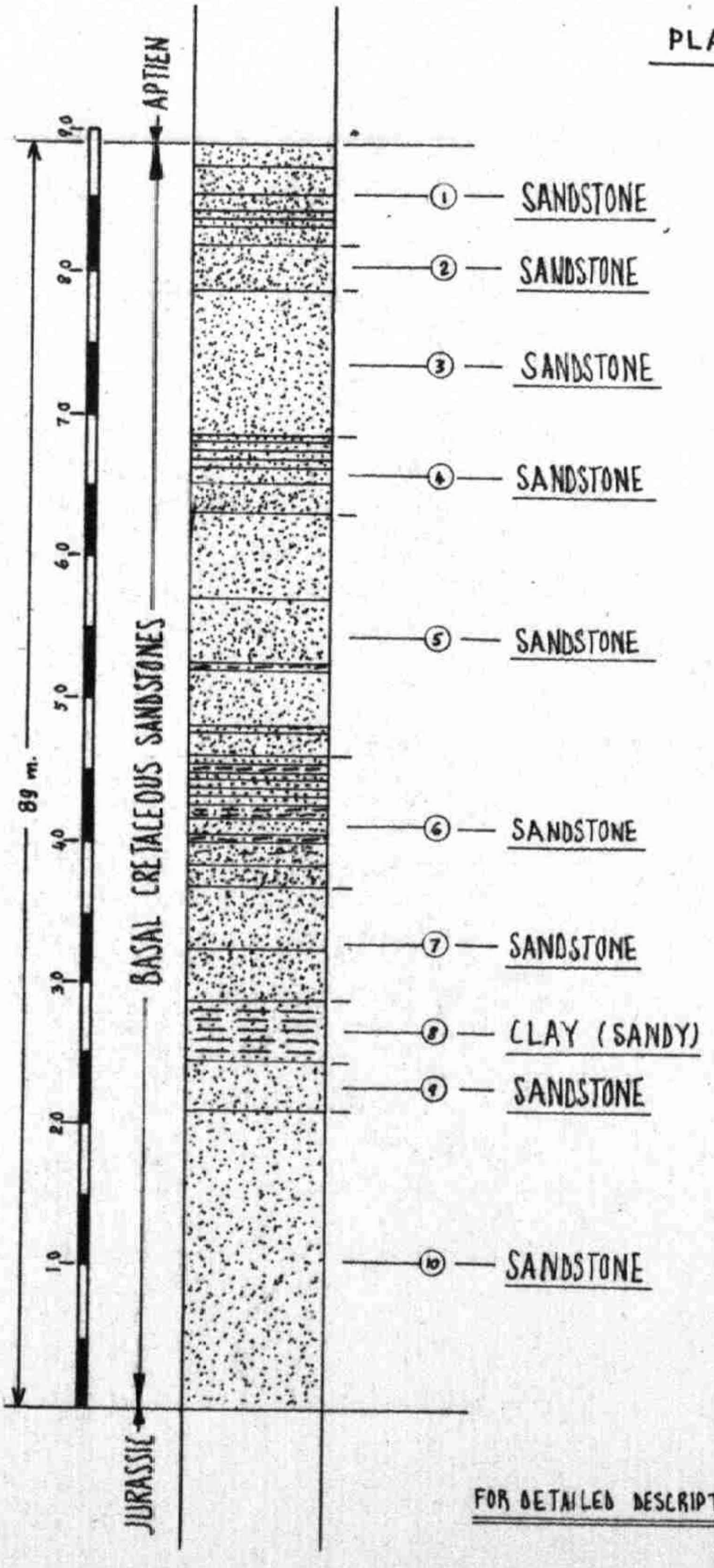
FOR DETAILED DESCRIPTION REFER TO APPEN (III)

19.

STRATIGRAPHIC SECTION
«BASAL CRETACEOUS SANDSTONES» OF CENTRAL LEBANON
LOCALITY OF QATTIN

BY F. M. HANA'AN & S. B. WAKIM, SUMMER 1965

PLATE [XIX.]



FOR DETAILED DESCRIPTION REFER TO APPEN (III)

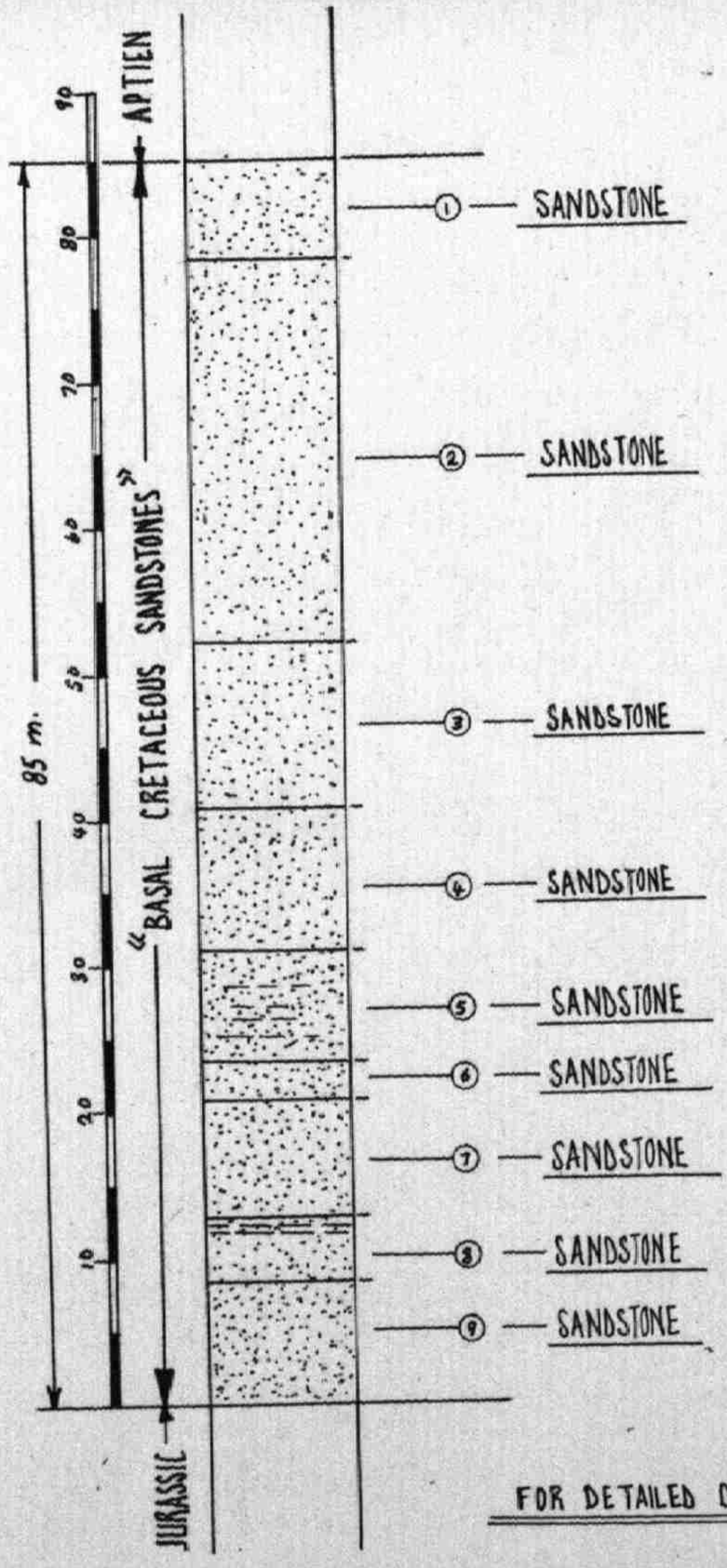
STRATIGRAPHIC SECTION

"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON

LOCALITY OF AIN-TOURA

BY F. M. KANA'AN & S. B. WAKIM, SUMMER, 1965

PLATE [XX]



FOR DETAILED DESCRIPTION REFER TO APPEN. (IV)

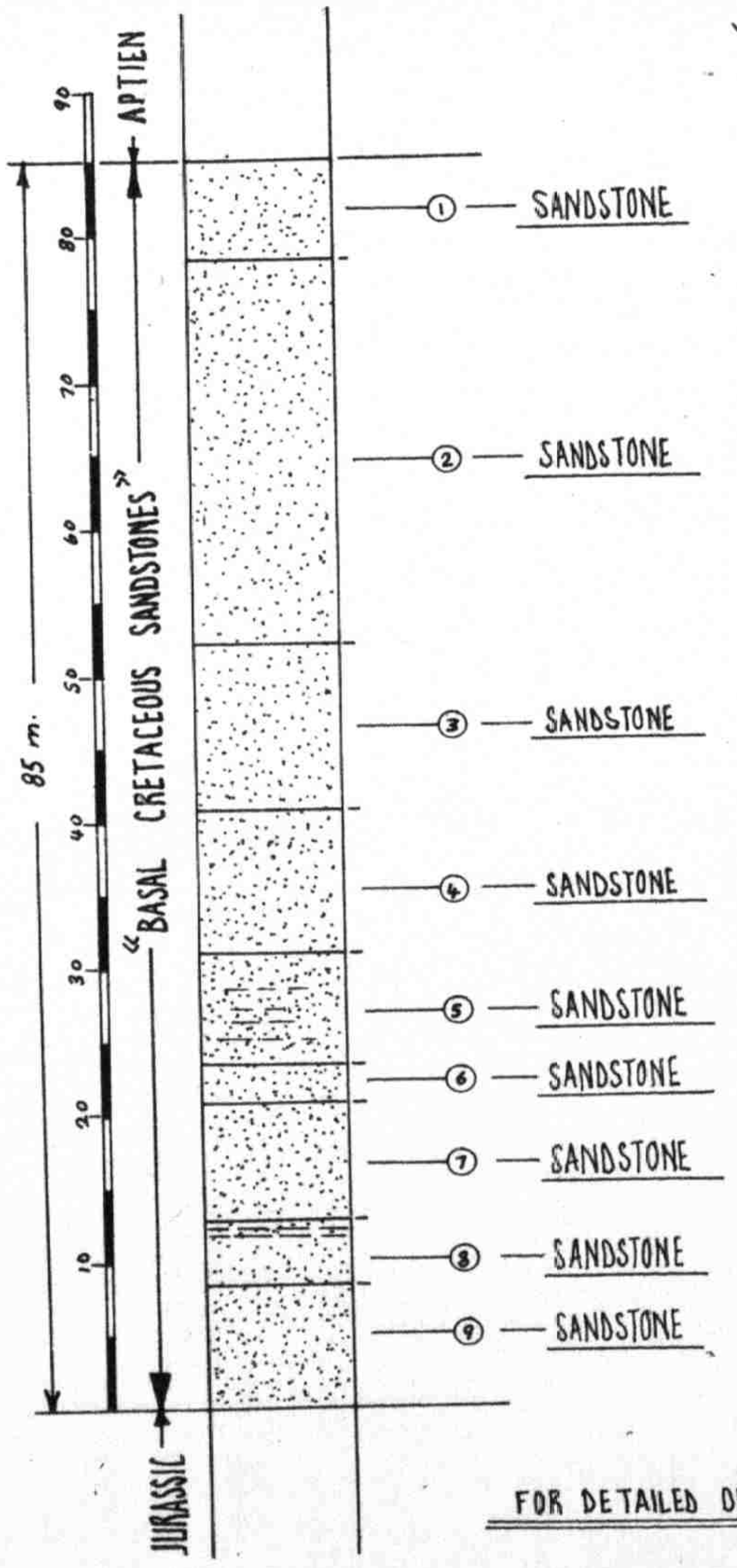
STRATIGRAPHIC SECTION

"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON

LOCALITY OF AIN-TOURA

BY F. M. KANA'AN, & S. B. WAKIM, SUMMER, 1965

PLATE [XX]



FOR DETAILED DESCRIPTION REFER TO APPEN. (IV)

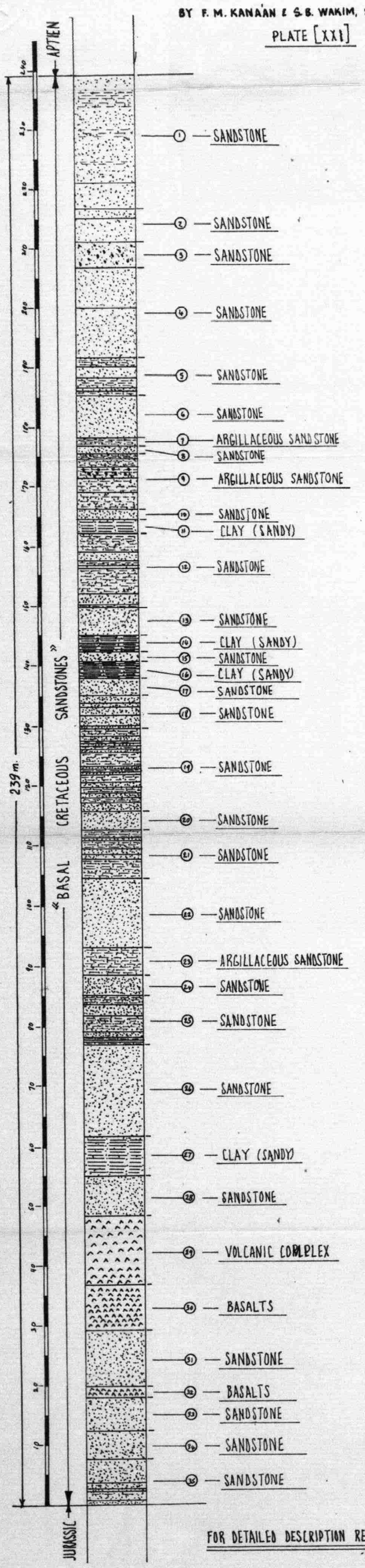
STRATIGRAPHIC SECTION

"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON

LOCALITY OF BESKINTA

BY F. M. KANA'AN & S.B. WAKIM, SUMMER, 1965

PLATE [XXI]

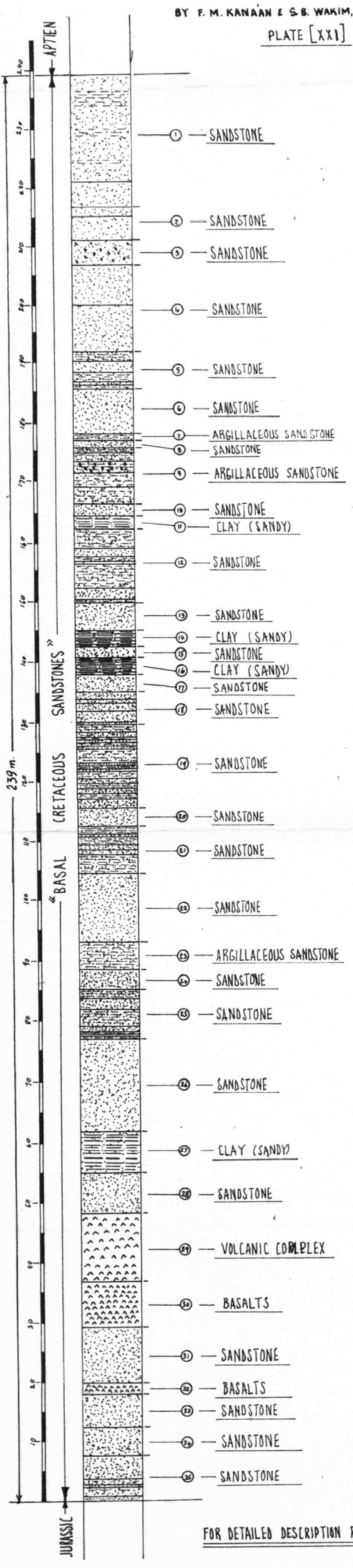


FOR DETAILED DESCRIPTION REFER TO APPEN. (V)

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF BESKINTA

BY F. M. KANA'AN & S.B. WAKIM, SUMMER, 1965

PLATE [XXI]

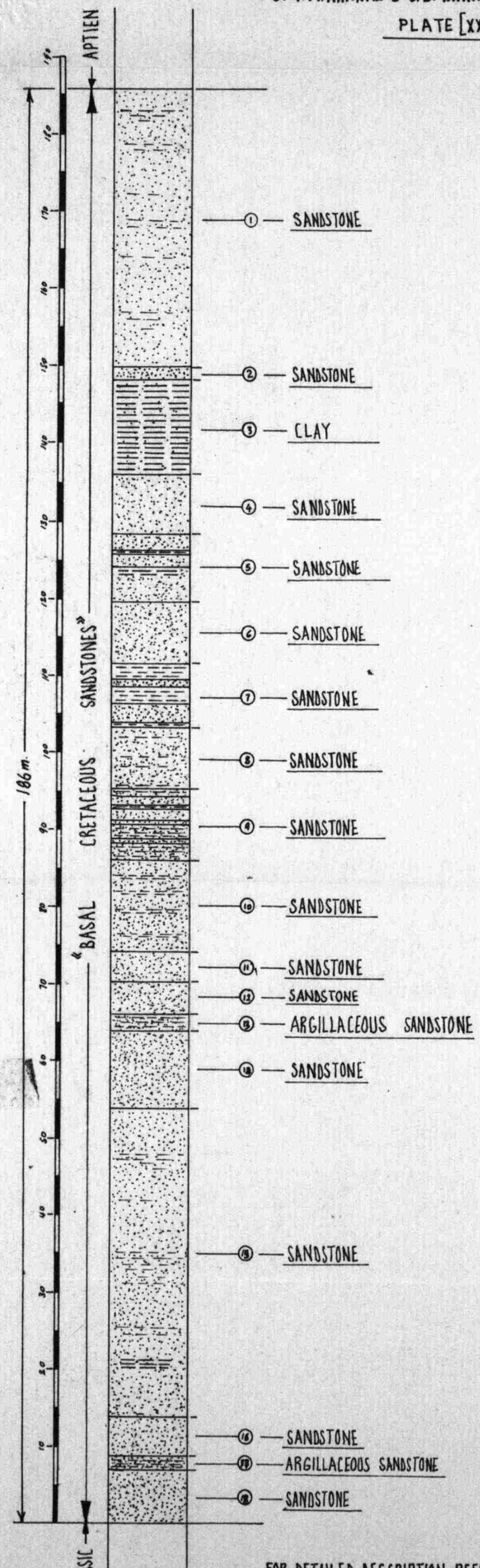


FOR DETAILED DESCRIPTION REFER TO APPEN. (V)

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF MAJDAL-TARCHICH

BY F. M. KANA'AN & S. B. WAKIM, SUMMER, 1965

PLATE [XXII]

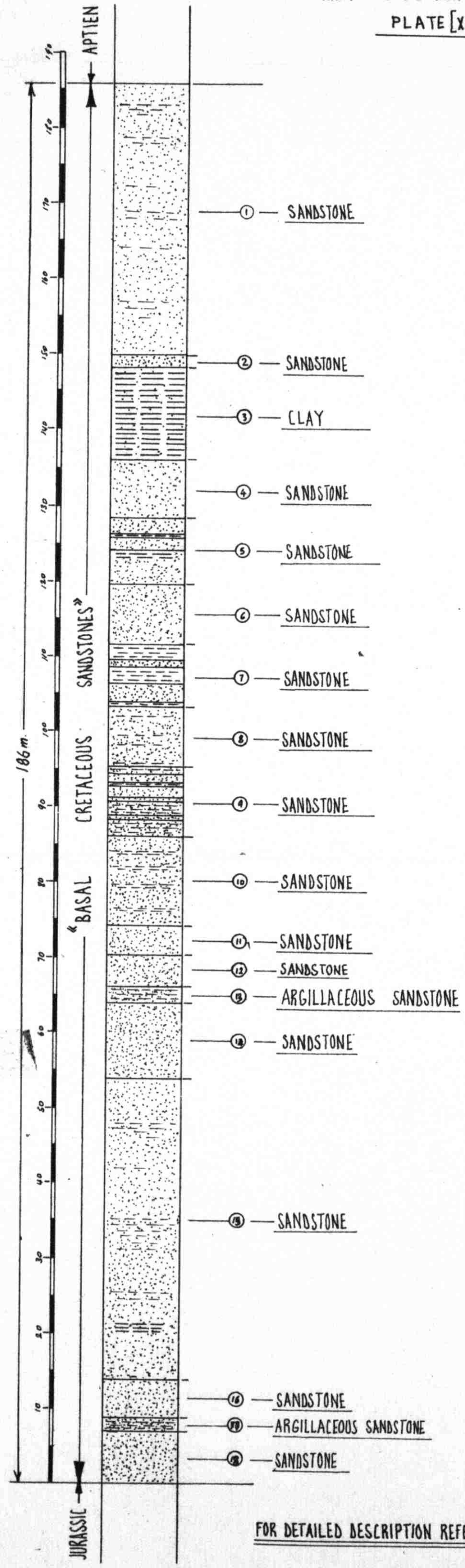


FOR DETAILED DESCRIPTION REFER TO APPEN (VI)

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF MAJDAL-TARCHICH

BY F.M. KANA'AN & S.B. WAKIM, SUMMER, 1965

PLATE [XXII]

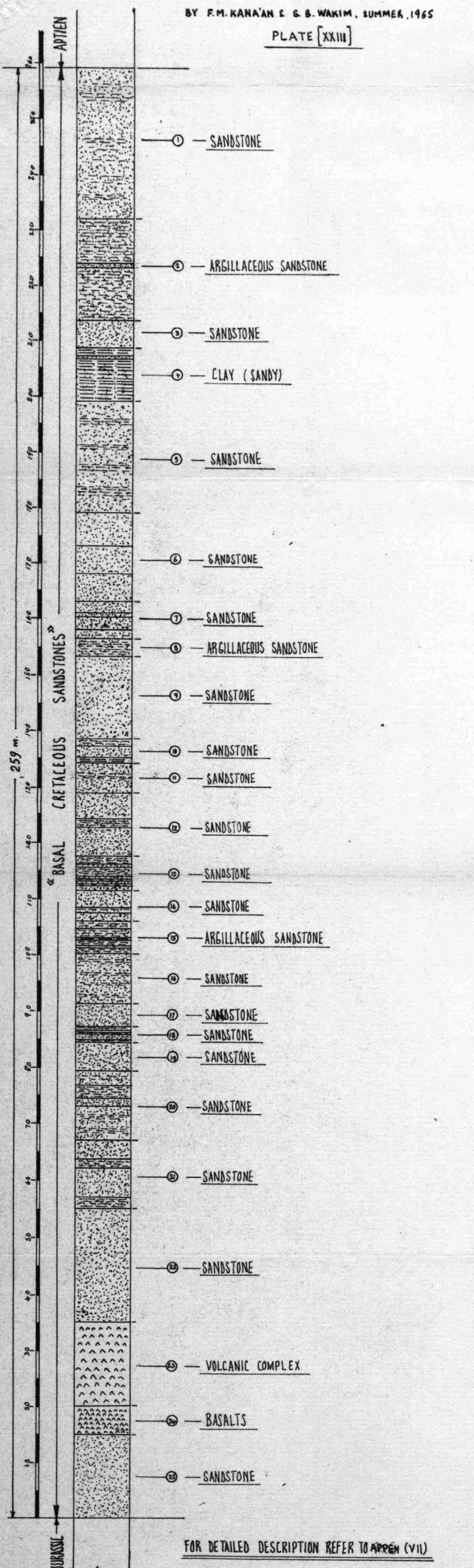


FOR DETAILED DESCRIPTION REFER TO APPEN (VI)

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF QUOBAI´

BY F.M. KANA'AN & S.B. WAKIM, SUMMER, 1965

PLATE [XXIII]

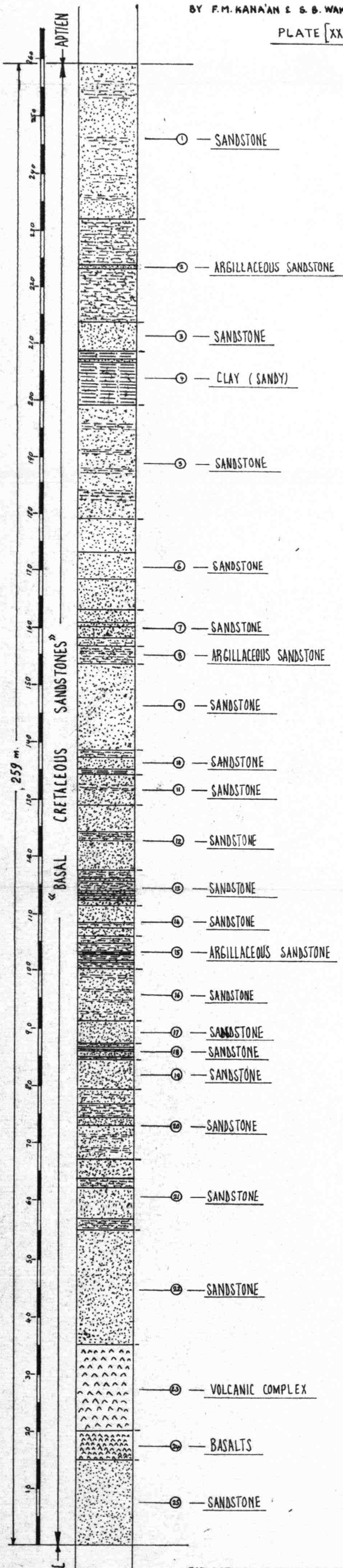


FOR DETAILED DESCRIPTION REFER TO APPEN (VII)

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF QUOBAI´

BY F.M. KANA'AN & S.B. WAKIM, SUMMER, 1965

PLATE [XXIII]

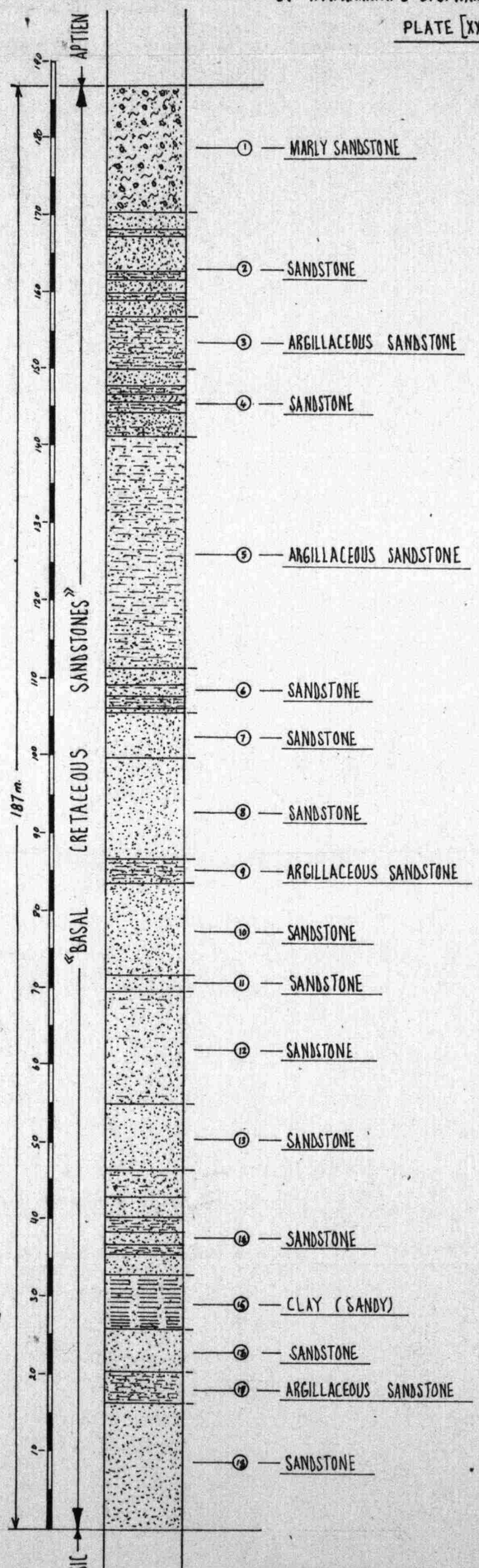


FOR DETAILED DESCRIPTION REFER TO APPEN (VII)

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF AGHMID

BY F. M. KANA'AN & S. B. WAKIM, SUMMER 1965

PLATE [XXIV] XXIV

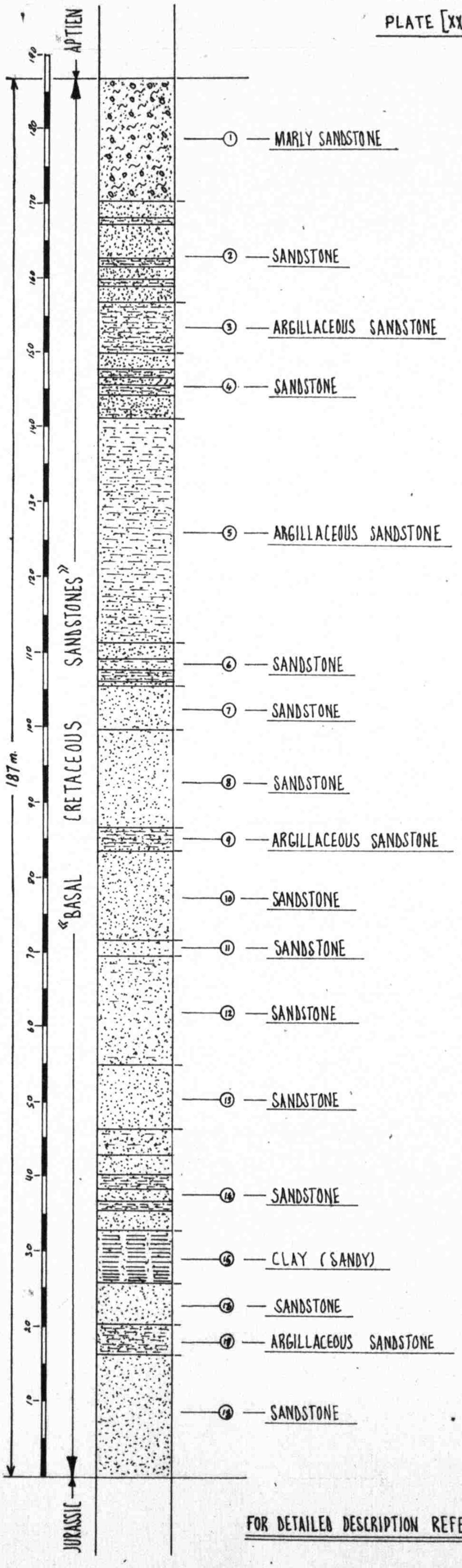


FOR DETAILED DESCRIPTION REFER TO APPEN (VIII)

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF AGHMID

BY F. M. KANA'AN & S. B. WAKIM, SUMMER 1965

PLATE [XXIV] XXIV

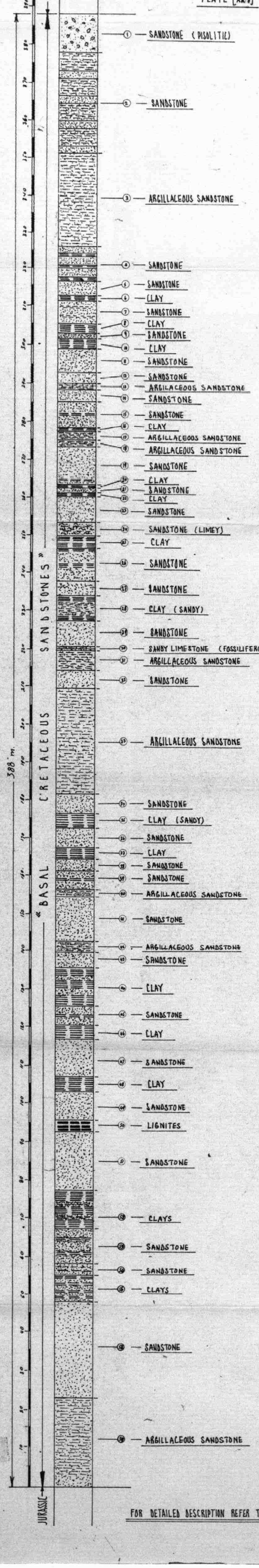


FOR DETAILED DESCRIPTION REFER TO APPEN (VIII)

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF JEZZINE

BY F. M. KANA'AN S, S. B. WAKIM, SUMMER, 1965

PLATE [XXV]

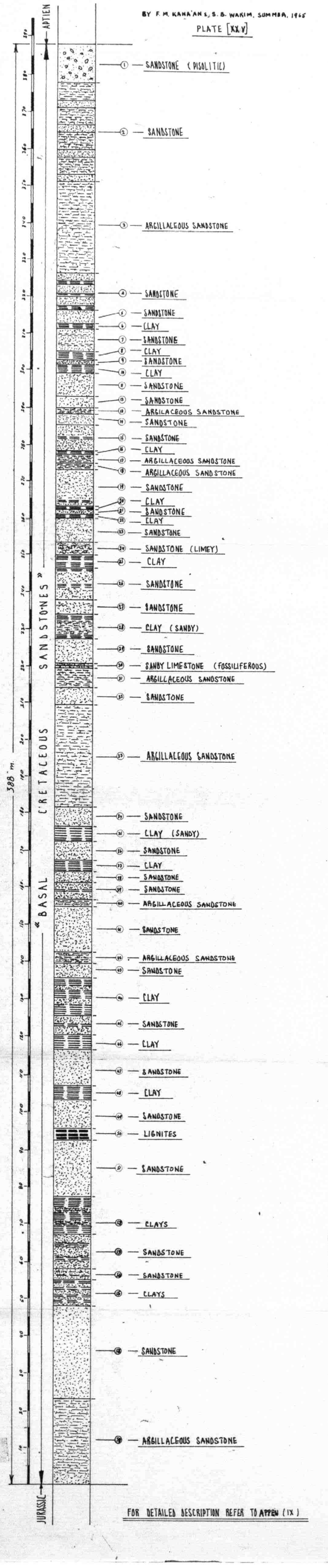


FOR DETAILED DESCRIPTION REFER TO APPEN (IX)

25

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF JEZZINE

BY F. M. KANA'AN S, S. B. WAKIM, SUMMER, 1965
PLATE [XXV]



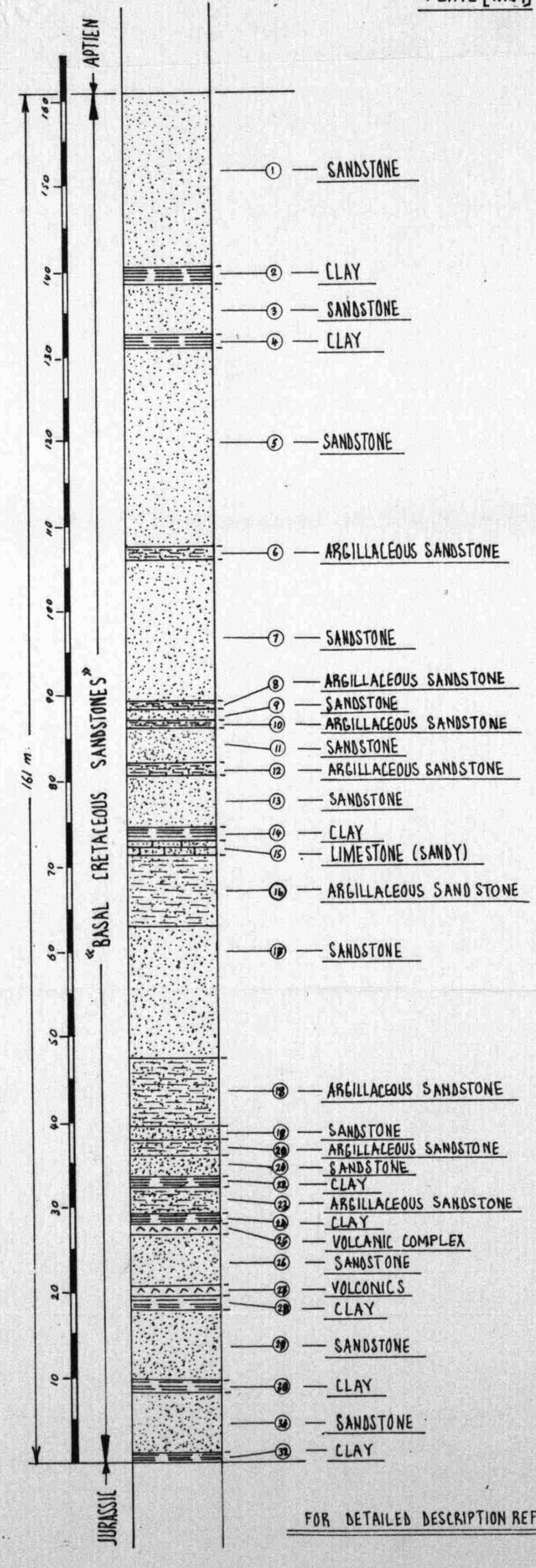
FOR DETAILED DESCRIPTION REFER TO APPEN (IX)

STRATIGRAPHIC SECTION

"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON

LOCALITY OF W-AL-MANSOURIEH

PLATE [XXVI]



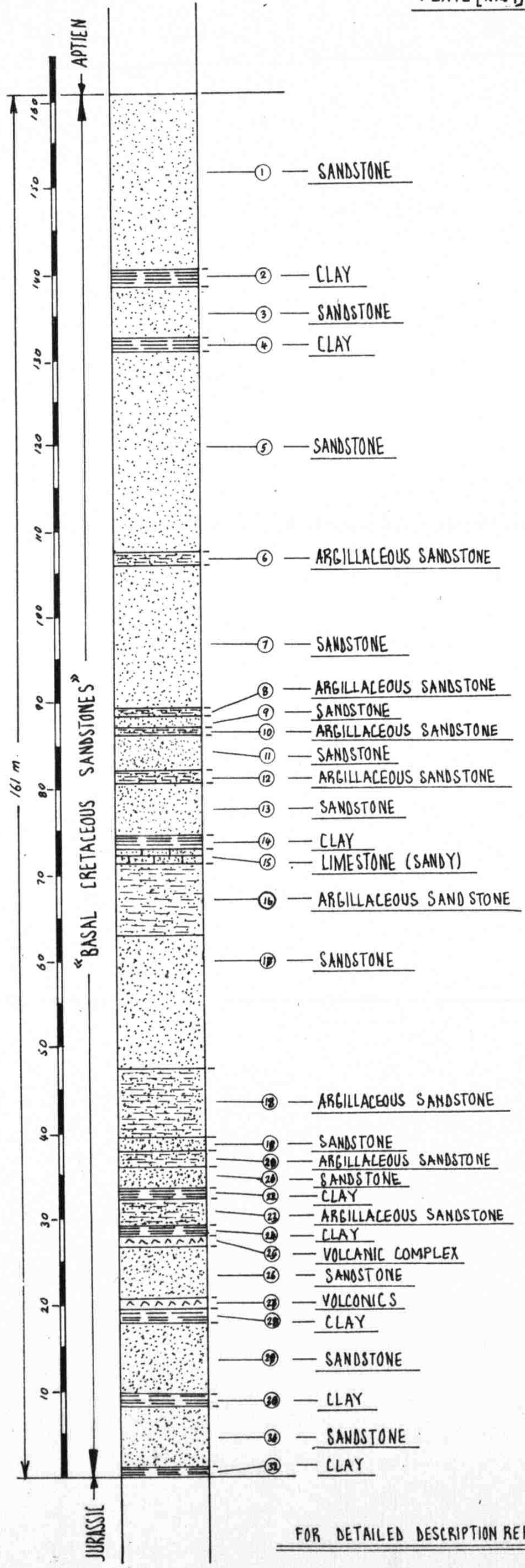
FOR DETAILED DESCRIPTION REFER TO APPEN (XI)

STRATIGRAPHIC SECTION

«BASAL CRETACEOUS SANDSTONES» OF CENTRAL LEBANON

LOCALITY OF W-AL-MANSOURIEH

PLATE [XXVI]



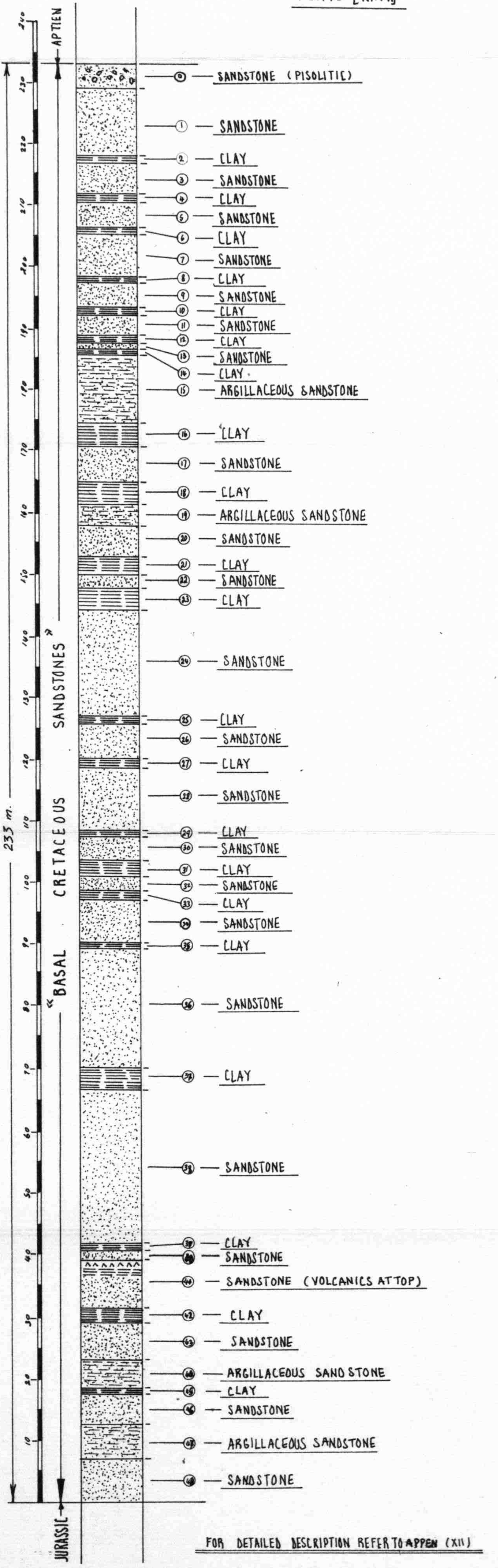
FOR DETAILED DESCRIPTION REFER TO APPEN (XI)

STRATIGRAPHIC SECTION

"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON

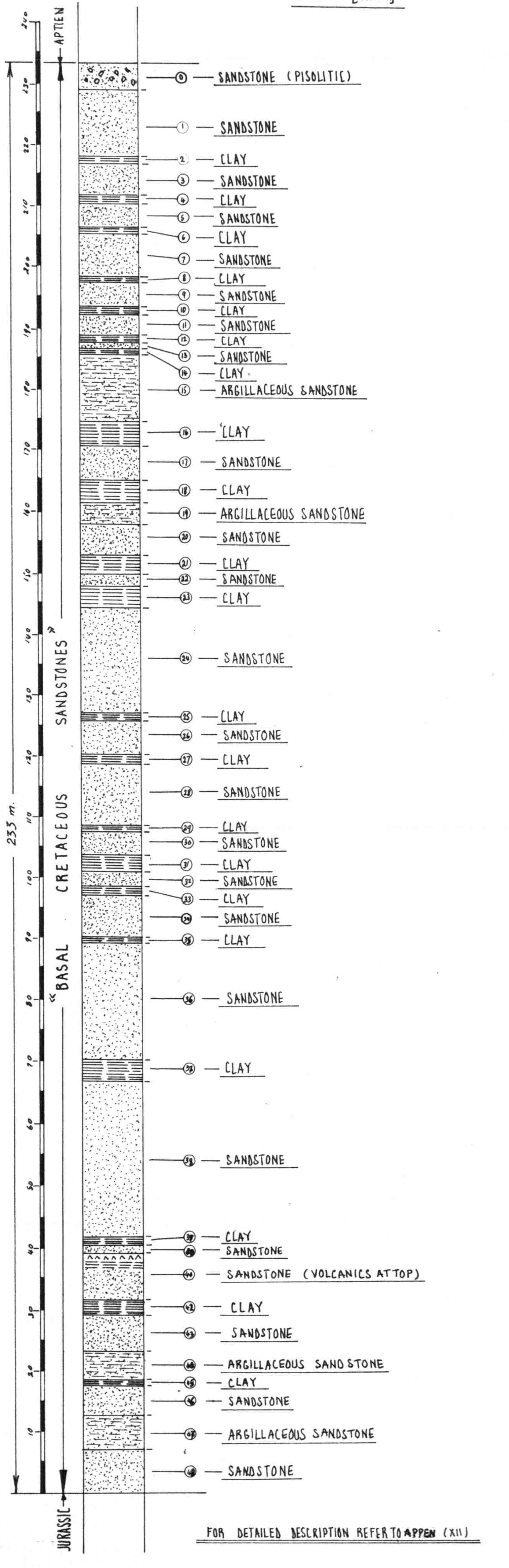
LOCALITY OF COL OF MACHGHARA

PLATE [XXVII]



FOR DETAILED DESCRIPTION REFER TO APPEN (XII)

STRATIGRAPHIC SECTION
"BASAL CRETACEOUS SANDSTONES" OF CENTRAL LEBANON
LOCALITY OF COL OF MACHGHARA
PLATE [XXVII]



FOR DETAILED DESCRIPTION REFER TO APPEN (XII)