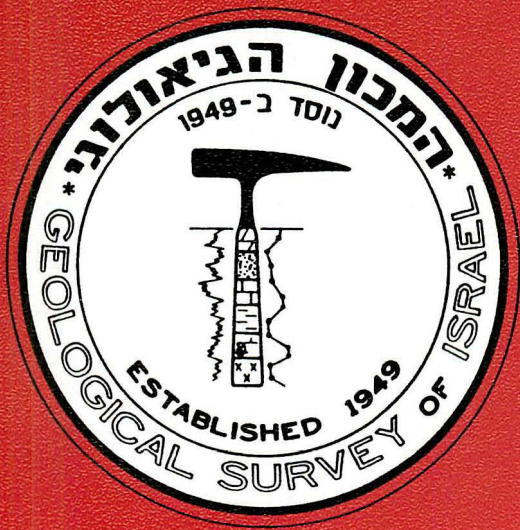


משרד האנרגיה והתשתית



**LITHOSTRATIGRAPHY OF THE JUDEA GROUP
IN EASTERN GALILEE, EMPHASIZING
THE NAFTALI MOUNTAINS**

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Abstract

The Judea Group in Eastern Galilee is subdivided into two subunits which differ from each other in their environment of deposition. The Lower Judea Group, which includes the Kefira and Yagur formations was deposited over a wide and shallow continental shelf, in places over a pre-depositional relief. Relative high water energies and syndepositional movements are indicated by cross laminations, intraformational conglomerates and syndepositional folds.

The Upper Judea Group, which includes the Deir Hanna, Sakhnin, Yanuh formations, represents mainly a carbonate deposition over a differentiated shelf. Facies changes from "basinal" mostly chalk facies to shallow dolomite and limestone facies are frequent. The main facies boundaries coincide with the major young faults suggesting that the Cenomanian-Turonian "highs" and "lows" were caused by syndepositional block movements which were later on reactivated.

The Judea Group sequence acts as a huge regional karstic aquifer drained in this region to the eastern Rift Valley base level. It is partly drained through numerous karstic springs. The regional distribution of the karst phenomena (springs, blind valleys, sinkholes etc.) coincides with the above mentioned facies boundaries accompanied by a parallel intensive joint system.

Introduction

The study of the lithostratigraphy of the Judea Group in Eastern Galilee was carried out as a continuation of the same type of study done previously by Kafri (1969, 1972) in Western and Central Galilee.

In the course of the present study, surface as well as subsurface (borehole) information from the entire region was incorporated to study the geometry, extension, thickness and facies changes of the different lithostratigraphic units. Detailed mapping which followed previous mapping (Rosenberg, 1960; Glikson, 1966a, b) in 1:50,000 scale was done in the Naftali mountains (Fig. 1). The discussed map is a combination of a normal lithostratigraphic map and in addition, it shows on the steep scarps lateral facies changes where recognized.

As a result of the frequent facies changes in the study area, only part of different units, exhibited on the map and the sections, are proper lithostratigraphic units. Part of them are rather lithofacial units, representing in the transition zones lenses and tongues of one unit within the other, and they are designated accordingly. The map (Fig. 1) is therefore a combined lithostratigraphic-lithofacial map.

Special attention was given in the course of the study to the lower boundary of the Judea Group, especially where it is exposed near Qiryat Shemona. Also, attention was given to hydrological feature and to the control of karst phenomena.

Lithostratigraphy of the Judea Group in Eastern Galilee1) Introduction and previous works

The lithostratigraphy of the Judea Group in Central and Eastern Galilee was discussed in details by Shiftan (1952), Golani (1957, 1961), Grader (1958), Eliezri (1959, 1965), Rosenberg (1960), Shlein (1961), Glikson (1964, 1966a, b), Saltzman (1964), Bein (1967) and Kafri (1969, 1972).

The major problems in discussion, as to the Judea Group in this region, are the lower boundary of the Group, its subdivision into lithostratigraphic units, and the facies and thickness changes within the Group.

Some of the works, mainly the previous ones, use a chronostratigraphic division, i.e., "Lower, Middle and Upper Cenomanian and Turonian". In the later a lithostratigraphic division is used although the boundaries of the units do not always coincide in the different works.

The upper boundary of the Judea Group is sharp and easily recognized. The lower boundary is not so sharp and some of the authors point to a "transition zone" between the Lower Cretaceous and Judea Group formations.

The most common subdivision of the Judea Group is that of Golani (1961). In the present work it is somewhat modified, using the same boundaries as done by Kafri (1972). The present subdivision use the term "Yagur Formation" which includes the Kamon Formation and the lower Karkara Member of the Deir Hanna Formation. A correlation chart of the different rock units is given in Table 1.

Similar to the western Galilee, two facies are recognized:

(a) Central Galilee facies, found in the Lower Galilee (center and east), typical of relatively lateral homogeneity, a thick dolomite (Sakhnin) sequence and thin Deir Hanna Formation.

TABLE 1. LITHOSTRATIGRAPHIC CORRELATION CHART

Grader 1958	Eliezri 1959	Rosenberg 1960	Glikson 1964	Saltzman 1964	Eliezri 1965	Bein 1967	Kafri 1972
			B'ina Fm.	B'ina Fm.		B'ina Fm.	B'ina Fm.
	Sabalan Fm.	C ₃ -Tu			Yanuh Fm.		Yanuh Fm.
UC ₂	Peqi'in Fm.		Sakhnin Fm.	Sakhnin Fm.	Sakhnin Fm.	Sakhnin Fm.	Sakhnin Fm.
				Deir		Deir	Ya'ara Mbr. Deir Hanna
UC _{1b}	Jernaq Fm.	C ₂	Yiftah Fm.	Hanna	Upper Mbr. Deir Hanna	Hanna	Rosh Haniqra Mbr. Fm.
UC _{1a}	Hamima Fm.	C ₁	Kamon	Fm.	Lower Mbr. Hanna Fm.	Fm.	Karkara Mbr. Yagur Fm.
LC	Ha'ari Fm.			Fm.		Kamon	Parod Mbr. Ka- mon
	Passage Zone	Ubergangsserie	Passage Zone		Fm.	Kesulot Mbr. Mbr	Kefira Fm > Kesulot Fm.
	Rami Fm.	Knemiceras serie			Rama Fm.	Zalmon Fm.	Zalmon Fm.

(b) Eastern Galilee facies, found in Mt. Meron and Manara regions, typical of frequent lateral facies and thickness changes of the Deir Hanna and Sakhnin formations.

In the vertical dimension the Judea Group is subdivided into two tectosedimentary cycles - the Lower and the Upper Judea Group, discussed later.

2) The lower boundary of the Judea Group

This boundary is found on top of the marl and limestone Zalmon Formation. It is overlain by a dolomite-limestone sequence, forming a rigid cliff morphology above the lower mild one.

It is sometimes difficult to recognize the boundary in exposures as well as in subsurface, due to the existence of the "transition zones", namely the marly-dolomitic Kessulot Formation, or the limy-marly Kefira Formation. Some of the authors relate these formations to the Zalmon Formation, while others relate them to the Judea Group. A detailed discussion of the nature of this boundary in the northern Naftali mountains is given in a separate chapter.

3) Judea Group - Lower part

Kessulot Formation

Synonymy: Kessulot Dolomite - Weiler, 1961.

Kamon Formation, Kessulot Member - Bein, 1967.

Contacts: The formation overlies marls, shales, and limestones of the Albian Zalmon Formation. It is overlain by the dolomites of the Yagur Formation, Kamon Member.

Distribution: The Kessulot Formation is exposed in Central Galilee and is known from exposures and wells in Tabor, Kessulot, Devora, Hazon, Hillel and Ha'ari mountains and in the Kefar Shamai quarry. The distribution of this formation was described by Bein (1967) and Kafri (1969).

Lithology: The formation consists of marls and dolomites. Its lower part consists of marly dolomites with marl intercalations and its upper part of yellow marls with some marly dolomites intercalations. Pyrite or limonite occur according to the amount of burial or exposure, and thus conditions of reduction or oxidation respectively.

Thickness: The thickness of this formation in Central Galilee (Bein, 1967; Kafri, 1969) is a few tens of meters. The lowest value of 14.1 m was described from Mt. Ha'ari as the "transition zone" by Eliezri (1959).

Age: The age of this formation was considered, according to its stratigraphic position, to Albian-Lower Cenomanian. Weiler (1961) attributed it to the Vraconian.

Kefira Formation: (Yitzhaki, Arkin, Brown and Lasman, 1964).

Synonymy: Transition zone - Eliezri, 1959

Uebergangsserie - Rosenberg, 1960

Transition zone - Glikson, 1964

Contacts: This formation overlies the marls and limestones of the Zalmon Formation and is overlain by the dolomites of the Yagur

Formation, Kamon Member. The term Kefira Formation is attributed to this unit in the Naftali mountains due to the resemblance in lithology and stratigraphic position to the Kefira Formation in the Judea mountains and in the Samaria mountains (Mimran, 1969). It is overlying the same formation, i.e. Zalmon and its equivalent Qatana Formation, and is overlain by the same, i.e. Yagur and Giv'at Yearim formations.

Distribution: The Kefira Formation is found in subsurface and exposed in Eastern Upper Galilee between Manara, 'Einan and Sede Eliezer. It was penetrated in the Sassa 1 and Jordan 2 boreholes. It seems, therefore, that this formation is limited to Eastern Galilee. It is also absent in a few places beneath Manara. The sequence described from Mt. Haari by Eliezri (1959) appears to be the lateral transition from the Kefira to the Kessulot Formation.

Lithology: The formation consists mainly of finely to coarse crystalline limestones, in places stylolitic. Its lower part is typical of biomicrites with fragments of megafossils and unsorted microfauna. In the upper part sparite is more abundant. In places, intercalations of finely crystalline dolomites (dolomicrosparite) are found, as well as some yellow marls and chalks, which become lesser upwards. Chert is known in this formation in the 'Einan area in 'Einan 2, 3, 5 boreholes. Intraformational conglomerates are also recognized in places.

The limestones are mostly biomicrites, and only a few biopelmicrites. They are partly mud supported and partly grain supported, poorly sorted with macrofossils debris which point to a relative high energy of deposition.

The geographic and stratigraphic position of the Kefira Formation, at the base of the regional aquifer and in a region of

large springs outlets, could point to a possibility that this sequence is a dedolomitized, initially dolomite sequence. This possibility is excluded because of the absence of any hints of dedolomitization in this region, although dedolomitization phenomena in this formation was described from the Samaria mountains by Mimran (1969).

Thickness (Table 2): The Kefira Formation does not exist in Central Galilee and its time equivalent seems to be the Kessulot Formation. The lateral transition between them occurs in the Bet Hakerem region. The largest thicknesses of this formation are known from the escarpment of the Naftali mountains extending from Manara in the north to Sede Eliezer in the south. Smaller thicknesses are known from Lower Eastern Galilee and the Kinneret region. In Margalioth area it is completely missing. In other parts of the country the thicknesses are as follows: 152-178 m in the Samaria mountains (Mimran, 1969), 171 m in the Ramalla area (Shachnai, pers. com.), and 180 m in the Judea mountains (Itzhaki et al., 1964).

Fauna: The samples are rich in mollusks debris, Nerinea sp., oysters and Echinoids spines. Among the foraminifera Orbitolina sp., Miliolidae and Ophtalmidiidae were found.

Age: The age of this formation was determined by the various authors, mainly due to its stratigraphic position as Upper Albian-Lower Cenomanian.

TABLE 2. THICKNESS OF LITHOSTRATIGRAPHIC UNITS

No.	Source	Coord.	Kefira Fm.	Kanon Member			Karkara Mbr.	Yagur Fm.	Lower Judea Group Total	Deir Hanna Fm.		Sakhnin Fm.	B'ina Fm.	Sakhnin + B'ina Fms. Total
				K1	K2	K3				Rosh Haniqra Member	Ya'ara Member			
1	Misgav 'Am	2020/2950	120	40	30	20	40	130	250	+60				
2	Hula 3	2044/2952										0	125	125
3	Margaliot	201/291	0		35		110	145	145	+220		90		
4	Manara (North)	202/290	0		80		120	200	200	100-140				
5	Manara (South)	201/289	100		155									
6	Mt. Nezer	2015/2865	100	50	25	38	37	150	250	79		+30		
7	Mitzpe Pe'er	2017/2854	100	45	35	50	40	170	270	0		50		
8	Mt. Ya'el	202/284								20-40		130	165	295
9	Yiftah	2025/2808								90				
10	"	2023/2820								40				
11	Jahula	20360/28040	+50											
12	Nahal Kadesh	202/280	+17					183	+200	135				
13	Nahal Kadesh	2020/2805								50				
14	Ramot Naftali	2025/2785	+15	28	44	0	91	163	+178	105				
15	'Einan 1	20337/27916	+111											
16	'Einan 2	20387/27637	+113											
17	'Einan 3	20385/27656	+123											
18	'Einan 4	20341/27585			+146		64	+210	+210	13		+135		
19	'Einan 5	20387/27657	+130.5											
20	Nahal Dishon	200/273								+110		140	134	274
21	Dishon	198/275										130	60	190
22	Nahal Hazor	200/269										+175		
23	Sede Eliezer 2	20357/27326	+27		99		45	144	+171	27		237	+30	+267

No.	Source	Coord.	Kefira Fm.	Kanon Member			Karkara Mbr.	Yagur Fn.	Lower Judea Group Total	Deir Hanna Fm.		Sakhnin Fm.	B'ina Fm.	Sakhnin + B'ina Fms. Total
				K1	K2	K3				Rosh Haniqra Member	Ya'ara Member			
24	Hindaj 1	20111/27208												+236.5
25	Hindaj 2	20154/27167												+192
26	Tel Hazor 1	20244/27061									+174	162		+336
27	Ayelet Hashahar	20258/27282										+111		
28	Zomet Golani 1	18727/24150			168		61	229	229	24	111	+128		
29	Hitin 1	19242/24687										+100	0	
30	Hitin 2	19506/24710										318	0	
31	Hitin 3	19317/24760										+182	0	
32	Hitin 4	19188/24648										+104	83	
33	Jordan 2	20093/24265	38		91		319	410	448	14		196	241	437
34	Mt. Ha'ari	185/262	14.4		131		81	212	227					
35	Mt. Meron	188/266					142			127		0		
36	Nahal Neria-Afa'im	185/266								30-150	80			
37	Mt. Peqi'in	183/266										+142		
38	Mt. Hillel	189/262					50			60	128			
39	Gush Halav - Mt. Gal'an	189 270										0-50	50-60	
40	Bar'am 1	19167/27312										+151	80	+231
41	S'asa 1	18641/27379	15		25		315	340	355					
42	Bir 'Uba 1	19533/27575										+98		

Yagur Formation (Picard and Kashai, 1958)

Synonymy: Lower Cenomanian + Upper Cenomanian, lower part -
Grader, 1958.

Ha'ari + Hamima (part) Formations - Eliezri, 1959

Ce 1 - Rosenberg, 1960

Kamon + Deir Hanna (part) formations - Golani, 1961

Contacts: The Yagur Formation generally overlies either the Kefira or the Kessulot Formation. In the Manara-Margalioth region, where both are missing, the Yagur Formation overlies directly the Zaimon Formation

It is generally overlain by the Deir-Hanna Formation, except for those regions where the latter is missing and there it is overlain by the Sakhnin Formation (Mitzpe Pe'er region).

Distribution: The Yagur Formation is known from exposures and subsurface from all over the study area.

Lithology: The formation consists mainly of dolomites, having a rugged cliff morphology. It is subdivided into two members:

Kamon Member - In places, where the member is not subdivided into secondary units it consists mostly of a finely to medium crystalline dolomite, and only sometimes coarsely crystalline dolomite (Jordan 2, Sassa 1). The sequence is generally devoid of chert, and it contains some intercalations of finely crystalline limestone (Margalioth-Manara) and some chalk interlayers (Margalioth). The dolomites are mostly dolmicrosparites and only a few dolmicrites showing a drusy growth to dolsparites. Zoning phenomena and

intraclasts are very rare within the dolomite mosaics. The limestones, when present, are mostly unsorted, mud-supported as well as grain-supported biomicrites which contain microfauna (miliolids) and larger debris of macrofossils. Cross bedding was found within this member, close to its basis along the Kefar Giladi-Margaliot roadcut.

In the Ramot Naftali area this member can be subdivided according to lithology and morphology into three subunits:

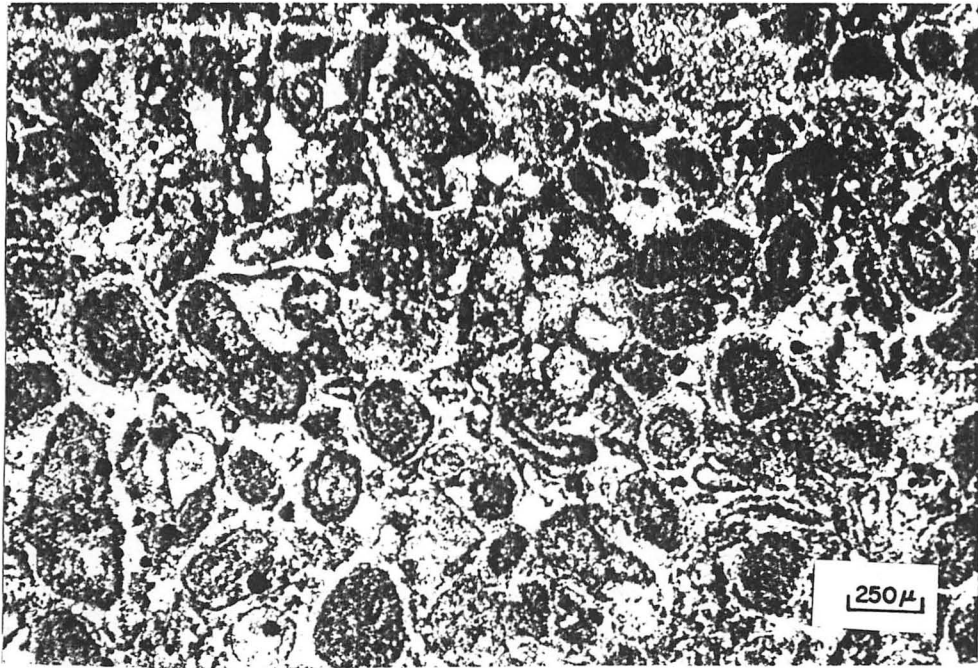
a) Lower Kamon Member (K_1) - consists mainly of dolomites and some finely crystalline limestones, forming a cliff morphology. On top of this unit bioclastic limestone and quartzolite bed are found.

b) Middle Kamon Member (K_2) - a soft unit covered with talus, forming a mild morphology. It consists of chalks and marls with intraformational conglomerates and intercalations of finely crystalline dolomites or limestones with microfauna and oolites (biomicrites) (Plate I, 1, 2). This unit is exposed along the Naftali mountains escarpment between Manara and Mitzpe Pe'er, and is known in subsurface in the 'Einan area.

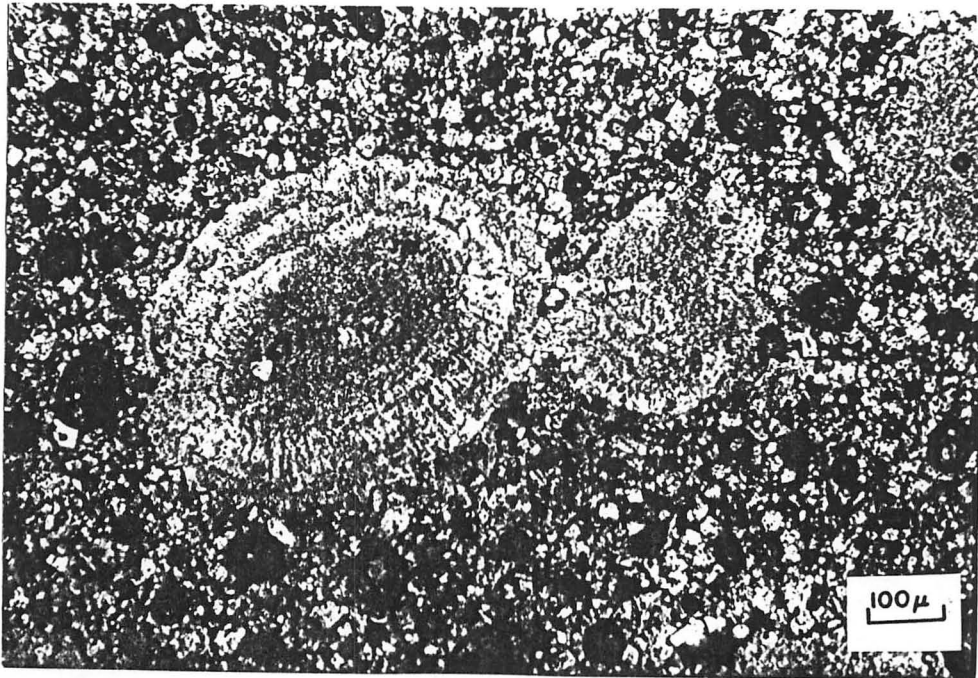
c) Upper Kamon Member (K_3) - a hard unit consisting mainly of finely to coarse crystalline dolomite, exposed along the Naftali mountains escarpment. On top of this unit, in the Mitzpe Pe'er area, there is a thin (a few meters) marl horizon which thins out towards north and south.

Karkara Member - The Karkara Member is distinguished from the underlying dolomites by its lighter colour and its softer appearance. It consists of finely crystalline soft dolomites or limestones and chalks, both with limonite staining. Lateral passage to chalk and marl lenses covered with "Nari" and talus also occur. The member contains cherts and quartzolites which become lesser upwards. In

PLATE I



1. Thin section. Oobiomicrorite, grain-supported. Ramon Mbr. Ramot Naftali. x 38.



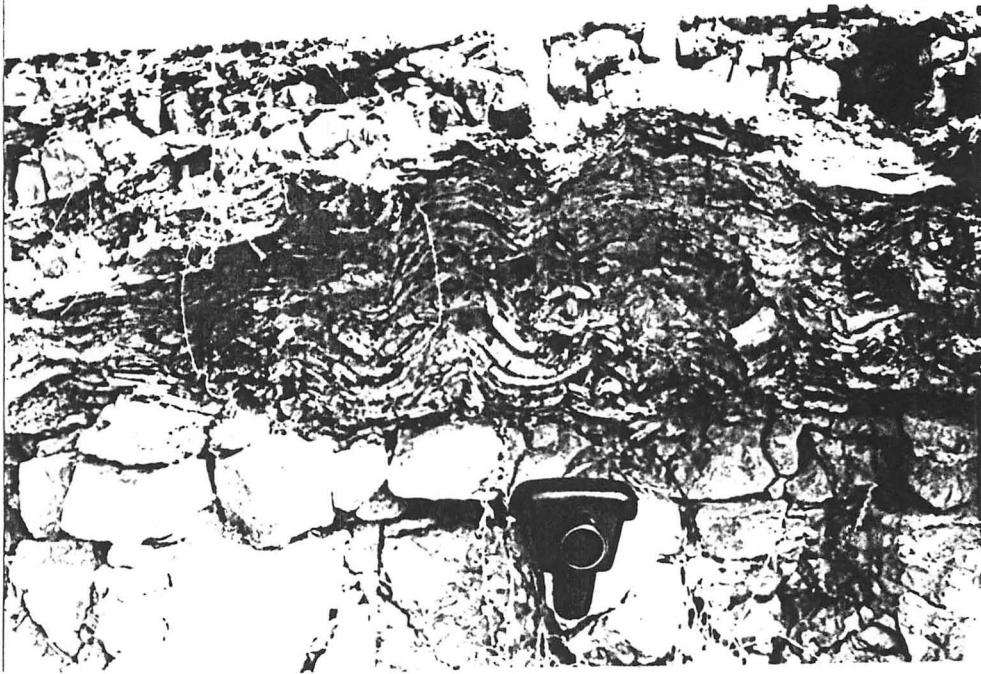
2. Thin section. Oooidmicrosparite. Ramon Mbr. Ramot Naftali. x 38.

places, large quartz geodes are abundant. The unit as a whole is well bedded. In a few places, where it is finely bedded, syndepositional, small folds and contortions, which formed possible due syndepositional landslides were encountered (Plate II, 1) pointing out, together with the intraformational conglomerates (Plate II, 2) to a tectonic instability during deposition times.

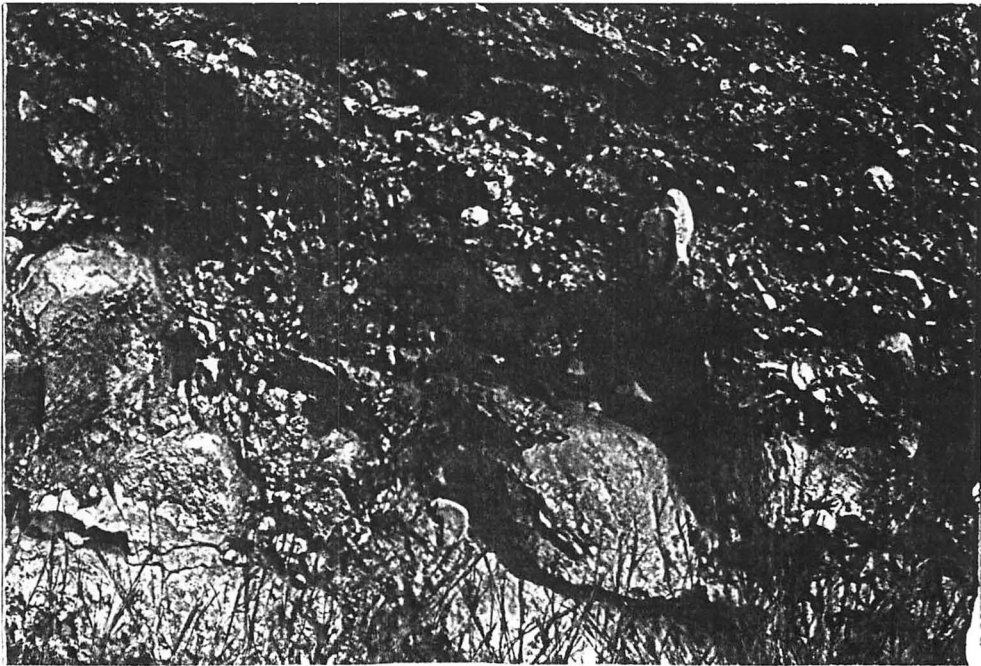
The dolomites of the Karkara Member are mostly dolmicrites, but sometimes dolmicrosparites containing large pellets (up to 500 μ) and intraclasts. The limestones are biomicrites or biopelmicrites, mostly grain supported. In several thin sections euhedral dolomite crystals are seen in the micrite matrix showing the very first stage of dedolomitization. In Qeren Naftali, Mt. Nezer and Mt. Meron different stages of dedolomite were also encountered from dolmicrosparite with some dedolomite crystals to completely dedolomitized microsparite with some dedolomite crystals (Plate III, 1) to completely dedolomitized microsparite.

The top of the Karkara Member in Mt. Meron area (coord. 1871/2671) terminates the sedimentary cycle of the Lower Judea Group. There, cross-laminated dolomite which contains up to 5% detrital quartz grains, and a quartzolitic coarse lumachelle together with dedolomitization phenomena were recognized. These may point to the shallowing of the sea and to a regime of currents which transport detrital quartz from the continent (Kafri, 1986).

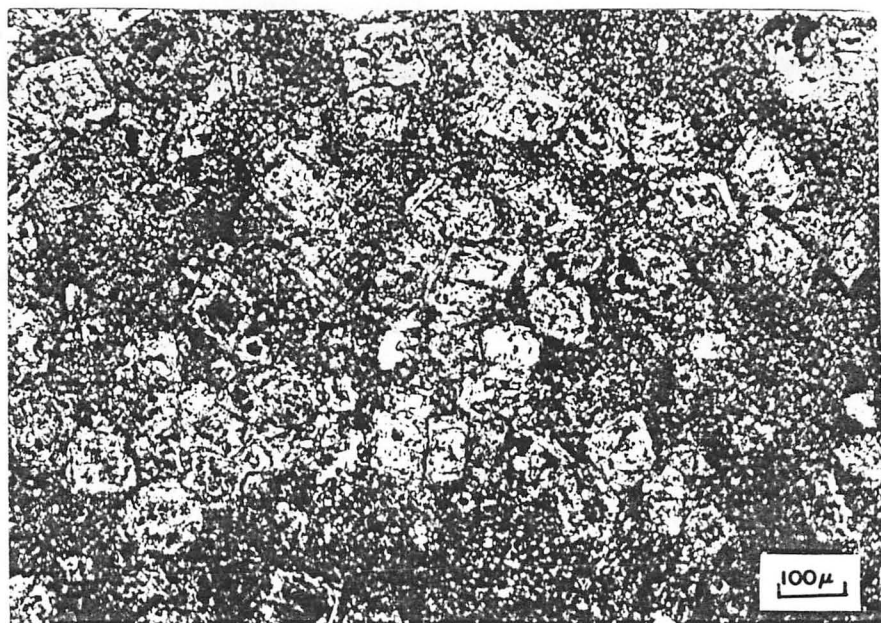
PLATE II



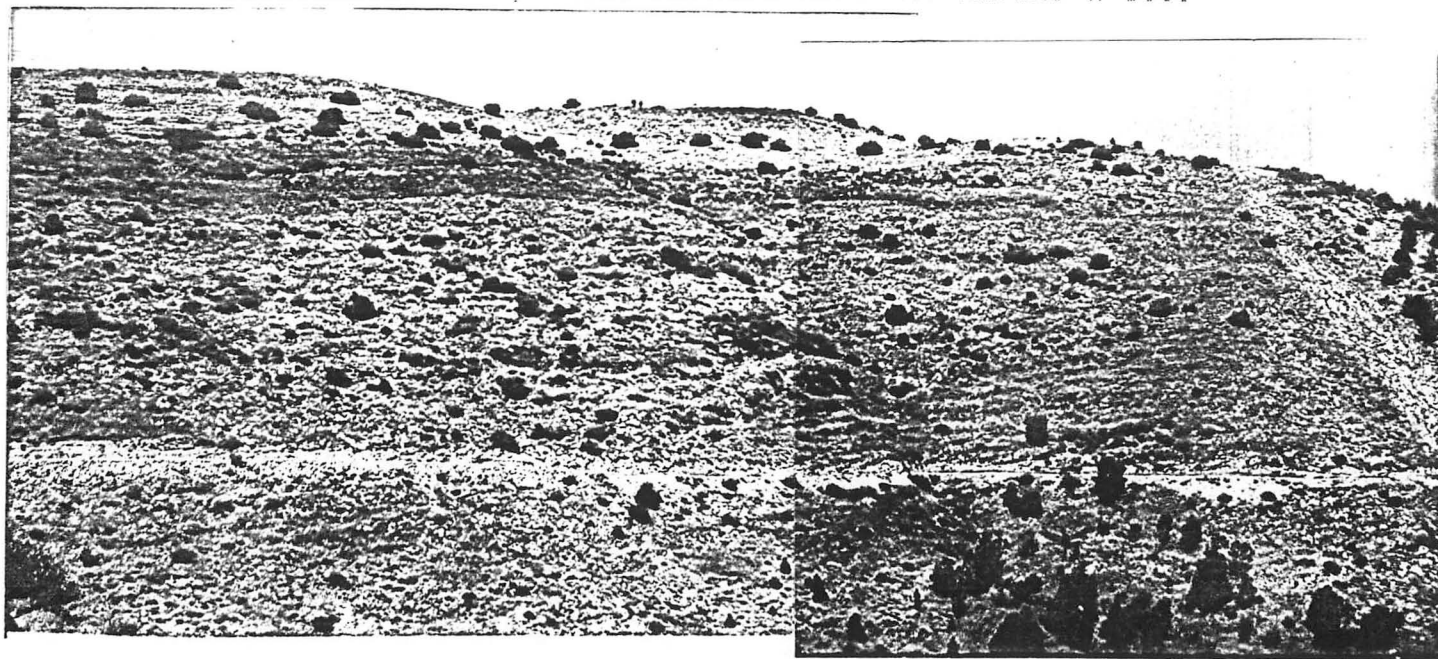
1. Intraformational contortions. Karkara Mbr. Nahal Zemer.



2. Intraformational conglomerates. Karkara Mbr. Nahal Zemer.



1. Thin section. Dolmicrosparite with zoned euhedral, partly dedolomitized crystals. Karkara Mbr. Mt. Meron. x 100.



2. Rosh Haniqra Mbr. "m" horizon on the upper part of the picture. Nahal Zemer.

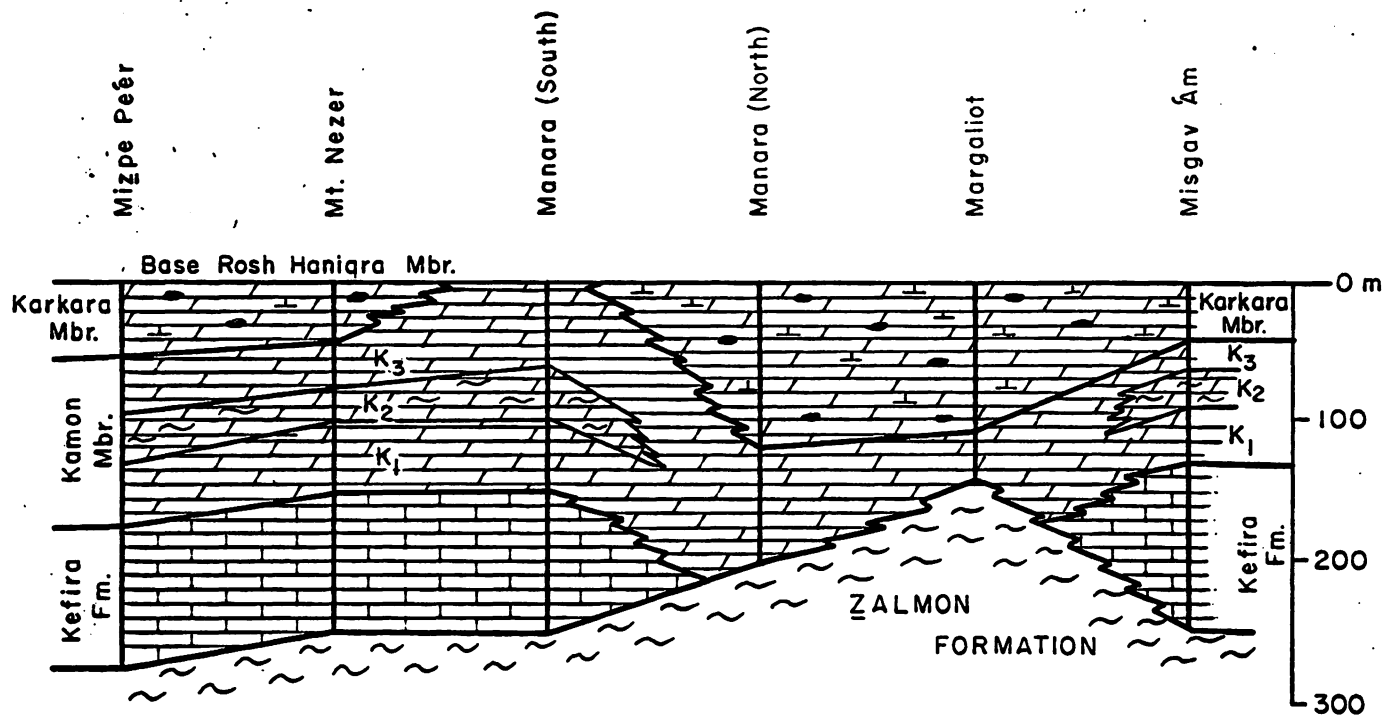
Thickness (Table 2): The thickness of the Yagur Formation in Central Galilee, according to Eliezri (1959), Bein (1967) and Kafri (1969, 1972), is as follows: the Kamon Member changes from 71-160 m and the Karkara Member from 92-172 m.

Pronounced differences in thickness of the Yagur Formation are encountered in the Margalioth area (Fig.2), where the thickness is only 145 m. Toward north and south the thickness increases over short distances to approx. 250 m in Misgav 'Am and to 200 m in Manara. The formation is also thick in S'asa 1 and Jordan 2 boreholes. In addition, thickness changes are encountered in the members of the formation (Fig. 3). The thickening and thinning of both Kamon and Karkara members seem to be on the account of each other. The Karkara Member is completely missing south of Manara and in Nahal Kadesh.

Fauna: The rocks of this formation include debris of Molluscs. Eliezri (1959) describes Cerithium elias and Nerinea cochleiformis. In the limestones, Miliolidae and Ophtalmidiidae were found.

Age: The age of this formation is considered by the various authors according to its stratigraphic position as Lower Cenomanian to Upper Cenomanian lower part.

Fig. 2. Schematic cross-section along the northern Nattali Mountains showing facies and thickness changes within the Lower Judea Group.



THE NATURE OF THE ZALMON FORMATION - LOWER JUDEA GROUP
CONTACT IN THE QIRYAT SHEMONA ESCARPMENT

Conspicuous thickness changes in the Lower Judea Group occur, as mentioned above, along the Qiryat Shemona escarpment (Fig. 2), which are recognized following a series of columnar sections done in the area.

The formations exposed on the Qiryat Shemona escarpment are dissected by numerous EW and NW-SE trending normal faults, which branch off the Rift and generate prominent fault blocks. Throws on these faults are easily assessed from measurement of the vertical displacement of the "Muraille de Blanche" ('Ein El Asad Formation) guide horizon exposed underneath (Plate IV).

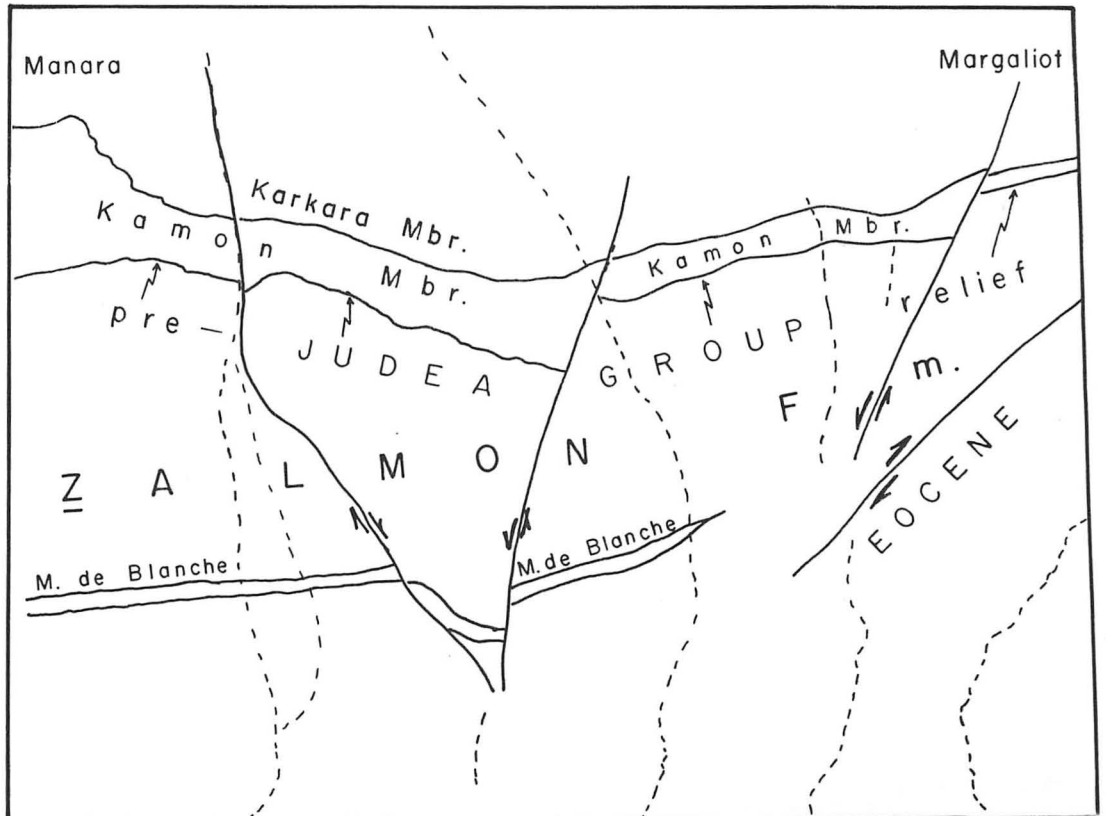
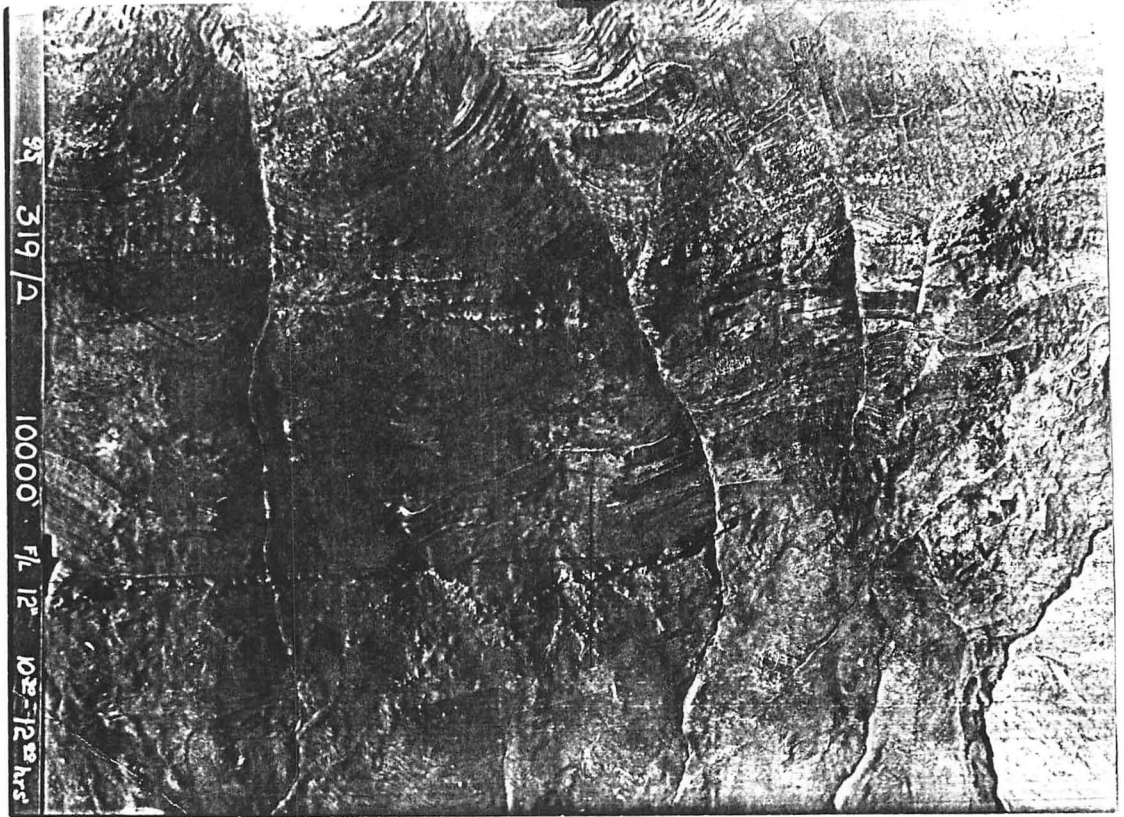
The Lower Judea Group between Margaliot and Manara reveals conspicuous thickness changes on very short distances, within and between the different blocks. These are mainly recognized in the Kefira Formation and the Kamon Member, as seen in Plate IV and Figure 2:

a) The thickness of the Kamon Member is reduced to 35 m and 80 m in Margaliot and north of Manara accordingly, compared to 155 m south of Manara and 130 m in Mitzpe Pe'er. These thicknesses change abruptly while passing from one block to another across the above mentioned E-W faults in the Manara-Margaliot region (Plate IV).

b) The Kefira Formation, which underlies the Kamon Member is completely missing in that same region where the thickness of the Kamon Member is reduced. Toward North and South a "normal" thickness of the Kefira Formation is encountered - 120 m below Misgav 'Am and 100 m south of Manara.

PLATE IV

Oblique view of the Qiryat Shemona escarpment, showing thickness changes of the Ramon Mbr. across transversal faults.



c) Within the Lower Kamon Member, the younger beds are seen to overlap the older ones, and at the same time they thin out laterally towards the sloping Zalmon-Judea contact. In spite of the bad exposure, conglomerates are found in places, associated with this contact.

These relationships, are interpreted herein as a deposition of the Lower Judea Group sequence unconformably on an elevated, pre-depositional relief, in the Manara-Margalioth region. This is supported by the complete absence of the Kefira Member, as well as the drastic reduced thicknesses of the Kamon Member in this region.

The nature of the tilted blocks relief is indicated by the abrupt changes of thickness across the fault lines, and the gradual change of the thickness within the blocks.

One could interpret the Zalmon-Judea contact as a N-S fault line. Being an East - dipping normal fault, such a fault would apparently increase the Kefira and Kamon thicknesses, which is not the case. An apparent decrease of thickness could have resulted by a W dipping normal fault, but this contradicts the topography of the region.

The discussed fault lines are seen to displace younger Cenomanian strata, pointing to a later rejuvenation phase.

Shaliv (1972) describes from the Faria region almost identical phenomena in the same stratigraphic level. He interprets a very similar contact as described herein as a fault line, but adds that it can be easily interpreted as an ancient unconformity.

These evidences indicate that the occurrence of previously unreported tectonic events in Late Early Cretaceous times cannot be ruled out.

LOWER JUDEA GROUP - Environment of Deposition

The discussed sequence of the Lower Judea Group (the Kefira, Kesulot and Yagur formations) is a tectosedimentary cycle, differentiated from the underlying and overlying rock sequences (see also Kafri, 1969, 1972). The unit as a whole consists of dolomites which were deposited on a wide shallow epicontinental shelf. The lower part of the sequence being composed of biomicrites points to somewhat more basinal environments. The lateral passage to marls and chalks points to a slight differentiation of deposition conditions of the shelf. Relative high water energies are evident by several sedimentary phenomena, such as lumachelles and large debris of macrofossils, intraformational conglomerates and oolites which indicate agitation. Intraformational folding and syndepositional faults point to tectonic activity at the time of deposition. It seems that at least in the Margalioth-Manara area the Lower Judea Group was deposited over a tilted block-faulted relief, and the thickness of the unit changes accordingly. All these indicate the differentiation of the shelf to structural highs and lows.

The thickness data in Galilee are too sparse to elucidate a complete paleogeographic map. The general scheme is that of thin Lower Judea Group (210-250 m) in eastern Galilee and a thick one in southwestern and southeastern Galilee (495 m in Asher 1, 415 m in Haifa Bay 1, and 448 m in Jordan 2 boreholes). An uplift of the region and the shallowing of the sea toward the end of this cycle is evident over most of Galilee and Mt. Carmel (Kafri, 1986).

4) Judea Group - Upper partDeir Hanna Formation (Golani, 1961)Rosh Hanigra Member (Kafri, 1969)

Synonymy: Middle Cenomanian, UC 1a - Grader, 1958

Jermaq Formation - Eliezri, 1959

C₂ - Rosenberg, 1960

Yiftach Formation - Glikson, 1964

Contacts: The Rosh Hanigra Member overlies in most of the research area the Karkara Member. In a few places where the latter is missing it overlies directly the Kamon Member, south of Manara and in Nahal Kadesh. It is always overlain by the Sakhnin Formation.

Distribution: This member is known from the entire study area, excluding those limited regions, i.e., Mitzpe Pe'er, where it is completely missing and the Sakhnin Formation develops on its account.

Lithology: The Rosh Hanigra Member is pronounced in the field by its mild morphology, by the abundance of talus, "Nari" crust and vegetation. In those regions where the unit is very thin it appears as a soft marly marker horizon - the "m" horizon (Plate III,2) (Glikson 1964, 1966). The member consists mainly of chalks and some marls, shales and greenish-yellow clays. It contains intercalations or lenses of chalky limestone, coarse crystalline reefal, limestone or dolomite which pass laterally to the chalks. Brown to black chert is abundant as horizons, lenses or concentric nodules. Reef banks which subject to silification appear as quartzolite beds - (e.g. coord. 2011/2898). Large quartz geodes are also abundant. There are few horizons where chert and quartz horizons are very abundant, a few centimeters apart. One of them is distinguished in the Mt. Meron

areas a "Marker Horizon" (Grader, 1958; Eliezri, 1959). The chalks are partly biomicrites rich in microfossils. In the uppermost part of this member, close and lateral to the overlying Sakhnin Formation, there is a pronounced increase in fragments of rudists and bryozoa. The occurrence of dolomite and limestone intercalations within the chalk sequence was previously discussed by the various authors. Eliezri (1959) describes the occurrence of coral reefs and benthonic pelecypodes from western Mt. Meron. Rosenberg (1960) mentions rudistid reef limestone from northeastern Galilee. Glikson (1964) describes from Nahal Kadesh a thick reef limestone bed as well as dolomite lenses within the Deir Hanna Formation. These same intercalations appear as cliffs or banks underneath Mt. Shenan (coord. 2005/2905) and between Ramot Naftali and Kadesh Valley. They are exposed on the summit of Mt. Meron and Hirbet Back (coord. 188/266), drained by the Afa'im spring. They extend toward SW to Beit Jann and the summit of Mt. Zafrir. These same intercalations are seen to dip from Mt. Meron eastward to Nahal Meron and Hirbet Sham'a, drained by small springs such as 'Ein Zevad (coord. 1904/2645). They appear, lithologically, stratigraphically and morphologically, to be identical with the pronounced limestone bank of Mt. Manor, in western Galilee (Kafri, 1969). The described intercalations consist of dolomicrosparite or microsparite to sparite with some pellets and interclasts in places and fragments of rudists and gastropods. Microfossils are not abundant. Secondary calcite, related to groundwater flow through these rocks is abundant.

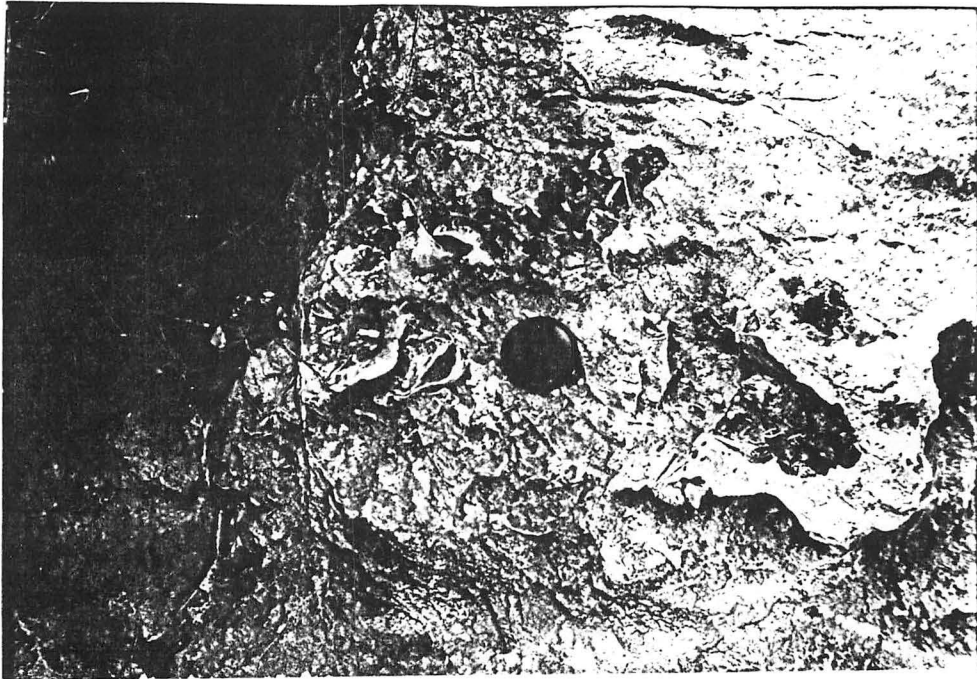
Intraformational conglomerates are abundant and dispersed over the entire sequence of this member. Cross bedding within the chalks is also found in places (e.g. coord. 2015/2923), sometimes associated with nearby reefal small bioherms.

Thickness (Table 2): The thickness of the Rosh Haniqra Member extremely changes laterally on short distances. In the regions of Margalioth - Manara and Mt. Meron, the Rosh Haniqra Member is very thick resembling the western Galilee facies (Kafri, 1969). South of Manara to Keren Naftali, thicknesses change from 80 to 140 m, accompanied by rapid facies changes. In the Mitzpe Pe'er area it is completely missing. South of Keren Naftali and the Mt. Meron region toward central, eastern Galilee and Lake Kinneret, the thickness of the Rosh Haniqra Member is 0-50 m, resembling the central Galilee facies (Kafri, 1969).

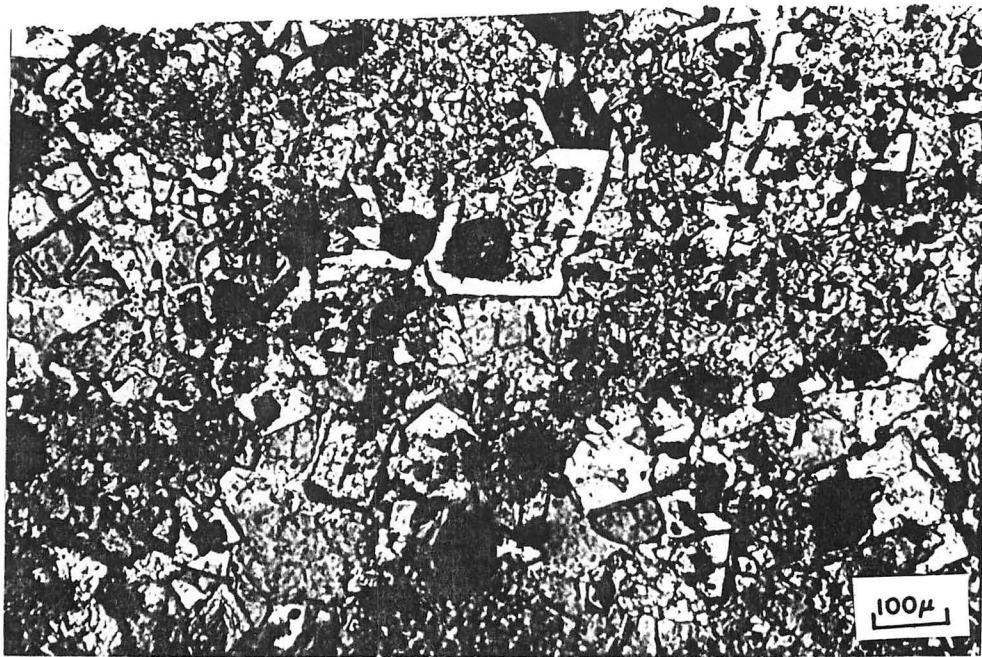
Fauna: The chalks of the Rosh Haniqra Member contain in places pelecypodes and echinids, and the limestone-dolomite intercalations, rudists gastropods and large oysters (Plate V, 1). Samples of this member were examined for microfossils (Paleontological Division, GSI) show that most of them were completely devoid of, or contain only some, microfossils. In adjacent samples, planktonic as well as benthonic microfossils were determined as follows: Asterohedbergella asterospinosa, Hedbergella spp., Textularia sp., Heterohelix sp., Praeglobotruncana sp., Gavelinella aumalensis, Porifera spicules and fragments of crinoids, echinids bryozoa and rudists. Ostracodes, determined from these samples indicate deepening of the sea relative to the underlying sequence (Rosenfeld and Raab, 1974).

Age: The age of this member is considered by the various authors as Upper Cenomanian.

PLATE V



1. Oyster bank. Rosh Haniqra Mbr. Kefar Shamai.



2. Thin section. Dolosparite, partly dedolomitized. Sakhnin Fm. Mitzpe Pe'er. x 100.

Sakhnin Formation (Golani, 1961)Synonymy: UC₂

- Grader (1958)

Peqi'in Formation - Eliezri (1959)

Contacts: The Sakhnin Formation overlies generally the Rosh Haniqra Member whereas the Ya'ara Member of the Deir Hanna Formation (Kafri, 1969) is completely missing. Only in central Galilee and north Mt. Meron where the latter is present, the Sakhnin Formation overlies and passes laterally to the Ya'ara Member. In those limited sites, where the Rosh Haniqra Member is completely missing (e.g. Mitzpe Pe'er) the Sakhnin Formation overlies directly the Karkara Member.

The Sakhnin Formation is generally overlain by the B'ina Formation, the contact between them being a dolomite-limestone transition zone. In those places where the B'ina Formation is missing due to dolomitization or pre-Senonian erosion, the Sakhnin Formation is overlain by chalks of the mountains Scopus Group.

Distribution: The Sakhnin Formation is known all over the region except for Mt. Meron and Margalioth regions where it is missing, possibly, due to non-deposition.

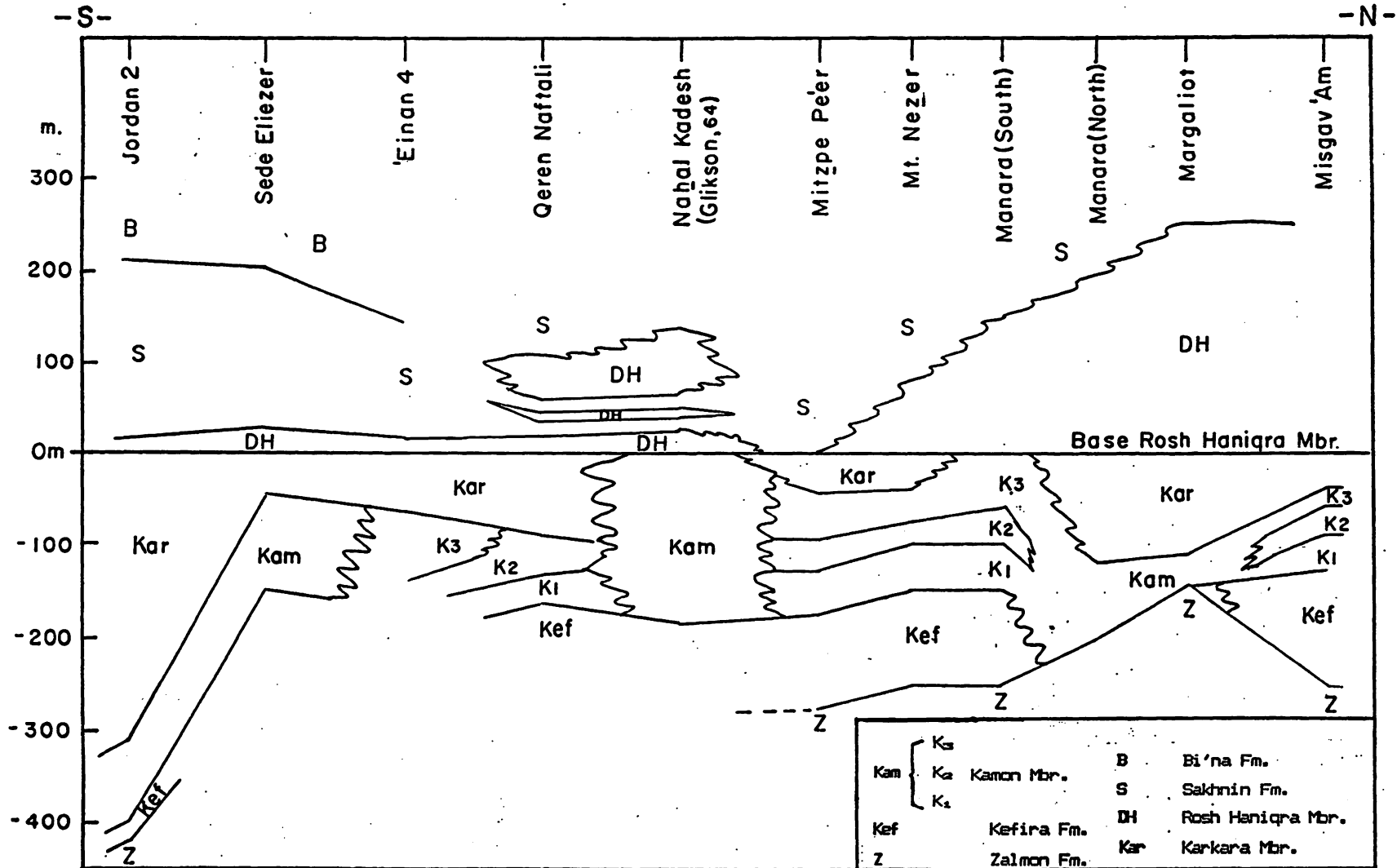
Lithology: The formation consists mainly of dark grey, hard dolomites forming a rugged karstic typical morphology. The dolomites are mainly medium to coarsely crystalline (dolomicrosparite to dolosparite). In the Ramot Naftali-Manara area it is characterized by dolomites, partly calcitic with irregular passages to lenses and horizons of limestone (microsparite to sparite) mentioned also by Rosenberg (1960) and Glikson (1964, 1966). In places, dedolomites are found (Plate V, 2).

Thickness (Table 2): The thickness of this formation changes drastically as can be seen in field relations and in measured sections. These changes reflect either the original thickness of deposition or irregular dolomitization of the overlying B'ina Formation. The Sakhnin Formation is completely missing in Margalioth and Hula 3 area, as well as in Mt. Meron, due to facies changes (see also Kafri, 1969). From Manara southwards, its thickness reduces being very thin in Mt. Nezer and Mitzpe Pe'er and from there it thickens quickly westwards and southward to Mt. Ya'el (Fig.3). From there southwards, it thickens again in the Sede Eliezer and Lake Kinneret areas. In Mt. Meron it wedges to very thin tongues (the dolomitic intercalations) which thicken again towards Neria, Zevul and Peqi'in mountains in the west. Similarly, the dolomite tongues thicken towards east to Nahal 'Amud and north to Gush-Halav and Dovev, where the Sakhnin Formation is only a few tens of meters thick. Eastwards (Nahal 'Amud" and northwards (Bar'am 1) the thicknesses increase to 250 m and 151 m accordingly.

Fauna: Most of the dolomites are completely devoid of any fauna. In places they contain fragments of rudists, pelecypodes, gastropodes, oysters, as well as microfossils, which are very rare within the dolomite mosaics.

Age: The age of the Sakhnin Formation is considered by the various authors as Upper Cenomanian-Turonian.

Fig. 3. Schematic N-S cross-section along eastern Galilee showing facies and thickness changes.



B'ina Formation (Shadmon, 1959)

Synonymy: Turonian - T₂ - (Eliezri, 1959).

Contacts: This formation overlies in most areas the Sakhnin Formation, the contact between them being gradational and irregular. In Hula 3 borehole only, where the Sakhnin Formation is missing, the B'ina Formation overlies the Yanuch Formation. The B'ina Formation is overlain by the Mt. Scopus Group.

Distribution: The B'ina Formation is known all over the explored area.

Lithology: The B'ina Formation consists of finely to coarsely crystalline limestone. It has a light grey colour and a karstic appearance. The contact with the underlying Sakhnin dolomites is transitional from dolomite to limestone. Dolomite lenses within this formation were named by Glikson (1964) as "B'ina Dolomites". In the Hindaj boreholes the sequence consists of dolomite and limestone alternations which do not enable a distinction between the Sakhnin and the B'ina formations.

Thickness (Table 2): The thickness of the B'ina Formation changes due to facies changes relations with the Sakhnin Formation and due to pre-Senonian erosion. Therefore, the combined thickness of both Sakhnin and B'ina formations has more of a sense. There are regions where the thickness is nil (Mt. Margalioth) as compared to regions where they exceed 400 m (Jordan 2).

Fauna: The formation is partly reefal, containing fragments of rudists, gastropodes and other pelecypodes.

Age: The age of this formation is attributed to the Upper Cenomanian-Turonian.

5) Facies changes in the Judea Group

The Judea Group, as mentioned before, can be subdivided into two subunits which differ in the intensity and frequency of facies changes as follows:

Lower Judea Group (Fig. 3). The facies changes recognized in this unit are as follows: the lowermost, mostly limy Kefira Formation is found all over eastern Galilee except for the area north of Manara where a relative thin Kamon Member overlies directly the Zalmon Formation. Toward west and south west the Kefira Formation disappears and possibly, passes laterally to the Kessulot Formation, known in central and western Galilee.

Facies changes of local importance are recognized within the Kamon Member, where the middle part changes in certain areas to a more marly unit. In the upper part of the Lower Judea Group, the Karkara Member wedges out, south of Manara and In Nahal Kadesh, and passes laterally to the Kamon Member. These similar lateral relationships can be recognized between Nahal Kadesh and Keren Naftali.

Upper Judea Group (Fig. 3). The main facies changes in this unit occur between the mainly chalky Rosh Haniqra Member and the Sakhnin Dolomites, causing the complete wedging of each accompanied by a thickening of the other. These facies changes are recognized in the following areas:

(a) Mt. Meron area is characterized by a developed chalky facies, surrounded by the dolomite facies of Mt. Zevul and Mt. Peqi'in in the west, and Nahal 'Amud area in the east. The lateral passage can be seen from Mt. Peqi'in through Nahal Neria and Afa'im to Mt. Meron through which the dolomite sequence unit thins out. The same lateral passage occurs along the line Kefar Shamai-Meron-Mt. Qal'an-Dovev, which bounds Mt. Meron to the east and northeast. Here the lateral passage is from the Rosh Haniqra chalks, through Ya'ara Member chalky dolomites with chert and quartz to the Sakhnin dolomites (Plate VI).

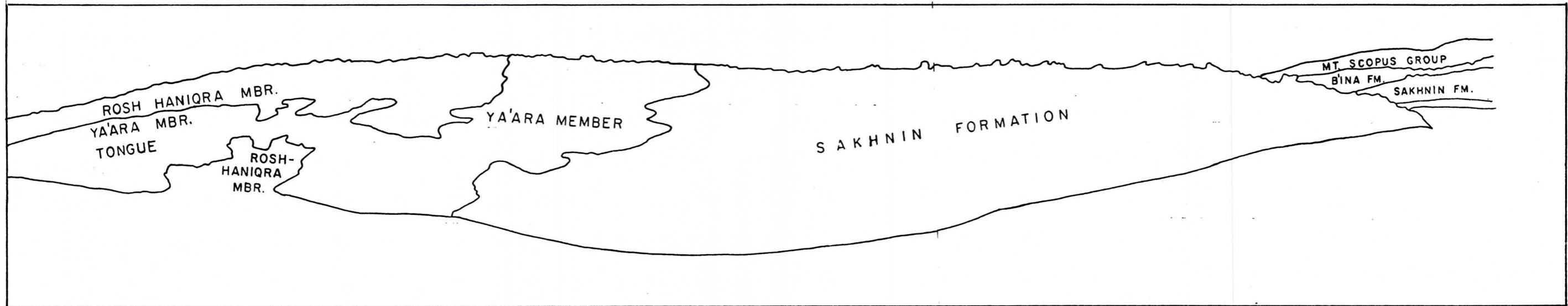
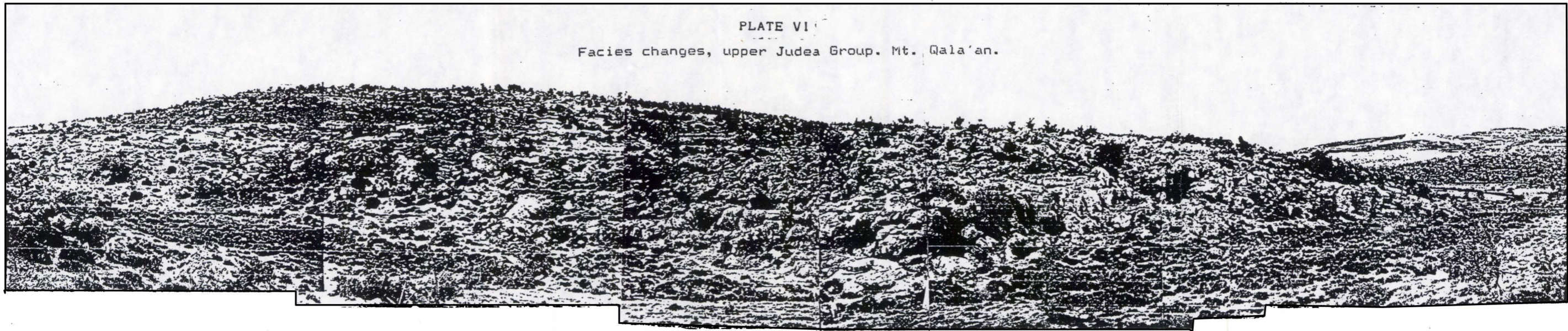
(b) In the Naftali mountains such facies changes are encountered between Mt. Nezer and Mitzpe Pe'er, where the Rosh Haniqra Member consisting of chalks, chert and finely crystalline limestone lenses, is seen to pass through chert bearing finely crystalline limestone to the karstic Sakhnin dolomite.

Another type of facies changes occurs between the Sakhnin and B'ina formations, which are seen to pass laterally and irregularly to each other through a limestone - dolomite transition zone. Limestone beds and lenses are included in Sakhnin dolomite sequence and accordingly dolomites are included in the B'ina limestone sequence.

The significance of facies changes. The above facies changes were partly discussed previously by the various authors. Eliezri (1965) attributes the dolomite facies to a deposition on an anticlinal area and the chalk facies to a synclinal environment. Glikson (1966) describes both lateral facies changes from the Deir Hanna to Sakhnin Formation and from the Sakhnin to the B'ina Formation in the Naftali mountains Bein (1967) described the gradual change within the Deir Hanna Formation from soft dolomites in Haari and Hillel mountains to soft chalks towards S'asa in the north, interpreted here as the

PLATE VI

Facies changes, upper Judea Group. Mt. Qala'an.



thickening of the Rosh Haniqra Member on the account of the Ya'ara Member. Kafri (1969, 1972) discussed these same facies changes in western and central Galilee.

These lateral changes in the Judea Group, although indicating a deposition on a wide shallow shelf, point to a slight differentiation of this shelf to somewhat elevated areas of the dolomite and reef limestone facies compared to shallow depressions or basins of the chalk facies. In spite of the small bathymetric differences the facies boundaries are geographically about the same for a long time span, which demands a tectonic mechanism to preserve these small differences. As previously assumed by Kafri (1969, 1972), this can be attributed to regional block movements in Cenomanian-Turonian times. Such syndepositional tectonic movements are evidenced by the following:

(a) Conspicuous thickness changes in the Lower Judea Group in the Margalioth area, changing from block to block and indicating Early Cretaceous block movements.

(b) Intraformational folding (landslides?) as well as intraformational conglomerates in the Lower Judea Group pointing to tectonic instability.

(c) Cross laminated dolomites with detrital quartz in the uppermost Lower Judea Group, indicating a shallowing of the sea and sand transportation by currents (Kafri, 1986).

(d) Intra-Cenomanian faults described by Glikson (1964) are seen to displace the "m" horizon in Naftali mountains, showing different thicknesses on both sides of the faults. Some of these faults which fail to cross upwards the "m" horizon were determined by Glikson (1964) as "detachment faults".

(e) The main facies boundaries approximately coincide with some of the major fault lines in the region (Fig. 4): The southern chalk dolomite facies boundary of Mt. Meron coincides with the fault system

of Beit Hakerem, the western boundary with the Peqi'in and Beit Jann-Mt. Adir faults, and the eastern boundary with the Kefar Shamai-Meron fault line. Accordingly, the chalk-dolomite facies boundary south of Manara coincides with 'Ein Gome-Mitzpe Pe'er fault line. This suggests that the mentioned young rejuvenated fault lines existed since Cretaceous times and the relative movement of their bounded blocks was responsible for the long preservation of facies differences. The present structure shows a reverse relationship to the ancient (Cretaceous) one. The ancient "lows" are at present elevated and vice versa, suggesting an inversion of movement along these faults. Similar phenomena are also encountered in western Galilee.

The connection between joint systems,
karst phenomena and springs in
Eastern Galilee

The relations between karst phenomena and morphology in Eastern Galilee were studied in detail by Yair (1962) and Gerson (1967), who described karst features such as blind valleys, sinkholes, collapsed caves and solution channels. Gerson (1967) who described the connection between the development of the karst system and the occurrence of faults and joints also mentioned the abundance of sinkholes and karstic chimneys in Mt. Peqi'in.

The karstic nature of the 'Einan and Teo springs was discussed by Gerson (1967) and Grossovitz (1969). The nature of the Mt. Meron and 'Amud springs was discussed by Shifan (1952) and Bein (1967).

The examination of the distribution of the karstic phenomena in eastern Galilee shows that they coincide with areas of developed open

joint systems which follow the transition zones between the chalk facies of eastern Galilee and the dolomite facies of the central Galilee types (Fig. 4).

West of Mt. Meron block in Mt. Peqi'in, several sinkholes are encountered. A strip of such phenomena can be traced north and northeast of Mt. Meron, coinciding with the facies transition zone of Bar'am-S'asa-Gush Halav.

The direction of this strip is parallel to the major faults direction and to the strike of the facies changes. In the Mt. Yakim area (coord. 193/265) an intensive $N70^{\circ}W - N80^{\circ}W$ directed joint system is encountered, forming solution channels and trenches leading towards the outlets of the Taron Yakim and Po'em springs. In this particular area the dolomite facies starts to thicken eastward. Northwest of this area, the extension of the joint system is recognized with $N40^{\circ}W - N50^{\circ}W$ directions near Meron and Mt. Qal'an. Here also, the rocks are karstic and sinkholes were encountered near S'asa and Doved (coord. 1892/2728).

In the Naftali mountains too, the open joints systems and the karst features follow the facies transition zone. The 'Einan and Teo springs appear along the main fault escarpment which bounds the Hula Valley to the west. Their appearance is controlled by factors such as faulting, joints and karst system, and strongly connected with the facies changes within the Judea Group similar to western Galilee (Kafri, 1969, 1970). As found in western Galilee, the Judea Group aquifer is perched above the regional aquiclude of the Zalmon Formation. It is subdivided into a lower and an upper subaquifers, separated by the Rosh Haniqra aquiclude. In places where the latter is thin or thins out completely, the aquifer is continuous due to the connection between both subaquifers. This can be supported by the absence of any spring, perched upon the Rosh Haniqra aquiclude and draining the upper subaquifer. A schematic block diagram (Fig. 5)

Fig. 4. Schematic map showing relationship between facies boundaries, major faults and joints systems.

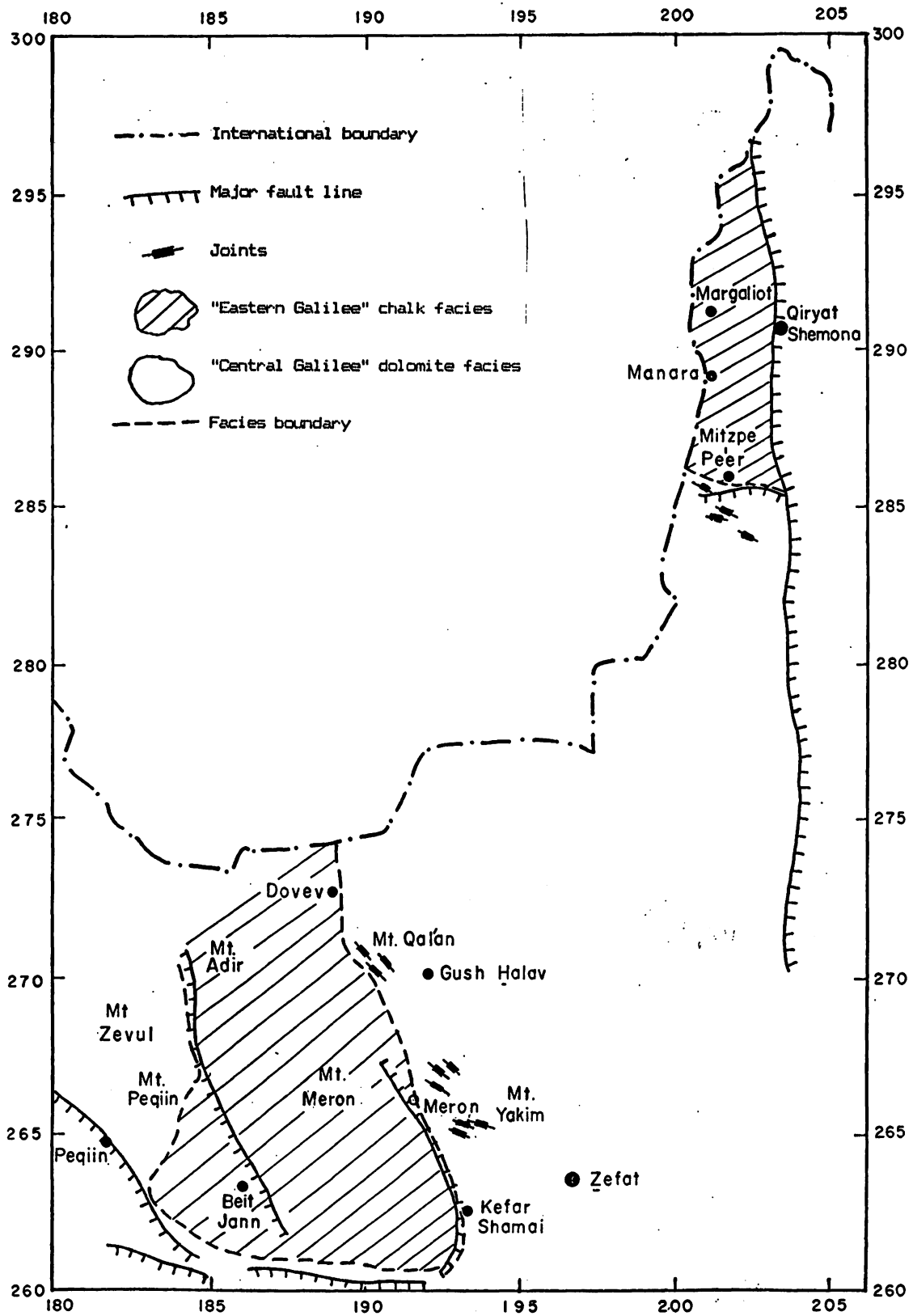
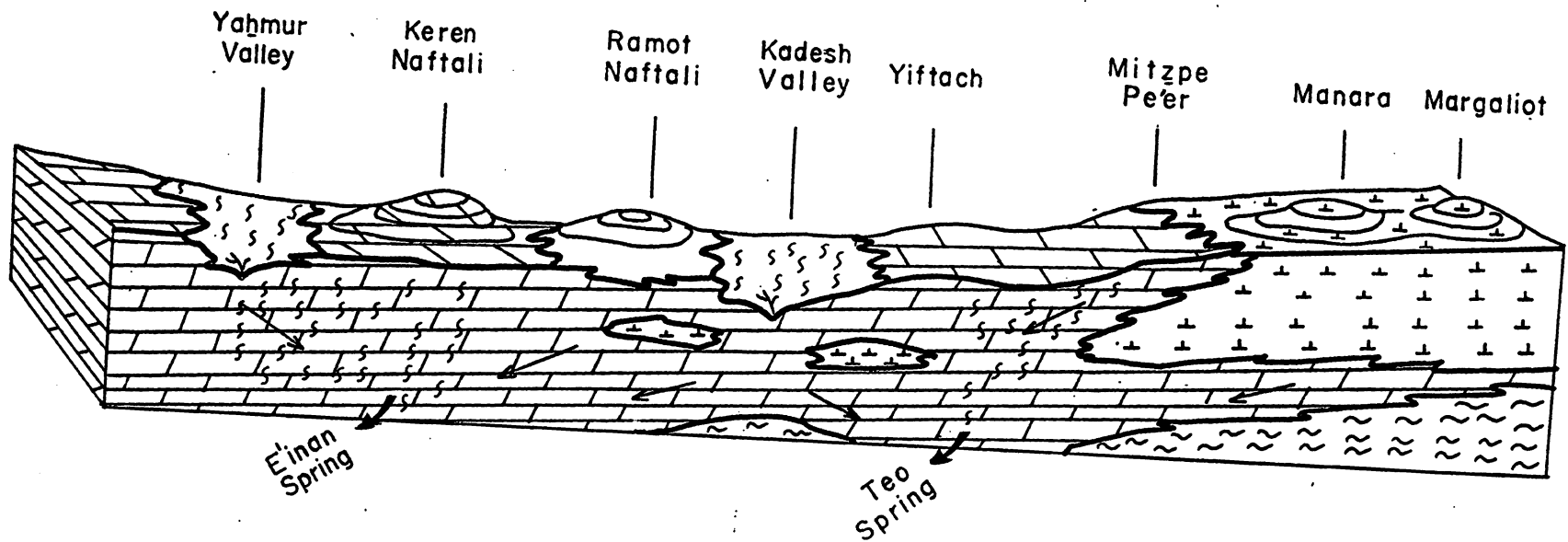


Fig. 5. Block diagram showing the relationship between facies changes and groundwater flow direction toward the Teo and 'Einan springs.



describes the distribution of the two subaquifers and the outlets of the 'Einan and Teo springs accordingly. The lower subaquifer is thin in the Margalioth area showing a gradual thickening towards Manara in the south. In this same area the Rosh Haniqra aquiclude is thick and the upper subaquifer does not exist. From Margalioth in the north to Mitzpe Pe'er in the south, the base of the aquifer dips from +600 m to +300 m above msl. There are no springs outlets perched on the base of the aquifer, which indicate that flow direction is due south, controlled by the regional dip. From Mitzpe Pe'er southwards, the thickness of the lower subaquifer exceeds 200 m. Its basis, due to faulting, is below the base level of the Hula Valley. From Mt. Nezer through Mitzpe Pe'er and southwards, the upper subaquifer starts to develop on the account of the Rosh Haniqra aquiclude which in places thins out. The upper subaquifer shows in this area a very developed karst system accompanying the $N40^{\circ}-85^{\circ}W$ trending joints, parallel to the strike of the facies changes and the main faults direction. Solution channels and secondary calcite which point to extensive groundwater flows in this region, are also recognized. Practically, a narrow elongated NW-SE directed subsurface hydrological channel is formed with a preferential SE flow direction. Transmissivities are high along this channel and due to the thinning out of the Rosh Haniqra aquiclude, a connection is formed with the lower subaquifer and subsequently a natural outlet -the Teo spring- is formed at the base of the channel. In the Yiftah area the Rosh Haniqra aquiclude thickens again and it appears in a lenticular form, and thus a connection between both subaquifers exists.

North of Yiftah (coord. 2020/2825) huge open joints trending SSE-WNW are recognized, forming karstic trenches with collapsed imbricated blocks towards SW. The direction of the joint system leads toward E to 'Ein Teo, and toward west (coord. 200/282) to Mt. Scopus Group beds filling a pre-Senonian (karstic?) relief and a Neogene

conglomerate deeply incised into the same formation, which might point to an early stage of karstification. The entire E-W zone is typical of karstic features and secondary calcite. Also collapse breccias were observed immediately above the 'Ein Teo.

Similar to the above, there is a geographical coincidence between the transition zone to the dolomite facies near Qeren Naftali and the Karstic Kadesh and Yahmur valley which partly feed the 'Einan spring.

The Nahal Kadesh creek is a structural, and therefore a hydrological, divide between the Teo and the 'Einan basins. It cuts down almost to the bottom of the Judea Group aquifer, thus preventing any hydrological connection between both banks of the valley, and defining the southern boundary of the Teo basin. In Qeren Naftali-Kadesh Valley, due to the thinning out of the Rosh Hanigra aquiclude, the Judea Group aquifer is practically a continuous dolomite limestone sequence. In this area karst features such as sinkholes, solution channels and blind valleys are abundant and most of the runoff replenishes the groundwater. The 'Einan spring is situated at the bottom of another subsurface groundwater channel connected to the karst system.

Karst development seems to be connected and initiated by fracturing and jointing. It is suggested that the Judea Group facies changes were caused by Cenomanian block movements along fault lines which were later on rejuvenated. The present joint systems are adjacent, parallel and possibly connected to these faults. There is no wonder, therefore, why the facies transition zones which were subject to jointing and fracturing during long periods display a developed karst system.

The age of the karst systems can be determined according to their structural position in relation to the active regional water table and to their amount of activity. Some of the systems are not

active, being perched high above the water table. These systems found in Peqi'in, Meron, Dovev and Naftali mountains, can be considered as fossil karst. Since the optimal karst development is in the shallow phreatic zone between the water table and the vadose zone, it is apparent that the karst was formed when this area was submerged below the water table, i.e., before they were tectonically uplifted.

It is more difficult to determine the age of the active karst systems not knowing when this process started.

Acknowledgements

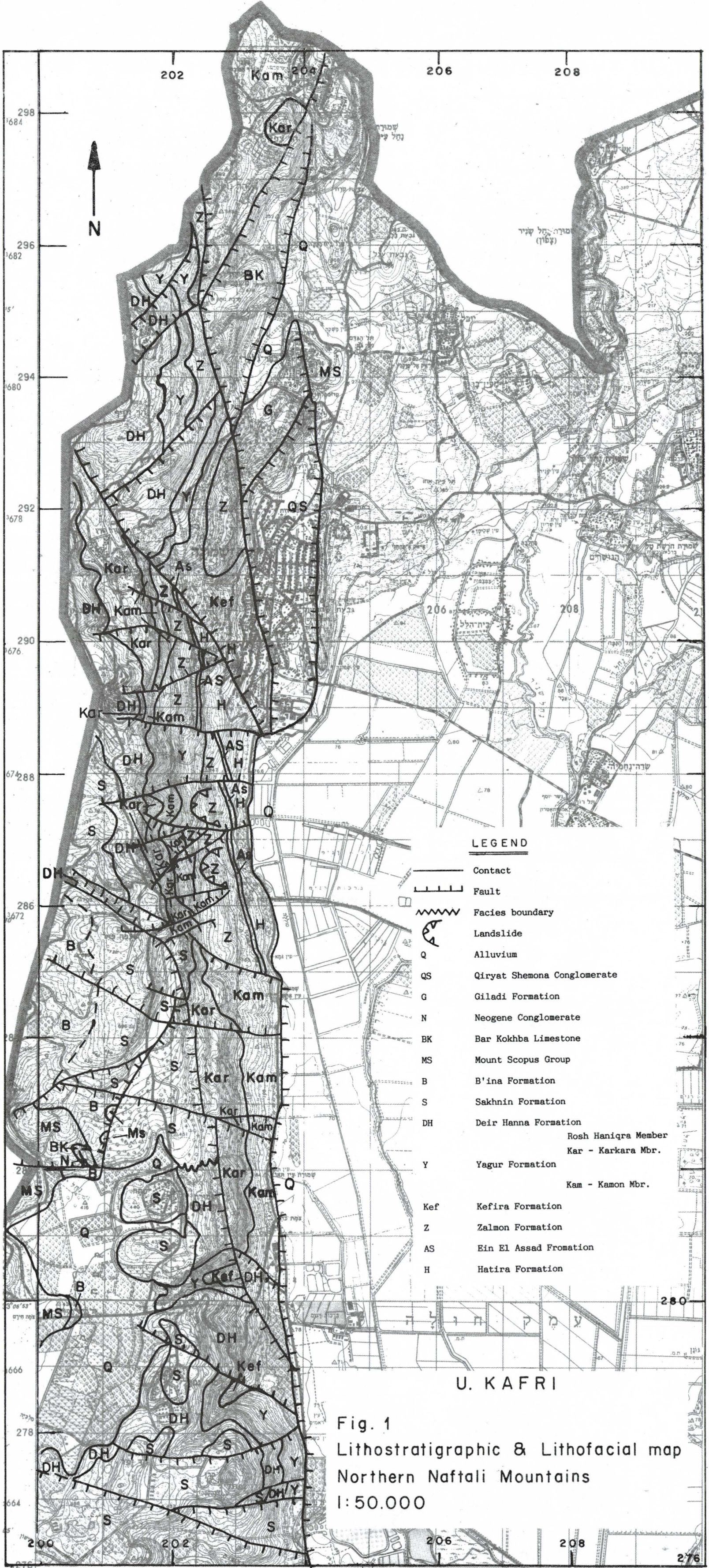
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REFERENCES

- Bein, A., 1967. The hydrogeology of Central and Eastern Galilee.
M.Sc. thesis Hebrew Univ. Jerusalem (in Hebrew).
- Eliezri, I.Z., 1959. The geology of Beit-Jann region. M.Sc. thesis,
Hebrew Univ. Jerusalem (in Hebrew).
- Eliezri, I.Z., 1965. The geology of the Beit-Jann region (Galilee,
Israel). *Isr. J. Earth-Sci.*, vol. 14, pp. 51-66.
- Gerson, R., 1967. Karst phenomena in the Naftali mountains M.Sc.
thesis,
Hebrew Univ. Jerusalem (in Hebrew).
- Glikson, Y.A., 1964. The geology of the southern Naftali Mts. M. Sc.
thesis, Hebrew Univ. Jerusalem (in Hebrew).
- Glikson, Y.A., 1966. Geology of the southern Naftali Mts (North
Eastern Galilee, Israel). *Isr. J. Earth-Sci.*, vol. 15, pp. 135-
154.
- Glikson, Y.A., 1966. The lacustrine Neogene in the Kefar Gil'adi
area, northern Jordan Valley. *Isr. J. Earth-Sci.*, vol. 15, pp.
85-100.
- Golani, U., 1957. The geology of the Maghar region. M.Sc. thesis,
Hebrew Univ. Jerusalem (in Hebrew).

- Golani, U., 1961. On the Cenomanian-Turonian lithostratigraphy of Central Galilee. Bull. Res. Counc., Israel, vol. 10G, pp. 115-146.
- Grader, P., 1958. Geological outline in the Sasa region. Geol. Surv. Israel, Bull. 20.
- Grossovitz, Y., 1969. The hydrogeology of the Cenomanian-Turonian aquifer of Naftali Mts. Diploma thesis, Groundwater Research Center. Hebrew Univ. Jerusalem (in Hebrew).
- Itzhaki, Y., Arkin, Y., Braun, M. and Lasman, N., 1964. The geological map of Israel, 1:50,000. Jerusalem-Bet Shemesh. Geol. Surv. Israel.
- Kafri, U., 1969. Geology and groundwater of the Cenomanian formations in Galilee, west of the watershed. Ph.D. thesis. Hebrew Univ. Jerusalem (in Hebrew).
- Kafri, U., 1970. The Cenomanian-Turonian calcareous aquifer of Central and Western Galilee. I.A.S.H. Bull. 15, pp. 77-91.
- Kafri, U., 1972. Lithostratigraphy and environment of deposition, Judea Group, Western and Central Galilee, Israel. Geol. Surv. Israel Bull. 54.
- Kafri, U., 1986. The Late Albian to Early Cenomanian Sedimentary break in Northern Israel. Isr. J. Earth-Sci., vol. 35, pp. 211-219.

- Rosenberg, E., 1960. Geologische Untersuchungen in den Naftalibergen.
Mitt. Geol. Univ. Zurich, Sur. C, No. 80, p. 107.
- Rosenfeld, A. and Raab, M., 1974. Cenomanian-Turonian ostracodes from
the Judea Group in Israel. Geol. Surv. Israel Bull. 62.
- Saltzman, U., 1964. Geology of the Tabgha-Hugog-Migdal region. M.Sc.
thesis, Hebrew Univ. Jerusalem (in Hebrew).
- Shadmon, A., 1959. The B'ina Limestone. Geol. Surv. Israel Bull. 24.
- Shaliv, G., 1972. Hydrogeology of the Nahal Faria region. Tahal
HR/72/097, (in Hebrew).
- Shiftan, Z., 1952. The geohydrology of the Safad region. Res. Council.
Israel Bull. 1G, pp. 1-19.
- Shlein, N., 1961. The geology of the 'Alma region. M.Sc. thesis,
Hebrew Univ. Jerusalem (in Hebrew).
- Weiler, Y., 1961. The geology of the Nazareth and Tabor Mts. M.Sc.
thesis, Hebrew Univ. Jerusalem (in Hebrew).
- Yair, A., 1962. The morphology of the Dishon River. M.Sc. thesis,
Hebrew Univ. Jerusalem (in Hebrew).



LEGEND

- Contact
- Fault
- ~ Facies boundary
- ⤴ Landslide
- Q Alluvium
- QS Qiryat Shemona Conglomerate
- G Giladi Formation
- N Neogene Conglomerate
- BK Bar Kokhba Limestone
- MS Mount Scopus Group
- B B'ina Formation
- S Sakhnin Formation
- DH Deir Hanna Formation
- Y Yagur Formation
- Kef Kefira Formation
- Z Zalmon Formation
- AS Ein El Assad Fromation
- H Hatira Formation
- Rosh Haniqra Member
- Kar - Karkara Mbr.
- Kam - Kamon Mbr.

U. KAFRI

Fig. 1
Lithostratigraphic & Lithofacial map
Northern Naftali Mountains
1:50.000

