SYRIAN ARAB REPUBLIC
MINISTRY OF INDUSTRY
DEPARTMENT OF GEOLOGICAL AND MINERAL RESEARCH

THE GEOLOGICAL MAP OF SYRIA

SCALE 1:200,000

Sheets J-37-V, XI
(Al-Hasakeh)

EXPLANATORY NOTES

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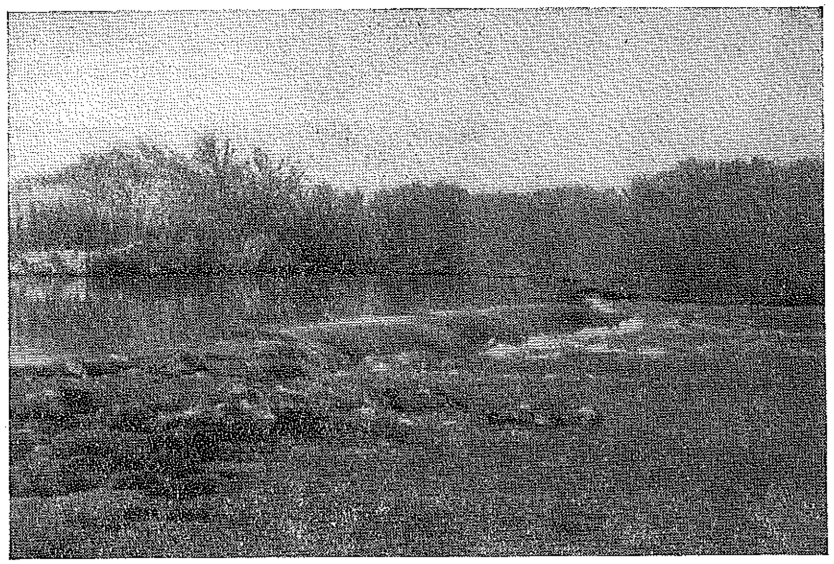


Fig. 1. A small man-made fell on the N. El-Khabour, near the town of Al-Hasakeh

The Abd El-Aziz mountains have a latitudinal trend stretching for over 60 km and reaching 10 to 15 km in width.

The mountains are of an asymmetrical pattern. The northern slope, up to 10 to 20° steep, is often bounded with 40 or 50-metre scarps and cut by deep ravines. The steepness of the southern slope is hardly over 5° and the relief is less rugged as compared with the northern slope. The relative elevation of the J. Abd El-Aziz above the surrounding plain is 400 to 500 m.

The drainage system is represented by the Nahr El-Khabour (Fig. 1) and its left tributaries. Most of the tributaries get dry about midsummer forming small isolated pools with hardly noticeable current, with the water flowing through the alluvium.

The source of the N. El-Khabour is considered to be highly discharged Ras El-Ein springs. The present valley of the N. El-Khabour, 1—2 km wide, cuts the fluvial deposits and, in places, the original riverside down to 10 or 15 m. The N. El-Khabour discharge is not constant due to the main precipitation falling out in winter time.

The winter floods of January-March sharply and irregularly increase the water discharge. Average monthly discharge of the N. El-Khabour, measured near Suwar village (the Deir Az-Zor sheet), ranges from 40 or 41 cu. m/sec in June—July to 69 or 93 cu. m/sec in January—March [13]. The deepest tributary of the N. El.-Khabour is the Jagh-Jagh having the discharge of 5.93 cu. m/sec near Qamishli and 1.68 cu. m/sec near Al-Hasakeh. Such a big difference in the discharge is due to the water being taken for irrigation.

Most of the territory under investigation is covered by loose Quaternary sediments which in some localities are rather thick. The best exposure of the rocks has been observed in the Abd El-Aziz mountains and somewhat worse exposed are the Tshumba and Jabiseh hills. Outcrops are also present in erosion cuts found in some localities of the plain north and south of the J. Abd El-Aziz. The edges of the basalt sheets are well exposed.

The climate of the area in question is transitional from subtropical Mediterranean to the continental climate of the desert. The northern portion of the territory belongs to a steppe zone, while the southern one is in the zone of semidesert. The boundary between them runs approximately along the latitude of the northern slope of the Abd El-Aziz mountains.

The steppe zone is characterized by a more humid and mild climate. The amount of precipitation ranges from 570 to 250 mm. Average annual temperature is +19, +20° C. Absolute minimum of —5,3°C is in January, maximum of +45.6°C — in July [13].

In the semidesert zone the precipitation decreases to 200—100 mm per year, average annual temperature is over +20°C, absolute minimum is —4.8°C and maximum is +47.8°C. The precipitation falls in the winter time mainly as a heavy rainfall.

In the northern areas and in the Abd El-Aziz mountains there is some snowfall, but the snow cover does not last long. There is no rainfall during the period from May to October.

In the north the relative humidity reaches 50% and in the semidesert zone it is much less.

Soil zones nearly correspond to the climate zones. The steppe zone is characterized by chestnut soil which is gradually replaced by grey soil southwards. In the semidesert zone grey soil is found but the soil cover is not continuous. There are localities devoid of soil but covered with gypsum crust and in some places with windblown sand.

The vegetation is luxuriant in spring and completely dry in midsummer.

Cereals and wormwood make the grass cover in the steppe zone, getting scarse to the south. The semidesert zone is covered with vegetation only in places. Perennian plants with deep roots grow here, such as tencrium, and also such annual plants as ephemeras.

In the Abd El-Aziz mountains there are some low woods.

In the N. El-Khabour valley there are dense thickets of weeping willow, tamarisk and Euphrates poplar. Fruit trees, vegetables, melons and cotton are cultivated.

The population is concentrated in the steppe zone, where its density ranges from 11 to 25 men per 1 km^2. The people living here are Arabs, Kurds, Armenians and Assyrians engaged in agriculture and cattle-breeding. South of the Abd El-Aziz mountains the density of population falls down to 1—5 men per 1 km^2.

Before the work on contract 944 was started, the territory in question had been insufficiently investigated geologically.

In 1932 L.Dubertret, A. Keller and H. Vautrin published the paper "Contribution a la géologie de la Djezireh" in which the authors gave a brief description and faunal characteristics of Carboniferous, Albian, Cenomanian, Turonian, Lower Senonian, Maestrichtian, Paleogene, Burdigalian and Vindobonian deposits in the Abd El-Aziz mountains.

From 1934 to 1937 "Iraq Petroleum Company, Ltd" made a geological survey and drilling on anticlinal structures marked in the relief. Several shallow core holes were drilled on the Jabiseh structure and a sketch geological map was made on the scale of 1 : 50,000.

In 1939 "Petroleum Concessions (Syria and Lebanon), Ltd" started drilling a well Jabiseh-1, and in 1941 — well Jabiseh-2. The former penetrated the deposits from Miocene to Lower Cretaceous inclusive, the latter was drilled in Miocene. Oil and gas shows were recorded in the holes nearly throughout the entire section. Well 1 gave a considerable gas flow from Lower Miocene.

In the same years J. Badoux and R. Farbriage conducted a geological survey of the central part of the Abd El-Aziz mountains on the scale of 1 : 100,000.

As a result of the investigations made by the French Geographical Institute two geological maps of Syria on scales of 1 : 1,000,000 and 1 : 2,000,000 were compiled (1943). The maps were edited by L. Dubertret. The geology of the territory of the Al-Hasakeh sheet is shown on these maps schematically.

During 1947—1950 "Syrian Petroleum Company, Ltd" made a gravity and magnetic survey on the scale of 1 : 500,000.

In 1949 a third well was spudded on the Jabiseh anticline. The well struck Jurassic. Oil and gas shows were recorded throughout the entire depth, but no commercial flow was obtained. Negative results of drilling on a number of structures served the reason for the abandonment of further prospecting and in the beginning of 1951 "Syrian Petroleum Company, Ltd" gave up the concessions [6]

In 1956 a West-German "Concordia Co." obtained a lease for oil prospecting in Syria. Out of the 49 lease areas, given to the company, 18 leases were on the territory described here. In 1957—1960 these areas were covered by a seismic reflection survey and 1 : 50,000 geological and structural maps were made, that are schematic and do not meet the requirements to this type of maps in the USSR.

The structure of El-Bawwab discovered in 1957 was drilled by well El-Bawwab-1 which penetrated the sequence from Miocene to Permian, and in 1958 well El-Bawwab-2 was drilled in the rocks from Miocene to Upper Cretaceous. Both wells recorded small oil and gas shows in Oligocene and non-commercial oil flow from Upper Cretaceous.

During the period from 1951 to 1957 several papers were published dealing with the problems of the geological structure, tectonics and physiographical information for extensive regions of the Near and Middle East including the territory described [8, 9, 18].

In the spring of 1958 a group of Soviet experts consisting of K. A. Goriachev, V. M. Filatov, A. V. Fomin, V. P. Ponikarov, A. A. Krasnov, B. V. Kotliarevsky and P. A. Strona visited Syria for the purpose of collecting, studying and summarizing the information available on geological, geophysical and prospecting work for oil in Syria. "The report on the present state and recommendations for further prospecting for oil in Syria", written by this group [19], served the basis for the projects of geological and geophysical work to be done under contract N 944. Through this contract the Soviet specialists have made an aeromagnetic survey of the entire territory of Syria and compiled a map of the vertical component of the magnetic field (ΔTa) on the scale of 1 : 200,000, the contour interval being 25 gammas [20].

In 1959—1960, under the same contract, a 1 : 200,000 gravity survey was made in the areas that had not been previously covered by the gravity work of "Syrian Petroleum Company, Ltd". The result of this servey was a gravity map of Bouguer anomalies with contour interval of 1 mgl, and a map of local anomalies [21].

STRATIGRAPHY

The territory of the Al-Hasakeh sheet is composed of Paleozoic (Ordovician, Silurian, Carboniferous and Permian), Mesozoic (Triassic, Jurassic and Cretaceous) and Cenozoic (Paleogene, Neogene and Quaternary) deposits. Ordovician, Silurian, Permian, Triassic and Jurassic are penetrated within the area under description by three deep wells. Carboniferous, Cretaceous and Paleogene deposits are outcropping in the Abd

El-Aziz mountains. Neogene and Quaternary formations compose the most part of the territory.

PALEOZOIC

Ordovician System (O)

(according to well Qamishli)

Ordovician beds were struck by well Qamishli at the interval of 2347—2674.8 m.

They are mostly made of grey mudstone with interbeds of light grey, fine-grained sandstone. The Ordovician age was determined by the following fossils: *Gramops* aff. *trentonensis* Hall, *Leptobolus* sp., *Ctenodonta* aff. *ala* (Barr.), *Orthoceras* sp., *Dalmanitina* cf. *socialis* (Barr.), *D.* aff. *deshayesi* (Barr.), *Tomaculum problematicum* Gkoom., *Hyolithes* cf. *cinctus* Barr., *Lingula* cf. *jejuna* Barr., *Craniops* aff. *trentonensis* Hall, *Orthis (Plectorthis?)* aff. *redux* Barr. and others. The thickness of the Ordovician rocks penetrated by the well is 327,8 m.

Silurian system (S)

(well Qamishli)

The Silurian deposits, pierced by well Qamishli at the interval of 2150—2347 m are represented by grey mudstone intercalated by grey, fine-grained sandstone. *Orthis (Plaesiomus?)* sp. was found in the mudstone. The thickness is 197 m.

Carboniferous system (C)

Tournaisian (C_1t)

The Tournaisian deposits are known in the core of the Abd El-Aziz anticlinal structure, 1.8 km to the northeast of 920-m elevation. They are shale, limestone and sandstone building the tectonic block, about 40 m wide. In the south this block is bounded by faults from the Lower Cretaceous and in the north from the Upper Cretaceous rocks. The block itself is broken by minor faults.

At the base, the outcropping sequence consists of thin-bedded shale alternating with sandstone and limestone, the observed thickness being 17 m. The shale is a grey and dark grey rock in places sandy. The sandstone is fine-grained, yellowish-grey with ferro-carbonate cement. The limestone is brownish-grey, thin-laminated, fine-crystalline. The shale and limestone contain numerous remains of brachiopods, among which N. Litvinovitch determined *Chonetes (Rugosochonetes) laguessianus* Kon., *Spirifer* aff. *tornacensis* Kon., *Buxtonia scabricula* Mart., *Camarotoechia* sp., *Syringothyris* sp. that indicate the Lower Carboniferous age, probably Tournaisian.

Further up comes ochreous-yellow, fine- and medium-grained sandstone with ferro-carbonate cement having the thickness of 4 m.

The total thickness of the exposed Tournaisian beds is 20 or 30 m.

L. Dubertret, A. Keller and Vautrin (1932) found the following fossils in the rocks: *Spirifer tornacensis* Kon., *Orthotetes crenistria* Phil., *Ambocoelia urei* Elem., *Lepidodendron* aff. *veltheimianum* Sternb., *Archeosigillaria* aff. *vanuxemi* Goepp., indicating the Tournaisian age.

Permian system (P)

(drilling data)

The Permian deposits were encountered by wells El-Bawwab-1 and Qamishli.

At the interval of 3415—3500 m well El-Bawwab-1 struck the Lower Permian beds composed of dark grey, sandy shale containing sandstone bands at the base. The rocks, 85 m thick, are unfossiliferous. The Upper Permian deposits occur at the interval of 2847—3415 m, among which three series may be distinguished (upwards):

1. Dark grey clay with thick interbeds of light grey, fine-grained sandstone (50 and 80 m). The clay contains *Spirifer alatus* Goldfuss, *Terebratuloida* cf. *depressa* Waagen, *Heliodopsis* cf. *abreviata* Waagen . . . . 345 m

2. Dark grey shale with thin intercalations of fine-grained sandstone and limestone, contains *Productus* cf. *burlingonensis* Hall., *P.* cf. *semireticulatus* Martin., *Lingula credneri* Geinitz, *Edmondia* cf. *sulcata* Phill., *Mytilus* cf. *squamosus* Sow., *Bakewelina* cf. *sedgwickiana* King, *Pleurophorus* aff. *jonnstonei* Dickins, *Nuculata subacuta* Waagen, *Albrisma* aff. *pleuromyoides* Waagen., *Streparollus permianus* King, *Bellerophon* cf. *permianus* Netschajew . . . . 155 m

3. Grey and dark grey limestone intercalated by dark grey shale, contains *Chonetes* cf. *kirkbyi* Trechm . . . . 68 m

The total thickness of the Permian deposits penetrated by well El-Bawwab-1 is 653 m.

In Qamishli well grey, fine-grained sandstone with mudstone bands, 30 m thick (1850—2150 m) is considered to be of the Permian age.

MESOZOIC

Triassic and Jurassic systems undifferentiated (T—J)

(drilling data)

The Triassic and Jurassic deposits were encountered by wells El-Bawwab-1, Qamishli and Jabiseh-3.

At the interval of 2140—2847 m well El-Bawwab-1 encountered (upwards):

1. Dolomitic sandstone and dark grey shale . . . . 22 m
2. Grey and brown-grey dolomite with *Cythereis senckenbergi*, *Lenticulina* sp., *Lagena* sp. at the top . . . . 320 m
3. Dolomite intercalated by dolomitic shale with *Lenticulina* sp., *Miliola (Hechtina) antigua*, *Lagena* sp., *Cythereis senckenbergi* . . . 70 m
4. Anhydrite with dolomite intercalations . . . . 35 m
5. Brown, bituminous dolomite with thin clay intercalations containing, *Lenticulina* cf. *cubalata Cristellaria* sp., *Ammodiscus* cf. *incertus* 200 m
6. Anhydrite with thin intercalations of green-grey clay . . . . 60 m

The total thickness of the deposits having the Triassic and Jurassic age is 707 m.

Taking into consideration the information available from the neighbouring areas the largest portion of the dolomitic series can be attributed to Jurassic. The Triassic sequence of the series can hardly be distinguished due to lack of evidence.

From the bottom hole (2624.3 m) up to 2435.8 m Jabiseh-3 well encountered:

1. Black shale, abundant in pyrite, with bands of grey limestone . 18.3 m
2. Grey limestone, in places pseudo-oolitic, with pyrite, containing bands of shale and at the top — of anhydrite . . . . 27.4 m
3. White, compact anhydrite with black shale and anhydrite bands 25.9 m
4. Greyish-brown limestone, at the bottom containing bands and inclusions of anhydrite, at the top containing *Valvulinella* sp., *Glomospira* sp. and others . . . . 118.9 m

The drilled thickness of the deposits supposed to be of the Triassic and Jurassic age, undivided, in Jabiseh-3 well is 190.5 m.

In Qamishli well the Triassic and Jurassic age was assigned to a grey dolomite series with greenish shade, containing bands of anhydrite, mudstone and in places marl, the total thickness being 200 m.

Cretaceous system

Lower Cretaceous (Cr_1)

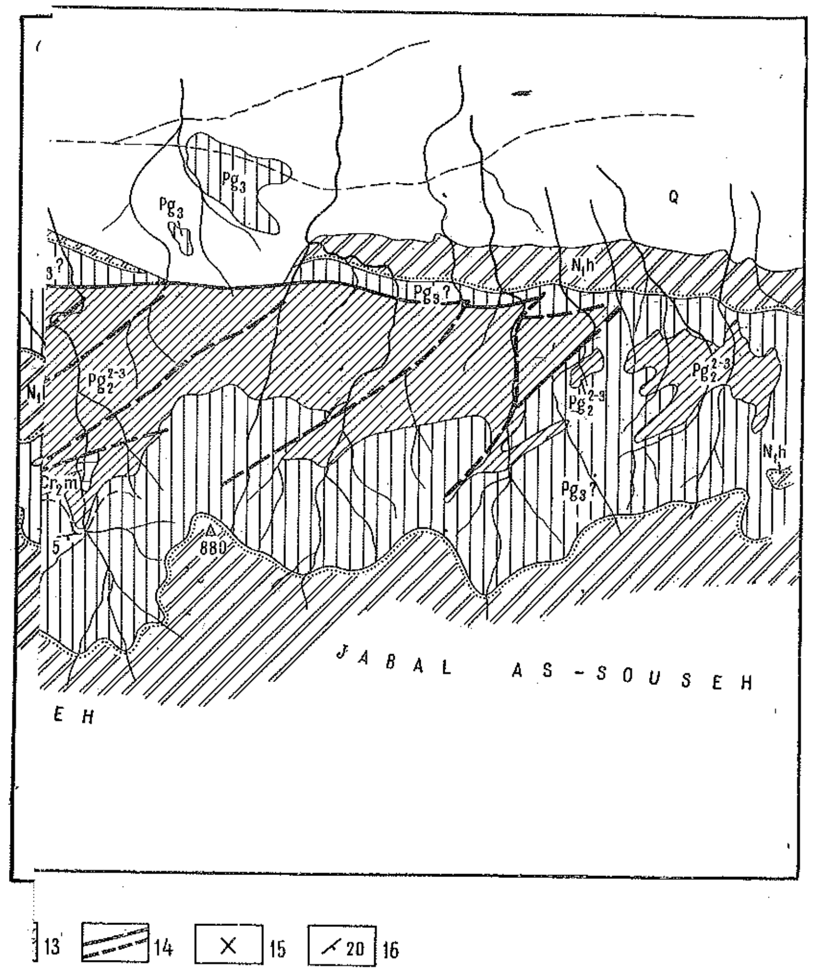
The Lower Cretaceous deposits are exposed in the Abd El-Aziz mountains. Among them there are Neocomian, Aptian and Albian rocks the

outcrops of which could be put only on the schematic geological map, 1 : 25,000 (Fig. 2).

On the map of 1 : 200,000 scale they are not subdivided but shown as Lower Cretaceous. These deposits are also encountered by deep wells Jabiseh-1 and 3, El-Bawwab-1 and Qamishli.

NEOCOMIAN

The Neocomian deposits are outcropping in three isolated localities. The]



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gene system: *3* — Oligo-
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e with flint nodules;
, Tournaisian. Sandstone,
faults; *15* — blocks and

Зак.

bands at the base. The rocks, 85 m thick, are unfossiliferous. The Upper Permian deposits occur at the interval of 2847—3415 m, among which three series may be distinguished (upwards):

1. Dark grey clay with thick interbeds of light grey, fine-grained sandstone (50 and 80 m). The clay contains *Spirifer alatus* Goldfuss, *Terebratuloida* cf. *depressa* Waagen, *Heliodopsis* cf. *abreviata* Waagen . . . . 345 m

2. Dark grey shale with thin intercalations of fine-grained sandstone and limestone, contains *Productus* cf. *burlingonensis* Hall, P. cf. semi-

outcrops of which could be put only on the schematic geological map, 1 : 25,000 (Fig. 2).

On the map of 1 : 200,000 scale they are not subdivided but shown as Lower Cretaceous. These deposits are also encountered by deep wells Jabiseh-1 and 3, El-Bawwab-1 and Qamishli.

NEOCOMIAN

The Neocomian deposits are outcropping in three isolated localities. The lower boundary is not observed on the day-surface.

The largest exposure, 300×150 m in area, is 0.5 km to the east of 682-m elevation. The sequence of the rocks here is the following:

1. Conglomerate made of pebbles and boulders with sand and gravels, of bright brown-yellow colour. The clastic material consists of medium, ill-rounded pebbles and boulders (up to 0.5 m) of fine-grained, sparkling dolomite and less frequently grey limestone. There are rare bands of gravel conglomerate and less frequently lenses of clayey sandstone. The cement is carbonate, compact, basal or pore-filling, with *Cyclamina* aff. *greisi* Henson, *Pseudocyclamina* sp., *Choffatella*(?) sp., *Orbitolina* sp.

According to V. Shokhina the fossils indicate the Neocomian age 35 m

2. Bright green, sendy, clayey* and dolomitic marl: $CaCO_3$ — 24—58%, $CaMg(CO_3)_2$ — 10—16% . . . . 3 m

3. Yellowish-grey compact inequigranular quartz sandstone with some gravels and carbonate cement. In places, mostly at the base, appears the admixture of coarse-detrital, ill-rounded material of the same composition as in layer 1 . . . . 20 m

4. Conglo-breccia consisting of medium, ill-rounded fragments, 0.25 and seldom 0.5 m in size, of yellow-grey dolomite with sandy-carbonate compact cement of grey-yellow colour. The conglo-breccia is laterally often replaced by inequigranular quartz sandstone with some carbonate grains, having obscure diagonal bedding. A poorly preserved fragment of Lima shell was found at the top of the bed, which according to the conclusion of N. A. Cheltsova "displays a remote likeness with *Lima* ex gr. *tunetana* Perv. from the Hauterivian of Tunisia" . . . . . . 1.5—3 m

The conglo-breccia and sandstone unconformably rest on the underlying rocks cutting off the sandstone and marl of layers 3 and 2 and partly conglomerate of layer 1.

5. A series of sandy-oolitic marl — $CaCO_3$ — 56%, $CaMg(CO_3)_2$ — 2%, dolomitic marl, calcareous dolomite — $CaMg(CO_3)_2$ — 57%, $CaCO_3$ — 33%, quartzose sandstone with calcareous and clayey cement and limestone generally dolomitic and sandy — $CaCO_3$ — 71%, $CaMg(Co_3)_2$ — 9.5%. The sandstone beds are mostly found at the top. The colour of the rocks is very bright varying from ochreous-yellow to brown and cherry-red, in some beds mottled. The lighter shades are less frequent: yellowish, pink and white. The thickness of individual beds ranges from 0.3 to 3.5 m.

At the base, the soft sandy-oolitic marl contains rare remains of regular echinoids, plenty of large foraminifera of the Orbitolina family, some fossils of *Pseudocyclamina* sp., *P.* aff. *grandis* Romanova, *Choffatella* sp., *Discorbis* (?) sp., *Lenticulina* sp. According to V. Shokhina the fossils indicate Neocomian age. The thickness of the member is 13.5 m.

The total thickness is about 75 m.

The rocks described above are characterized by some common features which distinguish them from the rocks of the upper part of the section. The most important feature is predomination of terrigenous rocks, coarse and obscure-bedded at the base; less coarse and distinctly bedded, mostly sandstones — in the middle; carbonate and sandy-carbonate, distinctly bedded at the top. Another feature is the bright colour which is ochreous-yellow at the base and in the middle and yellow-red, often mottled at the top. The series, as a whole, is of not easily recognized transgressive character what is quite typical for coastal facies of a normal sea basin.

The fossils of layer 4 permit to assume the Hauterivian age of the deposits.

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* For carbonate and clay rocks we assume the classification of S. Vishniakov.

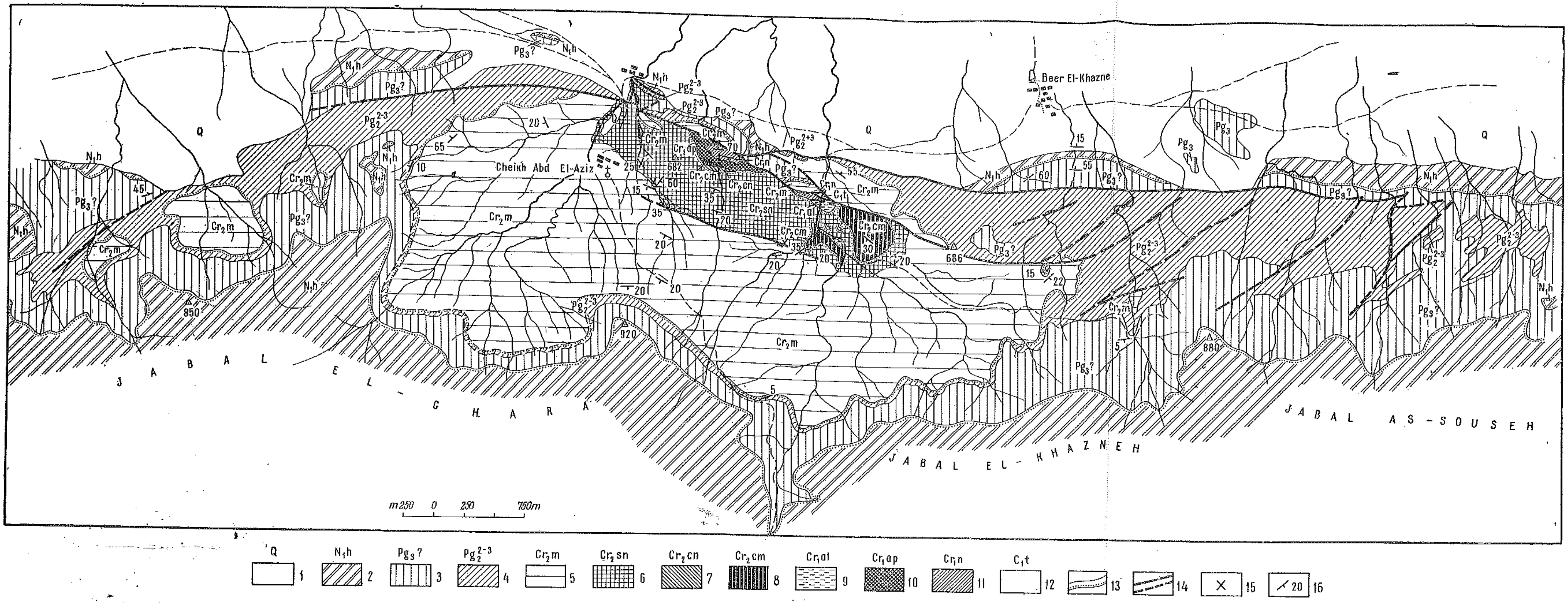

Fig. 2. Sketch geological map of the central part of the Abd El-Aziz mountains. Compiled by K. Ya. Mikhailov. The map has been compiled on the basis of air photo materials and field observations of B. Danilov, V. A. Krasheninnikov, K. Ya. Mikhailov, V. P. Ponikarov, B. Ya. Ponomarev

1 — Quaternary undifferentiated. Gypsumized gritty loams; *2* — Neogene system. Helvetian. Limestone, dolomites. Paleogene system: *3* — Oligocene (?). Clayey limestone, marl; *4* — Middle-Upper Eocene. Algal silicified limestone. Cretaceous system: *5* — Maestrichtian, upper part. Clayey limestone, marl; *6* — Senonian without upper part of Maestrichtian. Dolomitic marl, limestone, sandstone, conglomerate; *7* — Coniacian. Organogenous detrital limestone; *8* — Cenomanian. Dolomite, clayey dolomite; *9* — Albian. Dolomitic limestone with flint nodules; *10* — Aptian. Clay, marl, clayey limestone; *11* — Neocomian. Conglomerate, conglobreccia, marl; *12* — Carboniferous system, Tournaisian. Sandstone, shale limestone; *13* — geological boundaries: solid where conformable, solid and dotted where unconformable; *14* — faults; *15* — blocks and boulders of rocks with Carboniferous fossils; *16* — strike and dip.

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It is likely that the lower part of the sequence belongs to the Early Neocomian (Valanginian).

6. The Neocomian deposits are overlain by medium to coarse-grained, friable quartz sandstone with carbonate and carbonate-ferruginous cement, with the colour ranging from white to rust-brown, rust-red and violet-red. Bedding is obscure, often lenticular, in places obscure diagonal. Ferrugination is not uniform. There are spots and cakes (especially on bed interfaces) of pure, slightly sandy limonite.

The thickness of the sandstone member ranges from 5 to 50 m.

The sandstone rests on the underlying rocks with obscure unconformity what is proved by their different ages.

The sandstone is probably of the Barremian age since it unconformably overlies the deposits assumed to be Hauterivian and is conformably overlain by the fossiliferous Lower Aptian rocks.

APTIAN

The Barremian sandstone beds are conformably overlain by yellow-green, plastic, limy-dolomitic clay — $CaCO_3$ — 6—24 %, $CaMg(CO_3)_2$ — 6—10 % with thin bands of clayey marl rich in poorly preserved oysters. Among them N. A. Cheltsova identified *Btauris cf. praelongum Sharpe, Pholadomia* sp., *Dosinia* sp., *Roloboceras* (?) sp. indet. The species are typical for the North American Aptian.

At the base of the clay member there are thin intercalations of light clayey limestone which contains *Ceratostreon* aff. *tysiphone* Coq., *Btauris* aff. *praelongum* Sharpe.

The latter, according to A. Atabekian resembles the fossils of the Roloboceras genus widespread in Lower Aptian deposits.

The thickness of the clay member is 21 m. According to fossil evidence the clay belongs to the Aptian age.

ALBIAN

The deposits which are tentatively attributed to Albian compose a small locality, 1.2 km east of elevation 682. They contact the underlying Neocomian rocks along the fault.

The Albian beds are made up of coarse-bedded, compact dolomitic limestone. In some beds the colour is dark and yellow-brown, in others — light, yellow or grey. The middle and upper portions of the section contain nodules, lenses and bands of light flint. At the top the limestone is highly sandy.

The thickness of the exposed beds is 30 m.

In some places the limestone contains rare unidentified pelecypod remains. The age of the rocks is inferred to be Albian due to the position in the sequence (below the Cenomanian dolomite).

Lower Cretaceous undifferentiated (Cr^1)

(drilling data)

The Lower Cretaceous deposits are penetrated by wells Jabiseh-1, 3, Qamishli and El-Bawwab-1.

In Jabiseh-1 the Lower Cretaceous rocks are recorded at the interval from the bottom hole (2596.9 m) up to 2550.6 m. They are distinguished as the Hayane formation consisting of dark grey or blue-grey, slightly dolomitic shale with thin bands of limestone. The limestone contains *Orbitolina* cf. *discoides*, *Choffatella decipiens* typical for Aptian-Albian [6] The drilled thickness of the Lower Cretaceous rocks is 46.3 m.

The Lower Cretaceous beds pierced by well Qamishli are composed of light grey, greenish and light-brown limestone with bands of mudstone and marl, 85 m thick, with *Lenticulina* sp.

In well El-Bawwab the Aptian-Albian age is assigned to the Aasfir formation consisting of limestone and dolomite interbedded with grey-green shale. Ferruginous shale and sandstone beds are recorded at the base (the Aasfir formation).

The total thickness amounts to 150 m.

Upper Cretaceous

The Upper Cretaceous deposits outcrop in the Abd El-Aziz mountains. It is possible to distinguish: 1) Cenomanian, 2) Senonian (without the upper part of Maestrichtian), 3) Maestrichtian, the upper part.

In the geological cross-section, made from the data of wells Jebiseh, El-Bawwab and Qamishli, the Upper Cretaceous is not subdivided into stratigraphic units.

CENOMANIAN (Cr_2cm)

The Cenomanian deposits compose small localities in the central part of the Abd El-Aziz mountains. They are unconformably overlain by Senonian. The contact with the underlying rocks was not observed. The Cenomanian sequence consists of grey, massive-bedded, compact dolomite, argillaceous dolomite and dolomitic limestone. At the top the rocks are more light in colour and distinctly bedded, in places of lumpy structure and vermicular texture, typical for the Upper Cenomanian of the Central Syria. The observed thickness is 63 m.

In the locality, 300 m east of elevation 682 m, the dolomitic limestone contains *Gryphaea* ex gr. *vesiculosa* Sow., *Neithea* sp. indet., *Gryphaea* sp. indet.

The former, according to N. N. Bobkova, is widespread in the Cenomanian rocks of Great Britain, France, Italy and Southern India what makes it possible to define the age of the deposits as Cenomanian.

SENONIAN, WITHOUT UPPER MAESTRICHTIAN (Cr_2sn)

Coniacian

In the locality, 300 m east of elevation 682, the Cenomanian dolomitic limestone and Aptian clay are stratigraphically unconformably overlain by white, laminated, organodetrital limestone of aphanite structure with remains of *Pycnodonta* cf. *clavata* Nils., *P.*, cf. *vesicularis* Lam. which, according to N. A. Cheltsova, have cosmopolitan development.

The former is known from Lower Senonian, the latter is generally found throughout the whole of Senonian.

The limestone, 15—22 m thick, is with distinct erosion overlain by the rocks containing oysters and pelecypods that may be of the Santonian age. They belong either to the base of Senonian or most probably, to Coniacian.

Santonian, Campanian and Lower Maestrichtian, undivided

The undivided rocks of the Santonian, Campanian and Lower Maestrichtian age lie on the eroded surface of the rocks having different ages from the Neocomian many-colour marl and sandstone to the Coniacian limestone, with erosion pockets and crack inwash at the contact. At the base they are represented by a conglomerate which is upwards replaced by marl and limestone.

The conglomerate consists of boulders and pebbles with some gravel and sand, brownish-grey in colour, nearly unsorted, with carbonate cement. The clastic material is as a rule, ill-rounded, consisting of grey, sparkling granular dolomite (such dolomite is very common for the Cenomanian and Turonian of Central Syria), yellow dolomitic marl and conglomerate, red-brown ferruginous sandstone, typical for the base of Cretaceous, and reddish-brown clay. The latter also occurs in small lenses. Gravel conglomerate with basal cement predominates at the top; in places there are lenses of sandstone and white sandy limestone, up to 0.5 m thick. The sandstone and sandy limestone are abundant in fossils, mostly gastropods. The thickness is 10.5 m.

The fossils collected from the top of the member were identified by N. A. Cheltsova as *Trigonoarca camerunensis* Riedel, *T. curvatodonta* Riedel, *Acra (Eonavicula) bogaerti* Dart., *Neithea quinquecostata* Sow. typical for the Senonian of Cameroons, Angola and Gold Coast.

The basal conglomerate beds are overlain by dolomitic marl — $CaCO_3$ — 54 to 68%, $CaMg(CO_3)_2$ — 8 to 10% and dolomitic limestone — $CaCO_3$ — 87 to 90%, $CaMg(CO_3)_2$ — 6 to 7%, white or light grey, sandy, with bands of brownish-grey compact sandstone, often with some gravel-pebble material and conglomerate intercalations resembling the above discribed basal conglomerate.

The thickness of the series is 203 m.

At the top of the series the conglomerate as well as dolomite and other rocks contain nearly unrounded exotic boulders and large blocks of brownish-grey, limy-clayey, shaly sandstone and brownish-grey limestone with Tournaisian fossils. Similar rocks with Tournaisian fossils have been found as individual blocks up to 0.8-1 m in size, "floating" in marl and limestone. These boulders and blocks are probably debris of the coastal rocks. The fossils collected in the middle of the section (90 m from the base), in the sandstone and conglomerate, were defined by N. A. Cheltsova as *Lopha* cf. *tissoti Thomas* et *Peron* known from the Campanian-Maestrichtian of Syria, Tunisia and Algeria. Further upwards (150 m from the base) *Lucina* aff. *angolensis* Rennie were encountered in the sandstone—conglomeratic deposits, and also *Vautrinia syriaca* Vautrin, very well preserved (defined by N. N. Bobkova) which is knouwn from the Maestrichtian of Syria and Turkey. *Vautrinia syriaca* is also widespread in the topmost beds of the series. When the coarse sandstone-conglomerate deposits disappear, these fossils are never found.

The marl and clay limestone of the middle and upper parts of the series contain numerous foraminifera typical for the Maestrichtian stage. V. Shokhina determined them as *Anomalina complanata* Reuss, *An. monterelensis* (Marie), *Cibicides bembix* Marsson, *C. kurganicus* Neckaja, *C. aktulagayensis* Vassilenko, *Globotruncana rosetta* (Carsey), *C. arca* (Cushm), *G. fornicata* Plummer, *Bulimina quadrata* Plummer, *Bolivina incrassata* Reuss, *Bolivinoides delicatulus* Cushm., *Stensiöina stellaria* (Vassilenko).

The total thickness of the undivided Santonian, Campanian and Lower Maestrichtian rocks comes to 225 m.

On the basis of the fossil evidence and position in the sequence, the age of the deposits is considered to be in the range of Santonian — lower part of Maestrichtian. However, Santonian and Campanian ages are not yet sufficiently proved.

MAESTRICHTIAN, THE UPPER PART (Cr_2m)

The marl, limestone and conglomerate series described above is, with clear and stratigraphically normal contact, overlain by a thick series of carbonate rocks belonging to the upper portion of Maestrichtian. It consists of three, nearly equal in thickness, members.

The lower member, about 140 m thick consists mostly of soft shale and slightly dolomitic limestone — $CaCO_3$ — 72%, $CaMg(CO_3)_2$ — 6% with rare bands of marl $CaCO_3$ — 71 to 73%. The rocks are slightly sandy, especially at the bottom. At the base of the section there are many imprints of *Inoceramus*, ex gr. *balticus* Böhm.

The middle member, about 160 m thick, is mostly made of white unconsolidated marl ($CaCO_3$ — 71 to 74%) with rare intercalations of clayey limestone ($CaCO_3$ — 75 to 80%). The marl and limestone are also sandy but to a lesser degree, than in the lower member.

The upper member, 132 m thick, is composed of white limestone — $CaCO_3$ — 73 to 94%; $CaMg(CO_3)_2$ — to 6%, more compact than the above marl and limestone, in places clayey and dolomitic. The rock contains very little sandy material in the form of rare disseminated grains. The total thickness of the upper part of the Maestrichtian stage ranges from 430 to 500 m.

All the section is abundant in mikrofossils. V. Shokhina has determined *Gyroidinoides umbilicata* (Orb.), *Stensiöina stellaria* (Vassilenko), *S. caucasica* (Subbotina), *Globotruncana rosetta* (Carsey), *G. arca* (Cushm.), *G. fornicata* Plummer., *G. stuarti* Lapparent, *Bolivinoides delicatula* (Cushm.), *B. draco* (Marsson), *Rotundina marginata* (Reuss), *Cibicides* aff. *bembix* (Marsson), *Gyroidina* aff. *depressa* Alth., *Globigerina cretacea* Orb., *G. pseudobulloides* Plummer, *Gümbelina globulosa* (Ehrenberg), *G. globifera* (Reuss), *Neoflabellina interpunctata* Marck. and others.

The fossils indicate the Maestrichtian age of the deposits.

Upper Cretaceous undifferentiated (Cr_2)
(drilling data)

The Upper Cretaceous deposits encountered by deep wells, as recorded by the oil companies, are subdivided into different stratigraphic units, not correlated between the adjacent wells. Therefore in the geological section we distinguish them as Upper Cretaceous, undifferentiated.

Well El-Bawwab-1 encountered the Upper Cretaceous deposits at the interval of 1988-1396 m. Among them there are:

1. Cenomanian and Turonian, undifferentiated — clay with bands of dolomitic limestone in the middle, upwards replaced by limestone, dolomite and marl . . . 139 m
2. "Blind zone" — bituminous dolomite with sandstone interbeds . . 29 m
3. Santonian and Campanian, undivided — grey and dark-grey dolomite with intercalations of limestone and shale at the bottom . . . . 288 m
4. Maestrichtian — marly limestone with *Bolivina incrassata* Reuss, *Globigerina* sp. and others . . . 136 m

The total thickness of the Upper Cretaceous rocks pierced by well El-Bawwab-1 is 592 m.

In the area of the Jabiseh hill the thickness of the Upper Cretaceous beds increases to 1379 m. The following formations were distinguished in well Jabiseh-1:

1. Judea formation — dolomitic limestone with *Orbitolina* sp., resembling *Orbitolina* ex gr. *discoidea* which is "typical for Lower Cenomanian" [6] . . . 16 m
2. Derro red beds — reddish brown shale with partings and nodules of anhydrite at the top. According to the position in the sequence the shale is identified as Lower Senonian . . . 11 m
3. Soukhne formation — limestone, with shale interbeds. At the base there are sandy limestone intercalations, sometimes filled with pebbles, at the top — flinty limestone containing phosphate grains. Lower Senonian fossils were encountered, such as *Globigerina cretacea*, *Gümbelina globulosa*, *Bulimina prolixa*, *Anomalina ammonoides*, *Globotruncana marginata* . . . 167 m
4. Shiranish formation divided into several members:

   a) bituminous limestone (56 m) containing Lower Senonian fossils similar to those encountered in the Soukhne formation.

   b) greyish-brown, dolomitic, bituminous marl (115 m) with "Lower Maestrichtian fossils" [6] *Globigerina cretacea, Gümbelina globulosa, Clobotruncana arca, G. rosetta, G. fornicata, G. marginata.*

   c) grey and white marly limestone, in places bituminous, dark brown (895 m).

d) grey bituminous marl with shale intercalations (119 m) and fossils *Globotruncana rosetta, G. arca, G. stuarti, G. ventricosa, G. fornicata, G. conica, Gümbelina striata, Bolivina incrassata* and others (typical for Maestrichtian) [6].

The thickness of the Shiranish formation is 1185 m.

The smallest thickness of the Upper Cretaceous beds, 575 m, was recorded in well Qamishli, where they are composed of brownish-grey dolomite intercalated by limestone.

CENOZOIC

Paleogene system

The Paleogene deposits are outcropping in the Abd El-Aziz mountains where they consist of Middle-Upper Eocene and Oligocene (Fig. 3). The most complete sequence of the Paleogene rocks represented by all the 3 series was observed in deep wells Jabiseh-1 and 3, El-Bawwab-1 and 2 and Qamishli. However, not in all the wells the Paleocene is distinguished from the Eocene, therefore in the geological cross-section they are shown as undifferentiated.

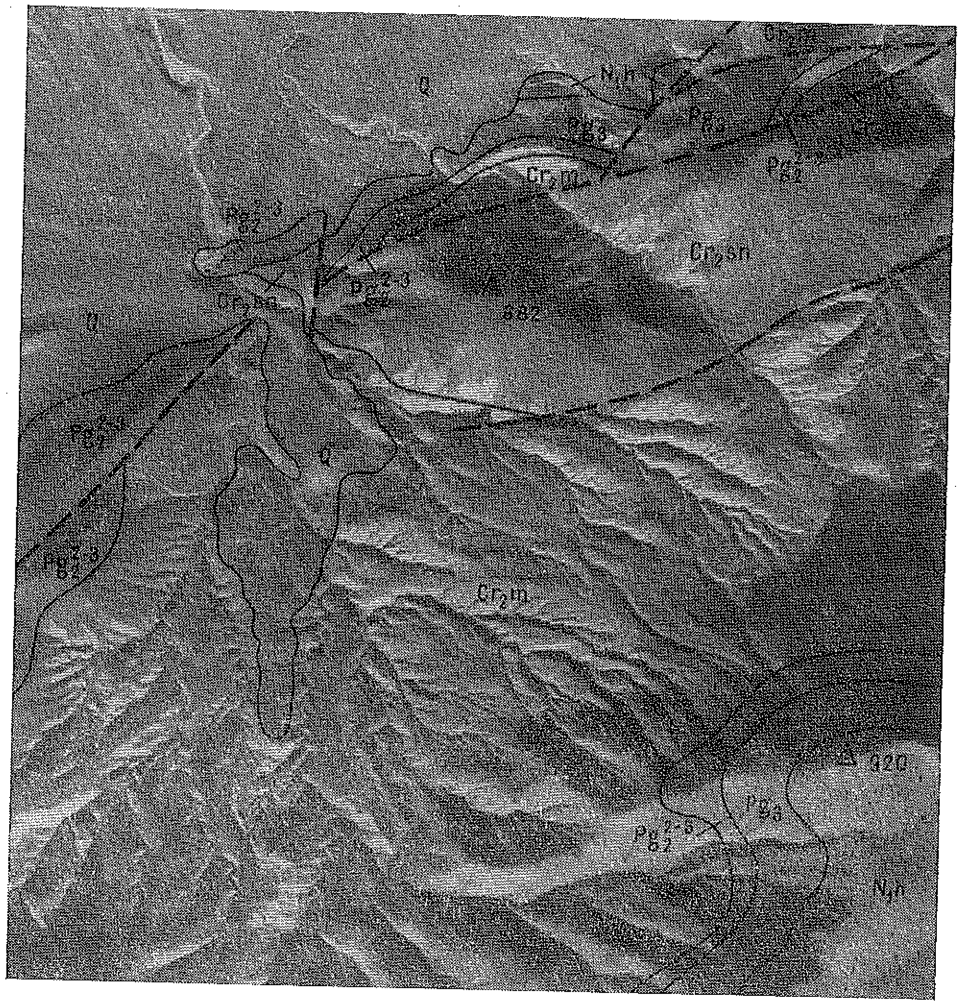


Fig. 3. An area composed of the Senonian without upper part of the Maesrichtian (Cr_2sn), Maestrichtian (Cr_2m), Middle-Upper Eocene (Pg_2^{2-3}), Oligocene (Pg_3), Helvetian (N_1h) rocks. Different units are characterized by different degree of interpretability of aerial photographs. J. Abd El-Aziz

Paleocene and Eocene undifferentiated (Pg_{1-2})
(drilling data)

Well El-Bawwab-1 encountered Paleocene and Eocene at the interval of 1396-1109 m. The lower members composed of brownish-grey, argillaceous, hard limestone, 69 m, thick, are tentatively dated as Paleocene. They are overlain by the Eocene deposits:

1. Brownish-grey, argillaceous limestone with many globigerina remains . . . . 92 m
2. Dark grey limestone with thin bituminous shale interbeds with *Cristellaria* cf. *cultrata, C.* cf. *inornata* . . . . 55 m
3. Pyritized limestone with *Cristellaria* cf. *akkorara* . . . . . . 17 m
4. Light grey, compact limestone . . . . 54 m

The thickness of the Eocene deposits is 218 m.

In well Jabiseh-3, Paleocene and Eocene, undifferentiated, are divided into several formations:

1. Aaliji formation — marl beds, at the base containing grey shale layers. The lower part of the formation, 12 m thick, containing *Globorotalia velascoensis,* Loxosctomum plaitum is attributed to Paleocene. The overlying beds, 48.8 m thick, containing *Globorotalia aragonensis, G. spinulosa, G. wilcoxensis* var. *Loxostomum applinae* are dated as Lower Eocene.
2. Araq flint member — marly limestones, bituminous, grey and brown, with small nodules of flint . . . . 62.5 m
3. Jaddala formation — grey and brown, marly limestone with some glauconite. The lower part of the formation, 88.4 m thick, containing fossils similar to those found in the Aaliji formation, is attributed to Lower Eocene. The overlying rocks, 50.3 m thick, containing *Globorotalia aragonensis G. centralis, G. lehneri, G. wilcoxensis, Nonion micrus, Vulvulina pennatula, Cassidulina subglobosa, Globigerina orbitormis, G. subcretacea* are dated as Middle Eocene, and the lower part of this series, 9.2 m thick, is considered transitional between the Lower and Middle Eocene.
4. The lower part of the Chilou formation, 35 m thick, composed of bituminous, calcareous marl with *Cibicides cushmani, C. mexicanus, C. perlucidus, Gluborotalia centralis, G. cocoaensis, Globigerina eocaena, G. orbiternis* is attributed to Middle — Upper Eocene.

The total thickness of the Paleocene and Eocene, undifferentiated, is 296 m in well Jabiseh-3.

In well Qamishli the thickness of the Paleocene and Eocene increases to 650 m. At the base lie dolomite and dolomitic limestone, 270 m thick, with thin clay interlayers and flint inclusions dated Paleocene—Lower Eocene. The rocks are overlain by light-grey limestone intercalated with dolomite and marl containing nummulites, 380 m thick, dated as Eocene.

Middle — Upper Eocene (Pg_2^{2-3})

The Middle—Upper Eocene deposits, outcropping in the central part of the Abd El-Aziz mountains consists of organic, compact limestone unconformably lying on the Maestrichtian rock with coarse-detrital rocks at the base.

The thickness and lithology of these deposits greatly vary from place to place.

On the northern slope of the Abd El-Aziz mountains, 0.5 km to the north-east of elevation 686 these deposits form a high ridge made of massive, reef limestone containing flint nodules and silicified remains of algae, sponges, corals and other organisms. Under the microscope one can distinguish remains of red algae, echinoderms and foraminifera cemented by pelitomorphic calcite. The thickness is about 100 m.

On the southern slope of the Abd El-Aziz mountains the thickness of the Middle-Upper Eocene rocks decreases to 7—10 m. Near the El-Charra mountain (920 m elevation mark) they are represented by white limestone, in places metachert, with inclusions of the underlying Maestrichtian limestone at the base, and with interbeds of organic, sandy limestone — in the middle.

South of Beer el Khazneh village, from the upper part of the massive limestone the following fossils were collected: *Nummulites striatus* (B r u g.) and more rare *N. incrassatus* de la H a r p e, which, according to V. A. Krasheninnikov, are widely known from various stratigraphical units and therefore enable to define the age of the limestone only as Middle-Upper Eocene.

Oligocene (Pg_3)

The deposits dated Oligocene conformably overlie the Middle-Upper Eocene limestone. In the Abd El-Aziz mountains they consist of a monotonous series of marlstone with marl interlayers. The rocks are of light, yellowish-green colour, distinctly bedded. Prevailing thickness of the beds is 0.1 to 0.2 m. At the top there is a member built of white marlstone in which bedding is hardly observable. The rock contains rare foraminifera and poorly preserved remains of echinoids and pelecypods.

The thickness of the Oligocene deposits ranges southwards from 190 m in Beer el Khazneh to 40—50 m.

The marlstone contains rare foraminifera: *Cibicides perlucidus* N u t t., *Uvigerina* sp., *Cibicides ungerianus* (O r b.), *Planulina costata* (H a n t k.), *Bolivinoides reticulatus* (H a n t k.), which, according to V. A. Krasheninnikov, are known from Oligocene, Upper Eocene and upper part of Middle Eocene. The rocks are dated Oligocene only according to their position in the sequence: they overlie the nummulitic limestones of the Middle-Upper Eocene age and underlie the Lower and Middle Miocene beds. The Oligocene age is also assigned to the marlstone and marl developed in the Abd El-Aziz, due to their lithological similarity with the deposits from the Al-Furat valley (the Jrablus sheet) whose Oligocene age is confirmed by foraminiferal evidence (A. K. Oufland, V. D. Nikolaev, 1963).

The Oligocene rocks were recorded in deep wells Jabiseh-1 and 3, El-Bawwab-1 and 2. Well Qamishli did not strike Oligocene. Well Jabiseh-1 encountered brown marly limestone. At the top it struck an anhydrite bed, 4 m thick. The limestone contains microfossils "typical for Oligocene" [6]: *Globigerinoides rubra, G. triloba, Asterigerina rotula, Globigerina bulloides, Cibicides praecinctus, Gyroidina soldanii, Cassidulina subglobosa, Uvigerina nuttalli.*

The thickness of the Oligocene deposits is 160 m.

In wells El-Bawwab-1 and 2 the thickness of the marlstone dated Oligocene is 347 m and that of the marly limestone and limestone is 328 m.

Neogene system

Lower Miocene

The Lower Miocene deposits are outcropping in the eastern part of the Abd El-Aziz mountains, where the rocks of Burdigalian stage were established by microfossil evidence. The rocks were distinguished as the Dhiban formation in the subsurface, when pierced by deep wells.

BURDIGALIAN

The Burdigalian stage is represented by limestone, marlstone and marl containing thick gypsum interbeds. The relation between the Burdigalian rocks and the underlying deposits is not clear for the lower boundary of the stage is not outcropping on the surface.

The most complete sequence of the Burdigalian rocks was observed on the eastern slope of elevation 835 (upwards):

1. Greyish-yellow-green, distinctly bedded marlstone alternating with marly limestone and marl. At the top there is a bed of cavernous, gypsiferous limestone (0.5 m)	4 m
2. White, sugar-like, compact, massive gypsum	8 m

3. A series of light-grey and yellow-grey limestone beds alternating with marlstone and marl. In the middle there is a 1.5-m bed of limestone rich in operculinidae. Rare fossils of *Fusus* cf. *valensiensis* G r a t., *Xenophora* sp., *Ostrea* cf. *lamellosa* B r o c c., *Pychnodonta* sp. are found at the top	40 m
4. White, massive gypsum with two interlayers of white, in places brown, recrystallized limestone (1 to 2 m thick)	23 m
5. White, with greenish shade, not compact argillaceous limestone with a shell limestone at the base and much gypsum in the middle	9 m
6. White, sugar-like, massive limestone intercalated by gypsiferous limestone, shell limestone and marl	10—12 m

The total thickness is 95 m

The beds are overlain by the Helvetian limestone.

From layer 1 and 3 V. A. Krasheninnikov has identified *Globigerinoides trilobus* (R e u s s), *Globigerina bulloides* O r b., *Elphidium kvesanensis* A r t c h v., *E.* aff. *macellum* (F. et M.), *Cibicides* aff. *stavropolensis* B o g d., *Nonion boueanus* (O r b.), *Textularia consecta* O r b., *Cancris auriculus* (F. et M.).

In spite of the poor, peculiar complex of foraminifera the deposits are undoubtedly of the Burdigalian age, according to V. A. Krasheninnikov.

All the above listed species are typical for the Burdigalian stage of north-western Syria (the area of Al-Latheqiyeh and Aafrin).

3 to 5 km east of the described section, the thickness of the gypsum interbeds and their number in the Burdigalian sequence increase. Further to the east, in the area of Jabiseh hill and El-Bawwab village, drilling has shown that the sequence described correlates well with a rock salt series intercalated with thin beds of anhydrite, limestone and marl.

At the interval of 696—527 m well Jabiseh-1 struck the rocks of the Dhiban formation consisting of two horizons. The lower salt-bearing horizon, 123 m thick, is composed of thick rock salt beds with thin layers of anhydrite and marly limestone. The upper zone, 46 m thick, is made up of anhydrite and limestone.

The thickness of the Dhiban formation in well Jabiseh-3, 4 km ESE of well Jabiseh-1, decreases to 71.7 m. Salt is absent from the sequence. The series is made of anhydrite and limestone.

Well El-Bawwab-1 struck the Dhiban formation at the interval of 762—613.5 m. where it consists of three members (upwards):

1. White, pure rock salt with thin anhydrite beds	97 m
2. Anhydrite with limestone and rock salt intercalations	20 m
3. Dolomitic limestone alternating with light-grey anhydrite, clay and marly limestone	31.5 m

In well El-Bawwab-2, 1 km north-north-west of well El-Bawwab-1 the Dhiban formation was recorded at the interval of 750—626 m.

It consists of two members:

1. White, lucid, rather pure rock salt with thin anhydrite layers, which are in places slightly saturated with oil	72.5 m
2. Anhydrite with thin limestone beds	51.5 m

The age of the Dhiban formation penetrated by deep wells is defined as Lower Miocene by the position in the sequence between the Oligocene and Middle Miocene beds.

According to the stratigraphical position, the Dhiban formation can be correlated with the Burdigalian deposits, found on the eastern slope of the Abd El-Aziz mountains.

Middle Miocene

HELVETIAN (N_1h)

The Helvetian deposits are developed in the Abd El-Aziz mountains, in the Beida mountain and in some isolated areas near Ras El-Ein town.

They are also struck by all the deep wells.

The Helvetian sequence is composed of organic-detrital limestone with dolomite intercalations. The limestone unconformably overlies the Burdigalian and Oligocene beds.

At the base of the Helvetian sequence lies algal limestone which in the eastern part of the Abd El-Aziz mountains overlies the Burdigalian gypsum beds, and to the west — the Oligocene limestones. At the top of the Helvetian deposits, the limestone contains nodules and lenses of gypsum.

The most complete section of the Helvetian deposits is observed on the northern slope of the J. Abd El-Aziz in the upper course of Wadi Maghlouja, where the Oligocene argillaceous limestone is overlain by medium- and thick-bedded limestone (0.5 to 10 m), 74.6 m thick. The beds of organic limestone, consisting of small pelecypod fragments, alternate with various types of limestones: light-grey, earthy, chalk-like, gypsiferous, argillaceous and dolomitic.

In the central part of the Abd El-Aziz mountains, near elevation 920, the thickness of the Helvetian rocks decreases to 30—35 m. In this locality lies white, massive limestone, in places indistinctly bedded, with pelecypod and gastropod remains. At the top lies dolomitic limestone, tough and cavernous, armouring the water divide and southern slope of the Abd El-Aziz mountains.

In the south-western trend the thickness of the Helvetian rocks increases and in the vicinity of J. Beida it exceeds 70 m. On the south-eastern slope of J. Beida the Helvetian limestone is found which contains partings of calcareous dolomite in the middle and at the base (see the description of the section in the notes for the J-37-IV sheet).

In the upper stream of the N. El-Khabour the Helvetian outcrops were found near Ras El-Ein town. In this locality white and light-yellow organic limestone intercalated with dolomite was found at the surface and in water well dumps.

The Helvetian deposits were struck by the wells drilled on the structures of El-Bawwab and Jabiseh. Well El-Bawwab encountered white, not very compact, porous limestone with thin anhydrite interbeds, 48 m thick. In wells Jabiseh 1,2 and 3 the limestone contains nodules and lenses of flint and anhydrite.

The prevailing rock among the Helvetian deposits is organic limestone of detrital structure and slightly porous irregular texture. The organic remains are recrystallized fragments of algae, echinoderms, pelecypods, ostracods, etc.

The cement is generally microgranular calcite. Algae limestone has a porous, irregular, in places breccia-like, texture, with organic algal material amounting to 40—80% and consisting of algae fragments cemented by microcrystalline and cryptocrystalline calcite.

Another known rock is shale, often recrystallized, of multi-granular, mostly pelitomorphic and microgranular structure and porous texture. The rock consists of pelitomorphic carbonate matter, in places crystalline, with some clay (5 to 25%) present in isolated inclusions.

Within the limestone there are some bands of calcareous dolomite, which, according to carbonate analysis, consists of dolomtie (60 to 70%), calcite (20 to 30%) and clay particles (up to 10%).

According to their stratigraphic position the above deposits correspond to the Jeribe formation, the equivalent stratotype of which is found in the Sinjar mountains (Iraq), close to the Syrian border, near Jaddala village, where this formation is represented by recrystallized dolomitic limestone dated Lower Miocene [11].

In the eastern part of the Abd El-Aziz mountains, in some soft limestone interbeds, V. A. Krasheninnikov has identified such foraminifera as *Dendritina rangi* Orb., *Peneroplis evolutus* Henson, *Borelis melo* (F. et M.), *Elphidium crispum* (L.), *Streblus beccarii* (L.).

This complex of shallow water foraminifera can be traced in the limestone of the Jeribe formation on the territory of northern Syria from Abou Kamal to Halab. In the area of Halab-Aafrin the Jeribe limestones contain, in addition to the above listed foraminifera, many other planktonic and bottom-dwelling foraminifera of the Helvetian age what enabled V. A. Krasheninnikov to date the Jeribe formation as Helvetian.

The mollusk fauna collected from the limestones of the Beida mountain does not provide a direct indication of the Helvetian age. However, on the territory of the adjacent sheet J-37-VI the limestone of the Tshumba mountains which stratigraphically and lithologically correlate with the above, contain such fossils as *Chlamys* ex gr. *opercularis* Linne, *Flabellipecten* ex gr. *larteti* Tourn., *Pecten cf. fuchsi* Font., *Ostrea gingensis* Schloth., *Gigantostrea crassicostata* Sow. which, according to I. Bertels-Uspenskaya, are characteristic of the Helvetian stage of the Mediterranean province and are encountered in the Helvetian deposits of western Syria.

TORTONIAN (LOWER FARS FORMATION)

The Tortonian deposits are exposed in the extensive areas of the Ab El-Aziz mountains, Tshumba and Jabiseh and in the north-western territories adjacent to the Turkish border. They are also struck by shallow core holes drilled for mapping purposes north of Al-Hasakeh and by the deep wells drilled on the structures of El-Bawwab and Qamishli.

The Tortonian deposits are regularly alternating chemogenous and carbonate-terrigenous rocks, conformably overlying the Helvetian limestone beds. The lower boundary of the Tortonian stage is drawn following the bottom of the lowermost thick gypsum bed.

According to some differences in lithology and fauna, the Tortonian deposits developed in the Abd El-Aziz, Tshumba and Jabiseh mountains can be divided into two parts, lower and upper. The lower part consists of gypsum beds intercalated with limestone, marl and, in some places, rock salt. Gypsum predominates over the other rocks making about 90% of the entire series. The upper part consists of gypsum intercalated with clayey marl, clay, marl, limestone, siltstone and sandstone, the amount of gypsum beds being smaller as compared with the lower part and the amount of terrigenous material being greater.

The Tortonian deposits, developed north of the Abd El-Aziz mountains and Al-Hasakeh, are not sudbivided. Their lithological composition is different as compared with the area of the Abd El-Aziz mountains and the Tshumba hills, the amount of gypsum decreasing and the amount of carbonate and terrigenous rocks increasing.

Tortonian, the lower part (N_1 ta)

The lower part of the Tortonian deposits is made of gypsum, limestone and marl.

The most complete section of the lower part of the Tortonian sequence was observed on the southern slope of the Abd El-Aziz mountains along the ravine from Tell Saffour to the south and south-east of the road Al-Hasakeh-Madfa. The Helvetian limestone is conformably overlain by:

1. White, fine-crystalline, massive gypsum	15 m
2. White, cavernous limestone with poorly preserved pelecypod remains	1 m
3. Milk-white, fine-crystalline gypsum	6 m
4. Light-grey limestone, at the bottom (0.7 m) clayey, upwards containing as much as 30% of gypsum (large nodules)	3.2 m
5. White, sugar-like, massive gypsum	2 m
6. Yellowish-white, chalk-like limestone with *Pecten* sp.	1.5 m
7. Milk-white, fine-crystalline gypsum	2.5 m

8. White, with yellowish shade, organogenous, clayey limestone with marl bands in the middle (0.5 m) and at the top (0.2 m), contains many fossils of *Chlamys* ex gr. *opercularis* L i n n e, *Pecten* cf. *fuchsi* F o n t., *Ostrea gingensis* S c h l o t h., *O.* cf. *frondosa* de S e r r, *Gigantostrea crassicostata* S o w., *Arca* sp. characteristic of Middle Miocene (identified by I. Bertels-Uspenskaya) . . . . 3.5 m

9. White, in some layers greenish-white, gypsum . . . . 6 m

10. Yellowish-grey, gypsiferous limestone . . . . 0.4 m

11. Milk-white, massive gypsum . . . . 15 m

12. Light-grey, at the top yellowish-grey, limestone with a lenticular gypsum band in the middle, contains valves of thick-walled oysters and fragments of *Pecten* sp. . . . . 3 m

13. White, in places light-grey, cellular gypsum . . . . 8 m

14. Yellowish-green marl, laterally replaced by clayey limestone which consists of detritus and small shells of *Clausinella* sp. . . . . . 0.8 m

15. Milk-white, in places greenish-blue gypsum . . . . 4 to 7 m

Fig. 4. Limestone, marl and gypsum beds of the lower part of the Tortonian forming questas on the southern slope of the J.Abd El-Aziz. Figures show bed numbers. Here and further on air photograph scale is 1:20,000

16. Light-grey with yellowish shade, gypsiferous limestone grading laterally into organic : . . . . 0.6 m

17. Milk-white and grey, mottled gypsum . . . . 20 to 40 m

18. Yellowish-green, thin-laminated, gypsiferous, clayey marl with a band of dolomitic limestone . . . . 3 m

19. White, in places blue-green gypsum . . . . 7 m

20. Greenish-grey, highly gypsiferous marl grading into clayey gypsum . . . . 2 m

21. Milk-white, in some bands light-green gypsum . . . . . . 15 m

22. Yellowish-green, gypsiferous marl . . . . 1.3 m

23. Milk-white and grey gypsum . . . . 20—25 m

24. Grey, cavernous dolomitic limestone (Fig. 4) . . . . 0.8 m

25. Milk-white and black, mottled gypsum . . . . 4.5 m

26. Grey, gypsiferous, at the base clayey, limestone . . . . . . 0.5 m

27. White, medium and thin-laminated gypsum . . . . 4 m

28. Greenish-grey, gypsiferous, clayey limestone . . . . 0.8 m

29. Milk-white and grey, massive, less frequently medium-laminated gypsum with limestone bands (0.1 to 0.2 m) . . . . 25 to 30 m

30. Yellowish-green, gypsiferous limestone grading laterally into yellow-green marl . . . . 1.5 m

31. Milk-white in some layers greenish-grey gypsum . . . . . 18 m

32—37. Gypsum interbedded with limestone, marl and sandstone . . 55 m

The total thickness of the Tortonian rocks is 250 to 280 m.

The ovelying rock is clayey marl of the upper part of the Tortonian (38 layers).

Layer 24, composed of dolomitic limestone is shown on the geological map as a marker bed. It can be traced on the southern and eastern slopes of the Abd El-Aziz mountains and near J. Beida.

To the south-west of the Abd El-Aziz mountains, near the J. Beida the thickness of the lower part of the Tortonian sequence increases to 340 m though the lithological composition of the rocks remains nearly the same.

To the south-east of the Abd El-Aziz mountains, near the J. Jabiseh, according to drilling data, the thickness of the lower part of the Tortonian increases to 500 m (well Jabiseh-3). Here, in addition to anhydrite, gypsum, limestone and marl, there are beds of rock salt.

According to the data obtained from wells Jabiseh (Syrian Petroleum Company, Ltd.) the Tortonian deposits called the "Lower Fars formation" can be subdivided into several zones. In wells Jabiseh-1, 2 and 3, three zones can be distinguished.

1. Transitional zone — alternation of anhydrite and limestone, 80 to 90 m thick.

2. Salt-bearing zone — alternation of anhydrite, limestone and rock salt, 330 to 380 m thick.

3. Upper zone — anhydrite, brown clay interbedded with limestone and sandstone. The thickness penetrated by well Jabiseh is 184 m.

The transitional and salt-bearing zones, and also the bottom of the upper zone are attributed to the lower part of the Tortonian stage.

Tortonian, the upper part (N_1 t *b*)

The upper part of the Tortonian consists of gypsum, clayey marl, clay, siltstone, sandstone, marl and limestone from layer 38 up to the topmost thick gypsum bed.

Layer 38, whose bottom is taken as a boundary between the lower and upper parts of the Tortonian is on the slopes of the Abd El-Aziz mountain composed of clayey marl grading upwards into marl and limestone, its thickness ranging from 2 to 4 m.

Following the extension of layer 38 within J-37-V, J-37-IV and J-37-XXII sheets, one can find oysters *Ostrea fimbriata* G r a t, and representative pelecypods which according to I. Bertels-Uspenskaya were not reported in paleontological literature and were not identified as far as their genetic and species determinations are concerned. They are relatively large fossils, about 3x2x1 cm in size, with strong shells. In the outcrops of this layer, under plain terrain conditions the fossils are well prepared and found on the surface in the form of eluvial placer. The cores of these pelecypods were encountered only in layer 38 what was very helpful in following this marker bed in the field. The oysters *Ostrea fimbriata* Grat. are widely developed in the upper part of the Tortonian beginning from the marl beds of layer 38 and were never found in the lower parts of the section. However, the above mentioned oysters and pelecypods were not encountered in layer 38 outcropping in the Tshumba hills. This layer was distinguished here merely by its position in the sequence below easily recognizable layer 40 made of red silty clay.

The complete sequence of the upper part of the Tortonian can be observed on the north-eastern slope of the Tshumba hill in Dbaghiyeh ravine. The Lower Tortonian gypsum beds with thin marl and limestone bands are overlain by:

38. Greenish-yellow marl ($CaCO_3$ – 51.7%) with lenses of grey, compact, gypsiferous limestone. Poorly preserved pelecypods were encountered, such as *Lucina* sp. nov., *Clausinella* ex gr. *persica* Cox . . . . . 1.2 m

This layer corresponds to the 38 horizon, traceable on the slopes of the Abd El-Aziz and Beida mountains.

39. Milk-white gypsum with a lenticular band of clayey marl . . 20 to 25 m
40. Red-brown, in some beds green-grey, gypsiferous, calcareous, silty clay. At the top it is replaced by green-yellow marl (1 m) with limestone lenses (Fig. 5) . . . . 9.5 m
41. White, massive, fine crystalline gypsum . . . . 14 m
42. Red-brown, silty clay (4 m) grading upwards into yellowish-green, clayey marl with thin interlayers of dolomitic marl – $CaCO_3$ – 65%, $CaMg(CO_3)_2$ – 5.2% and shell limestone . . . . 7.5 m
43. White gypsum, at the base – thin bedded, upwards massive . 25 m
44. Light-brown, in places sandy, calcareous clay with gypsum nodules 4 to 5 m
45. White gypsum (ill-exposed) . . . . 10 to 15 m
46. Red-brown silty clay grading upwards into grey-green clayey marl with limestone bands . . . . 4.5 m
47. Milk-white fine-crystalline gypsum . . . . 10 m
48. Greenish-grey, compact, salt-bearing, calcareous clay (1.5 m) overlain by greenish-yellow salt-bearing clayey marl. The salt content increases upwards. The upper two metres are made of limy-clayey-salt-bearing rock . . . . 5.5 m
49. White, in places blue-green, gypsum . . . . 20 to 25 m
50. Brown, silty clay (3 m) overlain by green clayey and gypsumized marl with thin limestone interbeds . . . . 5.5 m
51. White, with greenish-blue shade, gypsum . . . . 8 m
52. Red-brown, silty clay with lenticular bands of fine-grained sandstone (3 m); upwards – greyish-green, sandy and clayey marl . . . 6 m
53. White, fine to coarse crystalline gypsum . . . . 5 m
54. Red-brown clay with green spots, in places silty and sandy, upwards grading into yellowish-green, clayey marl with a thin (0.2 m) band of organic limestone . . . . 2.4 m
55. White, compact gypsum . . . . 10 m
56. Brownish-red clay, with green spots, gypsiferous (2.8 m), upwards – greenish-grey, fine-grained, silty sandstone with limestone-clay cement (1.2 m), at the top-grey, gypsiferous limestone with *Clausinella* cf. *persica* Cox (0.2 m) . . . . 4.2 m
57. White, vari-grained, massive gypsum with a clayey marl interbed (0.3 m) in the middle . . . . 22 m
58. Red-brown, silty clay with a band of clayey gypsum (0.7 m) and siltstone (1.2 m), upwards replaced by greenish-grey, calcareous clay and further up by clayey marl. Remains of *Ostrea fimbriata Grat.*, *O. frondosa* de Serr. were encountered . . . . 10.6 m
59. White and greyish gypsum . . . . 14 m
60. Silty, calcareous, in some layers sandy clay containing *Ostrea fimbriata* Grat., upwards grading into light yellow, clay marl ($CaCO_3$ – 46.1%) with clayey limestone lenses . . . . 9.5 m
61. Greyish-white, non-compact gypsum . . . . 8 m

62. Red-brown, silty, calcareous clay . . . . 3 m
63. White gypsum with greenish and reddish shade . . . . 4 m
64. Brown, silty, at the top greenish-grey, calcareous, clay . . . 1.5 m
65. White with greenish shade, thin-bedded gypsum . . . . . 3 m
66. Brown-grey, silty, in some beds sandy clay upwards grading into light green, clayey marl . . . . 2.8 m
67. White gypsum, in places greenish . . . . 12 m
68. Green-grey, gypsumized clay, in places grading into clayey gypsum (1.5 m), overlain by yellow-green clay marl (0.5 m) . . . . . 2 m
69. White gypsum, with greenish clay beds . . . . 3 m
70. Green-grey, calcareous clay, upwards grading into clay marl with *Ostrea fimbriata* Grat . . . . 5 m
71. White gypsum, in places light grey, not compact . . . . . . 3 m
72. Pinkish-yellow-grey, silty sandstone with siltstone bands (1.5 m), upwards grading into silty clay (1 m) and further up into clayey marl (6 m) with *Ostrea fimbriata* Grat . . . . 12 m
73. White gypsum, in places greenish and clayey . . . . 10 m

Fig. 5. Clay, marl, siltstone, sandstone and gypsum beds of the upper part of Tortonian. Figures indicate bed numbers (see the description). They form small questas on the northern slope of the Jabiseh mountain

74. Green-grey, fine-grained sandstone (1.2 m) overlain by white and greenish-white clayey gypsum (2.5 m) at the top greenish-grey, clay marl ($CaCO_3$ — 46.6%) . . . . 4.7 m

75. White gypsum, at the top green-grey, clayey . . . . 7 m

76. Red-brown, silty clay (2 m) overlain by: green-grey, fine-grained sandstone (1.2 m), yellow-grey siltstone (1.5 m), clayey gypsum (0.4 m), grey-green clayey marl ($CaCO_3$ — 32.8%) (2 m), at the top yellow-green marl ($CaCO_3$ — 54.8%) with pelecypods (0.5 m) . . . . 7.6 m

77. White gypsum with blueish shade, coarse-grained . . . . . 9 m

78. Pink-grey, in some beds green-grey, cross-bedded, fine-grained sandstone (3.2 m) upwards grading into sandy, nodular gypsum (0.3—0.6 m), at the top light green, clay marl ($CaCO_3$ — 36.7%) (3 m) . 6.6 m

79. White, medium-grained gypsum (Fig. 5) . . . . 8.9 m

The total thickness of the upper part of the Tortonian, observed in the Dbaghiyeh ravine, is 340 to 360 m.

The overlying rocks are terrigenous deposits dated Upper Miocene.

For the southern slope of the Abd El-Aziz mountains several layer-by-layer descriptions of the upper part of the Tortonian were made (Fig. 6), but a complete sequence was never found due to breaks in exposure.

To the south-east of the Abd El-Aziz mountains, in the area of Sahel el Khashab ravine, the upper members of the series contain much more terrigenous material, many thick interbeds of fine to medium-grained, cross-bedded sandstone appear; the thickness of the gypsum beds decreases to 2 or 3 m.

The sequence of the upper part of the Tortonian from layer 42 to the base of the Upper Miocene beds was observed in the south-west, in Wadi Sajriya. The rocks are similar to those observed in the Beida mountain [15]. There are some differences only in the upper part of the sequence. Layer 79, which in the Beida mountain is composed of radiated gypsum, 10 m thick, in Wadi Sajriya ravine is made of carbonate-terrigenous rocks, such as clay marl, siltstone and sandstone with thin gypsum bands, 5 cm to 1 m thick. Fossil *Diplodonta* sp. nov. N 2 characteristic of the Upper Tortonian was found in a marl interbed occurring high above the uppermost thick gypsum bed. This is why the boundary between the Tortonian and Upper Miocene in the area of Sajriya village — Dabshiya is drawn in the carbonate-terrigenous rocks, 20 m higher than the uppermost thick gypsum bed.

A few marker beds were distinguished in the upper part of the Tortonian.

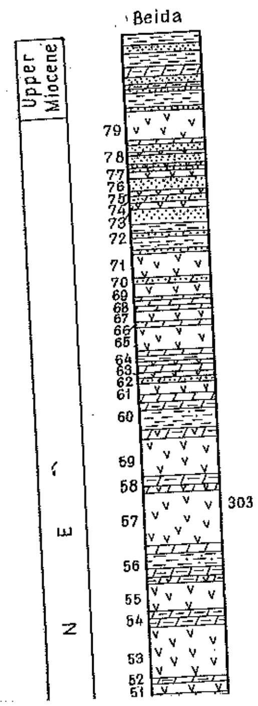
In the Tshumba hill one can trace a bed of clay and clay marl, described as layer 50, which can be easily distinguished on the aerial photographs.

Layer 58 composed of clay, siltstone and marl with oysters can be traced in the J. Jabiseh area, on the northern and southern slopes of the Tshumba hill and on the southern and eastern slopes of the Abd El-Aziz mountains. It also fringes the core of a small anticlinal fold, located 2—3 km south of Al-Hasakeh town. This layer can be easily followed in the area east and south-east of the Abd El-Aziz mountains due to abundant oyster fossils. South and south-west of the Abd El-Aziz mountains it does not contain oysters and sandstone beds appear at its base. In this area layer 58 can hardly be distinguished from the over- and underlying beds and can be traced only with the help of aerial photographs between the key sections.

South and south-east of Al-Hasakeh one can trace a clay and marl bed with oysters (layer 60) outlining two anticlinal folds.

Tortonian undifferentiated

Below are given the rocks attributed to the Tortonian, undifferentiated: marl, caly, limestone, siltstone, sandstone and gypsum outcropping in the north-western part of the J-37-V sheet and penetrated by mapping bore holes drilled north of Al-Hasakeh.



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A mapping well 19 drilled 19 km east of Ras El-Ein (pl. 1,2) penetrated the series of alternating marl, clay, limestone and gypsum beds, 81.7 m thick, lying on the Helvetian limestone.

The neighbouring wells 12, 13, 14 and 17 penetrated the upper part of the Tortonian sequence, which differs from the deposits described above by a larger number of sandstone and siltstone beds.

The fossils collected from the lower beds of the Tortonian near Mojaben village such as *Ostrea frondosa* de Serr., *Miltha* cf. *calipteryx* (Tourn.); *Chione* cf. *basteroti* (Desh.), indicate, according to I. Bertels-Uspenskaya, the Middle Miocene age. Abundant foraminifera: *Elphidium hauerinum* (Orb.), *E.* aff. *macellum* (F. et M.), *Valvulineria obtusa* Orb. and others are typical of the Tortonian stage (after V. A. Krasheninnikov).

Different from the above are the undifferentiated rocks of the Tortonian stage, encountered by well 10 drilled 10 km south-east of Derbasiyeh. They are mostly carbonate rocks: limestone, marl and dolomitic marl with *Ostrea fimbriata* Grat., *Turritella* sp., *Clausinella* sp. There are some calcareous clay and siltstone interbeds but in a smaller number. Gypsum is absent.

The thickness of the undifferentiated deposits of the Tortonian stage in the north-western portion of sheet J-37-XI, V is supposed to be 400 to 500 m.

The previous investigators distinguished the deposits described above as the Lower Fars formation. It was first mentioned by H. Busk and H. T. Majo in Iran, in 1918 [11].

The Tortonian age is assigned to these deposits due to foraminifera and ostracoda findings.

Among the fossils found in the lower part of the Tortonian (layers 2, 4, 6, 8) on the southern slope of the Abd El-Aziz mountains V. A. Krasheninnikov has identified: *Streblus beccarii* (L.) forma *ordinaria*, *Elphidium macellum* (F. et M.), *E. crispum* (L.), *E. listeri* (Orb.), *Globulina gibba* Orb., *Nonion granosus* (Orb.), *Florilus communis* (Orb.).

The upper part of the Tortonian (layers 38 to 78) on the northern slope of the Tshumba hill contains: *Streblus beccarii* forma *granosa*, *Elphidium antonina* (Orb.), *E. hauerinum* (Orb.), *Nonion granosus* (Orb.) *Cibicides dutemplei* (Orb.), *Clavulinoides* sp., *Textularia mayeriana* Orb., *Sigmoilina mediterranensis* Bogd., *Spiroloculina canaliculata* Orb., *Quinqueloculina contorta* Orb. and other species, encountered also in the lower part of the Tortonian.

According to the identification made by V. A. Krasheninnikov, the above listed foraminifera indicate the Tortonian age of the rocks incorporating them.

The upper part of the series contains a great variety of ostracods, among which N. N. Naidina identified: *Loxoconcha* aff. *cornuta* Schn., *L.* ex gr. *carinata* Linencl., *Cytherideis longula* Ulrich et Bassler, *Trachyleberis expunctata* Zalanyi, *T. magna* Schn., T. deformis (Reuss), *Cypridea mülleri* (Münster), *Leptocythere exanthemata* (Ulrich et Bassler), *L.* ex gr. *martini* (Ulrich et Bassler) and others. This complex of ostracods is according to N. N. Naidina typical for Middle Miocene. Some of the above species were described by G. Shneider in the Tortonian deposits of the Western Ukraine.

Upper Miocene (N_1^3)

The Upper Miocene deposits are exposed on a fairly wide territory north and south of the Abd El-Aziz and Tshumba mountains. They conformably overlie the Tortonian rocks. The boundary between the Tortonian

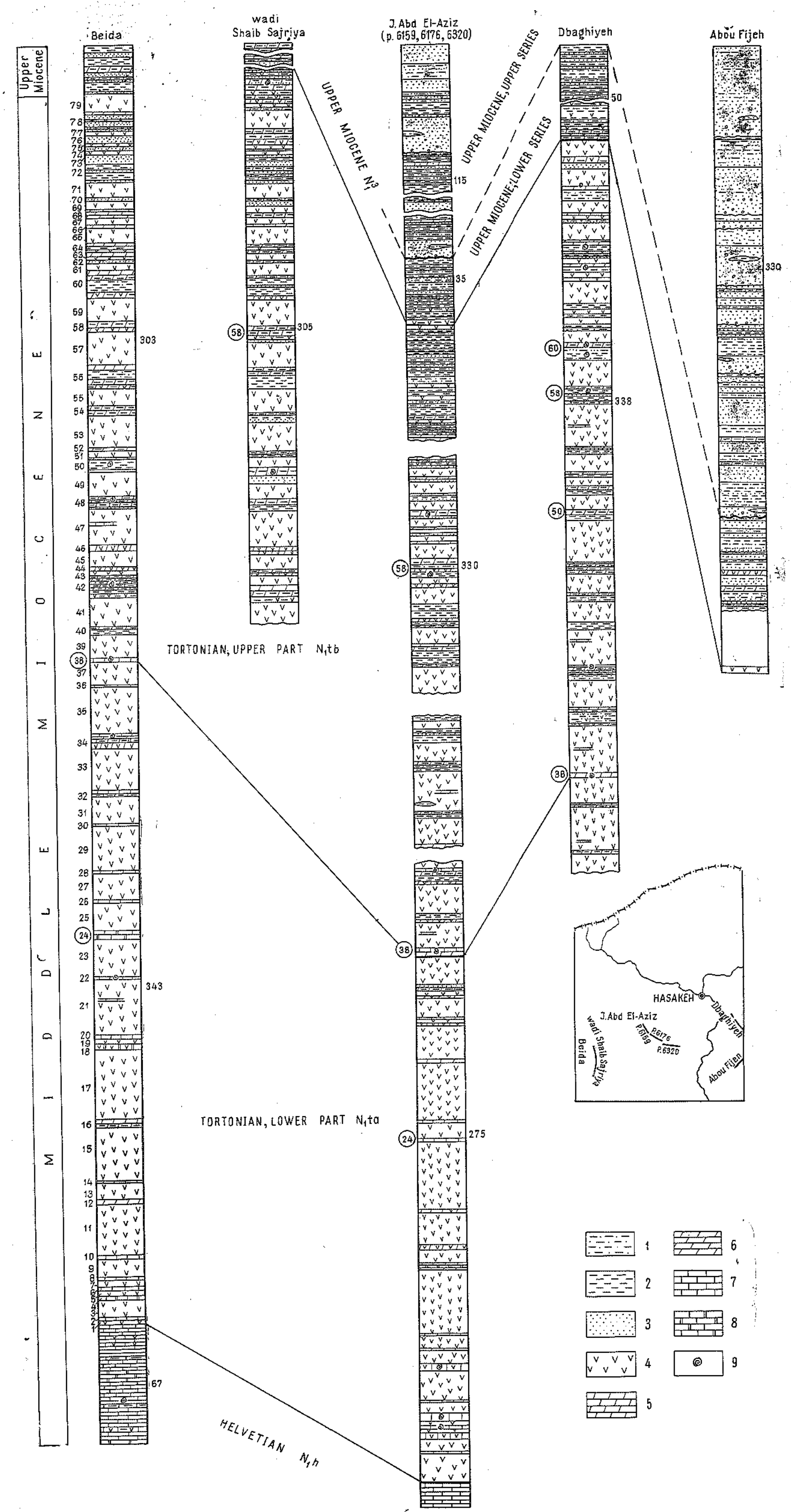

Fig. 6. Comparative columnar sections of Miocene deposits
1 — siltstone; *2* — clay; *3* — sandstone; *4* — gypsum; *5* — marl; *6* — clayey marl; *7* — limestone; *8* — dolomitic limestone; *9* — fauna. Figures on the left of columns correspond to the numeration of horizons according to the text. Key horizons are encircled. They are shown on the map. Thickness is shown on the right in metres

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and Upper Miocene corresponds to a sharp change in the lithology from terrigeno-chemogenous to terrigenous rocks. The boundary is drawn along the bottom of the uppermost thick gypsum bed.

The Upper Miocene rocks were studied in the outcrops on the southern slope of the Abd El-Aziz mountains, on the slopes of the Tshumba hill, in the Abou Feja ravine and in a number of shallow core holes drilled for mapping purposes.

The Upper Miocene sequence consists of clay, sandstone, sand, siltstone and marl. Lithologically these rocks can be divided into two members, lower and upper.

The lower member is a frequent alternation of bright reddish, well sorted siltstone, clay, marl, sandstone and gypsum of lacustrine origin. The thickness of the lower member changes eastwards from 30 to 80 m.

The upper member is made of coarse-bedded, poorly sorted rocks of dull, greenish-grey brown colours: sand, sandstone, clay, siltstone and marl (Fig. 7, 8). The thickness is about 230 m. Predominating rocks are sand and sandstone of greenish-grey colour which occur in thick beds (up to 20-25 m) consisting of many cross-bedded bands. Sand and sandstone generally contain rolls of clay and clay marl. These rocks are fluvial formations and they often rest on underlying deposist with erosion. The sand and sandstone beds regularly alternate with the beds of poorly sorted rocks, such as clay, siltstone, sandstone and clay marl occuring as a rule in small lenses.

The clay and clayey marl always contain accessory psammitic material and inclusions of sandy rocks. Laterally they are often replaced by sandstone and siltstone. The sandy-clayey rocks contain remains of lake and swamp plants in the form of small tubular cavities, partly filled with carbonaceous matter, carbonate and hydrous ferric oxides of gypsum.

According to the result of the palinological analysis the lower member of the Upper Miocene in a mapping well (N 4) contains a pollen and spores complex mainly of thermophilic vegetation.

Predominating are grass and shrub xerophytic plants, such as compositae and others, which make 40%. Broad-leaved trees, such as nut, chest nut and maple are present in a lesser amount — 20%.

Subtropical and tropical evergreen vegetation makes 12% (martle, pistachio-trees etc,). Cold-resisting conifers make only about 8% (pine, less frequently cedar).

Pollen and spore spectrum shows a warm and dry climate and mainly steppe country which had been present during the sedimentation of the lower part of the Upper Miocene. Pollen and spores were not discovered in the upper member of the Upper Miocene.

Samples were taken from the Upper Miocene sequences to identify ostracods. Ostracods were found in 89 samples out of 387. N. N. Naidina established a distinction between the ostracod complexes of the lower and upper members of the Upper Miocene sequence. The first five ostracod species, shown in the table, were found only in the upper member, species 6 to 11 were present both in the upper and lower member and the last four species were found only in the lower member (Table, page 28).

The Upper Miocene age has also been assigned to the deposits developed east and south-east of Derbasiyeh where they were struck by mapping wells.

These are mainly carbonate rocks, such as clay, marl and dolomitic limestone. There are some tuffite interbeds consisting of acid ash cemented by clay mass and also fine to medium-grained sandstone intercalations with calcareous-clayey cement. One well encountered a limestone bed at the depth of 20 m, which contains such ostracods as *Candona compressa* (K o c h.), *Zonocypris membranae* (L i v.), *Cyprinotus* sp., *Potamocypris* sp.,

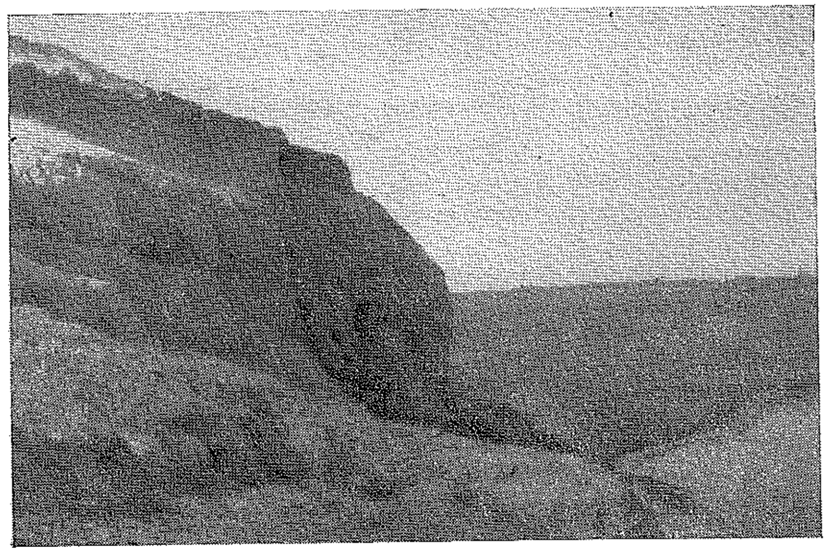

Fig. 7. An outcrop of the Upper Miocene rocks (the upper member) on the N. El-Khabour river bank, 25 km north-west of Al-Hasakeh

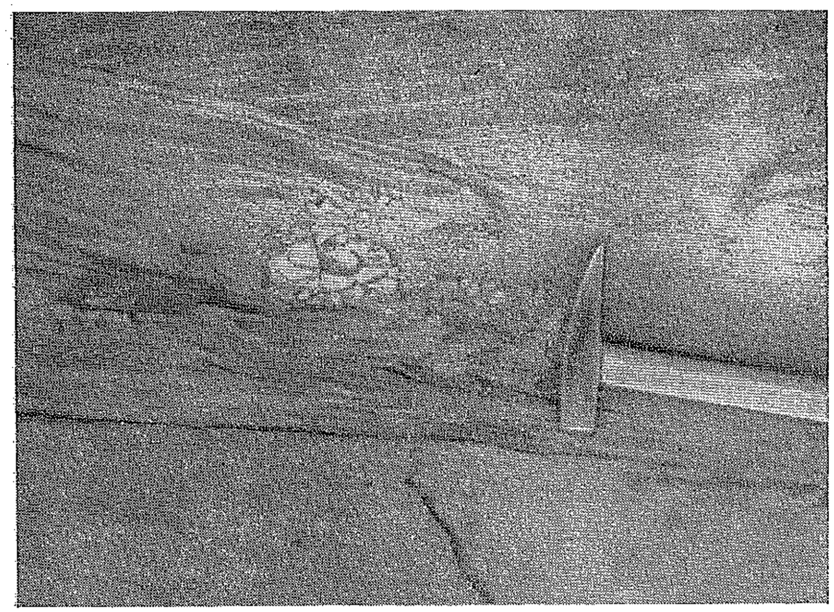

Fig. 8. Cross-bedded sandstone containing small clay concretions. Upper Miocene, upper member

Table of the distribution of ostracods in the Upper Miocene deposits of sheet J-37-V

Fossil name	Lower member													Upper member						
	Abou-Feja ravine							Dbagh-iyeh ravine	Abd El-Aziz			Sajriya		Abou Feja			Abd El-Aziz			Sajriya
	Number of sample																			
	6302/2	6302/4	6302/9	6302/11	6302/18	6302/21	6302/26	6148/23	6320/23	6320/2	6320/3	6115/17	6115/21	6305/50	6305/61	6305/82	6320/21	6320/25	6320/42	6115/23
Candoniella sp.																				O
Potamocypris sp.															O				O	O
Darvinula stevensoni (B r a d i et R o b e r t s)																				O
Candoniella albicans (B r a d y)																			O	
Zonocypris membranae (L i v.)															O					
Cyprinotus sp. 1															O					
Ilyocypris gibba (R a h m d.)							O		O											
Ilyocypris brady S a r s	×				×		O	×	×	O			×		×	O				
Limnocythere sp. 2	×	×			O	×			×				×			O				
Eucypris sp.		O															O			
Limnocythere sp. 1	×	×	O			×	×		×						O			×		
Cyprideis sp. 1	×		O			×														
Potamocypris punctillata V o r o s h.	×	×		O		O				O										
Cyclocypris minimus V o r o s h.												O								
Limnocythere sp. 3	×	×				×			×	×										

× — rare findings (1 to 3) O — frequent findings (up to 10)

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Cyclocypris sp. Pollen and spores complex of boreal, cool and damp climate plants, such as fir-tree, pine, cedar, birch, alder, lycopodium, etc., was found at the interval of 25 to 125 m. Dominating among the conifers is the fir pollen (*Picea* sp. sec. Eupicea). Foliage vegetation is mainly represented by birch and alder. Grass pollen is very rare. Thus, the pollen and spore spectrum of the bore hole shows a forest type of the country. As compared with well 4 warm-climate plants nearly disappear. The deposits seem to be upper horizons of the Upper Miocene but there is a possibility of Pliocene rocks being present.

The thickness of the Upper Miocene varies from place to place whithin the area under investigation. The largest thickness, up to 320 m, is recorded south of the Tshumba and Abd El-Aziz mountains.

In the north-eastern portion, from Al-Hasakeh to the Turkish border, it ranges from 100 to 200 m decreasing westwards.

The Upper Miocene age is assigned to the deposits tentatively due to their position over the Tortonian rocks and on the basis of geological and paleogeographical evidence such as ostracod fauna and pollen and spore spectra. The lower boundary is defined by a sharp change in the sedimentation environment from marine to continental, by a change in ostracod complex and by disappearance of foraminifera.

In the lower member of the Upper Miocene N. N. Naidina has identified *Potamocypris punctillata* V o r o s h., *Cyprideis* sp. (*Cyprideis gigantica?* V o r o s h.), *Cyclocypris minimus* V o r o s h., *Limnocythere* sp. 3, *L.* sp. 2, *L.* sp. 1, *Eucypris* sp., *Ilyocypris brady* S a r s, *Il. gibba* (R a h m.).

This complex of ostracods greatly differs from the Middle Miocene complex found in the underlying Tortonian deposits. However the first three species were described by A. Voroshilova (1956) from a salt-bearing — lagoonal formation of the Middle Miocene age. Species of the *Limnocythere* and *Ilyocypris genera* are found in the Miocene deposits.

The upper member of the Upper Miocene contains *Limnocythere* sp. 1, *L.* sp. 2, *Eucypris* sp., *Ilyocypris brady* S a r s, *Il. gibba* (R a h m.). *Zonocypris membranae* (L i v.). *Cyprinotus* sp. 1, *Candoniella albicans* (B r a d y), *Darwinula stevensoni* (B r a d y et R o b e r t s.), Potamocypris sq., *Candoniella sp.*

According to N. N. Naidina, a similar complex of ostracods is present both in the Upper Miocene and Pliocene deposits of the Crimea — Caucasian province of the USSR.

The pollen and spores found in the lower member of the Upper Miocene, 28 km north of Al-Hasakeh (mapping well 4) indicate a warm, subtropical climate what, according to N. Sadovskaya, does not contradict the conclusion about the Upper Miocene age, since the conditions of subtropical climate had been present in the area adjacent to the Black Sea during the first half of the Neogene period and lasted up to the Upper Sarmatian stage. The pollen and spores found in the northern part of the territory (well 11) testify that the climate got colder what, according to N. Sadovskaya, may indicate the uppermost strata of the Upper Miocene and the lowermost strata of the Pliocene.

A surface of the regional uncomformity distinguished as a result of the geological mapping is taken as the boundary between the Upper Miocene and Pliocene.

Pliocene

The Pliocene deposits are outcropping on the extensive territory north and south of the Abd El-Aziz mountains and north-east of the Ard esh Sheikh basalt plateau. Lithologically these deposits consist of two parts: the lower, composed of clay marl, sandstone, clay and gritstones; and the upper, consisting of limestone, marl, gritstone and conglomerates.

PLIOCENE, THE LOWER PART (N_2a)

The lower Pliocene sequence overlies the Upper Miocene and Tortonian deposits unconformably. The Pliocene base often contains sandstone beds with some gravels and in some places gritstone.

The most complete sequence of the lower series of the Pliocene has been observed on the right bank of the N. El-Khabour, 8 km west of Tell Tamr village, in well 14 where the Tortonian clay marl is overlain by:

1. Greenish-grey, quartzitic and feldspathic, fine-grained sandstone with calcareous and argillaceous cement, at the base grading into silty sand with small pebbles and gravels made of quartz, flint and limestone	9 m
2. Brown and light-grey, lumpy, silty, clay marl	3.9 m
3. Brownish-grey, silty, fine to medium-grained sandstone with argillaceous-calcareous cement, in places gypsiferous, with rare clay bands .	6.6 m
4. Brown-grey, silty, calcareous clay with small tubular cavities containing debris of argillaceous and calcareous rocks	2.9 m
5. Grey and greenish-grey, silty, fine-grained sandstone slightly cemented with argillo-calcareous material containing bands of siltstone and light-brown, silty clay	17.1 m
6. Conglomerate, slightly cemented with argillo-calcareous material. Limestone and flint pebbles are well rounded, up to 3 cm in size . . .	1.8 m
7. Greenish-grey, silty, fine-grained sandstone slightly cemented with argillo-calcareous material	3.7 m

The total thickness of the lower Pliocene series penetrated by the well is 44.5 m.

East and north-east of the Ard esh Sheikh basalt plateau the deposits of the lower Pliocene series are pierced by a number of wells drilled along a mapping profile. Prevailing is light-grey, fine- to medium-grained sandstone with calcareous and argillo-calcareous cement, containing in some places gravel grains of flint and limestone. Sand and gravel grains are sometimes surrounded with a coating of secondary limestone. Alongside with sandstone also occurs siltstone, clay marl, calcareous clay, limestone and gritstone. The thickness of the lower Pliocene part penetrated by wells 3 to 9 does not exceed 35 m somewhat increasing eastwards and reaching 50 to 60 m on the border with the J-37-VI sheet.

South of the Abd El-Aziz mountains the lower series is composed of sandstone, calcareous clay, clay marl and siltstone. Prevailing rock is grey, brownish-grey and greenish-grey sandstone with argillo-calcareous and calcareous cement. The sandstone contains flint and limestone gravels and pebbles. The rock also incorporates fragments and rolls of such local rocks as marl, clay and siltstone which had probably been deposited due to the erosion of the Upper Miocene.

According to the results of the mechanico-mineralogical analysis, clastic material in sandstone and siltstone consists of feldspar (mainly acid plagioclase) — 40 to 50%, quartz — 10 to 20%, limestone — 10 to 15%, siliceous rocks up to 5%, mica — 3 to 10% and heavy minerals — 5 to 10% among which dominating are epidote, ore minerals and hornblende; in less amounts there is garnet, pyroxene, zircon, anatase, sphene, tourmaline, rutile and spinel.

Lithologically the deposits of the lower series are similar to the underlying Upper Miocene rocks. They had been formed under nearly the same conditions and are composed of nearly the same types of rocks, what complicated the differentiation of the rocks during the field work. Therefore the boundary between the Pliocene and Upper Miocene is in some cases shown on the map tentatively. The distinguishing features of the Pliocene rocks are:

1) higher content of calcareous material in the rocks; clay marl prevailing over clay; sandstone cement being generally calcareous;

2) presence of gritstone in the form of interbeds and gravel grains of flint and limestone present in sandstone and other rocks;

3) peculiar structure of the clastic material in the terrigenous rocks marked by the coatings of secondary carbonate formed around grains, gravels and pebbles.

PLIOCENE, THE UPPER PART (N_2b)

The deposits of the upper Pliocene series are outcropping in the area north of the Abd El-Aziz mountains. They conformably overlie the rocks of the Pliocene lower part but in some localities have conglomerates and gritstones at the base. 20 km west-south-west of Tell Tamr village, in the ravine side, the calcareous clay of the lower Pliocene part is overlain by:

1. Gross-bedded gritstone, sandstone and conglomerate. The grains and pebbles are made of igneous and metamorphic rocks, less frequently of limestone. The topmost conglomerate consists of well rounded pebbles of limestone and seldom of igneous and metamorphic rocks. The filling material in the conglomerate and gritstone is coarse sand	4.5 m
The thickness of the member is 4—5 m.	
2. Light-grey, sandy siltstone with argillo-calcareous cement, pierced by small tubular holes, which were probably formed due to leaching of roots and stems of lake and swamp plants	3 m
3. Reddish-brown clayey marl	0.7 m
4. Grey limestone with inclusions of green-grey, highly gypsiferous marl	0.3 m
5. Green-grey clayey marl with fine gypsum crystals	1 m
6. Light-grey to white, porous limestone with numerous vertical algae channels	1 m

In the adjacent outcrops the thickness of the limestone bed increases to 5—6 m and interbeds of dolomite and dolomitic limestone appear.

The thickness of the upper series does not exceed 20 m.

The Pliocene rocks contain very rare ostracods. 15 km north-west of Al-Hasakeh the sandy clay of the upper series penetrated by a dug well was found to contain *Candona compressa* K o c h., *Cyprinotus* sp., *Advenocypris sp.*

According to N. N. Naidina, the first species is present in the Pliocene of the Central Asia (USSR), the two others can be found both in the Upper Miocene and Pliocene.

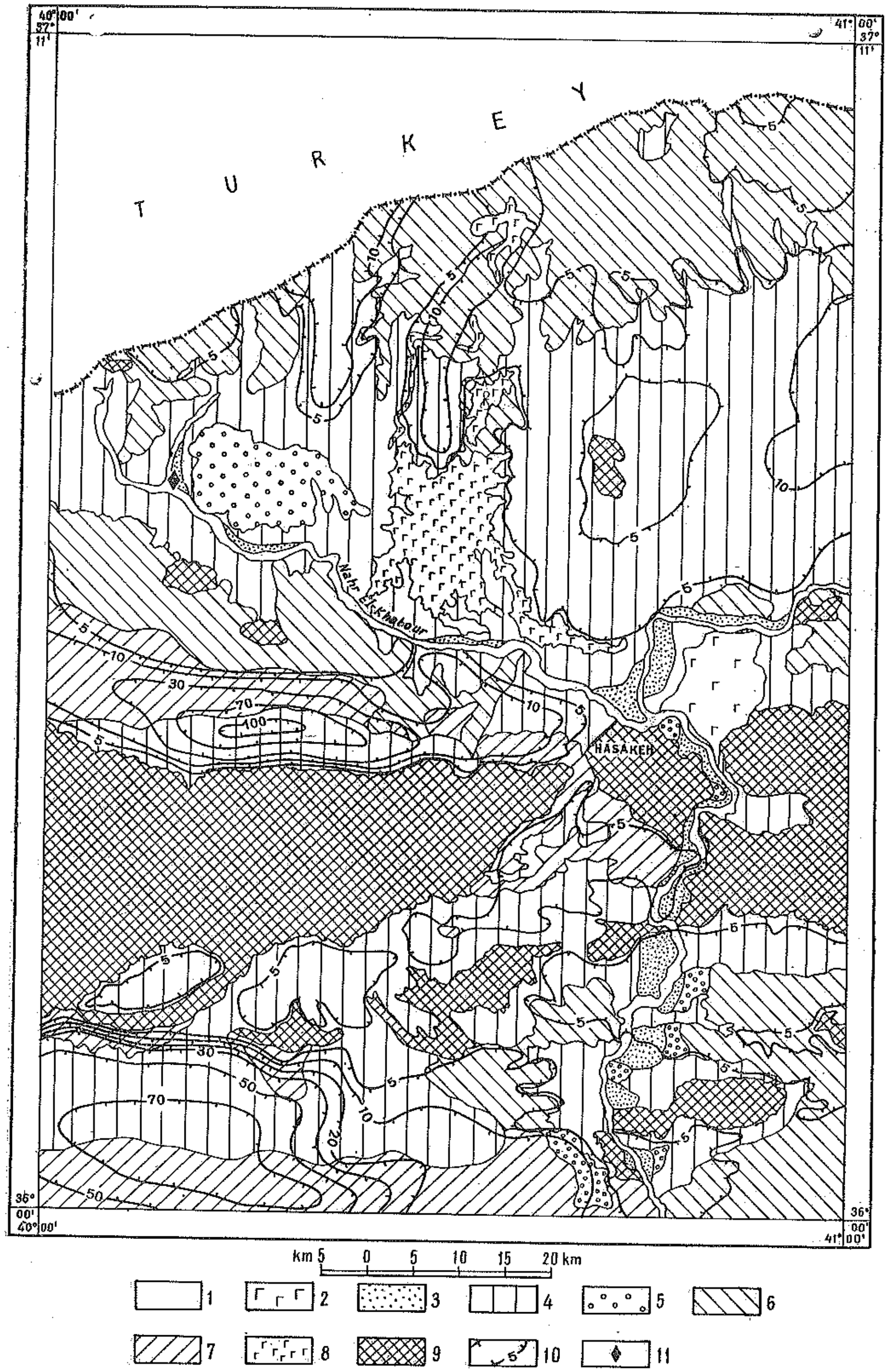
According to their stratigraphical position and lithology, the deposits described can be correlated with the Pliocene formations developed on the territory of the neighbouring J-37-VI sheet which contain ostracod fossils found 12 km southeast of Qamishli. N. N. Naidina has identified: *Candona neglecta* S a r s, *C. obrutschevi* M a n d e l., *Cypridopsis formosa* S c h n., *Herpetocypris* (?) *pellucida* S c h n., *Cyprinotus baturini* S c h n., *Candoniella albicans* (B r a d y), *C. suzini* S c h n., *Cyprideis* sp. N. N. Naidina points out that most of the fossils were described from the Pliocene of the Central Asia (Fergana, Ili and Tian-shan depressions).

Quaternary system

Quaternary is represented by the deposits of the Lower, Middle and Upper series corresponding together to Pleistocene and Recent. The Quaternary sediments are of various genetic types. The most widespread are proluvial deposits, the least important are basic effusive* rocks, alluvial and lacustrine deposits (Fig. 9).

The Quaternary deposits cover nearly the entire territory of the sheet with the exception of the J. Abd El-Aziz, Tshumba, Jabiseh and some small localities of the plain adjacent to the N. El-Khabour valley. However, even these localities are covered with a thin, non-continuous layer of eluvium, deluvium and partly proluvium.

* The description of the basic effusive rocks is given in chapter "Volcanic rocks".



The largest thickness of the Quaternary deposits (75 to 110 m) has been recorded at the foothills of the J. Abd El-Aziz.

On the plain lying north, northeast and southeast of the J. Abd El-Aziz the thickness of the Quaternary deposits ranges from 3 to 8 m, sometimes reaching 15 or 18 m.

Lower series (Q_1)

The Lower Quaternary age is tentatively assigned to the oldest proluvial gypsum-bearing deposits and basic effusive rocks.

The proluvial deposits fringing the J. Abd El-Aziz as a wide band are composed of peculiar coarse and obscure-bedded carbonate-clay-gypsum rocks with accessory silty, psammitic and psephitic material, intercalated with gypsumized loams.

The Lower Quaternary proluvial deposits transgressively overlie the Middle Miocene, Upper Miocene and Pliocene strata. North of the J. Abd El-Aziz shallow core wells drilled for mapping encountered debris and gritstone, the fragmental material of which is composed of limestone and marl of the upper Pliocene series.

The most complete sequence of the Lower Quaternary proluvial deposits has been observed in a well, located north of the J. Abd El-Aziz, 5 km north-north-west of elevation 682 m.

The siltstone of the lower Pliocene series is overlain by:

1. Light brown gypsiferous loam, in places grading into gypsum; it contains inclusions of limestone and marl debris and gravels	5 m
2. Light grey gypsum with great amount of carbonate-argillaceous material, with some silt and psammitic grains and rare inclusions of ill-rounded limestone gravels. There are some thin gypsumized loam interbeds	35.3 m
3. Light brown gypsiferous loam	6.3 m
4. Light grey, fine and medium-crystalline, calcaro-argillaceous gypsum with silty, psammitic and psephitic material	37.1 m

The total thickness is 83.7 m.

On the southern slope of the J. Abd El-Aziz, gritstone interbeds appear, gypsum content decreases and gypsumized loams dominate in the sequence.

Proluvial deposits of different composition were encountered in the scarps of the marginal part of the Ard esh Sheikh, near Tell Massas village, where the Pliocene rocks are overlain by brown loam containing ill-rounded limestone gravels and fragments, similar to those of Upper Pliocene, and also sandstone and clay fragments. The thickness of the loam is 1 m.

The Lower Quaternary age of the proluvial deposits was defined according to their position in the succession between the Pliocene and Middle Quaternary proluvial deposits. It is possible that the gypsiferous proluvial deposits of the J. Abd El-Aziz foothills began to form in the Upper Pliocene time, but having no direct evidence, we limit their age by the Lower series of the Quaternary system.

Middle series (Q_2)

The Middle Quaternary deposits are divided into alluvial, proluvial and lacustrine-proluvial.

Fig. 9. Generalized map of Quaternary deposits

Upper Quaternary, Recent: *1* — alluvial sands, loams, gravels; *2* — basalts and tuffs; *3* — alluvial pebbles, gravels, sands; *4* — proluvial loams and sandy loams with debries, gravels, pebbles. Middle Quaternary: *5* — alluvial pebbles and sands; *6* — proluvial conglomerates, loams with some pebbles, boulders, sands. Lower Quaternary: *7* — proluvial limy-clayey-gypseous rocks, loams, gypsum; *8* — basalts and tuffs; *9* — pre-Quaternary rocks cropping out or concealed by a thin cover of eluvial, deluvial and proluvial deposits; *10* — isopach lines of Quaternary deposits; *11* — places of finding stone implements

Alluvial deposits are developed in the N. El-Khabour valley. They compose a third terrace above the flood-plain which is 20-30 m high over the water level. The terrace is poorly preserved, its alluvial cover being composed of cross-bedded pebble, gravel and sand beds which are cemented with calcareous material.

The Middle Quaternary alluvial deposits have been exposed by quarries 48 km south of Al-Hasakeh, near the motor road. In the walls of the quarries one can see cross-bedded pebble beds with sand lenses and bands. The pebbles are well rounded and made of allogenic rocks such as flint, quartzite, porphyrite, sandstone and limestone. The size of the pebbles ranges from 1 to 3 cm, seldom reaching 10 cm. The filling material is greenish-grey, medium and coarse-grained sand with some gravels, in places grading into slightly cemented sandstone. Similar sand and sandstone are present among the cross-bedded series of pebble beds in the form of bands and lenses, 0.1 to 1 m thick. The pebbles on the surface of the bed are covered with concentric coatings of secondary, pink-grey limestone.

The thickness of the alluvial deposits does not exceed 10 m.

Proluvial deposits stretch in two wide bands northwards of the J. Abd El-Aziz and along the Turkish border. They are also preserved as patches southeast and north-east of the J. Abd El-Aziz.

At the Abd El-Aziz foothills the proluvial deposits are loams with pebbles, boulders and debris of the local rocks: limestone, marl and gypsum. Near the foothills the proluvium often contains fragments and pebbles of gypsum, while far from the mountains gypsum is encountered less frequently, the size of the fragments also getting smaller. On the right bank of the N. El-Khabour, 16 km north-west of Al-Haskeh, on a steep slope of a hill there is an outcrop of proluvial pebbles and loams. One can observe a hardly discernable bedding—loam beds with little amount of pebbles alternate with beds containing 30 to 40% pebbles. The pebbles are poorly or medium-rounded, 2 to 5 cm in size, composed of limestone and marl, enclosed into coating of secondary pinkish-grey limestone. The observed thickness of the proluvial deposits is 10 m. The surface of the proluvium is covered with a calcareous alluvial crust which appears to be a well consolidated conglomerate consisting of limestone pebbles and sometimes basalt and flint pebbles cemented by pink limestone. The thickness of the crust is 1 to 3 m.

In the northern portion of the territory the proluvial deposits are present as alluvial fans of the Tourous mountains in Turkey. Between Derbasiyeh and Ras El-Ein towns there are limestone coglomerates. The pebbles are well and medium rounded, 3 to 5 cm in size, sometimes up to 10 cm, made of pink, white and grey limestone. Occasionally the rocks contain nummulites. The cement is pink limestone. In some places conglomerates grade into limestones, on the weathered surface of which one can see relics of clastic texture.

The thickness of the Middle Quaternary proluvial deposits ranges from 2 to 20 m.

Lacustrine-proluvial pebbles, sands and loams are developed in the south-eastern part of the J-37-V sheet. They transgressively overlie the Upper Miocene and Pliocene deposits.

In Wadi Ar-Ramel the Upper Miocene clays are overlain by:

1. Pebble bed consisting of ill-rounded small limestone and gypsum pebbles. The filling material is brown sandy loam . . . . 0.5 m
2. Brown loam in places grading into sandy loam with bands and lenses of greenish-grey sand with algae remains such as dolium-shaped columns . . . . 2 m

In the rain rills south of Wadi Ar-Ramel there are outcrops of higher horizons — reddish-brown loams and sandy loams with limestone nodules, 1—2 cm in size. These nodules looking like gravels are strongly cemented

from the surface and inside they are made of pinkish-grey loose carbonate.

The thickness of the lacustrine-proluvial deposits does not exceed 10 m.

The Middle Quaternary age of the alluvial deposits composing the third terrace is determined by comparing this terrace with the third terrace of the Al-Furat in which K. M. Mirzaev found flint-licks — Middle Acheulian disk-shaped cores and flakes, 45 km north-west of Deir-Az-Zor (identification of A. Formozov).

Proluvial and lacustrine-proluvial deposits connected by gradual transitional zones with the alluvial deposits of the third terrace and making one surface together with the latter are also attributed to the Middle series of the Quaternary system.

Upper series (Q_3)

The Upper series is represented by alluvial and proluvial deposits.

Alluvial deposits compose the loose cover of the second terrace of the N. El-Khabour and Jagh-Jagh which stretches as an interrupted cover along the river valleys. They are pebbles, gravels and sands which in elevated localities are consolidated by limestone cement and grade into conglomerates, gritstones and sandstones. Pebbles are made of allogenic rocks, mostly limestone. In places adjacent to the Lower Quaternary basalts there are some basalt pebbles.

The Upper Quaternary alluvial deposits were exposed by quarries 2 km north-east of Al-Hasakeh where the Upper Miocene sandstone is overlain by:

1. Pebble bed consisting of medium and angular-rounded pebbles, poorly sorted ranging from gravels to large pebbles, up to 10 cm in size. In the composition of the pebbles dominates white and yellowish-white, often marmorized limestone, less frequent are flint, sandstone, dolomite, porphyrite and diabase. The pebbles are enclosed into a thin carbonate coating. There are also some large pebbles consisting of secondary limestone which were formed by sequential concentric accumulation of carbonate coatings around limestone gravel grains. The filling material is multi-granular gravelly sand . . . . 2—3 m
2. Gravel bed, cross-bedded, with some rare pebbles, similar to the underlying bed . . . . 0.6 m

The proluvial deposits are most widely spread covering the territory with a continuous mantle interrupted only in some localities.

They make alluvial cones around the J. Abd El-Aziz, which are composed of gypsumized loams with rare thin pebble and gravel bands. There is an alluvial gypsum crust, 1 to 2 m thick, on the surface of the loams.

The Upper Quaternary proluvial deposits adjacent to the N. El-Khabour valley and present in the northern part of the territory are loams and, less frequently, sandly loams of yellowish-grey and brown-grey colour containing some debris of calcareous rocks. There are some pebbles and gravels, transported during the erosion of the older Quaternary and Pliocene deposits. The thickness of the proluvial deposits reaches 15 and in some cases 20 m.

The Upper Quaternary age of the alluvial deposits is determined by the blades and flakes of the Upper Levallois found by French archeologist M. Perves [14] in the second terrace of the upper course of the N. El-Khabour near As-Safeh village.

The proluvial deposits are connected with the alluvial deposits of the second terrace by facial transitions. One can observe numerous ancient man-made hills on their surface. The oldest of them were made 6 or to 7 thousand years ago what is justified by a flint mattock found by K. M. Mirzaev at the base of the hill near Halab which indicates Tahoun and Jamouk culture (identification of A. Formozov). Hence, the surface of the proluvial valley and most of the proluvial deposits were mainly formed in the pre-historical time.

Recent (Q_4)

The Recent deposits are the alluvial mantle of the flood plain and the first terrace of the N. El-Khabour and Jagh-Jagh rivers and basalt sheets. The deposits of the first terrace can be traced nearly along all the river beds while on the map they are shown together with the flood plain sediments. According to the data obtained from the engineering geology drilling of contract 938 (Technoexport, contract 938, 1960), the first terrace is composed at the base of vari-grained gypsiferous sands with some gravels and pebbles, 5 m thick. The upper part is made of gypsiferous loams, about 8 m thick. The flood plain can also be divided into two horizons: the lower composed of coarse sands, gravels, and pebbles, 5 to 7 m thick, and the upper made of loams, in some places slightly gypsiferous, 3 to 4 m thick.

The Recent proluvial deposits are present in dry river beds and as a thin, non-continuous, 1 to 2-meter mantle covering the older deposits. They are yellow-grey loams. The Recent alluvial cones near the J. Abd El-Aziz are made of gritty loams with fragments and boulders of the local rocks. The Recent proluvium is not shown on the map of the Quaternary deposits.

The alluvial deposits composing the first terrace of the N. El-Khabour and Jagh-Jagh rivers are dated as Recent by their comparison with the alluvium of the first terrace of the All-Furat river, the Recent age of which was defined by flint mattocks (Tahoun and Jamouk culture) found in the area of Maskaneh village (sheet J-37-III) by K. M. Mirzaev (identification of A. Formozov).

VOLCANIC ROCKS

The effusive rocks developed on the territory in question are the Quaternary formations of the Lower and Recent series.

Lower Quaternary effusive rocks (βQ_1)

The Lower Quaternary effusive rocks make the Ard esh Sheikh lava sheet, Kapes Darh hill and Fakka lava flow. They overlie the Middle and Upper Miocene, Pliocene and probably the Lower Quaternary loams.

Ard esh Sheikh lava sheet lies north-west of Al-Hasakeh on the N. El-Khabour left-bank territory. Its area is 280 sq. km and thickness is 10 to 15 m. The effusive rocks make a nearly level, slightly tilted southwards sheet with bluff slopes rising 50 to 100 m above the N. El-Khabour valley. Nearly in the centre there is a low hill J. Qleib, 495 m high looking like a relic volcanic cone.

The effusive rocks are the products of basalt lava ejected at the earth's surface through fissures. These rocks are petrographically similar to the basalts developed in the Qarashouk area (sheet J-37-VII), being of the same composition and having the same mineralogical properties.

The effusive rocks make two flows. The lower flow is composed of basalt, compact at the base and porous at the top; the upper flow is microporous anamesite which at the top grades into fine-porous basalt forming the surface of the plateau. The effusive rocks present along the western margin of the sheet, near Tell Tamr village, are exclusively anamesite and dolerite of massive texture. Among them there are areas of agglomeration lava which contains pieces (about 20 cm in size) of vesicular basalt with

numerous calcite amygdules. They are welded into a better crystallized rock of massive texture and may be fragments of the previously solidified crustal part of the sheet, which was broken by the fluid moving lava and welded as xenoliths.

The effusive rocks of the sheet are dolerite, anamesite and basalt. These rocks are composed of the following constituents: plagioclase N 68, titan-augite, clivine ilmenite, apatite, volcanic glass. The secondary minerals are chlorophaeite, bowlingite, xylotile, limonite and calcite. By the composition these rocks are similar to plagiobasalt since plagioclase is a dominating component. By the composition of the impregnations they can be divided into olivine and plagioclase-olivine (less frequent) varieties. The texture is non-homogenous. The anamesite is mainly of poikilophytic and more seldom ophytic texture and the basalt has a microdoleritic texture. Less frequent are the rocks with vitreous texture prevailing. The characteristic feature of these rocks is poikiloblastic texture associated with carbonatization of the rocks. The structure is massive, fluidal, amygdaloidal and microtaxitic.

The effusive rocks of Kapes Darh. In the vicinity of Derbasiyeh town there is a table mountain, 2 km in diameter, with a level flat surface and cliffed slopes. It rises 70 or 80 m over the surrounding plain.The top of the mountain is composed of ankaramite which makes the flat brow of the mountain, 10 to 15 m thick. Below the brow, along the southern slope occurs a fine-clastic tuff series with the observed thickness of 22 m, which is an alternation of lapilli-granular, ash, granular and ash-granular tuff beds.

The constituents of the tuff are glass of different colours, fresh olivine, zonal greenish-brown augite and seldom hypersthene, microlitic basalt and pelitomorphic limestone. Amygdules in scoria glass are made of zeolite or chlorite, sometimes with halloysite in the middle. The tuff cement is of ash-type and secondary of pore-filling type. The composition of the cement is zeolitic and carbonate in some cases with some chrisotile. The structure is thin-striated.

The origin of the effusive rocks of the Kapes Darh is not yet clear. The underlying tuff beds having an oblique bedding are an evidence of volvanicity, but the table-like form of the Kapes Darh mountain and a flat occurrence of the effusive rocks in the form of a two-flow sheet contradict the idea of a volcanic cone. The most probable explanation might be the presence of an ancient tuff volcano which had later been covered with lava flows.

Fakka flow adjoins the Kapes Darh effusive rocks from the east but hypsometrically it is lower. The central part of the flow is preserved in the form of isolated patches, while the southern portion extends as far as 26 km near the Fakka valley.

The flow makes a narrow geniculate ridge, 0.5 to 1 m wide and about 5 m high. It corresponds to the bottom of an ancient valley. The Fakka flow is composed of plagioclasse-olivine basalt and anamesite of microporous structure, agglomeratic lava and plagioclase picrite.

The Lower Quaternary age has been tentatively assigned to the basalt by its position in the succession. The basalt lies on the loam and sandy loam beds which are believed to be of the Lower Quaternary age and is overlain by the Middle Quaternary proluvial deposits. The basalt of the Ard-Esh-Sheikh cover adjacent to the N. El-Khabour valley rises 10 to 20 m over the surface of the third terrace an approximately corresponds to the level of the fourth terrace which was dated as Lower Quaternary due to flint tools found on the territory of the adjacent J-37-XXIII sheet.

Recent effusive rocks (βQ_4)

East of Al-Hasakeh there is a group of volcanoes rising as seven hills in two chains confined to two north-north-easterly directed faults — the western and eastern. The volcanoes are surrounded with lava flows which extend in the same trend. There are five flows altogether which make sharp escarpments in the terrain. On the map they are shown as three flows-lower, middle and upper with the middle one consisting in its turn of three flows.

The lower flow ($\beta_1 Q_4$) represents the product of the earliest effusive activity in Recent time being most widely developed. The lava had been flowing as far as 8 or 12 km to the point marking the outskirts of Al-Hasakeh with some lava tongues offshooting along the slopes of the Jagh-Jagh valley where they come down to the water. The thickness of the flow in its central part is about 10 m decreasing to 3 m at the edges.

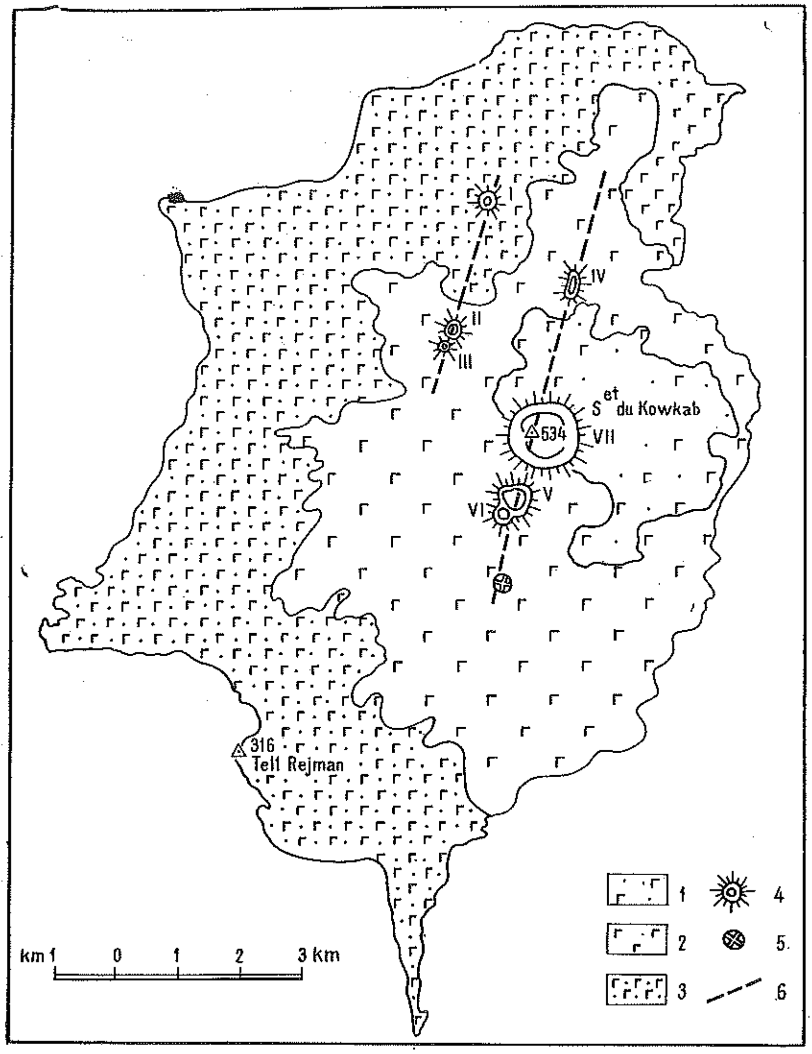


Fig. 10. A scheme showing relationship of basalt flows. The Kowkab massif
1 — basalt and tuff of the upper flow ($\beta_3 Q_4$); *2* — basalt of the middle flow ($\beta_2 Q_4$); *3* — basalt and tuff of the lower flow ($\beta_1 Q_4$); *4* — extinct volcanoes and their numbers; *5* — volcanic craters; *6* — supposed faults (inferred feeding canals)

There is a volcano I on the surface of the lower flow (Fig. 10). It has the form of a low hill, 10-15 m high, 200 m in diameter. The cone is well rounded, the crater being filled with basalt and loam detritus.

In the immediate vicinity of the volcano, south-westwards, there is an area of loose fine pyroclastic material, mainly volcanic sand which is probably related to the volcano that had either been completely destroyed or covered with the lava flow.

The middle flow ($\beta_2 Q_4$) had been flowing for shorter distances (not more than 4 km). Its thickness in the central part is 50 or 60 m decreasing to 5 m at the edges. Five volcanoes are present on the surface of the middle flow.

The same as volcano I, volcanoes II and III are associated with the western fault. They are well levelled but preserve distinct craters.

Valcano IV has an oval shape elongated in north-north-west trend, 0.7 km long and 0.2 km wide. It consists of two merging volcanoes with two craters. It is also highly eroded as the former ones.

Volcano V, located 1 km south of Kowkab is 30 to 40 m high and 0.5 km in diameter at the base. It has three vent funnels: a deep funnel of the southern main crater about 50 m deep with nearly vertical sides and two small craters in the northern part. One can see a multiple alternation of many hundreds of thin lava outpourings. In the crater the lava flows are very steep, in its upper part they are flat and along the slopes of the volcano they are gentle with reverse dip. The thin flows are composed of fine-bubbly, foamy lava, the thicker ones (more than 20 cm) are made of massive basalt at the base and of bubbly lava at the top. The lava layers are separated by red ferruginous scoria cakes. Sintered scoria is present on a wide scale. The scoria has tubercular, twisted and striated surfaces, typical for corded lava. One can see lava swellings, 2 to 5 m in size, on the volcano slopes, which had probably resulted from local pressures of the fluid lava on the solidified cake. From the inside of these swellings humid and warm air is coming out through cracks (t+35°C).

Volcano VI has no cone but a deep (about 35 m) and wide (0.25 km in diameter) crater with steep walls. It is composed of numerous alternating thin beds of foamy lava like volcano V.

Volcanoes V and especially VI are close to the type of shield volcanoes.

This type of volcanoes is characterized by a small and gentle cone and thinly-bedded foamy lava without pyroclastic outbursts.

The upper flow ($\beta_3 Q_4$) is developed on a small area north and east of Kowkab volcano (Fig. 10, 11). The length of the flow in some tongues is 3 km and the thickness near the cone is about 50 m decreasing to 15 m at the edges.

Kowkab volcano is the youngest. It has an elevation of 534 m rising 150 to 200 m above the surface of the middle flow, which had been errupted earlier. The diameter of the cone base is 1.2 km, and that of the deep crater is 0.2 km. The cone has steep slopes and had hardly been affected by erosion. It is composed of loose, uncemented fine pyroclastic material — ash, sand and sometimes lapilli making thin alternating laminae, 2 to 10 cm thick. They are nearly parallel to the slopes of the volcano. Within the sand and ash there are some volcanic bombs and blocks — lumpy and whorly with red scoria cake, their amount increasing at the top of the cone. The top of the volcano is covered with lava flow which had not run down the slopes of the cone. The crater is composed of alternating lava flows which have undulating surfaces with red scoria cakes. These flows had been outpouring eastwards breaking through the wall of the crater. In the immediate vicinity of the eastern edge of the crater there is a small lava hill, nearly 50 m in diameter and 10 m in altitude.

East of Kowkab the upper flow has an uneven tubercular surface. It is composed of basalt and tuff which are compact and massive at the bottom

Fig. 11. The Kowkab basalt massif. The Kowkab volcano and upper lava flow (β_3Q_4) are seen in the upper part of the photo. An older volcano and its lava flow (the middle flow — β_2Q_4) are observed south-west of Kowkab

and more porous at the top. On the surface the lava is bubbly and spongy, having an undulated scoria cake of black colour. The pores are oriented along the course of the lava flowing. In places there are calcite amygdules. The lava has a coarse-polygonal, short-columnar jointing. In some lava tongues one can observe an arched cross-section and random fine-polygonal jointing. The lava flows alternate with granular tuff layers.

The Recent effusive rocks are ankaramite, basalt, picrite, their scoria and tuff. The lower flow is essentially made of ankaramite, the middle of ankaramite and basalt and the upper — of picrite.

The constituents of the effusive rocks are plagioclase N 65-68, normal augite, fresh olivine, ilmenite, apatite and volcanic glass. The content of plagioclase ranges from 50-60% in basalt, to 15-25% in ankaramite. The

texture is crypto-and fine-granular, microdoleritic, tholeitic, intersertal and poikilitic. Microglomeroporphyritic texture is also typical. Impregnations, making from 10 to 25%, are made of olivine crystals, 0.5 to 1.2 mm in size and less frequently of augite.The structure is massive, porous or bubbly. The rocks are sometimes kaolinized.

The main effusive flows are dated Recent, due to the lower flow lying on the Upper Quaternary proluvial loams, observed on the bank of the N. El-Khabour river near Tell Rejmane and on the bank of the Jagh-Jagh river.

TECTONICS

The territory of the Al-Hasakeh sheet is located in the area of junction of the Arabian platform and Mesopotamian foredeep.

The basement of the Arabian platform buried under a thick mantle of slightly disturbed Paleozoic, Mesozoic and Cenozoic sediments is plunging northwards. In the marginal part of the platform, at the border with the Mesopotamian foredeep one can trace the Tuwal el-Aba-Sinjar swell which includes such uplifts as Abd El-Aziz and Tshumba bounded from the north by a regional fault.

The Mesopotamian foredeep is located north of the swell. Within the territory under description only the external zone of the foredeep in present while its internal zone which according to some investigators [4, 9, 8, 18] adjoins the Alpine geosynclinal region is on the territory of Turkey.

The sedimentary formations of the Neogene and Quaternary systems composing the southern portion of the territory which is considered to be a part of the Arabian platform do not differ much by lithology and thickness from the contemporaneous formations developed in the external zone of the Mesopotamian foredeep. The above mentioned tectonic zonation and establishment of the boundary between the platform and foredeep is based on geophysical information, results of deep drilling and data obtained from the geological survey.

According to gravity data the territory is a negative gravitational field with the gravity values (Bouguer reduction) decreasing northwards from 4 to 52 mgl. Along the northern slope of the Abd El-Aziz and north of the Tshumba, on the gravity map one can distinguish a gravity bench (a belt of a high gravity gradient) expressed by a sharp densing of the contours from 8 to 20 mgl. North of the gravity bench the contours become relatively dense and stretch in one trend. The local anomalies are of an elongated form and essentially latitudinal trend. Such features of a gravitational field are typical for foredeeps (О. Асташенков, 1960; И. Лобачевский, 1960). South of the gravity bench the gravity anomalies have no special orientation, making a complex mosaic pattern characteristic of platform regions.

According to magnetic data the territory is a positive magnetic field, the intensity of which ranges from zero to +275 gammas. The magnetic field consists of two zones, the northern and southern ones, separated by a relative magnetic minimum (up to zero), which corresponds to the Abd El-Aziz uplift. The northern zone confined to the Mesopotamian foredeep is characterized by a higher intensity of the magnetic field and densing of the isodynamic lines. The highest intensity (275 gammas) was observed east of Ras el-Ein town. Dominating trend of the isodynamic lines is sublatidudinal. The southern zone located in the area of the Arabian platform differs from the northern one by a somewhat lower intensity of the magnetic field (from 25 to 150 gammas) and by the absence of a clear trend of the isodynamic lines. The magnetic field evidently reflects the structure of the basement, for the overlying sedimentary rocks are not of appreciable magnetic susceptibility.

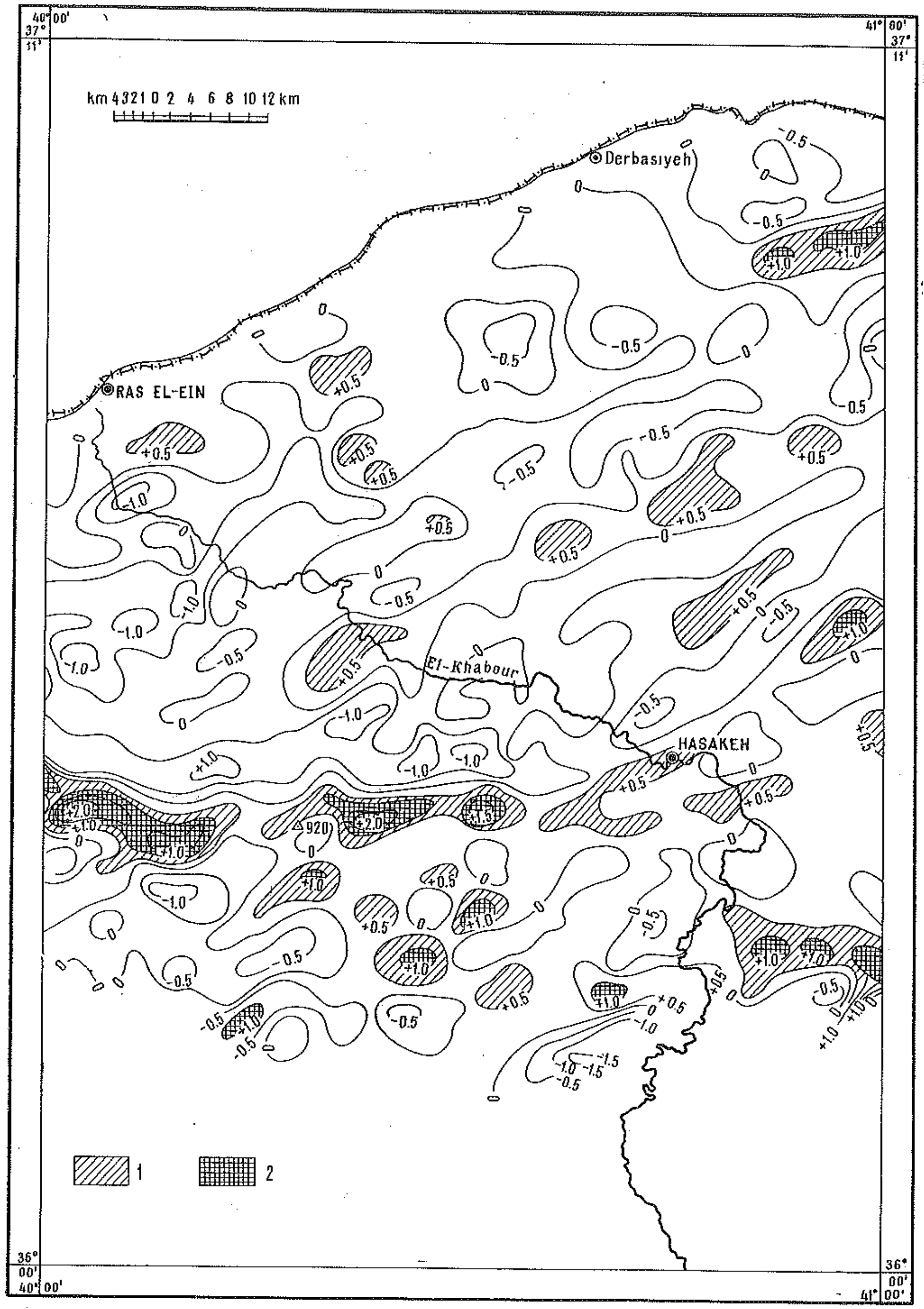


Fig. 12. Map of local gravity anomalies of Djezire region. Composed by I. F. Shelegova
Local anomalies shoron as: *1* — from +0,5 to +1; *2* — over +1

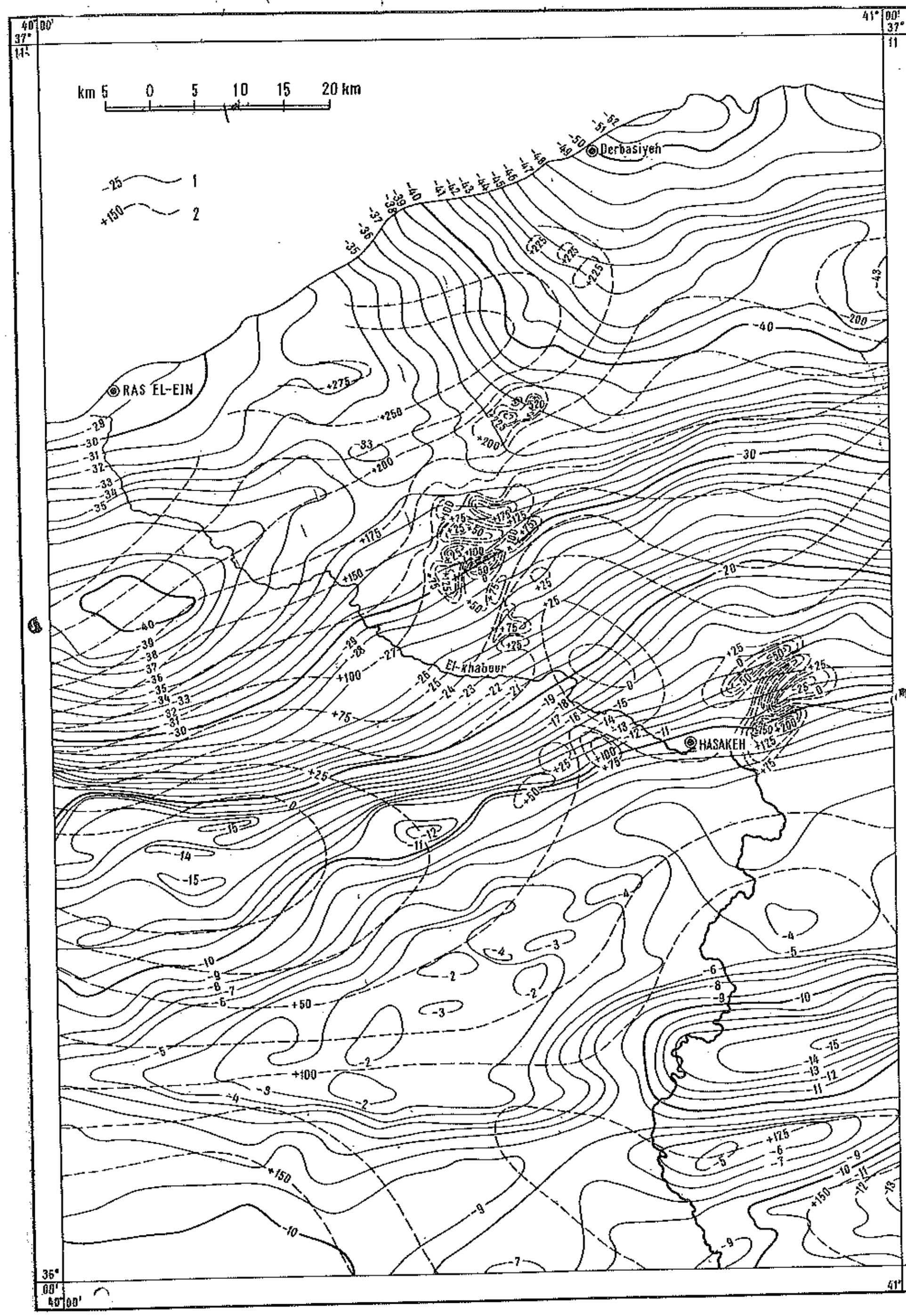


Fig. 13. Combined map of gravity anomalies (Bouguer reduction $\sigma = 2{,}53$) and magnetic anomalies (ΔTa)
1 — gravity isoanomals; *2* — magnetic isoanomals

North-east and north-west of Al-Hasakeh on the background of the low-disturbed magnetic field one can distinguish areas of a highly disturbed field which consists of a number of local anomalies with the magnitudes of −50 to +200 gammas. They are associated with the basalt sheets roughly reflecting their outlines.

The analysis of the geophysical data suggests that the basement is composed of the crystalline rocks capable to affect the character of the magnetic field. The decrease in gravity values from south to north is an evidence of the basement submergence in the same direction, this submergence going deeper in the Mesopotamian foredeep. Gravity highs traceable along the Abd El-Aziz and Tshumba reflect the uplifted block of the basement bounded by faults from the north and south. The magnetic minimum associated with this uplift shows that the crystalline basement is composed here of low-magnetic rocks.

According to the gravity data a number of local gravity anomalies can be located on the territory of the sheet (Fig. 12, 13). Some positive local anomalies (gravity highs) correspond to anticline structures recognized on the surface although there is a 2 to 4 km noncoincidence between them on the horizontal plan.

The seismic survey conducted on the territory of the neighbouring J-37-VI, VII sheets show that the local gravity highs are as a rule associated with anticline structures. The seismic data suggest that the positive local anomalies identified on the map of local anomalies also correspond to the subsurface anticline structures. These inferred structures are shown on the structural map. However, not all the gravity highs correspond to anticline structures. The location of some small local anomalies having the values of 0.5 of the adopted unit cannot be reliable since it is on the verge of the method accuracy. The presence or absence of anticline structures corresponding to local gravity highs can be proved only by a seismic survey.

Marginal part of the Arabian platform

The marginal part of the Arabian platform includes the Tuwal el-Aba — Sinjar swell and Al-Furatian depression.

The Tuwal el-Aba — Sinjar swell is recognized in the present relief as the J. Abd El-Aziz, Tshumba and other less elevated hills. It extends beyond the territory of the sheet westwards to the Tuwal el-Aba hills and eastwards to the Sinjar mountains. Contoured on the top of Tortonian, the width of the swell is 32 km in the area of the J. Abd El-Aziz and 26 km in the Tshumba area. In the swell zone the thickness of Mesozoic, Paleogene and Lower Neogene is smaller as compared with the adjoining troughs, with Pliocene beds being altogether absent. The swell is complicated by anticlines, flexures and faults.

A d b E l-A z i z a n t i c l i n e (1)* is the largest structure in north-eastern Syria, its length contoured on the top of Helvetian being 50 km and its width — 10 km. The anticline is complicated by a number of faults and has a sharply asymmetrical structure, its northern limb dipping at the angle of 70 or 90° and the southern limb being inclined in the zone close to the core at the angle of 20° and getting gentler (3 to 5°) southwards. The core of the anticline is composed of the Cretaceous rocks and the faulted block — of Carboniferous. The limbs are made of Paleogene, Lower and Middle Miocene up to Lower Tortonian. The northern limb is broken by a latitudinal fault which had caused the steep dip of the beds and asymmetrical structure of the anticline. The result of the apex undulation is a number of gentle uplifts within the Abd El-Aziz anticline which can be

* Figures in brackets stand for the numbers of the structures shown on the tectonic scheme (Fig. 14).

recognized on the surface as outcrops of the Paleogene and Lower Miocene deposits. Many of these are complicated by minor faults of the north-eastern trend.

H o r r a a n t i c l i n e (II) located south of Al-Hasakeh town is a gentle brachy-anticlinal fold of a latitudinal trend. According to the closure of marker beds 58 and 60 of the Tortonian age the anticline can be traced 6 or 8 km in length and 3 km in width. The northern limb is inclined at 2—3°, the dip of the southern limb not exceeding 1°.

E l - K h o u e n e a n t i c l i n e (III) is located 17 km east-south-east of Al-Hasakeh. This brachy-anticlinal fold can be traced along the Tortonian marker bed 60 as 5 km in length and 2 km in width. In the core of the fold the beds are horizontal, the dips at the limbs ranging from 1 to 3°.

T s h u m b a a n t i c l i n e (IV) according to the Tortonian marker bed 50 is 30 km long and 9 km wide within the area under investigation. The core of the anticline made of the Helvetian limestone and Lower Tortonian rocks is located on the territory of the adjoining sheet J-37-VI. The dip of the northern limb is 3 or 4°, of the southern — 4 or 6°.

West of the Tshumba anticline one more anticline seems to be present, but its western closure has not been established. It is possible that this anticline is opened towards the Abd El-Aziz anticline.

B e i d a a n t i c l i n e (V) can be traced along the Tortonian marker bed 25. Within the area surveyed it is 5 km long and 4 km wide. The core and the western pericline of the structure are on the territory of the adjacent J-37-IV sheet. The core is made of the Helvetian rocks, the limbs — of the Lower Tortonian deposits. The structure is asymmetrical. The southern limb is steep having dips of 15 to 25°, and the northern limb is inclined at the angle of not more than 5°. From the south-east the anticline is bounded by a north-eastern fault recognized on the surface as an escarpment, 15 or 20 m high. The magnitude of displacement between the south-eastern hanging wall and the north-western foot-wall may be 50 or 70 m.

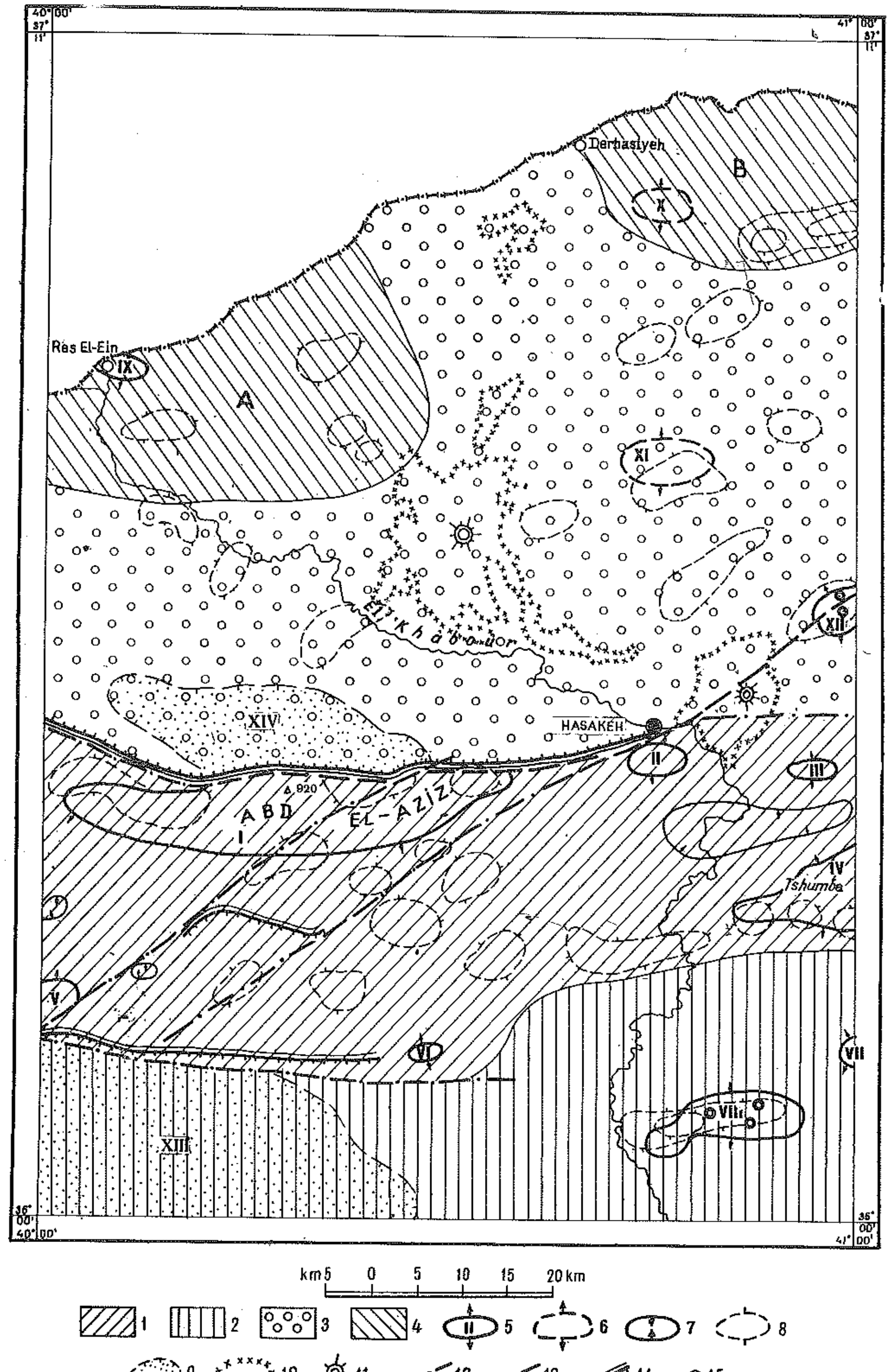
M e t i a h a a n t i c l i n e (VI) as contoured on the top of Tortonian is 2 km long and 1.5 km wide. The dips in the north-western part of the fold are 1 to 2°, in south-eastern — up to 5°.

S y n c l i n e s have been recorded between the Beida and Abd El-Aziz anticlines and north of the Tshumba anticline. Between these folds within the Tortonian rocks there are some small brachy-synclines 2 or 3 km long and 1 or 2 km wide which can be traced by the closure of the beds. The dip at the limbs of the synclines is generally 2 or 3°.

The largest syncline is located north-west of the Tshumba anticline. Contoured on the Upper Miocene beds its length is 20 km and width 3 or 6 km. The core and the limbs are composed of the Upper Miocene rocks. The beds in the core are flat, while the limb beds are inclined at the angle of 2 or 3°.

According to gravity data there are several local anomalies within the Tuwal el-Aba — Sinjar swell.

The most significant is the group of positive gravity anomalies of about 1.5 or 2 adopted units, located along the axis of the Abd El-Aziz anticline. Exact coincidence of a gravity high with the anticline recognized on the surface has not been recorded. The most important gravity highs (+1.5 or +2) are located east and west of the anticline core and on the periclines, while the core shown on the surface by the exposure of the oldest rocks and the steepest dips coincides with a weak gravity high of about 0.5 of the adopted unit. South of the Abd El-Aziz anticline, in the area of a gentle monocline marked on the surface, the gravity survey has located four local anomalies with the value of +1 and three — with the value of 0.5 adopted units.



On the map of local anomalies the Tshumba anticline is marked as a +0.5 gravity high which consists of three +1 local anomalies shifted 2 or 3 km south of the Tshumba axis.

On the right-hand bank of the N. El-Khabour, west of the Tshumba anticline one can see a +1 gravity high. It may possibly correspond to the anticline inferred on the surface in the Tortonian beds, 4 or 5 km north-east of the above mentioned high.

In the area of Al-Hasakeh one can mark two weak gravity highs (+0.5) which can neither by the pattern nor by the position be correlated with the anticlines observed on the surface.

F l e x u r e s are recorded in the southern part of Tuwal el-Aba — Sinjar swell south of the Abd El-Aziz mountains.

Along the line Tell Bourga — Madfaa — Dibshiye a nearly 40-km flexure can be traced in Upper Tortonian and early Upper Miocene rocks in the zone 2 or 3 km wideé It is marked by a sharp increase of dip angles up to 10—15° and in places to 25° in comparison with gentle dips (1—2°) observed north and south of this zone. The flexure is associated with a fault present in the subsurface according to gravity data.

To the north of the above mentioned flexure, on the southern slope of the Abd El-Aziz mountains, in the Tortonian rocks, there is a second flexure, about 15 km long and 1 or 1.5 km wide with dips of 10—15° and in places of 40°.

T h e f r a c t u r e s are classified as latitudinal and northeasterly according to their character and trend. Latitudinal fractures are faults. They bound the Tuwal el-Aba — Sinjar swell from the north and south. The north-easterly fractures are shift faults, they cut the Tuwal el-Aba — Sinjar swell and are traced within the Mesopotamian foredeep.

The largest and most vividly expressed fault of a latitudinal trend bounding the Tuwal el-Aba — Sinjar structure from the north is distinguished on the northern slope of the J. Abd El-Aziz. On the surface the fault is recognized by crushed zone and by a saddle or escarpment in the relief. In the area near the core of the Abd El-Aziz anticline the Cretaceous beds are brought against the Neogene, i. e., the northern block being downthrown with respect to the southern one. The magnitude of displacement in the central part of the J. Abd El-Aziz is 1000—1500 m decreasing westwards and eastwards to several hundred and to a few dozens of metres. The fault is surrounded by many minor faults which form a complicated system of blocks. Carboniferous rocks are brought to the surface in one of the blocks. In the western part of the J. Abd El-Aziz and north of the Tshumba hills the fault can be followed only by geophysical data as a gravity bench.

On the gravity map south of the J. Abd El-Aziz one can see a gravity change with a small gradient (from —3 to —8 mgl) which is possibly due to a latitudinal fracture which on the surface, in the Tortonian plastic rocks

Fig. 14. Tectonic scheme

The marginal part of the Arabian platform (A mobile part of a platform slope with the linear and block-type folding in the sedimentary platform cover; the basement lies at different depth): *1* — Tuwal El-Aba — Sinjar swell (rampart); *2* — Al-Furation depression. *Mesopotamian foredeep: 3* — North-Khabourian depression; *4* — Ras El-Ein (A) and Qamishli (*B*) highs (uplifts); the latter is a part of the Quarashouk-Qamishli rampart. *Structure symbols: 5* — anticlines located on the surface by the geological survey; *6* — anticlines supposed according to shallow core drilling for mapping purposes; *7* — synclines found on the surface by the geological survey; *8* — anticlines supposed by the gravity survey; *9* — Troughs filled with Quaternary rocks; *10* — outlines of basalt sheets; *11* — extinct volcanoes; *12* — proved faults; *13* — supposed faults; *14* — flexures; *15* — deep wells. *Anticlines: I* — Abd El-Aziz, *II* — Horra, *III* — El-Khouene, *IV* — Tshumba (Jambe), *V* — Beida, *VI* — Metuaha, *VII* — Ghouna, *VIII* — Jabiseh, *IX* — Ras El-Ein, *X* — Metsallem, *XI* — Afandi, *XII* — El-Bawwab. Troughs: *XIII* — Muqhabb, *XIV* — Ghara is recognized as a flexure. The fracture is probably a fault, the southern block of which is downthrown with respect to the northern one. The geophysical data show that in the subsurface the fault is shifted southwards with respect to the flexure marked on the surface what indicates that the fault plane is inclined to the south.

A major north-easterly fracture is extending 90 km from the Khnezii village through Al-Hasakeh to the El-Bawwab anticline and about 70 km beyond the territory described. 16 or 18 km south of the J. Abd El-Aziz the fracture zone shows a 0.5 or 1—km displacement of the Tortonian beds and a sharp change of their strike. South-east of Al-Hasakeh the fracture is recognized in the relief as a 2 or 5 m escarpment with the displacement of beds and a change of strike. North-east of Al-Hasakeh the fracture zone incorporates a set of volcanoes, most of which are not directly associated with the fracture described but with the surrounding cracks of a submeridional trend. Further to the north-east, on the El-Bawwab anticline, the fracture is marked by displacement of the Upper Miocene beds and is easily seen on aerial photographs. On the gravity maps one can see a number of local anomalies in the fracture zone and change of the contours' trend. The fracture described can be placed into the category of shift faults, having its south-eastern block shifted 5 km to the north-east with respect to the north-western block.

Another north-easterly fracture can be traced extending 55 km from the southern slope of the J. Beida to the north-eastern slope of the J. Abd El-Aziz. On the south-eastern slope of the J. Beida it is marked by a 20 m escarpment and by displacement or absence of several Tortonian beds. Further to the north-east the fracture zone shows a sharp change of strike. In the eastern part of the J. Abd El-Aziz the fracture is recognized as a 30 or 50 m escarpment with a direct contact of the Oligocene and Helvetian beds. This fracture is a strike-slip fault with the south-eastern block shifted to the north-east and upthrown 70 or 100 m in respect to the north-western block in J. Abd El-Aziz and the north-western block upthrown in J. Beida, the magnitude of displacement being 50 or 70 m.

In addition to the above mentioned large folds and faults, minor folds (100 or 200 m in size) are present in the plastic rocks of the Tortonian age.

The Al-Furatian depression is situated south of the Tuwal el-Aba — Sinjar swell and can be traced in the area of the Arabian platform far beyond the limits of the sheet under description to the west, east and south. In the area adjacent to the swell the beds are inclined southwards at the angle of 5 to 10°, getting flatter (1—2° and less) to the south. A relative decrease of gravity values from —4 or —6 to —10 mgl is recorded in the area of the depression as compared with the area of the swell. It is due to a larger depth of the basement and thicker sedimentary strata. The correlation of the Mesozoic, Paleogene and Neogene sections shows that their thicknesses within the swell area are smaller than within the depression.

Stratigraphic unit	Thickness in the area of the Tuwal el-Aba—Sinjar swell, in m	Thickness in the area of the Al-Furatian depression, in m
Pliocene	—	50—70
Upper Miocene	50	300
Tortonian (upper)	330	?
Tortonian (lower)	275	500
Helvetian	50—70	50—70
Lower Miocene	0—105	71—167
Paleogene	260	300
Upper Cretaceous	800	1400

Two brachy-anticlinal structures, Ghouna and Jabiseh, can be located in the area of the Al-Furatian depression south of the Tshumba hills, and the Muqhabb trough can be located south and south-east of the Beida mountain.

G h o u n a a n t i c l i n e (VII) is a brachy-anticlinal fold the core of which made of the Upper Tortonian rocks is on the territory of the J-37-VI sheet. Contoured on the top of the Tortonian, the length of the fold is 9 km and the width is 4 or 5 km. On the territory described there is a western pericline of the structure, the dip being 4 or 5°.

J a b i s e h a n t i c l i n e (VIII) is also a brachy-anticlinal fold which comprises four small domes revealed by the closure of some Tortonian beds. The lower Tortonian rocks are brought to the surface in the core of the central dome. The anticline limbs are composed of the Upper Tortonian and Upper Miocene rocks. The length of the brachy-anticline contoured by the Tortonian is 13 km, the width is 5 km. The dip in the core is 2 or 3°, at the limbs increasing to 8 or 10°.

The anticlinal structure marked on the surface corresponds to a local gravity high the max. value of which corresponds to the western pericline of the structure.

M u q h a b b t r o u g h (XIII) adjoins the swell from the south. The trough is filled with Quaternary proluvial deposits which are alluvial cones of the Abd El-Aziz mountains, having the thickness of 70 or 80 m. The trough is elongated in a latitudinal direction, being 50 km long and 25 or 30 m wide (including the territory of adjacent sheets J-37-IV and J-37-XXIII).

Mesopotamian foredeep

North-Khabourian and Sinjar depressions and Ras el-Ein and Qamishli highs can be located within the area of the Mesopotamian foredeep.

North-Khabourian depression is separated from the Tuwal el-Aba — Sinjar swell by a latitudinal fault in the south, and in the north it is bounded by the Ras el-Ein and Qamishli highs. To the west and to the east it can be traced on sheets J-37-IV and J-37-VI. On the boundary between the depression and the swell there is a flexure conjugate with a latitudinal fault. The dips near the core of the Abd El-Aziz anticline amount to 50 or 60° reducing to 10 or 15° to the west and east. The width of the flexure ranges from 0.5 to 1 km. North of the flexure the dips are never higher than 2 or 3°.

According to gravity data the North-Khabourian depression differs from the Tuwal el-Aba — Sinjar swell by a sharp change of the gravity values from —10 or —15 mgl in the marginal part of the swell to —40 or —50 mgl in the northern part of the depression. This is due to a greater depth of the basement and larger thickness of the sedimentary cover. El-Bawwab bore holes drilled in the marginal part of the depression showed a sharp increase of the Paleogene thickness up to 630 m, compared with 260 m within the swell area (Abd El-Aziz mountains). Data about the thickness variations in the central part of the depression are not available. Smaller gravity values suggest a still greater increase of the thickness of the Paleogene and possibly of Mesozoic and Miocene, along the profile of the core holes drilled for mapping purposes from Al-Hasakeh to Derbasiyeh.

30 km north of Al-Hasakeh one can distinguish another a n t i c l i n e A f f a n d i (XI). The core is probably in the area of well 4 which penetrated a thick series of the Upper Miocene rocks and struck Tortonian. Due to large spacings between the wells it is not possible to define the size and morphology of the structure. On the surface it can hardly be observed. It is not confirmed by dip and strike evidence and it is marked only by the

outcrop of the Upper Miocene rocks and some decrease of the Quaternary thickness. On the map of local anomalies the above anticline is marked by a gravity high shifted 2 or 3 km southwards.

The El-Bawwab anticline (XII) is located near the boundary between the North-Khabourian depression and Tuwal el-Aba — Sinjar swell. This anticline is cut by a north-easterly fault. The dip in some places amounts to 20° possibly due to the fault. The limbs are inclined at the angle of 3 or 5°. The size of the structure shown on the surface is hard to define due to poor exposure. It may be not more than 10 km long and about 4 km wide. The oil company "Concordia" has conducted a seismic survey over the El-Bawwab anticline. Contoured along a reference horizon "B" which is supposed to occur at the top of Cretaceous, the anticline has the size of 18×11 km.

In the southern part the axis of the anticline is latitudinal gradually changing for north-easterly. The structure is cut by a number of faults into individual blocks the relative elevations of which range from 100 to 400 m. The largest displacement along the faults is recorded in the horizons occurring below 2000 m. On the map of local anomalies the El-Bawwab anticline is marked by a local gravity high roughly coinciding with the surface structure. Within the North-Khabourian depression on the map of local anomalies one can see a number of gravity highs which may correspond to subsurface anticlines.

North of the J. Abd El-Aziz there is Ghara trough (XIV) with Quaternary proluvial filling, up to 110 m thick. The trough stretches 35 km in a latitudinal trend, its width being 8 or 10 km.

The Pliocene deposits within the North-Khabourian depression increase their thickness south-eastwards.

Fore-Sinjar depression has only its south-western termination within the territory of sheet J-37-V. Most of the depression is located within the neighbouring sheets J-37-VI, VII where it is bounded by the Tuwal el-Aba — Sinjar swell from the south and by a north-easterly fault from the north-west (from the North-Khabourian depression). The Fore-Sinjar depression differs from the North-Khabourian one by a sharp increase of the Pliocene thickness up to 800 or 1000 metres as compared with the 50 or 100 metre thickness in the North-Khabourian depression what has been proved by the seismic and drilling data obtained from sheets J-37-VI, VII.

Ras El-Ein high is recognized on the surace as an extensive outcrop of the Middle Miocene rocks on the background of the Upper Miocene and Pliocene deposits filling the depression. On the gravity map the Ras el-Ein high is marked by a relative gravity low of —36 to —29 mgl and on the map of Δ Ta anomalies by a geomagnetic maximum of 200—275 gammas. The length of the high within the territory of Syria is 50 km and the width is about 30 km. From the south and south-east the high is bounded by the North-Khabourian depression, in the east it is separated from the Qamishli high by an offshoot of the North-Khabourian depression and in the north and west the high extends further to the territory of Turkey.

In the area of Ras El-Ein town it is possible to locate a positive structure, called Ras El-Ein anticline (IX), by the outcrops of the Helvetian limestone beds. Due to a poor exposure of the rocks composing the fold, the dip and strike could not be measured, therefore the size and type of the structure are not known.

On the map of the local anomalies four local gravity positive anomalies can be distinguished within the area of the Ras el-Ein high. These anomalies may reflect deep-seated synclines.

Qamishli high can be traced stretching for about 50 km from Derbasiyeh. The width of this high including the J-37-VI sheet does not

exceed 20 km. At the surface this high is marked by the Tortonian and Upper Miocene deposits outcropping amidst the Pliocene rocks. The data obtained from drilling Qamishli well on the high suggest that the Lower Paleozoic deposits are relatively shallow, Devonian and Carboniferous are absent and Mesozoic is reduced. Whereas the thickness of the Paleogene and Neogene remains the same as in El-Bawwab wells. According to gravity data the Qamishli high corresponds to a —42 or —52 mgl gravity low. Reduced gravity values may probably be explained by a change in the basement rocks composition and possibly by the appearance of sedimentary rocks.

Metsalem anticline (X) has been located along the profile of shallow core holes, 10 km south-east of Derbasiyeh. The core of the anticline composed of the Tortonian rocks must be at the depth of 75 m. The crest can be located by a correlation with the neighbouring holes where the top of Tortonian is deeper. The fold is not expressed at the surface.

25 or 30 km south-east of Derbasiyeh there is a local anomaly of +0.5 adopted units, comprising some local gravity highs of +1. One more local gravity high located on the territory of the J-37-VI sheet close to the above highs, corresponds to anticlinal structure Qamishli suggesting that the local gravity highs located west of the Qamishli high mark deep anticlinal folds.

Geological history

The data available enable one to bring back the geological history of the area beginning with Cretaceous. Any older stages of the history can be outlined only schematically and for some selected localities only.

During Ordovician and Silurian the north-eastern portion of the area was a sea in which terrigenous sediments (clay, siltstone and sandstone) were deposited.

During Devonian and Carboniferous the Qamishli high came into being and in this area sedimentation ceased and possibly denudation of the formerly deposited rocks occurred from time to time. In the Abd El-Aziz mountains marine thin-stratified formations, such as sandstones, shales and limestones were depositing during Carboniferous.

In Permian time most of the territory underwent subsidence which resulted in transgressive accumulation of sandstones, clays, shales and at the top limestones. During Permian, probably between Paleozoic and Mesozoic, the Tuwal el-Aba — Sinjar swell was formed in the area of the J. Abd El-Aziz what resulted in the Permian rocks being absent.

At the end of Paleozoic general uplifting of the territory took place and the sea retreated.

The Mesozoic period started by the advance of the sea what was marked by the deposition of sandstone at the base of the Triassic sequence.

During Triassic and Jurassic marine and lagoonal-marine sediments such as dolomite, anhydrite, shale and limestone accumulated in the North-Khabourian and Al-Furatian depressions. Although the Qamishli high was in the zone of sedimentation, the amplitude of downwarping was much smaller here than in the North-Khabourian depression. Within the Tuwal el-Aba — Sinjar swell the amount of sedimentation varied from one locality to another.

In the area of Tuwal el-Aba (sheet J-37-IV) the deposition of limestone was accompanied by erruptions of basic effusives. The area of the J. Abd El-Aziz must have been the place where sedimentation alternated with denudation.

At the end of Jurassic huge uplifting took place here, followed by a washout of the Jurassic, Triassic and probably older rocks the remains of which can be encountered as boulders and pebbles at the base of Lower Cretaceous.

The Lower Cretaceous period is characterized by the advance of the sea into the zone of the Tuwal el-Aba — Sinjar swell. Sedimentation took place all over the area. Mostly terrigenous rocks were deposited in the area of the J. Abd El-Aziz, such as conglomerate and sandstone and only in late Lower Cretaceous — marl and limestone. The sedimentation was interrupted by local upliftings followed by erosion. In the rest of the area carbonate and clayey rocks were deposited.

During Upper Cretaceous sedimentation was going on all over the territory, but the Tuwal el-Aba — Sinjar swell, Qamishli and perhaps Ras El-Ein areas were slower in sinking than the North-Khabourian and Al-Furatian depressions. In Late Coniacian slow sinking was interrupted by a sudden rise of the Abd El-Aziz area. As a result of this rising and later denudation Santonian rocks were deposited on the eroded surface of the Lower Cretaceous, Cenomanian, Turonian and Coniacian sediments. During later periods up to Paleogene accumulation of carbonate and carbonate-terrigenous deposits took place. In the North-Khabourian and Al-Furatian depressions a thick series of carbonate and clayey-carbonate rocks was deposited during Upper Cretaceous.

Between Mesozoic and Cenozoic the marginal part of the Arabian platform underwent upwarping followed by the retreat of the sea while in the area of the Mesopotamian foredeep sinking was going on.

The Paleogene advance of the sea in the area of the Al-Furatian depression started in Lower Eocene and in the zone of the Tuwal el-Aba — Sinjar swell — in Middle Eocene. Up to the end of Paleogene mostly carbonate rocks were deposited in this area, same as in the Mesopotamian foredeep. Only the Qamishli high was subject to rising during Oligocene.

Late Paleogene — Early Neogene is characterized by strong tectonic movements, the strongest occurring in the central and western parts of the J. Abd El-Aziz and in the Tuwal el-Aba hills. As a result of uplifting Paleogene deposits were eroded.

Uplifting of the Tuwal el-Aba — Sinjar swell took place in Aquitanian time and in the western part of the swell it continued during Burdigalian. The eastern part of the swell including the eastern slope of the J. Abd El-Aziz, parts of the North-Khabourian and Al-Furatian depressions adjoining the swell came into the zone of subsidence during Burdigalian time with chemogenous sediments, such as gypsum, rock salt and partly limestone being deposited. The largest amplitude of sinking is recorded south of the Tshumba hills, in the area of Jabiseh, Ghouna and Gbeibe anticlinal structures (sheet J-37-VI). In the most part of the Mesopotamian foredeep during Lower Miocene a small-scale subsidence took place which was followed by deposition of carbonate sediments.

Middle Miocene began with the advance of the sea over the entire territory.

During Helvetian, limestone with open sea fauna was deposited.

In Tortonian time all the territory of sheets J-37-V, XI underwent further sinking, but the areas of the Tuwal el-Aba — Sinjar swell as well as Ras El-Ein and Qamishli highs were somewhat slower in sinking than the Al-Furatian and North-Khabourian depressions. At that time accumulation of gypsum and also limestone and marl took place. North and south of the Tshumba area rock salt was also precipitated. In the middle of Tortonian the addition of terrigenous material occurred which constantly increased in amount and at the end of Tortonian terrigenous rocks were accumulated on a par with evaporites. This regularity was probably due to a rhythmic subsidence of the base level of erosion associated with vertical movements in the areas of supply of terrigenous material and also with periodical changes in climate. The movements were slow and of small magnitude what caused the absence of coarse clastic material. The presence of pyroxene grains and amphybols in the clastic material of the sandstone is an evidence of the fact that basic igneous rocks took part in the rock formation. From the dip of the oblique series in the sandstone directed mostly to the south one can state that the sources of the transported rocks were located to the north of the area, possibly in the zone of the Alpine geosyncline.

In Late Middle Miocene the sea retreated and beginning with Upper Miocene sedimentation took place under continental conditions.

In Earlier Upper Miocene the tectonic activity was relatively low. In lake basins thin-bedded terrigenous sediments were accumulated. Later mostly sandy and clayey rocks were deposited. They were ill-sorted and contained lake and swamp plant remains. Alluvial facies rhythmically alternated with lacustrine-swampy and lacustrine-proluvial.

Frequent washouts and local unconformities are present in bedding. Clay contains fragments of sandstone and limy-clayey rocks. Clay rolls are disseminated in sand. It is possible that local anticlines and synclines started to be formed at that time.

In late Upper Miocene and Early Pliocene general uplifting of the area was going on, with local structures springing up followed by denudation. The Tuwal el-Aba — Sinjar swell including Tuwal el-Aba, Abd El-Aziz and Tshumba anticlines kept on rising, meanwhile the North-Khabourian and Al-Furatian depressions were undergoing subsidence of small magnitude.

Both depressions were filled with lacustrine-alluvial sediments of similar composition, which contain accessory gravels of flint and basic igneous rocks transported probably from the Alpine geosynclinal zone situated in Turkey. Apart from allogenic clastic material, Pliocene deposits contain debris and poorly rounded pebbles of in situ rocks: clay, clayey marl, limestone and gypsum which were formed by the erosion of the anticlines of the Tuwal el-Aba — Sinjar swell and Ras El-Ein high. Later a closed lake basin was formed north of the J. Abd El-Aziz, in which marl and limestone were deposited.

In Quaternary time general upwarping of the area was still going on, the areas of sediment accumulation were getting less in number and recent relief started to be formed.

In Lower Quaternary the Abd El-Aziz mountains were formed, the slow rising of which was followed by accumulation of proluvial gypsum and loam in conjugate troughs.

In Late Lower Quaternary basalt lava was ejected at the surface through faults and fissures in the sedimentary strata, forming the Ard esh Sheikh, Kapes-Darh and Fakka flows and sheets.

In Middle Quaternary significant growth of the Abd El-Aziz and Armenian Tourous mountains took place what caused a formation of a coarse-detrital debris cone. The area of the Abd El-Aziz uplifting expanded to the adjacent localities which had previously been zones of accumulation of Lower Quaternary proluvial deposits. Thus, on the eastern pericline of the J. Abd El-Aziz the Lower Quaternary proluvial deposits were raised up to 100 m and cut by deep gorges.

In Middle Quaternary the N. El-Khabour came into existence. Pebbles, gravels and sands were deposited in its valley.

In Late Middle Quaternary — Early Upper Quaternary new uplifting of the area took place. The N. El-Khabour cut the deposits of the third terrare. Middle Quaternary alluvial cones were partly washed out by temporary torrents. During Upper Quaternary mountains and uplands of Abd El-Aziz, Tshumba, Jabiseh etc. continued to rise. Debris cones were formed in the areas adjoining the uplands. Clastic deposits were accumulated within gently sloping plains. Pebble beds of the second terrace were deposited in the N. El-Khabour and Jagh-Jagh valleys.

At the beginning of Recent the basalt flows and sheets of Kowkab were formed, the N. El-Khabour cut the second terrace and loam and sand of the first terrace and flood plain were deposited.

ECONOMIC GEOLOGY

The area of the sheet under description is interesting with respect to prospection for oil, gas and rock salt. In the course of the field work especial attention has been given to locating anticlinal structures, luminescence-bituminological analysis, gypsum and gypsiferous rock sampling for determining boron content, looking for rock salt and selecting the localities favourable for quarrying building materials.

Oil and gas possibilities

The fact that the area is oil and gas promising is proved by its position in the zone of junction of two major geotectonic provinces: the Arabian platform and Mesopotamian foredeep. Major oil fields were discovered in Saudi Arabia within the Arabian platform. In the Mesopotamian foredeep big oil fields are producing in Iraq, Iran and Kuwait. The producing oil fields in Syria are Qarashouk and Suweidiyeh, 120—130 km north-east of Al-Hasakeh.

The location of the areae in question near biggest petroliferous provinces of the world suggests its estimation as promising for oil and gas prospecting.

Thus far no commercial oil pools have been discovered in the area. Drilling of Jabiseh and El-Bawwab structures has not yielded positive results. However, numerous oil and gas shows have been recorded in the process of drilling.

In well Jabiseh-1 the first indications of bituminous rocks have been marked in the Lower Fars formation at the depth of 322 m. Traces of oil and gas have been encountered downwards throughout the entire section drilled. At the depth of 491.6 m a dry gas flow was obtained from the Helvetian limestone (Jeribe limestone) at the rate of 650.000 cubic metres per day with a 1.25″ pipe. The analysis of a gas sample taken from the well mouth is as follows:

	Per cent of the total volume
Methane and elastic gases	91.9
Ethane	4.0
Propane	1.6
Butane	0.8
Hydrogen sulphide H_2S	1.7

Specific gravity related to air is 0.640. If 91.9% of the volume is methane, the specific gravity of such a gas should be 0.612. It is possible that sampling was not properly made and the results of the analysis are not quite reliable.

Oil-stained rocks and bitumens have been found in Burdigalian (Dhiban formation), Oligocene, Eocene and Cretaceous deposits. Commercial testing of the Upper Cretaceous has resulted in a significant flow of salt water with oil.

The results of the crude oil analysis are as follows: specific gravity at t=60°F — 0.876, viscosity by Redwood N 1 at 70°F — 102 sec, at 100° — 58 sec, sulfur content — 1.87%, asphalt — 0.1%, paraffin — 2.9%.

Engler fractionation

Boiling point — 75°C

Products of fractionation in %:

100°C — 1.5	225°C — 22.5
125°C — 3.5	250°C — 28.0
150°C — 8.5	275°C — 34.0
175°C — 13.0	300°C — 40.0
200°C — 19.0	

The total product of distillation is 41.0%, its specific gravity at t=15.6°C is 0.791, specific gravity of the residue — 0.932, the volume of the residue — 58.5%, loss of distillation — 0.5%. The oil is paraffinic.

Small gas flows have been obtained from the Miocene horizons penetrated by wells Jabiseh-2 and Jabiseh-3. The composition of gas is similar to the gas of Jabiseh-1.

In well Jabiseh-2 at the base of the Helvetian and top of the Burdigalian a small amount of oil with water has been recorded. The oil is heavy, its specific gravity at 60°F is 0.962, the total product of distillation is 21%.

In exploratory wells El-Bawwab-1 and 2 oil and gas have been obtained from the Oligocene beds in the following amounts, respectively: 650 and 300 litres (oil) and 20 and 42 cu m (gas).

The results of the analysis are not available. In well El-Bawwab-2 slight oil shows have been recorded from the Upper Cretaceous.

In prospecting for new structures commercial accumulations of oil and gas may be expected from the Helvetian (Jeribe limestone), Oligocene and Eocene. These deposits are equivalent to the famous Asmari limestone or the "Main limestone" of the Iraq oil fields, producing the largest amount of oil in Iran and Iraq. Potentially promising is also Upper Cretaceous, since it produces commercial oil in the Qarashouk and Suweidiyeh structures.

Jurassic also deserves consideration bearing in mind that oil has been obtained from the Jurassic sequence in Suweidiyeh field.

The fact that the wells drilled in Jabiseh structure have failed to discover commercial quantities of oil can be explained by the lack of preliminary investigations.

The seismic operations conducted recently on the territories of sheets J-37-VI and J-37-VII have shown that at greater depths the arches of the structures are shifted. According to gravity data the area of the Jabiseh anticline shows a gravity high which is not located in the core but in the western pericline of the structure. It may be the evidence of the deep crests shifted westwards. This suggestion is confirmed by drilling. Well Jabiseh-1 drilled in the western part of the structure has given a big gas flow and marked oil shows unlike Jabiseh-2 and Jabiseh-3 drilled in the east. However, in order to come to a final solution of the problem of deep structure of the Jabiseh anticline and hence to estimate its oil and gas possibilities, it is necessary to conduct a seismic survey.

The Abd El-Aziz structure is not practically important for oil and gas prospecting since it is deeply eroded and all the horizons with possible accumulations of oil are brought to the surface. Fluoro-bituminological analysis of the deposits occurring in the arch has revealed traces of bitumen "A" in a number of samples. It is an evidence of favourable conditions of oil formation which had existed during Upper Cretaceous — Middle Miocene. However, no oil pool had evidently been present here, since the core of the Abd El-Aziz anticline never contains rocks with oil oxidation products.

Interesting with respect to oil and gas prospecting is the area of the Mesopotamian foredeep where commercial oil fields of north-eastern Syria are known. This territory has not yet been sufficiently investigated with respect to the structure. When a profile of shallow core holes was drilled in the area of Tell Affandi and Metsallem village, anticlinal structures were located the first of which corresponds to a local gravity high. An anticlinal structure can be distinguished in the area of Ras El-Ein. A number of mapped gravity highs are not expressed at the surface and not checked by seismic operations and shallow core drilling. However, local gravity highs suggest the presence of deeper anticlines promising for oil and gas prospecting. Fluoro-bituminological analysis of the Tortonian rocks penetrated by core holes east and south-east of Ras el-Ein has revealed traces of bitumen "A" in a number of samples.

The deposits with possible oil and gas accumulations are overlain by a sufficiently thick mantle of terrigenous and chemogenic rocks which serve as a good caprock. The most effective method for locating structures in the area is an areal seismic survey.

The areas south and east of the J. Abd El-Aziz had been included into the Concessions of "Concordia Co" and covered by an areal seismic survey. The results of this survey are not available. A number of anticlines have been located on the surface. These are Horra, El-Khouene, Tshumba, Metuaha, Jabiseh. A number of local gravity highs are present. These highs may correspond to deep structures. Fluoro-bituminological analysis has shown traces of bitumen "A" in the Tortonian rocks present in the area of the Tshumba structure. Gas and oil-stained rocks obtained from well Jabiseh-1 place this area into the category of areas promising for oil and gas. Recommendations for further oil and gas prospecting can be made only on the basis of seismic investigations.

Rock salt

Salt has been found by exploratory oil wells on the Jabiseh and El-Bawwab anticlines.

Salt-bearing rocks have been encountered amongst homogenous deposits of the Lower and Middle Miocene. Two distinct salt-bearing horizons can be easily distinguished, one of which is confined to the Burdigalian base (Dhiban formation) and the other — to the base of Tortonian (Lower Fars formation).

The Burdigalian salt-bearing horizon has been encountered by Jabiseh-1 at the interval of 573—695 m and by El-Bawwab-1 at the interval of 644—762 m. The salt-bearing formation is composed of white halite with some bands of anhydrite and clayey limestone.

The Tortonian salt-bearing horizon has been struck by Jabiseh-1 at the interval of 85—412 m, by Jabiseh-2 at the interval of 187—546 m, by Jabiseh-3 at the interval of 94—477 m and by El-Bawwab at the interval of 480—522 m. The salt-bearing formation consists of alternating anhydrites, limestones and marls with bands and lenses of salt, 1 to 20 m thick.

A four-metre-bed of salt-bearing clay has been located in Dbaghiyeh ravine during mapping. The clay is non-compact and soft on the weathered surface and hard in a fresh-cut trench. It is possible that salt in the outcrops of this bed has been partly leached out by ground water and pure salt may be found deeper. It is the only case of salt-bearing deposits present in the upper (chemogeno-terrigenous) part of the Tortonian in the area.

On the western slope of the Jabiseh hills a highly mineralized sodium-chloride spring has been encountered with the flow of 15 litres per second. The water of the spring is accumulated in low places of the terrain, where the local people make small basins for getting salt by evaporation. According to NaC1 content the spring brings out about 8000 tons of common salt per year. Using modern methods of exploitation much salt can be produced here.

Prospecting for salt should be conducted in the area restricted by the latitude of the Jabiseh hill in the south, by the latitude of El-Bawwab in the north and by the latitude of the eastern end of the Abd El-Aziz mountains in the west.

The first step of prospecting should be made along the eastern frame of sheet J-37-V in the area of Dbaghiyeh ravine and Jabiseh structure.

Results of metallometric testing

Metallometric testing has been made in the area of chemogenic rocks of the Middle Miocene age in order to select most favourable localities promising for boron. Many samples were found to contain boron traces.

In a number of samples the boron content is 0.006—0.001% and in three samples it is 0.003—0.01% (4 km south of elevation 346 m and 36 km south-south-west of Al-Hasakeh). The results of the analysis are not good to recommend any areas for boron prospecting. Of some interest is the area 4 km south of elevation 346 m where a somewhat higher content of boron has been recorded along the distance of one kilometre.

Building materials

The area contains the following building materials: gypsum, marl, limestone, basalt, basalt tuff, cinder, pebbles and gravels.

Gypsum is mostly developed at the base of the Tortonian, where gypsum beds are up to 30 m thick and are divided from each other by thin bands (1—3 m) of limestone and marl. In the upper part of the Tortonian the thickness of the gypsum beds decreases to 10—20 m and the thickness of the dividing members increases up to 15 m.

Gypsum is white, sometimes with greenish shade, fine to coarse-crystalline, massive, less frequently stratified. In the lower part of the Tortonian, gypsum is mostly snow-white, pure, with sugar fracture (alabaster). In the upper part of the Tortonian alongside with a white variety there is light green gypsum, containing some admixture of terrigenous and argillo-calcareous material. The upper Tortonian beds contains thick-platy gypsum.

Samples of white gypsum taken in the area of the adjacent sheet J-37-IV from the Tortonian beds have shown a high content of $CaSO_4 \cdot 2H_2O$ amounting to 98.5= and low content of other admixtures [15]. Within the area described here, the Tortonian gypsum does not differ in composition from the gypsum present on the territory of sheet J-37-IV. Therefore, the area of the Tortonian outcrops may be recommended for gypsum prospecting. The most favourable areas in this respect are the southern slope of the J. Abd El-Aziz, the eastern slope of the Beida mountain and the Tshumba and Jabiseh hills.

Marl is widely present in the Senonian and Oligocene deposits. In most cases it is light yellow or yellow. The rock is sufficiently strong as a building material. According to carbonate analysis the $CaCO_3$ content ranges from 54 to 74%. In some beds marl grades into clayey limestone with the $CaCO_3$ content up to 89—90% and into dolomitized varieties — about 8% of $CaMg(CO_3)_2$. Marl can be used in the building industry in the form of blocks as well as in the form of sawn and quarry stone. Senonian and Oligocene marl in the central part of the Abd El-Aziz mountains can be recommended for prospecting for cement raw materials.

Limestone is widely known in the Eocene and Helvetian (Jeribe limestone) formations.

Eocene limestone is a very hard, organogenous and reef rock. The rock is aphanitic and fine-grained, in some beds slightly porous with flint nodules and silicified organic remains. It is characteristic of the Eocene limestone that bedding is altogether absent.

The Helvetian limestone is a white, organo-detrital rock often gypsiferous and argillaceous. There are many chalk-like, very porous varieties and also recrystallized, "grainy" ones.

According to carbonate analysis the $CaCO_3$ content in the Eocene limestone varies within the range of 91 to 99.5% what corresponds to CO_2 content of 51 to 55%. Some beds are slightly dolomitized, not exceeding 5% (MgO — 2.4%). As a rule, the rock is completely soluble in HC1.

The Eocene limestone can be used as ornamental and building materials, as a product for producing astringents and also for chemical industry. The most favourable area for getting the rock is an area near the core of the Abd El-Aziz anticline.

$CaCO_3$ content in the Helvetian limestone ranges from 80 to 99%. There are some dolomitic varieties with a magnesium carbonate content of 15 to 20%. The rock can be easily worked and may be used as sawn building stones. It can also be recommended for cement raw material prospecting.

To be used as a building material, limestone has practically unlimited reserves and can be quarried by open works on the northern slope of the J. Abd El-Aziz anticline.

Basalt occupies extensive areas on the left bank of the N. El-Khabour, 4—6 km east and 12—15 km north-west of Al-Hasakeh and in the north of the area south-west of Derbasiyeh. Basalt is widely used in road building as crushed stone and less in building.

Tuff composes the cone of the Kowkab volcano. It is used for road paving and for moulding slag cement bricks and blocks. The reserves are substantial.

Cinder is exposed in a ravine near Sebirka village, 4—6 km west of the Kapes-Darh basalt sheet. The cinder is light, highly porous, unstratified, very hard. The exposed thickness is about 10 m.

It can easily be worked and used in building industry. It may be possibly used as adsorbent. The reserves are rather big.

Pebbles and gravels are present in the N. El-Khabour valley, where they compose the third terrace above the flood plain. Pebbles and gravels are quarried 8 km west of Shaddadi village and in the area of All-Hasakeh.

BRIEF INFORMATION ABOUT GROUND WATER AND WATER SUPPLY

Hydrogeological observations were made in the course of the geological survey. About 900 dug water wells have been examined and described. Water has been sampled from 140 wells to be chemically analized.

One of the main sources of water supply is the N. El-Khabour and its tributaries. The areas outside of the river valleys are supplied by water from dug wells reaching ground water.

The discharge of the wells and chemical composition of water depend on the precipitation and on chemical and physical properties of the water-bearing rocks. In the north of the area, where the precipitation is more than 300 mm a year [13] the discharge of the wells is the highest and the water is least saline (see hydrogeological sketch, Fig. 15). The amount of water in the rocks of the northern portion of the area is also influenced by the closeness to the mountain lands of the Armenian Tourous which make the source of ground water. In southern areas, where the precipitation decreases to 200—150 mm a year, the rocks become less watery and the salinity of the water becomes higher.

Also one can observe seasonal changes in the amount and salinity of ground water and in some wells in chemical composition. The highest discharge of the wells, low salinity and in some localities bicarbonate composition of the water are recorded in rainy winter time. In summer the well discharges decrease and some wells get dry, salinity increases and bicarbonate composition of the water changes for sulphate.

Ground water has been recorded in all the deposits of the area.

Ground water in the Quaternary formations

The Quaternary rocks cover nearly the entire territory described but only thick proluvial deposits and the alluvium of the river valleys are water-bearing.

The water-bearing proluvial rocks have been found in three isolated localities: the north-eastern portion of the area and two localities north and south of the J. Abd El-Aziz.

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In the northeast, near Aamouda town, dug wells reach fresh water occurring in proluvial conglomerates. Waterproof beds are generally composed of marl and clayey limestone of the Upper Miocene age. Ground water is present at the depths of 3 to 10 m with the average discharge of the wells being 1.5 to 1.9 cu. m/day*. The water is of bicarbonate-calcium-magnesium type with the salinity of 0.4 to 0.6 g/l.

In the localities north and south of the J. Abd El-Aziz the proluvial deposits contain saline water occurring in highly gypsiferous sandy loams and pebble interbeds. The depth of the water ranges from 7 to 65 m. According to the composition, calcium -sulphate water prevails and there are some sodium-chloride types, the salinity ranging from 2.5 to 6.3 g/l.

As to the alluvial deposits, water is present in Recent sands, sandstones, sandy loams and loams, making the flood plain and first terrace of the N. El-Khabour and its tributaries.

According to ground water investigations conducted in 1960 through Contract 938 by the USSR "Technoexport" in the N. El-Khabour valley, the depth of the ground water within the flood plain ranges from zero to 3 m and in the first terrace from 3 to 5 m. The thickness of the water-bearing zone is 5 to 8 m, the filtration ratio of the sand-pebble rocks amounting to 40 cu. m/day. Predominating fresh water is of a magnesium-calcium-sulphate type and some water of sodium-chloride type with the salinity of 0.8 to 1.5 g/l, in some places amounting to 3 g/l.

The N. El-Khabour valley is an area of ground water discharge. Therefore the salinity and chemical composition of the water circulating in the alluvium depend on the type of the water-bearing beds adjacent to the river valley and the degree of dilution with the river water.

The Upper Quaternary pebble beds of the second terrace of the N. El-Khabour may in some places contain water of magnesium-calcium-sulphate type, not very saline, although sometimes the salinity amounts to 7-10 g/1.

Ground water in the Pliocene formations

Sandstones, pebbles and limestones are water-bearing among the Pliocene rocks. Ground water is present in three isolated localities.

In the north-eastern part of the area, south of Aamouda town, there is fresh water occurring at the depth of about 30 m. Discharge of the wells ranges from 1 to 10 cu. m/day, with 3 to 4 cu. m/day discharge dominating. The water is of a magnesium-calcium-bicarbonate type with the salinity of 0.4 to 0.8 g/l, seldom exceeding 1 g/l.

North of the J. Abd El-Aziz Pliocene water is encounterd by dug wells at the depths ranging from 25 to 65 m. The discharge ranges from 0.04 to 1 cu. m per day. In summer many wells get dry. The water is of calcium-sulphate and calcium-chloride-sulphate types with the salinity varying from 1.4 to 6.5 g/1.

South of the J. Abd El-Aziz the depth of the water ranges from 12 to 55 m. Discharge data are not available. The height of the water column in the wells is 2 to 3 m. The water is of a calcium-sulphate type with the salinity ranging from 1.8 to 5.2 g/1.

Ground water in the Upper Miocene formations

Ground water in the Upper Miocene rocks is present over an extensive area. Water-bearing rocks are sands, sandstones and siltstones. Water-resisting rocks are clays and clay marls.

* The discharge data are taken for summer time, given by the local people. In winter the discharge is much higher.

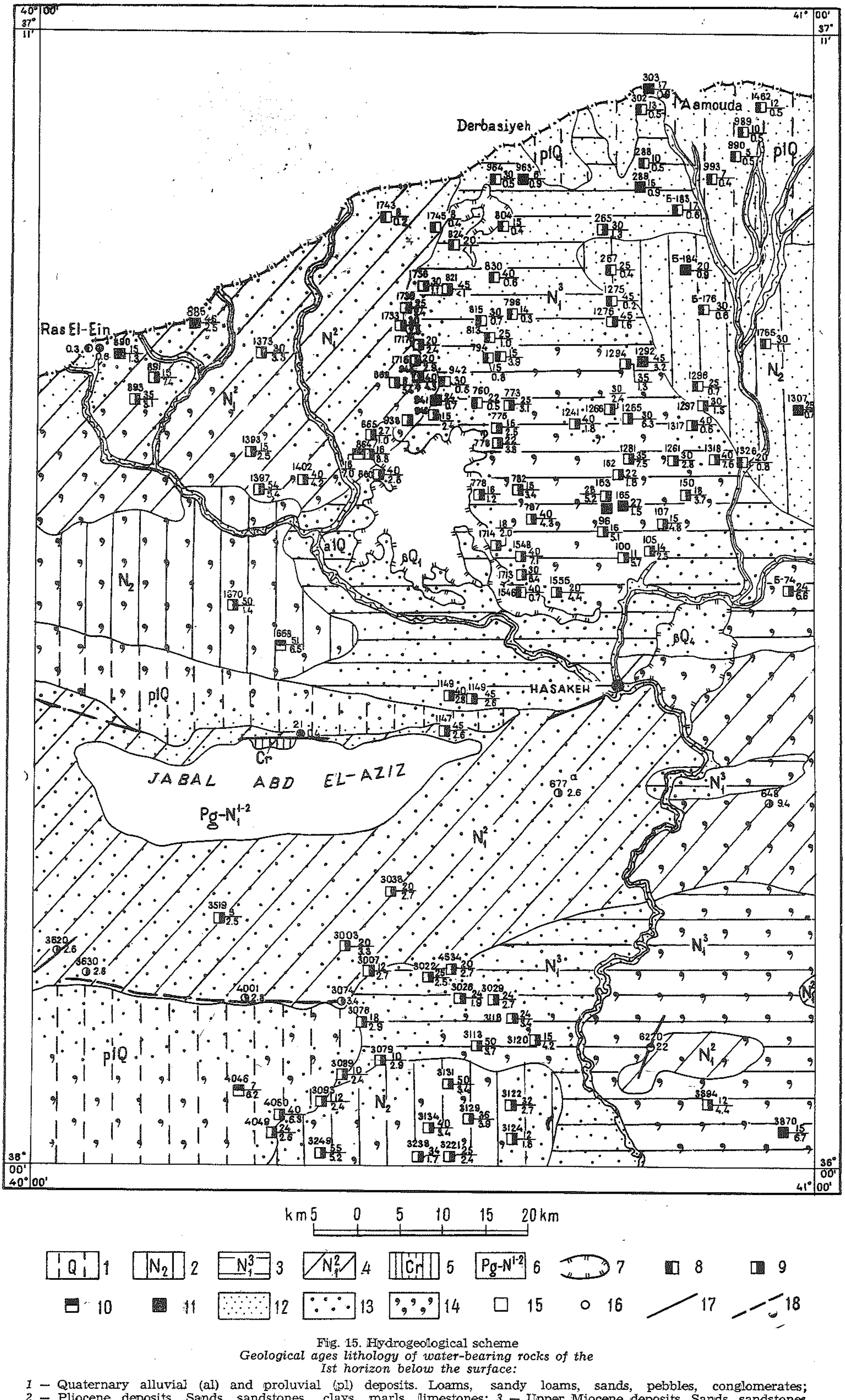

Fig. 15. Hydrogeological scheme
Geological ages lithology of water-bearing rocks of the 1st horizon below the surface:

1 — Quaternary alluvial (al) and proluvial (pl) deposits. Loams, sandy loams, sands, pebbles, conglomerates; *2* — Pliocene deposits. Sands, sandstones, clays, marls, limestones; *3* — Upper Miocene deposits. Sands, sandstones, clays; *4* — Middle Miocene deposits. Gypsum, limestones, marls, sandstones; *5* — Cretaceous deposits. Limestones, marls, dolomites, conglomerates; Distribution of waterless rocks cropping out at the surface; *6* — Paleogene, Lower and Middle Miocene waterless deposits. Gypsum, limestones, marls; *7* — Recent (βQ_4) and Lower Quaternary (βQ_1) waterproof basalts cropping out the surface. *Chemical composition: 8* — where major anion is hydro-carbonate; *9* — where major anion is sulphate; *10* — where major anion is chloride; *11* — Mixed composition. Salinity of water: *12* — less than 1 g/l; *13* — from 1 to 3 g/l; *14* — over 3 g/l. *Water sources: 15* — well. At top its number, on the right salinity in g/l.; *16* — spring. At top its number, on the right salinity in g/l.; *17* — faults meaked morphologically, *18* — faults shown according to the geophysical data

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In the north, between the Ard esh Sheikh basalt massif and the Turkish frontier there is an area of fresh bicarbonate water. The average depth of the water is 15 to 30 m. The discharge amounts to 10 cu. m/day, the average being 3 to 5 cu. m/day. The water is of magnesium-bicarbonate type, seldom calcium-bicarbonate with the salinity of not more than 1 g/1.

On the rest of the territory saline sulphate water is present, with the depth ranging from 15 to 60 m, average 25 to 40 m. The discharge of the wells is low (below 1 cu. m/day), in some cases reaching 3.5 cu. m/day. There is some regularity in the distribution of the water according to chemical composition: to the left of the N. El-Khabour dominate magnesium-sulphate water, whereas to the right, south-east of the J. Abd El-Aziz, calcium-sulphate water is present.

South of the Tshumba hill the water is more saline (more than 4 g/1) and of mixed sulphate-chloride composition what is probably due to slow water exchange and presence of stagnant water zones.

Ground water in the Middle Miocene formations

Ground water is present in the Middle Miocene rocks composing the slopes of the J. Abd El-Aziz, Tshumba and Jabiseh hills and north-western portion of the J-37-V sheet.

Water-bearing rocks are cavernous and fractured limestones and gypsums and at the top of Tortonian – sandstones and siltstones. Water-resisting rocks are compact clayey limestones, clay marls, clays and compact, massive gypsums.

On the southern slope of the J. Abd El-Aziz dug wells strike ground water at the depths of 5 to 20 m, while on the northern slope the depth of the water increases to 45 m and more. The discharge of the wells in rainy winter time is rather high (over 3 cu. m/day), greatly decreasing in summer. The water is of a calcium-sulphate type with the salinity of 2.5 to 3.3 g/l.

In the north-western portion of the sheet, adjacent to the Turkish border, ground water is present at various depths from 6 to 54 m with the largest depths being recorded at water divides and smallest in dry valleys. The discharge of the wells located near the river-beds amounts to 5–10 cu. m/day and becomes smaller at water divides (0.7 to 0.9 cu. m/day). The water is of bicarbonate and sulphate types. Fresh, bicarbonate water is present in an isolated area, west of the Kapes Darh hill (the Dheileh area). South and south-west the water changes in composition and becomes sulphate water with the salinity of 2.5 to 7 g/l. East and south-east of Ras El-Ein town the amount of ground water increases, the discharge of the wells becoming high and constant, reaching over 20 cu. m/day. The water is mainly of calcium-sulphate composition and 3-gram-salinity. The composition of the water taken from well 893 is as follows:

$$S_3 \frac{SO^4_{42}\,Cl_4\,HCO^3_3\,NO^3_1}{Ca_{30}\,Mg_{18}\,(Na+K)_2}.$$

Ground water in the Lower Miocene and Paleogene formations

In the area of the Lower Miocene and Paleogene outcrops (J. Abd El-Aziz) no water springs or wells have been encountered. In the data obtained from drilling deep wells which struck Lower Miocene and Paleogene on the Jabiseh hill and near El-Bawwab village no information about ground water is available. One can suppose that fresh water can be present in the fractured limestones of the Eocene age considering their good permeability and wide development in the area of the ground water source in the Urfa plateau in Turkey [7].

Ground water of the Mesozoic deposits

The Mesozoic rocks composing the core of the Abd El-Aziz anticline contain fracture and vein water confined to fault zones and fractures in the Cretaceous rocks.

Fracture and vein water flows out at the surface through little fresh water springs. The largest spring is flowing out of the Maestrichtian clayey limestone in Abd El-Aziz village, 1.2 km north-west of elevation 920 m. The discharge of the spring is about 100 cu. m/day, the water is of a bicarbonate type with the salinity of 0.7 g/l.

$$S_{0.7} \frac{HCO^3_{37}\,SO^4_9\,Cl_4}{Ca_{25}\,Mg_{20}\,Na_5}.$$

Formation water is present in the Mesozoic deposits penetrated by deep wells.

In well Jabiseh-1 a flow of saline water with traces of oil was obtained from the Upper Cretaceous. The water is sodium-chloride with the salinity of 123 g/l.

In well Jabiseh-3 the Upper Cretaceous horizons contain sodium-chloride water with the salinity of 77 g/l. Similar water has been found in the Lower Cretaceous.

In well El-Bawwab-2 a flow of pure, very slightly saline water was obtained from the intervals of 1565–1653 m, 1675–1708 m and 1708–1730 m from the Upper Cretaceous rocks of 12 to 15% porosity. The results of the analysis of this water are not available.

Ground water of the Paleozoic deposits

No water has been encountered in the Paleozoic rocks outcropping in the J. Abd El-Aziz. In Qamishli well, 15 km south-east of Aamouda town, ground water was recorded in the Permian sandstone. A number of water horizons were located by electric logging and core analyses. The table below gives the results of the analyses.

Type of analysis	Sampling interval in m	
	1900.9–1905.5	2030–2036
1. Permeability	357	26.5
2. Porosity	25.9	22.7
3. Salinity grams per litre	54.4	93
4. Water saturation	100%	97.1%

Fracture and vein water is associated with faults and fissures. It flows out at the surface in ascending springs.

On the southern slope of the J. Abd El-Aziz from Beida to Dabshiya village one can trace seven springs associated with a flexure bend which seems to correspond to a deep fault. The springs flow out of small cracks and funnels present in the gypsum of the Tortonian age. The most important springs are Khnezir and Madfa (N 4001). The flows of these springs amount to 2000 cu. m/day in winter but get much lower in summer. These springs become small creeks, some 200 or 300 m long, the water being taken by the local people for drinking and watering vegetable gardens. The composition of the Madfa water is as follows:

$$S_{2.8} \frac{SO^4_{43}\,NO^3_3\,HCO^3_2\,Cl_2}{Ca_{36}\,Mg_{10}\,Na_4}.$$

The water of the other springs is also of calcium-sulphate composition, the salinity varying from 2.6 to 3.4 g/l. The flow is not more than 50 cu. m/day.

On the eastern slope of the J. Abd El-Aziz, near elevation 381 m, there is a spring flowing out of a funnel in the Tortonian gypsum. The flow is about 1000 cu. m/day. The water is of calcium-sulphate composition with the salinity of 2.6 g/l.

On the northern slope of the J. Abd El-Aziz there are several springs located in the zone of a regional latitudinal fault. In Mazhloja and Beer El-Khazneh the springs are probably flowing out of the fissures in the Helvetian limestone. The flows of the springs are about 150—200 cu. m/day. The water is fresh, of a calcium-bicarbonate type. The composition of the Beer El-Khazneh water is as follows:

$$S_{0.4}\frac{HCO^{3}_{21}\,SO^{4}_{19}\,NO^{3}_{5}\,Cl_{5}}{Ca_{30}\,Mg_{16}\,(K+Na)_{4}}.$$

The El-Qaran and Beer Jili Balagha springs, located in the western portion of the J. Abd El-Aziz, are flowing out of the Tortonian rocks. Their flows do not exceed 80 cu. m/day.

Within the Tshumba hill there are several low-flow springs leaking out of cracks and funnels formed in the Tortonian gypsum. The flows of these springs do not exceed 10 cu. m/day, the water is of a calcium-sulphate type with the salinity of more than 3 g/l.

On the western slope of the Jabiseh hills a spring is flowing out of a north-north-east fissure with the discharge of about 1200 cu. m/day. The water is of a sodium-chloride type with the salinity of 22 g/l.

$$S_{22}\frac{Cl_{42}SO^{4}_{8}}{Na_{39}\,Ca_{8}\,Mg_{2}K_{1}}.$$

High concentration of salts may possibly be explained by the fact that the water of this spring is associated with the Tortonian salt-bearing rocks. The rocks are described in the report of well Jabiseh-1. Their depth is some 200—300 m.

In the area of Ras El-Ein town fracture water flows out as strong springs from which the N. El-Khabour originates. According to Verdon D. [7] the total discharge of the springs is 20 cu. m/day, remaining constant nearly all year round.

The biggest springs are flowing out of cracks in the Helvetian limestone. In Ras El-Ein town a number of springs make a small lake that is one of the sources of the N. El-Khabour river. The water in the lake is fresh and mixed in composition.

$$S_{0.6}\frac{Cl_{21}\,HCO^{3}_{15}\,SO^{4}_{14}}{Na_{21}\,Ca_{18}\,Mg_{11}}.$$

In some of the springs the water contains some sulphur.

South of Ras El-Ein several springs flow out of cracks in gypsum, limestone and marl of the Tortonian age. Their discharge is much lower than that of the springs of Ras El-Ein town, and the salinity is somewhat higher.

According to ground water supply, the territory of sheet J-37-V, XI can be divided into three categories:

1. Areas where demand of the local population is completely satisfied by ground water. This category includes a northern part of the sheet with fresh and low saline ground water of a bicarbonate type occurring not

very deep in the Quaternary, Pliocene, Upper and Middle Miocene beds. This area may have big reserves of fresh ground water in the Tortonian and Upper Miocene rocks at the depth of more than 50 m.

2. Areas with poor water supply for drinking purposes. Most of the territory belongs to this category. The main water supply is ground water present in the Quaternary, Pliocene, Upper and Middle Miocene deposits. Salinity of this water varies greatly, the prevailing one being 2 to 4 g/l. The water is of a sulphate type. The water with salt content exceeding 5 g/l is used only in winter being diluted with rain water. Fracture and vein water of 3 g/l salts content is also used for water supply from the springs flowing out of the Middle Miocene rocks.

3. Areas with no ground water. To this category belongs the area of water divide, upper part of the J. Abd El-Aziz and also the area between the Tshumba hill and the southern border of the territory. In the Abd El-Aziz mountains ground water is very deep, unreachable by dug wells. Ground and fracture water south of the Tshumba hill is not potable due to a high salinity (over 5 g/l).

The problem of water supply for the most of the territory can be solved by using surface water of the N. El-Khabour and its tributaries. In the area north and north-west of Al-Hasakeh to the Turkish frontier fresh water can be obtained by drilling in the Helvetian beds to the depth of more than 400—500 m.

CONCLUSION

As a result of the survey conducted on the territory of the Al-Hasakeh sheet new information has been obtained about the geological structure of the area.

In the J. Abd El-Aziz the Cretaceous has been subdivided into two series in which a number of stages have been distinguished. The ages of the majority of the stratigraphical units have been identified on the basis of faunal evidence. An extensive area of the Middle Miocene deposits represented by Tortonian and Helvetian rocks has been located in the north-western portion of the territory.

The deposits previously distinguished as "The Lower Fars" formation have been dated as Tortonian after the microfauna analysis, and divided into two members each incorporating marker beds what has made it possible to show on the map all the principal structures expressed at the surface.

The continental deposits, distinguished by previous investigators as "The Upper Fars" formation have been for the first time divided into the Upper Miocene and Pliocene, the latter being also divided into two members — upper and lower. But the absence of fossils and guide microfossils made it impossible to give an exact identification of the ages of the continental deposits and to draw a boundary between the Miocene and Pliocene.

The Quaternary deposits previously undifferentiated have been divided into the Lower, Middle, Upper and Recent series among which different genetic types have been established.

According to the geophysical and geological data the area has been tectonically divided into two major units — the marginal part of the Arabian platform and external zone of Mesopotamian foredeep. The Tuwal el-Aba — Sinjar swell and Al-Furatian depression have been distinguished within the Arabian platform. The North-Khabourian depression and Ras El-Ein and Qamishli highs have been distinguished within the Mesopotamian foredeep.

According to the field geological observations and geophysical data the main faults have been located and local anticlinal structures have been outlined.

Information about salinity, composition and depth of ground water and also about the content of water in the rocks has been obtained from the ground water investigations.

An area of fresh water good for water supply has been located in the north of the territory.

A seismic survey has been recommended in order to investigate deep anticlinal structures and to outline the localities favourable for oil and gas drilling.

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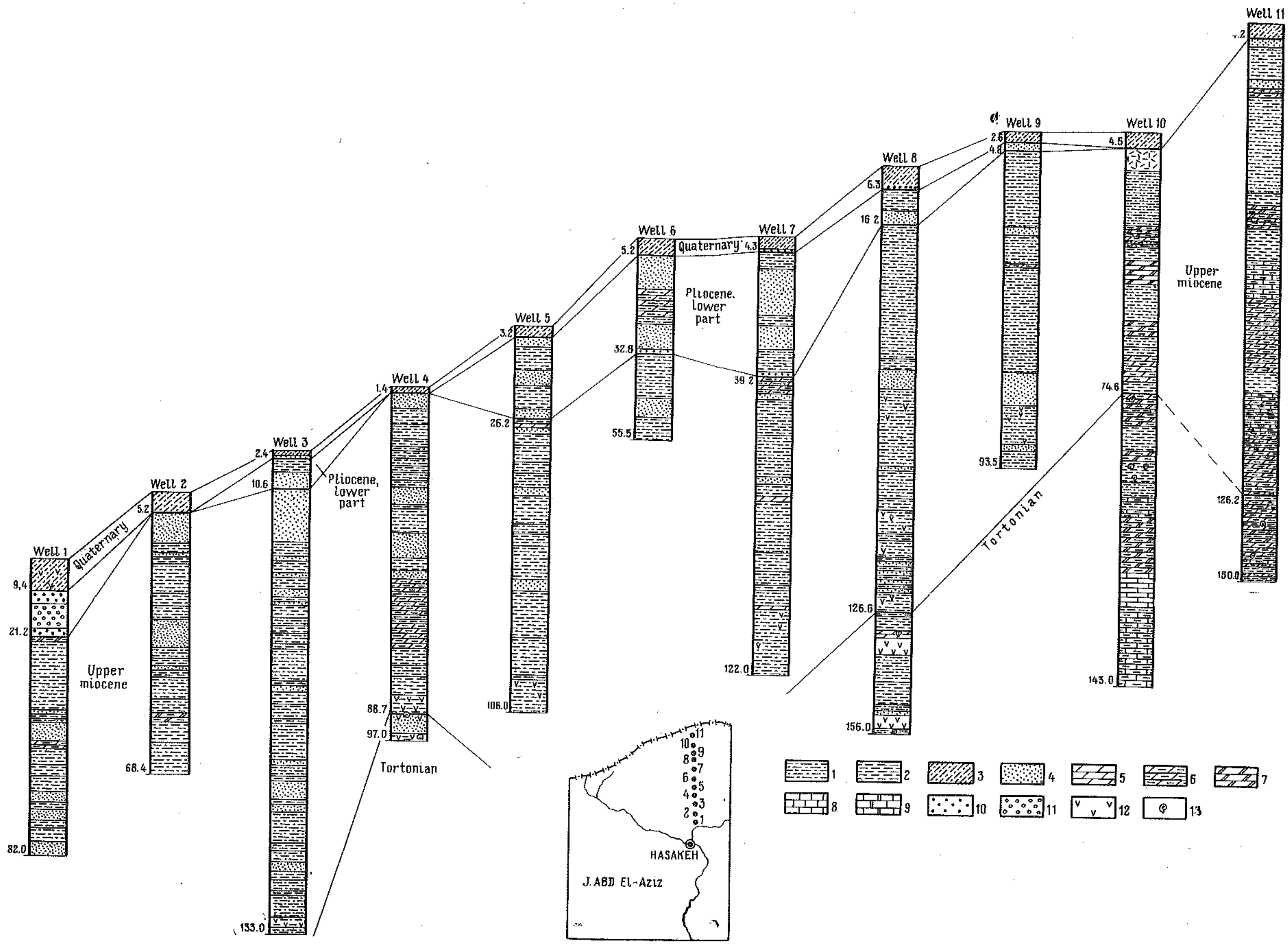

Pl. 1. Sections of mapping wells

1 — silstone; *2* — clay; *3* — loam; *4* — sandstone; *5* — marl; *6* — clayey marl; *7* — dolomitic marl; *8* — limestone; *9* — dolomitic limestone; *10* — gravel; *11* — conglomerate; *12* — gypsum; *13* — fauna. On the left of the column is shown depth in m from the surface

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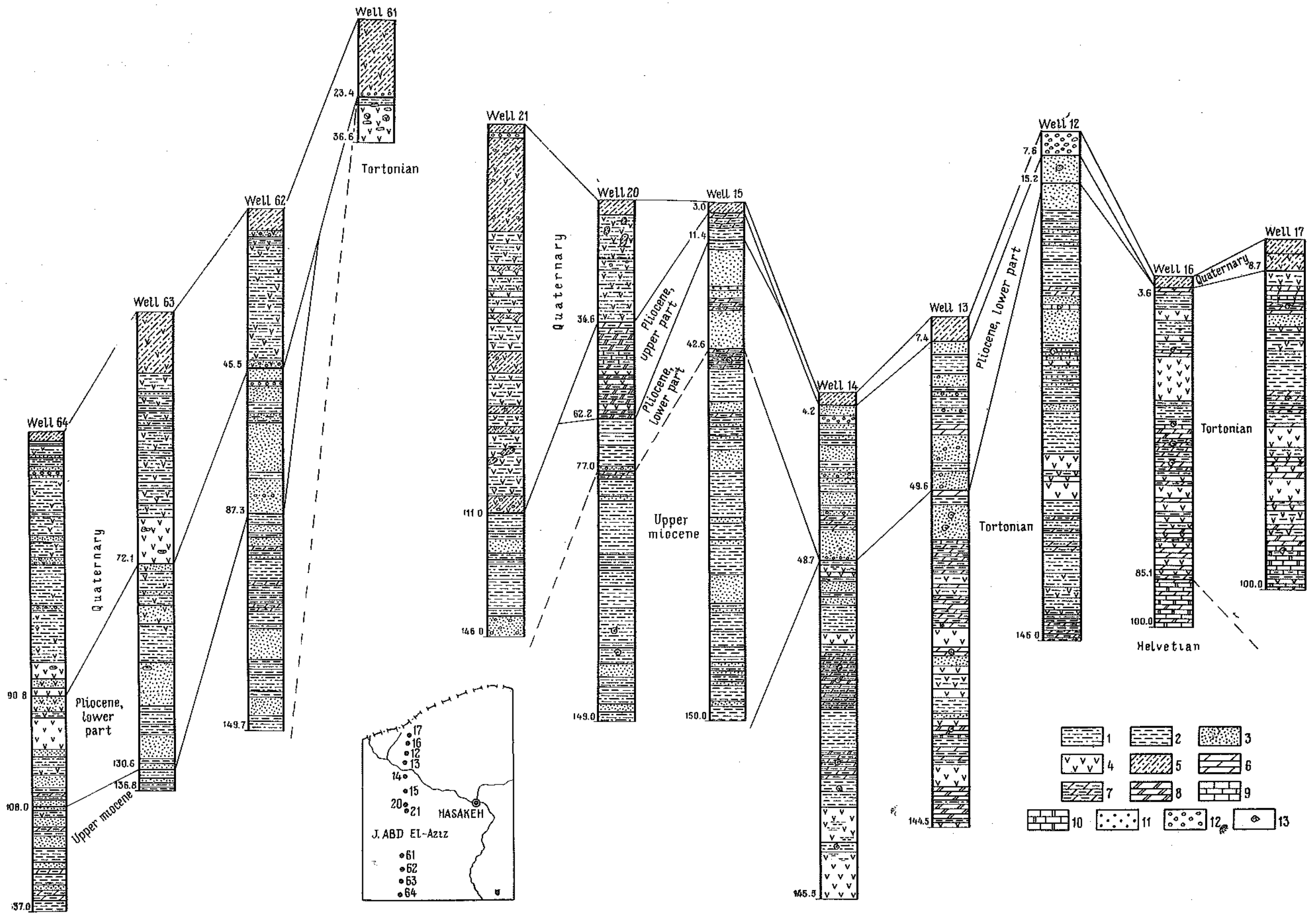

Pl. 2. Sections of mapping wells

1 — siltstone; *2* —clay; *3* — sandstone; *4* — gypsum; *5* — loam; *6* — marl; *7* — clayey marl; *8* — dolomitic marl; *9* — limestone; *10* — dolomitic limestone; *11* — gravel; *12* — conglomerate; *13* — fauna

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