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THE ISRAEL GEOLOGICAL SOCIETY

SUMMARY OF THE LECTURES PRESENTED AT THE MAKHTESH RAMON SYMPOSIUM

10th - 12th February, 1963

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THE MAGMATIC PETROLOGY OF MAKHTESH RAMON

Y.K. Bentor. The Geological Survey of Israel, and Department of Geology, The Hebrew University of Jerusalem.

Igneous rocks, intrusive as well as extrusive, are widespread in Makhtesh Ramon. They show a large variety in form and include stocks, a laccolith, bosses and the so-called "ridges"; there are dikes (single and composite) and sills as well as flows with some associated pyroclastics. The most interesting bodies, morphologically, are the "ridges" -- large intrusive masses having vertical cross-cutting flanks but flat conformable roofs.

The petrography of this rock series is at present under study and only preliminary results can be given. The series is highly differentiated and ranges from ultra-basic to fairly acid. The most widespread rock types seem to belong to the following groups: ankaramites, picrites, essexites and olivine-nepheline-basalts, monzonites and trachy-andesites, syenites and trachytes, and nordmarkites and bostonites. Textures vary from coarse to very fine-grained. The series is typically alkaline and partly hyper-alkaline; sodic types appear alongside pronouncedly potassic ones. There seems to be no simple differentiation pattern, probably on account of considerable assimilation, particularly in the smaller rock bodies.

Many of the rocks are considerably altered and two types of alteration can be distinguished. Many rocks carry variable amounts of carbonates, mainly calcite; these alteration products are assumed to be secondary and non-magmatic. Hydrothermal alteration, however, also occurs: many sills and dikes, particularly the acid, are transformed into an almost pure kaolinite rock with a high titanium content; the wall rocks show corresponding silicification and ferrugination (contact quartzites). In other rocks potash felspars are largely altered to alunite.

The magmatic activity is assumed to have started in Middle Jurassic time and to have continued into the earlier part of the Lower Cretaceous. It is connected with an extensive phase of faulting known to have occurred in the Jurassic; this tectonic environment is responsible for the alkaline character of the rock sequence.

The magmatic rocks of Makhtesh Ramon are part of an extensive magmatic province extending from the eastern desert of Egypt through Sinai and Israel to Lebanon and Syria. Rocks very similar to those of Makhtesh Ramon occur in Makhtesh Arif and A'raif-el-Na'qa and have been found by deep oil drillings in the northern Negev (Makhtesh Hathira, Zohar etc.).

THE RAMON FOLD IN ITS LEVANTINE SETTING

A.J. Vroman. The Geological Survey of Israel.

It is becoming more generally accepted by students of tectonics that the stresses which cause the "epidermis-folds" within sediments of moderate thickness act in the basement and not within the sediments themselves. The basement is broken along two shear planes, and movement taking place along these faults plays a greater role in the formation of folds than would pure compression. This fact was proved by N. Pavoni in his experiments simulating the Jura folds.

Only slight modification of the above experiments are required to produce results comparable to the Middle Eastern folds. These were apparently formed by the interaction of two shear stresses, one along the Jordan-Arava and the second in an east-west direction, such as the Ramon fault. As the experiments demonstrate that such folds are bent along the shear lines, there is no necessity to explain the bending of the anticlinal axis as a result of additional folding.

The Arava- Dead Sea - Jordan depression itself, as earlier explained by the author, was formed by tension, and only its trend is controlled by the shear-stresses which acted before the sinking of the belt. The Ramon affords a splendid example for folding of the type described, firstly because of its large size, and secondly because it is situated at the intersection of the two shear trends.

A MAGNETIC AND GRAVIMETRIC SURVEY IN THE MAKHTESH RAMON.

U. Amitai. The Geophysical Institute of Israel.

A combined gravimetric and magnetometric survey was conducted by the Geophysical Institute of Israel on behalf of Naphtha Israel Petroleum Company in Makhtesh Ramon. The aim of the survey was to detect subsurface igneous intrusions, on the assumption that such intrusions might play a dominant part in the formation of the Ramon structure.

No magnetic anomaly large enough to be accounted for by a large intrusion was detected. A magnetic and gravimetric high corresponding in location and trend with the surface laccolith was mapped.

Both methods point to the existence of a structural trend oriented ENE - WSW in the vicinity of the long axis of the laccolith.

REMARKS ON THE STRATIGRAPHY AND TECTONICS OF THE TRIASSIC OF MAKHTESH RAMON

Israel Zak, Geological Survey of Israel, Jerusalem.

Triassic sediments, about 500 m. thick, are exposed in the Makhtesh Ramon (see columnar section fig. 1). These are mainly of marine, littoral and neritic facies with some terrestrial horizons at the deeper part and lagoonal facies at the upper part.

Other occurrences of marine triassic beds in the surrounding area are known at: Har Arif, south of Ramon, in deep drillholes in the northern Negev, Araif el-Naga in Sinai, and Nahr el Zarqa, wadi Hisban, Humrat Ma'in and Zarqa Ma'in in Jordan. South of these only "Nubian sandstone" of terrestrial origin is found between the marine cambrian and cretaceous.

A resemblence exists between the Ramon and Araif el Naga sections and possibly also the section of Wadi Hisban. The section of Haf Arif, although very close to both (Ramon and Araif el Naga) is quite different. There the section is composed mainly of terrestrial sediments, with a few marine intercalations.

The sea invaded the region in werfenian time (deltaic sediments in Humrat Ma'in); short transgressions reached the Ramon area during the werfenian (?) and Anisian (Gvanim Fm.).

A longer transgression started at the upper anisian or lower Ladinian and the sea covered the region until middle (?) carnian (Sa'haronim Fm. in Ramon and in Araif el-Naga, Calcaire de Hisban in Wadi Hisban).

During the middle ladinian and the lower carnian this transgression reached for a few short periods also the Har Arif area. In the neotrias time a period of folding movement occurred and lagoons were formed locally, in separated basins (Mohilla Fm.). Angular unconformities appear in the section of Mohilla Fm., together with marked lateral changes in facies; Gypsum facies of subsidence lagoonal basins and cellular limestone facies of elevated bars (Har Sa'haronim, southern flanks of Giv'ot Afor). Faulting and magmatic intrusion are considered to have taken place at this (Norian (?)) time.

The Ramon area was uplifted at the end of the triassic and the lateritic and bauxitic horizon, including flint clay (base of Ardon Fm.), was deposited above an erosion relief and in sinkholes. Rocks of the Ardon Fm., silty at the base, are found overlying the Sa'haronim Fm., in Araif el-Naga, with complete missing of Mohilla Fm.

Folding, faulting and magmatic activity, of upper Jurassic age and younger periods affected the triassic rocks in the Ramon (as well as Har Arif, Araif el-Naga and other occurrences). The fluviatile conglomerate at the base of the lower Cretaceous cuts across the jurassic sections in Ramon and Araif el-Naga and the triassic section of Har Arif. It also seems to occur overlying rocks of Sa'haronim Fm. at the southern flanks of Giv'ot Afor.

Astride the WSW-ENE anticlinal axis of the Ramon there are some en echelon folds, trending SW-NE. In the cores of some of these folds the deeper beds of the Triassic formations are exposed.

A line of Thrust faults trending WSW-ENE, with a strike slip component, brought Triassic rocks on the northern elevated blocks against lower Cretaceous and cenomanian rocks on the southern blocks. Strike slip faults, running E-W, broke the southern wall of the Makhtesh and affected also the triassic strata. Rocks of younger periods, i.e., turonian, senonian and eocene, were "pushed" along these faults in-between the segments of the southern wall.

The anticlinal axis of Ramon is considered to "follow" the crests of the en echelon folds. In places it is cut by the WSW-ENE thrust faults and also by the E-W strike slip faults.

The folds and faults described above are considered to result from an E-W or ESE-WNW compressional stress, during the cretaceous and tertiary times, which was barred by an old (meso-neotrias?), WSW-ENE border line of a sedimentary basin (followed possibly an older fault in the basement). This border line might have also caused the division between the Ramon and Har Arif areas. The unconformities in the neotrias; Jurassic and Lower cretaceous sections appear more developed approaching southwards towards this border line.

(Manuscript received too late for editing - Ed.)

MINOR ELEMENTS IN THE TRIASSIC LIMESTONE OF MAKHTESH RAMON

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This work describes the distribution and geochemical behaviour of the four minor elements cobalt, nickel, copper and zinc in the Triassic limestones and dolomites of the Makhtesh Ramon.

I. Analytical techniques. Twenty-nine selected carbonate rocks from the Triassic profile representing some 300 m. of sediments were analysed. The analytical procedure is principally a combined organic-solvent extraction of the four elements at controlled pH from the rock solution, followed by separation of the elements using a paper-chromatography partition technique, and finally their individual spectrophotometric determination.

In addition, the Ca, Mg, and CO_2 content of all samples were determined, Ca and Mg complexometrically and CO_2 gasometrically. The acid-insoluble residue was determined gravimetrically.

2. Results. Ni, Cu and Co were found to be restricted mainly to the acid insoluble residue. This is true to a lesser degree in the case of Zn which occurs with a constant concentration of 50 ppm in the carbonate acid soluble fraction.

The average concentrations of the four elements bound to the insoluble matter are as follows: Ni - 250 ppm; Co - 184 ppm; Cu 325 ppm; and Zn - 550 ppm. These values were calculated from statistical regression curves.

The total concentration ratios of the elements, excluding Zn, are very constant, deviating but little from the ratio Ni:Co:Cu = 3.5:2.5:4.5.

According to results of the major element analyses most of the 29 rocks are relatively pure limestones in which the $MgCO_3$ content by weight rarely exceeds 10%; all but six analysed limestones leave less than 5.5% residue after treatment with hot 6N HCl.

No correlation of any kind could be found between the element concentrations and the sample position in the rock sequence, but this may be due to the paucity of samples taken from a highly varied lithological mass.

3. Conclusions. a) Ni, Co and Cu are bound to the non-carbonate insoluble material. This material is probably composed mainly of clay minerals, and occasionally some organic matter; the metals are apparently adsorbed on the clay surfaces being thus easily extractable by a 6N HCl solution. Virtually no metals could be recovered from the residue following the HCl extraction.

b) Zn is bound in two different ways: i, within the insoluble residue, and ii, associated with the carbonate fraction. The Zn, type i, is definitely not adsorbed but structurally incorporated; this is proved by the inability of the acid to extract it. Type ii Zn occurs at a constant 50 ppm level in relation to the carbonate fraction.

c) The equivalent ratio Zn/Ca was computed to be about $1:10^4$, i.e., one in ten thousand Ca atoms is replaced by a Zn atom.

d) The metal concentrations in the acid insoluble fraction are comparable to those known from clays and shale, offering further support for a clay mineral composition for the insoluble fraction.

e) Since the concentration ratios of Ni, Co and Cu are very constant throughout the sequence, it seems that their concentration in the Triassic sea did not change much over a long span of time. It is thus apparent that the insoluble non-carbonate fraction is the main, if not sole, source of these metals within the carbonate rocks examined.

THE JURASSIC STRATA OF MAKHTESH RAMON

Eviatar Nevo. Saar, Galil Maaravi, Israel

The southernmost recognisable Jurassic strata of Israel are found in Makhtesh Ramon. The sequence, ranging from Liassic to Bathonian, is thin (about 400 m) and mostly terrestrial in contrast to the thick (over 1500 m) and entirely marine Jurassic rocks of western and northern Israel. Approximately 125 sq. kms. of Jurassic outcrops occur in the centre of the anticlinorium, mostly north of the tectonic axis.

A revised columnar section has been worked out. The sequence consists of sandstones, kaolinitic and limonitic clays, and shales. The probably Liassic base and definitely Dogger top consist mostly of shallow water marine deposits comprising fossiliferous limestones, shales, marls and dolomites. The lowest part (0-7 m.) consists of terrestrial deposits comprising red pisolitic and limonitic clays with layers and lenses of white flint clay. The Malm is missing. Magmatic features are multifarious.

Definite correlation is dubious with other Jurassic sections of Israel and of adjacent countries excepting the section of Araif e.-Naga, NE Sinai. Regional and local unconformites and disconformities abound, and there are extreme lateral variations in facies and thicknesses. The Lower Cretaceous basal conglomerate lies with pronounced angular unconformity on the Jurassic strata, or even directly upon the Mid-Triassic Gevanim Formation.

The disturbances in sedimentation - widespread also in Sinai, Jordan and Lebanon - suggest that folding movements occured before and after, as well as during, the Jurassic, these disturbances being associated with extensive magmatic activity, and with faulting.

Economic deposits of proven or potential interest include flint clay, ceramic clays, glass sands and iron ores.

THE MIDDLE JURASSIC FAUNA OF MAKHTESH RAMON

A. **Parnes**. Department of Geology, The Hebrew University of Jerusalem, and The Geological Survey of Israel

The marine sequence of the "Brown Cuesta" of the Makhtesh Ramon, about 30 m. thick, contains two main fossiliferous horizons. One at the base of the Cuesta bears Stephanoceras sp. of the group humphriesianum Sowerby, Stemmatoceras cf. bigoti Manier-Chalmas, Teloceras acuticostatum Weisert, all indicative of Middle Bajocian age. The other horizon at the top of the Cuesta contains ammonites of the genus Teloceras (T. cf. labrum Buckman) and Normannites (N. cf. orbigny Buckman, Normannites cf. egyptiacus Arkell, N. cf. lopsiusi Gillet). This assemblage may be of Middle to Upper Bajocian age.

Particularly significant are the ammonites of the genus Ermoceras (E. splendens Arkell, E. cf. elegans Douv.) which connect the Negev with the zone of Ermoceras fauna of the Southern Tethys extending from N. Africa through Sinai (Moghara) and the Negev to Central Arabia.

The accompanying fauna includes characteristic forms of Brachiopoda (Rhynconella quadriplicata Hartmann, Rh. obsoleta Sow., Stiphrothyris sp.), Lamellibranchiata (Trigonia tenuicosta Lycett, Alectryonia asellus Merian, Camptonectes lens Sow., Pholadomya deserti Douv., Ph. zieteni Agassiz, Arcomya deserti Douv., Pinnabuchii Koch et Dunker) and Gasteropoda (Spinigera sp., Cerithium flexuosum Münster) indicating a Middle to Upper Bajocian age.

The overlying sequence of marly, sandy and shaly sediments, about 60 m. thick, is devoid of ammonites, but contains species described by H. Douville from the Bathonian of Moghara (Eudesia cardioides Douv., Leda *decorata* Douv., *Nucula tenuistriata* Sow., *Astarte pisiformis* Sow.) and other characteristic forms such as *Stomechinus* sp., *Acrosalenia* sp., *Trigonopsis similis*, Sow.. The uppermost part of the sequence, including a lumachelle bed with *Pteroperna* cf. *jarbas* d'Orb., is cut by a conglomerate and a basaltic flow at the base of the variegated sands of the Lower Cretaceous.

THE FOSSIL FLORA OF MAKHTESH RAMON

Y. Lorch. Department of Botany, The Hebrew University of Jerusalem.

Two plant assemblages from the Jurassic have been studied.

The first, from the Lower Jurassic, comprises conifer remains. Branchlets with cuticles, stem fragments and male cones, as well as female cone fragments, have been recovered. The cuticles are generally well preserved. All the conifers have small scale-like leaves.

The second assemblage, from the Middle Jurassic, comprises *Equisetites* sp., a pit cast, as well as stem impressions and diaphragms (?); and *Phlebopteris* cf. *branneri* -- well known from the Lower Cretaceous of Africa and elsewhere. A new species of *Klukia* with fused pinnules, and a new species of *Onychiopsis* were also found in fertile and sterile condition. *Sphenopteris* and *Delgadoa* (?) are also represented. There are numerous male and female cone imprints of a new species of *Elatocladus* (?), and also of *Brachyphyllum* cf. *obesum* and *Podozamites*. *Bennettitales* are represented by *Otoramites* cf. *feistmanteli* and *O.* cf. *mimetes*, as well as by a new species having tubercled rachis; several other species probably referable to the *Bennettitales* were found. Several specimens of *Williamsonia* were collected.

Two Lower Cretaceous plant assemblages imprinted in clay were surveyed. One of these, associated with a deposit of fossil frogs, consists of *Brachyphyllum obesum*, *Schizolepis*, *Cladophlebis* cf. *dunberi* and *Cladophlebis* cf. *browniana*, as well as *Desmiophyllum* sp.. The second assemblage comprises *Sagenopteris* and many other species.

THE LOWER TURONIAN OF MAKHTESH RAMON

R. Freund. Department of Geology, The Hebrew University of Jerusalem.

The Lower Turonian section around Makhtesh Ramon is characterised by abundant ammonites which occur in beds of rubbly detrital yellowish limestone, or in white or red chalk. These beds vary in thickness from zero to 15 m.. They are underlain by yellow soft dolomites and marls of 2 - 10 m. thickness which contain infrequent *Neolobites* sp., *Exogyra flabellata* (Goldfuss) and other fossils indicative of a Cenomanian age.

Four Lower Turonian ammonite zones were recognized in the area. The lowest one occurs in the north-east on Darb-es-Sultan, and is characterised by *Paravascoceras cauvini* (Chudeau) and several *Paramammites* sp., The next higher zone contains dwarf (2-3 cm.) *Choffaticeras* spp.; it occurs in Nahal Nekarot. The third zone is the most prominent: it contains abundant *Choffaticeras*, thick *Vascoceras* and *Thomasites*. Its type fossil is the thin *Choffaticeras quassi* (Peron). The type fossil of the uppermost Lower Turonian zone is *Choffaticeras luciae trisellatum* Freund; it is accompanied by *Thomasites*, *Fagesia*, *Neoptchites* and *Protexanites*. The above zones are denoted in the writer's Ph.D. thesis as zones 2, 3-4, 5, and 6 respectively.

Zone 5 is thicker (3 - 10 m.) along a NE - SW line running from the southern plunge of Hamakhtesh Hakatan anticline through Ma'avar Makhmal and the southern entrance of Makhtesh Ramon to Har Arif, whilst it wedges out towards the NW and the SE. In the latter direction, near Har Govai, a considerable accumulation of weathered and broken ammonites indicates a shore environment. Zone 6 occupies an area with the same NE-SW trend, but shifted about 10 km. to the NW, from Har Nafkah through Nahal Nizana and Har

Hatul to Har Batur. This zone (6) shows the shore phenomena wedging-out towards the NW; the zone reappears to the SE in Nahal Nekarot.

The ammonite zones are overlain by a thick formation of green shales absent in the NE but growing thicker towards the SW where they attain 50 m.. In the NW (Rosh Ramon) and SE (Har Govai) these shales lie directly upon the Cenomanian yellow dolomites and marls. Rare Coilopoceras sp. occur above the shales and indicate an Upper Turonian age.

The evidence indicates the existence of an elongated Lower Turonian basin into which the sea entered from the NE.

THE ECONOMIC DEPOSITS OF MAKHTESH RAMON

T. Weissbrod. The Geological Survey of Israel.

Every geological formation exposed in the Makhtesh Ramon (Triassic - upper Cretaceous) contains an economic deposit. These include: gypsum, flint-clay, kaolin, variegated clays, bentonite, brown marble, white marble, limestone for the chemical industry, gravel and natural pigments.

THE FLINT CLAY OF MAKHTESH RAMON

U. Würtzburger. The Geological Survey of Israel.

The flint clays of Makhtesh Ramon lie within Jurassic clays conventionally known as "Seven Meter Band" lying unconformably upon triassic lagoonal limestones. The clays also fill pockets or sink holes in the underlying limestones, and as their thickness may attain 18 m. the alternative term "Clay Sequence" is preferred in place of "Seven Meter Band".

Mineralogically the Clay Sequence is composed of kaolinite with lesser amounts of boehmite, hematite, anatase and diaspore; rutile and goethite are minor consituents. In some clays kaolinite and boehmite predominate and the Al_2O_3 content reaches 65%. Alternatively there may be sufficient hematite for the Fe_2O_3 content to attain 45% giving a violet-reddish ferrugineous clay. Flint clay suitable for exploitation, without artifical enrichment, must contain no more than 1.5% Fe_2O_3.

Within the sink holes the white flint clay usually occurs in the centre of the depressions with ferrugineous clays below and around them.

There are variable amounts of pisolites of various sizes; they are very rich in Al_2O_3. According to Slatkine and Heller they have a concentric structure and are formed mainly of boehmite. There are also some occurrences of pisolites rich in hematite.

Two distinct genetic problems await explanation:

1. Origin of the Clay Sequence as a whole; it could be either residual, or a true sediment.

2. Origin of the flint clay within the Clay Sequence. The ferrugineous clay may be a

syngenetic deposit, the flint clay being derived from it by leaching. Alternatively, the white flint clay may itself be of syngenetic origin.

Economic considerations. The economic value of the flint clay depends directly on the amount of TiO_2 and Al_2O_3 it contains, these constituents raising the fire-resistance of the product.

The flint clay is presently being extracted from open pits having an overburden of 15 metres, but normal mining will be required in the future.

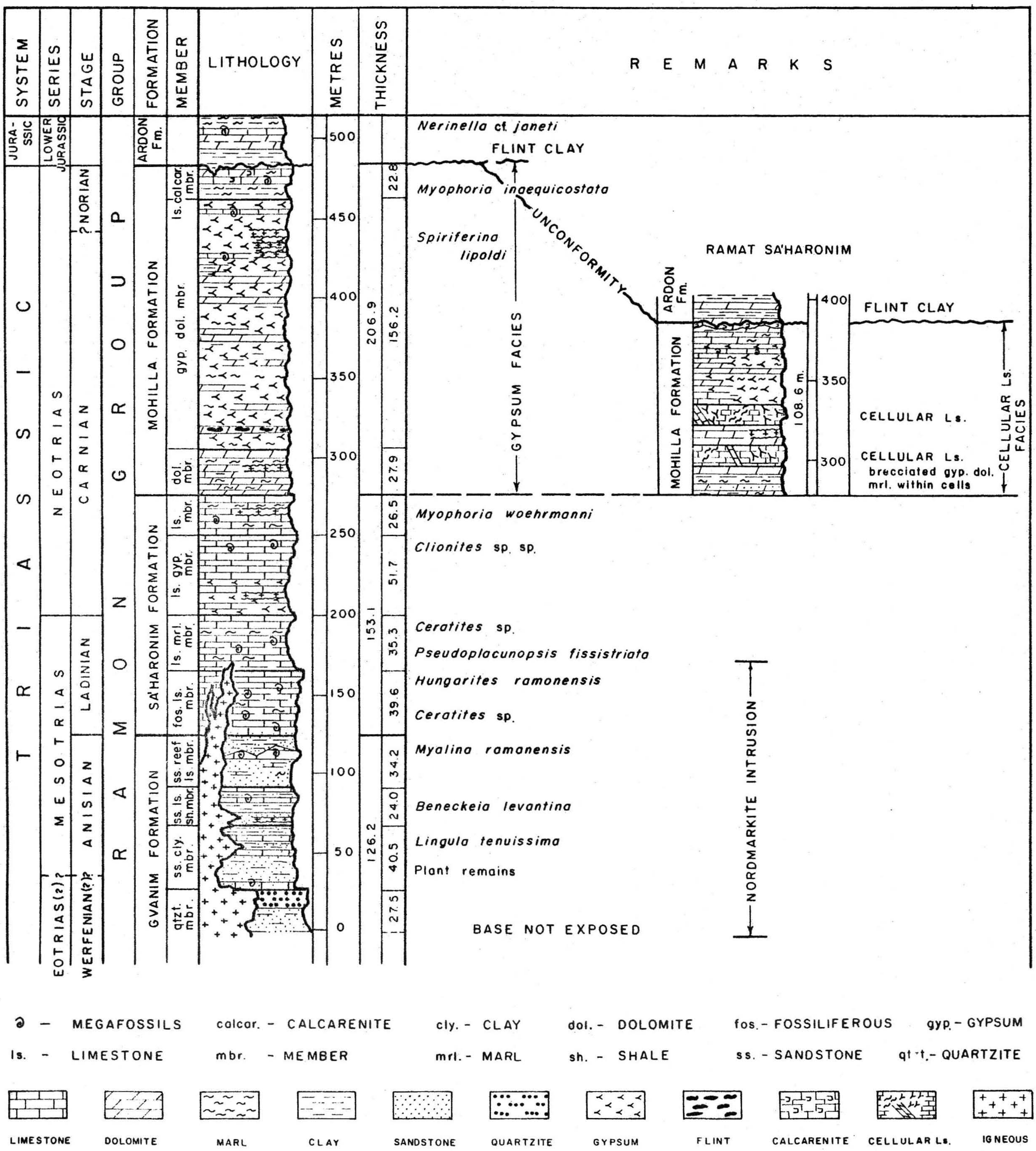
There are both physical and chemical methods for removing the iron oxide fraction from the white clay. Magnetic separation is being considered as well as roasting processes to ensure a suitable product for the world markets.

GEOLOGICAL MAP OF MAKHTESH RAMON after Y. K. Bentor and A. Vroman

COLUMNAR SECTION OF THE TRIASSIC
HAR GVANIM, MAKHTESH RAMON

by I. Zak

STRATIGRAPHY by A. Parnes



Draw. Sec. G.S.I. J.L.

fig. 1

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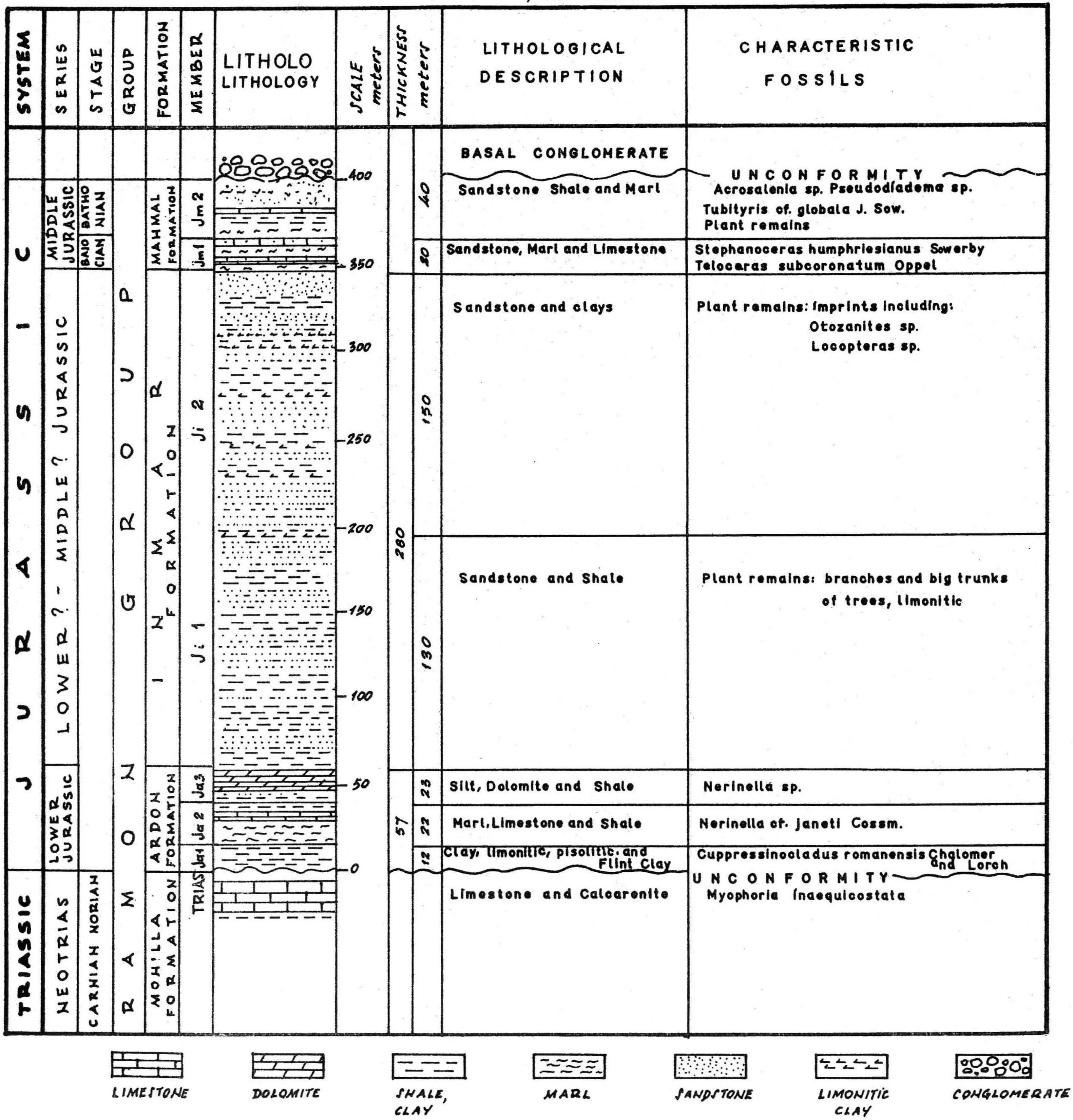
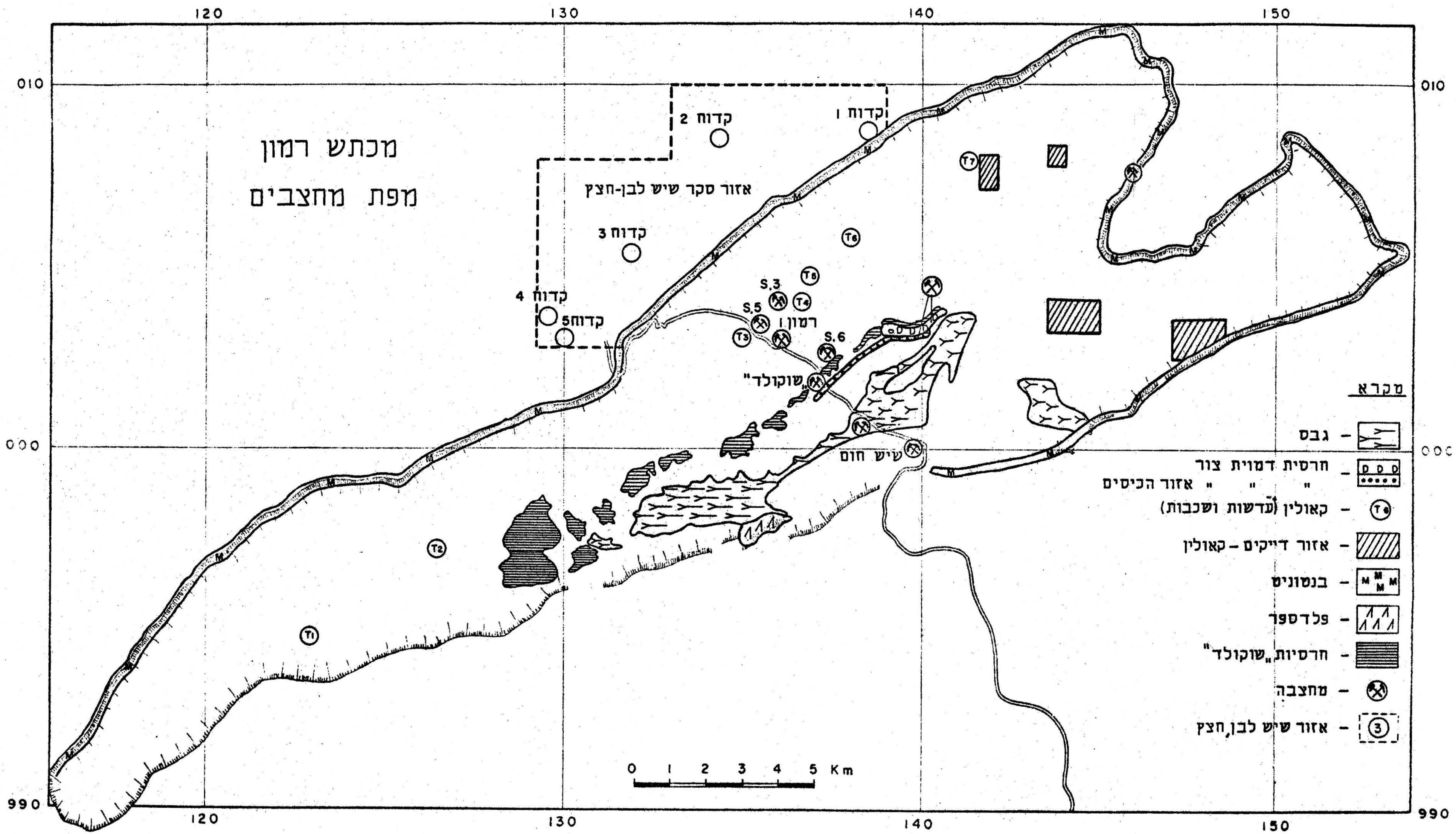
GENERALIZED COLUMNAR SECTION OF THE JURASSIC IN MAKHTESH RAMON

By E. Nevo





מכתש רמון
מפת מחצבים
אזור סקר שיש לבן-חצץ
קדוח 1
קדוח 2
קדוח 3
קדוח 4
קדוח 5
S.3
S.5
S.6
רמון 1
"שוקולד"
שיש חום
מקרא
גבס
חרסית דמוית צור
" " אזור הכיסים
קאולין (עדשות ושכבות)
אזור דייקים – קאולין
בנטוניט
פלדספר
חרסיות "שוקולד"
מחצבה
אזור שיש לבן, חצץ
0 1 2 3 4 5 Km
120
130
140
150
010
000
990

י. ק. בן-תור:	הפטרולוגיה המגמתית של מכתש רמון.
ע.י. פרומן:	קמט רמון במסגרת קמטי הלבנט.
א. אמיתי:	סקר גרוימטרי ומגנטומטרי במכתש רמון.
י. זק:	הסטרטיגרפיה והסטרוקטורה של הטריאס במכתש רמון.
א. כץ:	אלמנטים בעקבות בגיר הטריאסי של מכתש רמון.
א. נבו:	השכבות היורסיות של מכתש רמון.
א. פרנס:	פאונה של יורא תיכון במכתש רמון.
י. לורך:	צמחים מאובנים במכתש רמון.
ר. פרוינד:	הטורון התחתון סביב מכתש רמון.
ט. ויסברוד:	מרבצים במכתש רמון.
א. וירצבורגר:	חרסית-דמוית-צור במכתש רמון.

החברה הגיאולוגית הישראלית

תקצירי הרצאות,

כנס רמון

10 - 12.2.1963

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