A REVIEW OF PERMIAN AND MESOZOIC FORMATIONS EXPOSED NEAR THE TURKEY/IRAQ BORDER AT HARBOL *

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ABSTRACT. — None of the rock unit terms found in the literature on the Cudi Dağ-Harbol area in Southeast Turkey can be taken and used at face value in regional stratigraphic comparisons. Based on results of personal field work and careful review of published and unpublished data collected by previous investigators from 1930 to 1963, the author defines and describes the Harbol Formation, Goyan Group, and Cudi Group.

It is demonstrated that the type section of the Harbol (Limestone) Formation is exclusively of Permian age, probably not older than Upper Permian. East of the type section the Harbol appears to *rest,* with disconformity, on the Lower Carboniferous Harur Limestone. This (Variscan) break is of regional extent in Southeast Turkey and North Iraq; there is no continuous «Permo-Caiboniferous». The Harbol Formation is geographically continuous with and closely comparable to the Chia Zairi Limestone in Iraq.

The Goyan Group is of Lower to Middle Triassic age and overlies the Harbol Formation conformably. From bottom to top within the Goyan Group, three formations known in North Iraq are easily recognized : The Mirga Mir (predominantly limestone); Beduh (purple shales, thin-bedded sandstone, minor limestone); and Geli Khana (sandy limestone, dolomite, and gray shale). However, the Geli Khana at Harbol is much thinner than in the type section in Iraq, probably due to intraformational condensation zones and a non-depositiorial hiatus at the base of the overlying Cudi Group. It is strongly suspected that the lowest portion of the Cudi Group correlates with the uppermost Geli Khana of the Iraq type section. Further field and paleontological investigations would be required for a more satisfactory breakdown.

The Cudi Group comprising predominantly limestone and dolomite probably reflects a time span from Middle Triassic through Middle Cretaceous which includes gaps in the geologic record. Our knowledge of this group in Turkey is very limited. In North Iraq, I.P.C. geologists have differentiated 13 formations within the gross interval correlative with the Cudi Group of Southeast Turkey with four unconformities. At least two of these breaks are expected to be present on Turkish territory : The unconformity at the base of the Cretaceous, and the one near the Cenomanian/Turonian boundary. The Cudi Group is terminated at the top by a major disconformity which is widespread throughout Southeast Turkey and North Iraq. Upper Campanian sediments are found overlying the Turonian.

The stratigraphic relationships of some Cretaceous oil reservoirs in Southeast Turkey to the Cudi Group and younger formations, exposed near the Turkey/Iraq border, are briefly mentioned.

INTRODUCTION

In the autochthonous terrain of Petroleum District V, Southeast Turkey, there are three key areas where older Mesozoic and/or Paleozoic formations can be studied in outcrop. These are indicated on Plate 1 : Mardin Uplift, Hazro Anticline, and the region east of Cudi Dağ to beyond Goyan. The latter area is of particular interest

with respect to stratigraphic correlations between Southeast Turkey and North Iraq. In Iraq a thoroughly founded rock unit nomenclature has been worked out and published by I.P.C. geologists (see Lex. Strat. Internat, Vol. III, Fasc. 10 a, 1959). . Based on personal field work in the vicinity of Harbol, east of Cudi Dağ, and a, critical review of the literature, the author will discuss the stratigraphy, nomenclature, and correlation of Permian to Cretaceous rock units exposed near the Turkey / Iraq frontier. In the field, Permian and Triassic formations were studied in detail, while the younger sediments were investigated only in reconnaissance fashion. The field work was carried out in October, 1959.

The Harbol area is well known among geologists in Turkey for the occurrence of the so-called «Harbolite», a solid asphaltic hydrocarbon which appears to be the dissipation product of an old petroleum accumulation. This subject will not be dealt with in the present article. The first M.T.A. geologist to make an evaluation of the «Harbolite» deposit seems to have been Foley (1938, unpublished M.T.A. report). Taşman (1946) gave the first published account. Some other geologists also investigated the «asphaltic» deposit and at the same time collected some preliminary data on the stratigraphy of the area.

The outcrops of Paleozoic rocks near Harbol were independently discovered by Mason (1930) and Taşman (1931); according to Taşman (1949, p. 24). They were briefly described by Maxson (1937) and Foley (1938) in unpublished M.T.A. reports. Tromp (1941) introduced the «Harbol Formation», «Goyan Formation», «Tanintanin Formation», and other «formation» names used by M.T.A. geologists into the published literature, but without defining and describing type sections, rock types, and contacts. The Harbol area was also studied by Blumenthal (1944, unpublished M.T.A. report) who gave the best account of the stratigraphy and structure written on the subject area to that date. Publications by Ta§man (1949), Altınlı (1954), Türkünal (1955), and Tolun (1960) contain sketchy stratigraphic information on the Harbol area and surrounding region. The Explanatory Notes for the 1:500,000 Geologic Map, Sheet Cizre, by Altınlı (1963) incorporate the results of the older investigations but present no new evidence.

The author is not aware of any publication or unpublished M.T.A. report that contains a complete, detailed, lithologic and paleontologic record of the section exposed in the Cudi Dağ and surrounding area on Turkish territory. Properly measured and described type sections do not seem to exist for any of the rock units mentioned by the authors listed above. (Except in oil company files.) In the published literature only Altınlı (1954) made an effort to compile lithologic types to substantiate the loosely defined formations. None of the literature rock units can be taken and used at face value in regional stratigraphic comparisons.

STRUCTURE

Plate 2 shows the general structure of the Cudi Dağ - Harbol area. This illustration is merely intended to serve as guide to the stratigraphic sections and is not to be understood as a very reliable tectonic analysis. At the time of the author's field work, 1 : 25,000 topographic maps of the area were not available. The reconnaissance map was made on a scale of 1 : 200,000.

DISTRICT V INDEX MAP

NAPPE ZONE

VI V

NAPPE ZONE

HAZRO ANTICLINE

HAZRO-1 & 2A

HANDOF-1

SİLVAN-1

KÂTİN-1

SHELL KAYAKÖY #2

SHELL KURKAN

SELMO MOBIL #1

TPAO CELİKLİ

DEEPEST TEST IN TURKEY

MOBIL SİLİVANKA #2

KASTEL-1

BATMAN

TPAO GERMİK

TPAO MAGRİP

KAVIKADAĞ #1

KURTALAN TPAO

SİİRT

DİYARBAKIR

SİNAN-1

DICLE

TPAO GARZAN

#7 #2 KENTALAN

TPAO

BATI-RAMAN MOBIL

#14 RAMAN TPAO

ESSO GERCÜŞ-1

REPORT AREA

THIS MAP SHOWS ONLY WELLS WHICH PENE-TRATED PERMIAN & / OR TRIASSIC FORMATIONS

MARDİN UPLIFT

DERİK

SOSINK

BEDİNAN

MARDİN

DICLE

CİZRE

CUDİ DAĞ

HARBOL

GOYAN

SHIRANISH

BANIK

CHALKI 16 Kms

TURKEY

BAKUK-1

KAMICHLIE-1

SYRIA

GPA KARATCHOK

GPA T. ROUMELANE

DEA SOUEDIE

IRAQ

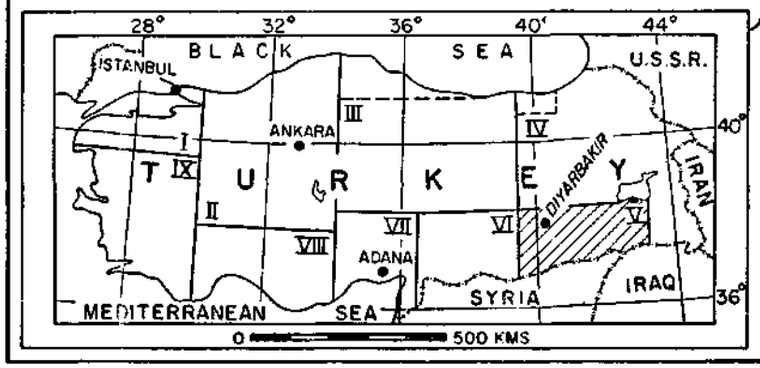
TIGRIS

IPC AIN ZALAH

IPC BUTMAH #2

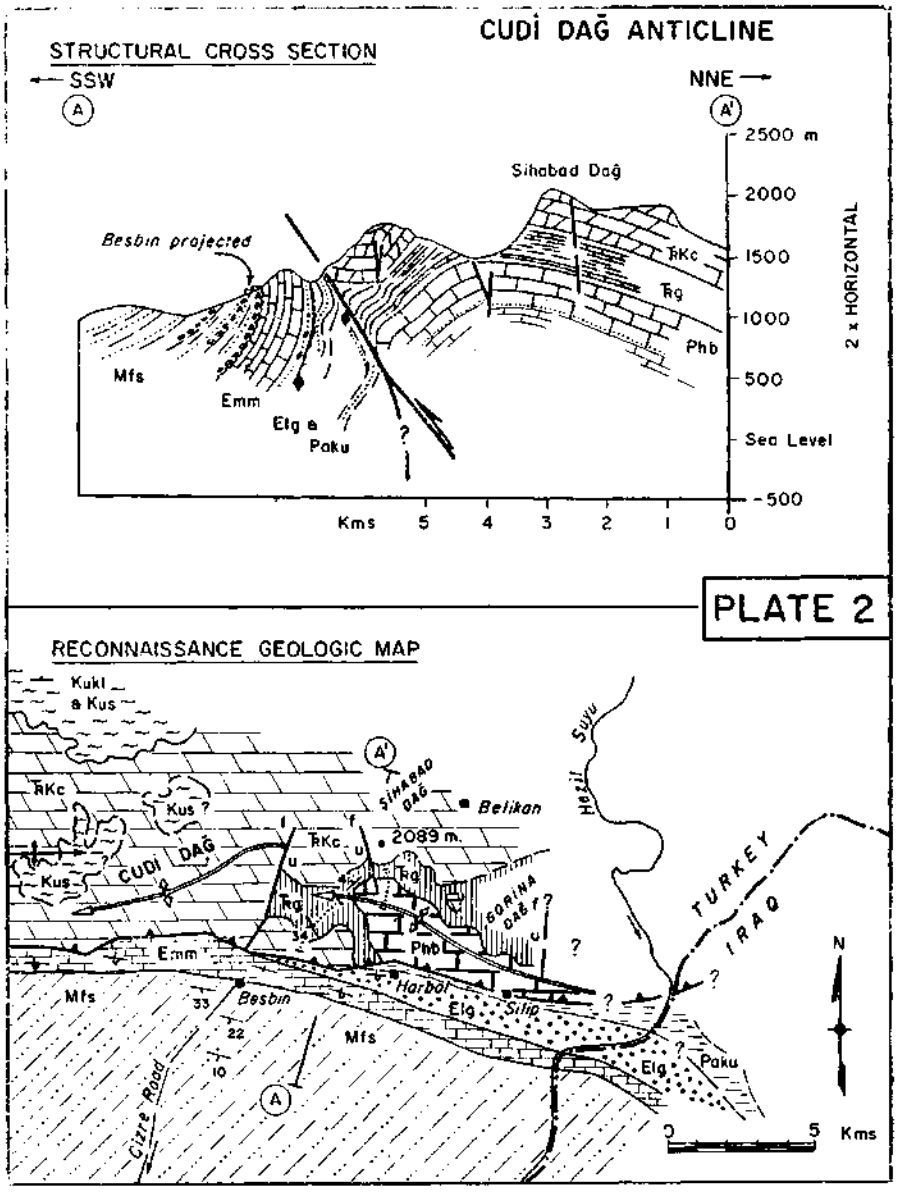
10 5 0 10 20 30 KMS

36°30' 38°30' 40°00' 42°00' 42°30' 36°00' 38°00' 37°30' 39°30' 40°00' 41°00' 37°00'



LEGEND:

- PROVEN & PROBABLE OUTLINE OF OIL FIELD
- THRUST FRONTS OF ANTI-TOROS MTNS
- X IMPORTANT SURFACE SECTION
- P&A WELL, NO SHOWS
- P&A WELL, OIL & GAS SHOWS
- OIL PRODUCING WELL



LEGEND

- Mfs — Fars Fm — MIDDLE - UPPER MIOCENE
- Emm — Midyat Fm — MIDDLE EOCENE (possibly includes some younger carbonates)
- Etg — Gercüs Fm — LOWER EOCENE
- Paku — Upper Kermav Fm — PALEOCENE - L.EOCENE?
- Asphalt a Gilsonite
- Kukl–Kus — Lower Kermav Fm a Shiranish Fm — UPPER CRETACEOUS
- TRKc — Cudi Group — MIDDLE TRIASSIC? - MIDDLE /UPPER? CRETACEOUS
- Trg — Goyan Group — LOWER - MIDDLE TRIASSIC
- Phb — Harbol Fm — PERMIAN
- Stratigraphic Traverse

GCS '58

Elevations in the mapped area range from 1000 to 2089 meters above sea level. The relief is very rugged, with deeply incised steep slopes and nearly vertical cliffs, particularly in the terrain underlain by the Harbol Formation and Cudi Group carbonates.

The exposures of Permian and Triassic rocks are located in the eastern core outcrop of the large Cudi Dağ Anticline. In the area worked, the axis of this fold plunges to the west. A north-northeast trending transverse fault north of Besbin, east side up, reinforces the west plunge. The anticline is asymmetrical to the south. Permian and Triassic strata of the south flank are thrusted over Paleocene to Eocene beds which are overturned or vertical. The thrust fault trends approximately east-west and can be traced for about 60 kilometers from northwest of Cizre to the east beyond the Turkey/Iraq border (Altınlı, 1954). The high ridge of vertical to steeply dipping Midyat Limestone immediately south of this major fault forms the morphological boundary between the high-relief frontal folds of the East Anatolian Toros and the Cizre Plain which has only outcrops of Late Miocene and Pliocene elastics.

STRATIGRAPHY

The rock units investigated in the Cudi Dag - Harbol area are summarized on Plate 3. This chart also shows the correlation with formations exposed in the adjacent region of North Iraq; see Plate 1 for localities. Plate 4 with accompanying text gives a detailed account of the Permian and Triassic formations near Harbol.

The lowest beds exposed in the immediate vicinity of Harbol and south of Şehabad Dağ are definitely of Permian age. Supposedly Lower Carboniferous fossils are reported by Maxson (1937), Blumenthal (1944), Altınlı (1954), and Tolun (1960). None of these authors states exactly where and in what part of the section the fossils were found. Some fossil determinations also contradict each other. See discussion of age under Harbol Formation.

According to Altınlı (1954, pp. 9-10) pre-Permian formations are exposed in the Hezil Suyu gorge, northeast of Silip, which was not visited by the present author. The meager lithologic and paieontologic record available suggests that Lower Carboniferous-Upper Devonian and Ordovician strata disconformably underlie the Permian, in analogy to the section in North Iraq (see Plate 3). The oldest formation on Turkish territory, the Giri Quartzite, is homotaxial and almost certainly correlative with the Khabour Quartzite - Shale Formation in Iraq (see Wetzel, 1959, in: Lex, Strat. Internat., Iraq, pp. 147-148).

HARBOL FORMATION - PERMIAN

Definition

Predominantly neritic limestones with very subordinate elastics, which were introduced disconformably or with very slight angular unconformity by the Permian transgression over an eroded but smooth surface of Lower Carboniferous and older rocks (Variscan break). The unit is terminated at the top by a change to restricted sea conditions in earliest Triassic times. Analogy: Chia Zairi Limestone of North Iraq.

Type Locality and Section

The Harbol (Limestone) Formation was originally named by Maxson (1937), but no type section and no detailed description has been published to date. The present author defines the well exposed section in the gorge and cliffs of the Begürüf Dere leading north from Harbol village to Şehabad Dağ to be the type section. This locality is easily accessible on foot.

Brief Description of Type Section

Thickness : 319 meters. The bottom of the formation is not exposed, and it is not known how much additional thickness of the type lithology is present in the subsurface below the lowest exposed bed. Any additional section matching the rock types combined in the exposed type section and continuous with the type section must, of course, be included in the Harbol Formation. A supplementary type section could perhaps be measured in the gorge of the Hezil Suyu which, however, is very difficult to reach.

Lithology : From bottom to top.— The lowest exposed 45 meters (No. 1-10 on Plate 4) are about 3/4 limestone, dark gray to black, very fine- and cryptocrystalline, splintery hard, (with conchoidal fracture, and some softer argillaceous beds, thin- and thick-bedded, slightly sandy in part; with thin interbeds and uneven partings of shale, black, fissile, hard. There are four intervals of quartz-sandstone. The lower three are 1 to 2 meters thick each, light gray to white, weathered yellow, very fine-grained, angular, well sorted, micaceous, hard, tight, cross-bedded and ripple-marked, and have pinch-outs. The upper sandy interval is almost 7 meters thick and is a lenticularly cross-bedded sequence of : Sandstone, very fine-grained, well sorted, angular, laminated by argillaceous material, hard, non-calcareous, slightly quartzitic, slightly micaceous; black, fissile shale and non-descript shale-silt-sand mixtures. The next gross interval (No. 11-12 on Plate 4) is 185 meters of limestone, dark gray to black, fine- to very fine-crystalline or cryptocrystalline. Some beds are almost entirely composed of calcareous algae. In the upper part the limestone is thick-bedded to massive and very resistant. Many beds emit a fetid odor from freshly broken surfaces. Unit 12 also has dark chert concretions. Its lower part is thick- to medium-bedded, has more argillaceous beds and a minor number of dark gray shale partings. The following interval (No. 13 on Plate 4) is 47 meters of very fossiliferous limestone, dark bluish gray, fine- to cryptocrystalline, thin-bedded and nodular, with thin argillaceous partings. The youngest 42 meters (No. 14-20 on Plate 4) are highly variable limestone types with a 2 meters thick bed of calcareous quartz-sandstone in the lower part. The limestones are mostly gray to black, thick-bedded. Thin-bedded and nodular limestones in the lower part of the interval are very fossiliferous. The upper part contains cross-bedded, oolitic limestone, thick-bedded to massive, with big stylolites.. The oolitic limestone smells slightly fetid on newly broken surfaces. There is some silty limestone near the top. Indications of unstable sedimentary conditions are abundant : Lenticular beds, wavy bedding planes, and intraformational pebbles.

Fossils and age : Although the fauna and flora of the Harbol Formation are incompletely studied, there is conclusive evidence that units 1 through 17 of the exposed type section are of Permian age. Carboniferous is definitely not included at the base. The uppermost 20 meters may be a Permo-Triassic transition zone. Species of the calcareous alga *Mizzia* (e. g. *Mizzia velebitana* Schubert) occur commonly throughout the

limestones from units 1 to 16, occasionally associated with *Gymnocodium bellerophontis* (Rothpletz). In many intervals these algae are rock-forming. Small Foraminifera are also abundant in numerous beds, e. g. *Robuloides* sp., *Glomospira* sp., *Hemigordius* sp., *Palaeolingulina* sp., *Palaeotextularia* sp., *Pachyphloia* sp. (determined by Miss Solmaz Erdoğan of Mobil). As indicated on Plate 4,-brachiopods, gastropods, and crinoids are prominent among the macrofossils, but nearly all of these still await exact determination. The author has found species of *Productus, Schelhvienella,* and *Bellerophon*. Shell geologists found plant fossils in the black, carbonaceous shales which are associated with the sandstones in the lower part of the type section. This flora is comparable to the Middle - Upper Permian *Glossopteris,* etc. assemblage published from the upper Hazro Formation on the Hazro Anticline by Wagner, 1959- (D. W. Gossage, verbal communication).

Taşman (1949, p. 24) lists *Productus semireticulatus* Martin and *Productus giganteus* Martin from the lower part of our type section and claims a Carboniferous age for this part. Tolun (1960, p. 224) mentions the same species «in upper sections of the limestone» associated with *Mizzia* which is an index fossil for the Permian. The determination of these productids appears to be questionable. From «higher» in the section Taşman (1949, p. 24) reports the Permian *Productus horridus* Sow. and *Derbya armenica* Arth., based on older M.T.A. reports.

The present author suspects that the Lower. Carboniferous (Dinantian) corals and brachiopods quoted by Altınlı (1954, p. 10) and Tolun (1960, p. 224) came from the Harur Limestone in the Hezil Suyu gorge and other areas east of the Harbol type section (compare Lex. Strat. Internal., Iraq, 1959, p. 130). However, the determinations require confirmation.

The algae from the Chia Zairi Limestone in northern Iraq which is «geographically continuous with (part of) the Harbol formation of Turkey» have been studied by Elliot (1955, quotation from p. 83). They indicate an Upper Permian age.

Contacts : The contact of the Harbol Formation with older rocks is not exposed in the area studied by the author. However, it is suspected that the Lower Carboniferous Harur Limestone known from North Iraq disconformably underlies the Harbol in the deeper section exposed near the Hezil Suyu east of Şehabad Dağ; see discussion above. The Lower Triassic Mirga Mir Formation overlies the Harbol with conformable contact. It is therefore more appropriate to talk about a Permo-Triassic succession than a «Permo-Carboniferous» one. The latter term is frequently found in the literature (authors cit.).

Correlations

Lithological and paleontological correlation between the exposed Harbol type section and the upper part of the Chia Zairi Limestone in Iraq is perfect. The Harbol Formation is homotaxial and its main body correlative with the Gomaniibrik Formation exposed on the Hazro Anticline and penetrated by eight exploratory wells in Petroleum District V; see Place 1 (G. C. Schmidt, unpublished company report).

Remarks

Altınlı (1963, p. 62) refers to the «Permo-Carboniferous» rocks mapped on the 1:500,000 Geologic Map, Sheet Cizre, as «Tanintanin Formation»; also called «Tanin» in a previous paper by Altınlı (1954, p. 10). Maxson (1937) who invented the term «Tanintanin Formation» reported that unit as being of Triassic to perhaps Liassic age and overlying his Goyan unit. Part of the Goyan has long been proved

to be of Triassic age. The so-called Tanintanin Formation appears as «Mesozoic in general» in Blumenthal's report (1944) and as «Jurassic» in Türkünal's publication (1955). Taşman (1949, p. 26) suggests a Middle? Triassic to Lower? Cretaceous age for the Tanintanin rocks. Careful reading of the communications cited above reveals that none of the authors measured and defined the section in question in the Tanin Mountains, about 32 kilometers northeast of Harbol. The present author therefore does not consider the «Tanintanin Formation» a valid stratigraphical term and recommends that the name be abandoned.

Stratigraphic studies by the author and other oil company geologists have shown that the Variscan unconformity is present throughout Petroleum District V in Southeast Turkey. In outcrops on the Hazro Anticline (Tolun's Hacertun Dağ section, 1951) the Middle or Upper Permian, continental-estuarine, Hazro Formation is paraconformable on marine Upper Devonian. In deep exploratory wells the Hazro or the marine Gomaniibrik Formation has been found to rest on strata ranging in age from Lower or Middle Silurian to Middle Ordovician

GOYAN GROUP - LOWER AND MIDDLE TRIASSIG

The three formations combined in the Goyan Group by the present author were originally described as Goyan «formation» by Maxson (1937). However, Maxson did not establish a type section for the unit near Goyan town (also called Uludere on Turkish topographic maps). He only mentioned that the best exposures of the Goyan were at Şehabad Dağ north of Harbol and gave a very sketchy description of that section. The contacts with overlying and underlying rock units were not clearly defined. Consequently there is considerable confusion in the literature as to how much section the Goyan «formation» comprises at Goyan, and Türkünal (1955, Plate II and XV) even called supposedly «Upper Triassic?-Lower Jurassic» strata «Goyan formation».

A detailed accont of Lower to Middle Triassic formations exposed in North Iraq is available through the Lexique Stratigraphique International, vol. III, fasc. 10 a (1959). The following formations known in North Iraq are easily recognized in the section measured by the author in the Harbol area; from bottom to top : Mirga Mir, Beduh, and Geli Khana. The uppermost part of the type Geli Khana in North Iraq is probably included in the lowermost beds of the Cudi Group (as defined by the author). The suspect interval cannot be separated from the bulk of the Cudi Group carbonates with the data presently at hand (provisional contact on Plate 3). Further field work and paleontological research would be required for a more satisfactory breakdown.

As the name «Goyan» is deeply rooted in published and unpublished reports on the stratigraphy of Southeast Turkey and is understood by many geologists to designate Triassic rocks, the author suggests to maintain that term but to apply it with group rank. The Goyan Group is hereby defined to include all the rocks between the Harbol Formation and the Cudi Group, i. e. the Mirga Mir, Beduh, and Geli Khana Formation (exclusive of its uppermost part). The nomenclature established in North Iraq can be used for a more refined breakdown of the Stratigraphic column in those areas of Southeast Turkey where the corresponding formations are recognizable. The bottom and the top of the Goyan Group at Harbol are conformable contacts as are all the contacts within the group. However, the upper boundary may hide a considerable time span due to condensation or non-deposition.

Part of the Goyan Group is also recognized in outcrops on the Hazro Anticline where it is disconformably overlain by the Middle Cretaceous Mardin Formation. Fourteen exploratory wells in Petroleum District V have partially or completely penetrated the Goyan Group; see Plate 1 (G. G. Schmidt, unpublished company report).

Mirga Mir Formation (Lower Triassic)

The type locality of the Mirga Mir is in the Amadia District of North Iraq, about 20 kilometers east of Chalki and a little over 2 kilometers south of the Turkish border (Wetzel, 1959, in: Lex. Strat. Internat., Iraq, p. 186). The type section is 200 meters thick and consists of «thin-bedded, grey and yellow, marly limestones and shales with slump beds and recrystallization breccias; oolitic limestones at base, with wisps of sandstone». *Pseudomonotis (Claraia) clarai* Emmrich and other pelecypods indicate a Lower Triassic, Lower Werfenian, age.

In the Harbol area the Mirga Mir measures 67 meters thick and consists of thin-bedded, platy limestones, fresh gray, weathered Fe-stained, fine- or cryptocrystalline, more or less argillaceous, in part laminated by sandy streaks, with intraformational conglomerates and probable mud cracks; 5 to 10 cm thick beds of sandstone, very fine-grained, finely micaceous and calcareous; interbedded with gray, very calcareous shale. Poorly preserved casts of pelecypods, worm burrows, feeding tracks, and questionable imprints of seaweeds are common. One interval (No. 22 on Plate 4) contains abundant, well distinguishable, *Pseudomonotis (Claraia) clarai* Emmrich.

The contact with the underlying Harbol Formation is conformable though morphologically abrupt in the field. The first influx of Mirga Mir lithology occurs 5 meters below the contact; see Plate 4. The contact with the overlying Beduh Formation is gradational, taken at the color change from gray and yellow (below) to violet and red-brown (above).

Beduh Formation (Lower Triassic)

The type section of the Beduh (Shale) Formation is about 20 kilometers east of Chalki and 1 kilometer west of Beduh village (Wetzel, 1959, in : Lex. Strat. Internat., Iraq, p. 60). The type section is 64 meters thick and consists of «red-brown and purplish shales and marls, some silty, with subordinate thin ribs of limestones with sandy streaks». A pelecypod fauna indicates a Lower Triassic, Werfenian, age. The Lower Werfenian index fossil *Pseudomonotis (Claraia) clarai* Emmrich seems to be absent from the Beduh fauna. Wetzel therefore assumes an Upper Werfenian age for the formation.

In the Harbol area the Beduh is 98 meters thick and consists of shale, violet-purple and red-brown, with subordinate amounts of gray; thin streaks of ripple-marked quartz-sandstone, and thin limestone and dolomite beds. The lower part of the formation has zones of reworking and probable solution breccias. The author observed only poorly preserved pelecypod molds and ostracods, but a more intense search would probably turn up some determinable fossils. Lithologic correlation between the North Iraq Mirga Mir-Beduh succession and the sequence at Harbol is excellent. After having seen the Beduh lithology near Harbol, it seems conceivable to the writer that *Pseudomonotis (Claraia) clarai* is not represented in the fauna at Beduh and Harbol because of adverse ecological conditions. The «probable Upper» Werfenian age (Wetzel) for the entire formation appears somewhat uncertain.

The contact with the underlying Mirga Mir has been described in the preceding chapter. The contact with the overlying Geli Khana Formation is gradational and placed at the color change from violet (below) to gray (above), which corresponds to a lithological change from predominant shales to predominant limestones. The author suspects both contacts to be diachronous on a regional scale.

Because of its conspicuous and unique color and lithology the Beduh ranks as a prominent marker for surface mapping and regional correlations in Petroleum District V. The Beduh is also typically developed *on* the Hazro Anticline and has been encountered in several exploratory wells (G. C. Schmidt, unpublished company report).

Geli Khana Formation (Middle Triassic)

The type locality of the Geli Khana Formation is along the Geli Khana River in the Amadia District of North Iraq, about 20 kilometers east of Chalki and 1 kilometer south of the Turkish border (Wetzel, 1959, in : Lex. Strat. Internal., Iraq, p. 106). The type section is 575 meters thick and consists of, from bottom to top: (1) «156 meters of greyish thin-bedded limestones and hard, limy shales, with streaks and ribs of ripple-marked sandstones»; (2) «65 meters of greyish and yellowish thin-bedded limestones and shales with bands of recrystallization breccias»; (3) «154 meters of bluish shales, with intercalations of yellowish limestones and occasional sandy bands»; (4) «138 meters of hard, fine-grained, dark grey, scarp-forming limestones, alternately thin- and thick-bedded, with intercalations of olive green shales and yellow-brown marls in the lower part and occasional bands of flint nodules near the top»; (5) «58 meters of dark, foetid dolomites with bands of grey, dolomitic limestones containing abundant recrystallized gastropods»; (6) «uppermost unit of laminated ferruginous dolomites, 3.5 meters thick, with streaks of black chert and bands of nodular haematite». Fossils and correlation indicate a Middle Triassic (Anis-Ladinic) age for the type section which is overlain, with disconformity, by the Upper Triassic Kurra Chine Limestone.

In the Harbol area the unit presently classified as Geli Khana Formation by the author is only 159 meters thick and consists of two intervals of differing gross lithology which are of almost equal thickness. The lower interval (No. 34-39 on Plate 4) is predominantly limestone, gray, fine- or cryptocrystalline, argillaceous, hard, thin-bedded to platy, laminated by sandy streaks, with intraformational limestone-conglomerates (possibly recrystallization breccias?), small channels and wavy bedding planes; interstratified with thin, ripple-marked quartz-sandstone beds and very calcareous gray shale. Feeding tracks and worm burrows are common in unit 35. The upper interval (No. 40-43 on Plate 4) is mainly gray to dark gray shale, very calcareous to non-calcareous, with thin beds of gray-yellow dolomite, and subordinate limestone beds which show intraformational reworking. No diagnostic fossils were found.

The overlying Cudi Group starts with dark bluish gray, fetid limestone and dolomite, thick-bedded to massive, oolitic in part, with fossil debris and abundant tiny gastropods. This lithology is comparable to unit (5) of the Geli Khana type section. It appears that only the strata of units (1) - (3) of the type section have correlatives in the much thinner section at Harbol. Unit (4) of the type section is not recognizable at all. There is abundant evidence of intraformational reworking at Harbol, and the great difference in thickness between the Harbol Geli Khana section and units (1) - (3) of the type section can easily be explained by intraformational condensation.

Unit (4) may be absent due to a non-depesitional hiatus at the base of the Cudi Group.

As the basal Cudi Group seems to include rocks correlative with units (5) and (6) of the type Geli Khana in Iraq, the section called Geli Khana Formation at Harbol by the author does not correspond to the entire Geli Khana as defined in Iraq. Unfortunately, field data and paleontological evidence available to date do not permit a separation of the suspected uppermost Geli Khana from the Cudi Group.

CUDI GROUP - MIDDLETRIASSIC?-MIDDLE/UPPER?CRETACEOUS

The conflicting accounts given by Taşman (1949, p. 26), Tolun (1962, p. 43), and Altınlı (1954, p. 10 and 12; 1962, pp. 64-65) of what the terms «Tanintanin Formation», «Cudi Group», and «Massive Limestone» signify will not be discussed here. The present author's usage of the term Cudi Group is fairly close to Altınlı's (1954).

The Cudi Group is defined by the writer to comprise all the rock units between the Goyan Group as described in this article and the Shiranish Formation or its equivalents (Upper Campanian). The bottom of the Cudi Group is a conformable contact although very probably a condensation horizon, the top is a major regional disconformity. Thickness of the Cudi Group in the Cudi Dağ - Harbol area is estimated to be about 1000 meters. Farther northeast, beyond Goyan, the thickness may be perhaps up to 2500 meters (Altınlı, 1954, p. 14).

The total lime span reflected by the Cudi Group sediments, including gaps in the geologic record, is probably from Middle Triassic to Middle or Upper Cretaceous. Our knowledge of the Cudi Group is very limited. Better than by words, this is demonstrated by the comparison of the Southeast Turkey stratigraphic nomenclature with the nomenclature in North Iraq on Plate 3.

The present author investigated only the lowermost 30 meters of the Cudi Group in detail. As has been discussed in the preceding text, this interval is probably correlative with the upper part of the Middle Triassic Geli Khana Formation in Iraq. The short section studied is limestone, dark gray to bluish black, very fine- to cryptocrystalline, emitting a strong fetid-gassy odor on impact, with crinoid remnants, shell debris, and tiny gastropods; some limestone is oolitic, some is dolomitized; also present are light gray to white dolomite beds, very fine- to fine-crystalline, and dark argillaceous partings. Some crinoid stem joints were determined to be either *Pentacrinus* (range of genus : Lower Triassic to Upper Jurassic) or *Holocrinus* (restricted to Middle Triassic).

The bulk of the Cudi Group in the Cudi Dağ - Şehabad Dağ area is fetid - smelling dolomite and limestone, but bands and discontinuous units of softer, marly - shaly (?) rocks were noticed from the distance. Altınlı (1954, p. 12) reports : «Black calcareous shales taper laterally. No key bed is detected; unconformities remained too local. Nevertheless future detailed mapping and measured sections may unravel the subdivisions». Berriasian, Barremian, and Cenomanian - Turonian fossils are listed by Altınlı (1954 and 1963), but it is not known from what part of the succession these fossils were collected.

In North Iraq, 13 formations have been differentiated within the gross interval correlative with the Cudi Group of Southeast Turkey. Four unconformities are indicated; see Plate 3. Based on experience in other areas of Petroleum District V, the author

suspects that at least two of these unconformities extend into the Cudi Dağ area : The unconformity at the base of the Cretaceous, probably with a much greater hiatus; and the unconformity near the Cenomanian/Turonian boundary.

Accounts of the disconformity at the top of the Cudi Group on the Turkey-Iraq border are given by Altınlı (1954, p. 12) and particularly by Wetzel (1959, in : Lex. Strat. Internat., Iraq, p. 62). This major break is well documented throughout Petroleum District V in surface sections on the Mardin Uplift and the Hazro Anticline, and in numerous wells drilled for oil (G. C. Schmidt, unpublished company report).

STRATIGRAPHIC CLASSIFICATION OF SOME OIL RESERVOIRS IN SOUTHEAST TURKEY

For these comments the reader is referred to Plates 1 and 3. The Mardin (Limestone/Dolomite) Formation, which falls within the Cudi Group, is yielding oil in the Kayaköy and Kurkan fields. The so-called «Raman Limestone», which is homotaxial and correlative with the Bekhme Limestone of North Iraq, is the reservoir in the Raman field. The formation lies disconformably on the Mardin in that part of District V. Another sedimentary break separates the «Raman» from the younger «Garzan Limestone» which is the reservoir in the Garzan, Germik, Batı Raman and Magrip fields. The «Garzan» is homotaxial and probably correlative with the Aqra Limestone of North Iraq, but the sedimentary break below its base is apparently not developed in North Iraq and southeastern District V. The terms «Raman Limestone» and «Garzan Limestone» are considered informal names by the author.

DESCRIPTION OF MEASURED SECTION SHOWN ON PLATE 4

Interval No. — *Lithology and Paleontology*

47-44 : Cudi Group- Undifferentiated Middle Triassic? - Middle I Upper? Cretaceous

47. Not studied in detail. Thickness estimate of 970 meters based on outcrops and supposed average axial plunge on southeast side of Cudi Dag. Elevations and distance taken from 1 : 200,000 topographic map. The gross lithology is massive and thick-bedded, resistant limestone, dolomitic limestone, but bands and discontinuous units of softer, marly-shaly (?) rocks are also present, as seen from a distance of a few hundred meters. The lower 300 meters, briefly studied west of Zini Dağ, are banded limestone and dolomite. Limestone: dull gray, very fine-crystalline, very dolomitic; the lighter-colored beds are the more dolomitic beds; fetid odor on impact.

46. 10 m - Limestone, very dark gray to bluish black, fine- to cryptocrystalline, bituminous, fetid-gassy odor when freshly broken, beds 10-40 cm thick, mostly evenly bedded, with very thin ar-gillaceous partings; small crinoid remnants (1-2 mm diameter) scattered through many beds, especially close to partings. Some limestone is oolitic, ooids 0.5 mm diameter, limonitic when weathered. Poorly preserved shell debris in some beds close to partings, tiny gastropods; joints of crinoid stems fairly well preserved : similar to *Pentacrinus* or *Holocrinus*. Dolomitization : Light brown nests of dolomite, 3 cm in diameter, have fine-crystalline sucrosic matrix with larger calcitic particles, e. g. crinoid stem pieces, still preserved.

45. 10 m - Dolomite, dull gray, fine-crystalline, beds 5 cm to 1.0 m thick; and limestone, dark gray to bluish black, very fine- to cryptocrystalline; some beds of gray limestone: 1 and 5-20 cm thick; some thin, platy limestone beds are sandy

Interval No. *Lithology and Paleontology*

with fine- to medium-size subangular quartz grains. Minor ferrugineous specks like oolitic limestone above. Thin partings of black shale throughout.

44. 10 m - Mostly dolomite, light gray to almost white, very fine-crystalline, thick-bedded to massive; at bottom : limestone, dark bluish gray, fine-crystalline, bituminous, thick-bedded, fractured.

43-34 : Geli Khana Formation of Goyan Group - Middle Triassic

43. 11.5 m - Shale, dark gray, some is calcareous, with 3 dolomite beds, gray-yellow; the upper one has an intraformational conglomerate at the top : lenticular, with angular pebbles of limestone, dark gray to bluish gray, fine-crystalline, bituminous. At base: Dolomite with limestone on top, fine-crystalline and finely fragmental (coquina), oolitic, with poorly preserved pelecypods.

42. 29 m - Shale, dark gray, fissile, hard, non-calcareous, with few dolomite beds, 5-30 cm thick, becoming thicker towards the top, yellowish gray, fine-crystalline.

41. 12.5 m - Dolomite, gray-yellow, very fine-to fine-crystalline, beds 50 cm thick, platy towards bottom and top, hard; near bottom : subordinate interbeds of gray shale and limestone, gray, fine-crystalline, platy, with worm burrows.

40. 32.5 m - 80% Shale, gray, very calcareous, fissile, hard, platy in part, with a few beds of dolomite, 5-10 cm thick, light gray to tannish yellow, fine-crystalline, and some thin limestone beds, gray, with intraformational «mud» conglomerates (synsedimentary reworking). In lower part: Several beds of intraformational limestone-conglomerate, 5 cm thick each. Limestone near base slightly sandy.

39. 31 m - Mainly limestone and calcareous shale, gray, platy sequence. Limestone: medium to dark gray, fine-crystalline and cryptocrystalline varieties, argillaceous, hard, some beds have pyrite; laminated by sandy streaks (quartz); intraformational limestone-conglomerates; also small channels (5-6 cm deep, 30 cm wide); few little gastropod cross-sections. Few sandstone beds: 10 cm thick, one 50 cm thick, light gray to white, fine- to medium-grained, subangular, fair sorting, apparently all quartz, very calcareous, hard, tight; tops with beautiful ripple marks.

38. 5 m - Dolomite, light tannish gray, very fine- to cryptocrystalline, thin-bedded, with gray shale and thin limestone beds.

37. 8.5 m - Limestone, gray, with more or less argillaceous and sandy streaks; tiny sandstone channels; minor shale, gray, very calcareous; thin-platy sequence. At bottom: some beds of sandstone, calcareous, grading to sandy limestone, fine-grained, 4-5 and 10-15 cm thick; and 1-2 cm thick sandstone lenses in dense limestone.

36. 9 m - Limestone, gray, fine- to cryptocrystalline, argillaceous, laminated by silt and fine-grained sand, wavy bedding; one bed of limestone-conglomerate, 10 cm thick, sandy, fragments from this section, granule- to small pebble-size; thin interbeds of gray shale, very calcareous, hard. All this a thin-bedded, platy sequence.

35. 10 m - Shale and limestone, gray, as above, thin-bedded. At top: thin beds of siltstone and very fine-grained sandstone, calcareous, tight, cross-bedded. Limestone near bottom has feeding tracks and worm burrows like *Rhizocorallium.*

Interval No. *Lithology and Paleontology*

34. 11m- Limestone, gray, fine- to cryptocrystalline, variably argillaceous, laminated by silty to very fine-grained sandy streaks; with intraformational limestone-conglomerates, sand channels and lime-mud channels. Questionable slump features. One bed of gray-violet shale about middle, very calcareous, hard.

33-25 : *Beduh Formation of Goyan Group - Lower Trlassie*

33. 5.5 m - Limestone etc. as above, with minor interbeds of gray and purple-violet shale. At top : about 1 m of purplish violet shale, with gradational contacts to the bracketing rock types.

32. 8 m - From bottom to top: Limestone, gray, fine- to cryptocrystalline, hard, thin - platy, and calcareous sandstone plates with wavy bottoms. Shale, violet-purple, very calcareous, grades up into limestone, brown-gray, dense, argillaceous, blocky disintegrating. Shale, violet-purple, calcareous, hard; near top: thin limestone, light gray, medium-crystalline, and 60 cm of very calcareous shale/argillaceous limestone, mottled red-greenish. At top 3-4 cm calcareous sandstone with ripple marks.

31. 48 m - Shale, purple-violet and partly red-brown, calcareous, fissile, hard, with numerous thin beds of quartzose sandstone, 0.5 to 1 to 10 cm thick, light gray to white, very fine-grained, angular to subangular, well sorted, calcareous, tight; tops have beautiful ripple marks, some single-set but also crossing of two ripple systems with angle of 90°; bottoms of sandstone beds often wavy; some beds 5 cm thick, medium- to coarse-grained, subround to round, all quartz, very calcareous, tight. Some sandstone beds are micaceous (muscovite). About middle: 1 m limestone, gray, fine- to cryptocrystalline, very thin-bedded; sandstone just below has poorly preserved shell molds.

30. 5 m - Limestone, gray, dense, some fragmental (organic?), interbedded with gray and violet-purple shale; thin-bedded platy sequence. Some ostracods. At top: 0.8 m shale, grayish violet to violet, with hard sandstone interbeds, 1-20 cm thick, medium- and silt-grained, all quartz, very calcareous, tight.

29. 7 m - From bottom to top: Limestone-conglomerate, angular fragments in yellow matrix, gray shale and yellow limestone, dense, silty. Limestone, gray, fine- to medium-crystalline, with Fe-stained patches, silty. Gray shale, very calcareous. Limestone, light gray, dense, splintery hard, thin-bedded, laminated by argillaceous and silty to fine-sandy streaks. Shale, violet-purple and gray, calcareous, with some 1-5 cm thick beds of siltstone and very fine-grained sandstone, very calcareous; shale evenly bedded, sandstone with wavy bedding.

28. 8 m - Shale, gray, non-calcareous, blocky disintegrating, with 2-10 cm thick stringers of yellow siltstone and sandstone.

27. 3 m - Shale,mostly violet-purple, overlain by limestone-conglomerate, yellow siltstone, gray shale; and limestone, light gray to yellow, fine-crystalline, vuggy : may have been evaporitic.

26. 6.5 m - From bottom to top: 0.7 m Shale-conglomerate, angular pebbles of gray shale in yellow calcareous matrix, top gradational; solution breccia? 1.2 m Shale, gray, thinly laminated. 1 m Limestone, yellow, fine-crystalline, slightly dolomitic,

Interval No. *Lithology and Paleontology*

soft, with some gray shale pebbles. 3.6 m Conglomerate with very disturbed bedding, may be solution breccia; in calcareous matrix: angular shale fragments, pebble- to boulder-size, violet-purple and gray; also yellow limestone pebbles, angular.

25. 7 m - Shale, violet-purple, fine-blocky disintegrating, with interbeds of limestone and dolomite, light gray to yellow, fine- to cryptocrystalline, with sandy streaks 1-2 cm thick. The upper 2 m are gray shale, thinly laminated, slightly calcareous, with thin dolomite beds, light brown, slightly calcareous.

24-21 : Mirga Mir Formation of Goyan Group - Lower Triassic

24. 27.5 m - Limestone, gray, fine- to cryptocrystalline, variably argillaceous, has features of synsedimentary reworking in lime-mud, laminated by silty and sandy streaks; scattered throughout are 5-10 cm beds of calcareous sandstone, very fine-grained, subangular, well sorted, finely micaceous (muscovite), more sandstone in lower part of interval. With thin interbeds of gray shale, very calcareous. Shale near top dark gray, slightly calcareous. All this a thin-bedded, platy sequence. Poorly preserved casts of pelecypods, fairly abundant worm burrows and feeding tracks.

23. 10.5 m - Limestone similar to above, gray, hard, platy, some is slightly pyritic. Casts of pelecypods, imprints of seaweeds (?).

22. 9 m - Same limestone as above, with few thin shaly partings, but more abundant shell remains; probable mud cracks. Monospecific shell assemblages, very small (probably brackish environment). Few bedding planes covered with good impressions of *Pseudomonotis (Claraia) clarai* Emmrich (Lower Triassic, Werfenian).

21. 20 m - Limestone, gray, fine- and cryptocrystalline, variably argillaceous, laminated by silty and very fine-grained sandy streaks, hard, platy and in 30 cm thick beds, Fe-stained when weathered, with fine mica (muscovite) on the sandy bedding planes.

20-7 : *Harbol Formation - Permian (perhaps Permo-Triassic ? at top)*

20. 3.6 m - Limestone, medium to dark gray, very fine- to fine- to medium-crystalline, hard, thick-bedded to massive, oolitic in part, with big stylolites; intraformational pebbles near top; wavy laminations.

19. 1.25 m - Limestone, yellowish, thinly laminated, silty, mica (muscovite) on bedding planes.

18. 18.5 m- Limestone, gray, appears medium-crystalline but is oolitic almost throughout, cross-bedded, with big stylolites, slight fetid odor on freshly broken surface, ooids weather out limonitic; thick-bedded to massive unit. In lower part some very fine- to fine-crystalline limestone, brown-gray and dolomitic near bottom; wavy bedding surfaces. At bottom : Extensive lensing, with intraformational conglomerate : brown-gray, very fine-crystalline limestone boulders in gray shale matrix.

17. 4.5 m-Limestone as in lower part of unit 18, but thin-bedded, less resistant, caves in on cliff faces.

Interval No. *Lithology and Paleontology*

16. 6.5 m- Limestone, dark bluish black, fine-to cryptocrystalline, many zones finely organic-fragmental, thick-bedded to massive, in lower part thin-bedded and nodular, wavy surfaces. Bottom very fossiliferous : Crinoids, brachiopods *(Productus* sp. sp.), algae, small Foraminifera. Lime-secreting algae throughout unit: *Mizzia velebitana* Schubert, *Gymnocodium bellerophontis* (Rothpletz).

15. 1.9 m-Sandstone, massive bed, faint 30 cm bedding within, fine- to medium-grained, angular to subangular, fair sorting, all quartz, calcareous, tight.

14. 6 m - Limestone, brownish dark gray, very fine- to cryptocrystalline, thin nodular bedding, with silty streaks, very fossiliferous. At top gray shale with dark blue-gray to black, nodular limestone. Abundant brachiopods : *Productus* sp. sp., *Schellwienella* cf. *crenistria* (Phillips) ; also many crinoids, algae.

13. 45 m - Limestone, dark bluish gray, thin-bedded (10-30 cm) and nodular, with thin argillaceous partings, very fossiliferous like unit 16. Some cryptocrystalline limestone is sterile.

12. 180 m-Limestone, dark gray to black, fine-and some very fine-crystalline to cryptocrystalline, thick-bedded to massive, upper 60 m very resistant: Gorina Dağ cliff. Most beds 0.30-1.50 m thick. Fetid odor when freshly broken. Some beds in upper part with black to smoky gray chert concretions. Thick units of organic - fragmental limestone, mostly algal *(Mizzia velebitana* rock-forming), also many small Foraminifera : Species of *Palaeolingulina, Palaeotextularia, Pachyphloia, Robuloides, Glomospira.* (Determined by Miss Solmaz Erdoğan of Mobil.) Abundant brachiopods, gastropods *(Bellerophon* sp.). The average bed thickness decreases downward, with complementary increase of subordinate interbeds of dark gray to black shale.

11. 3.5 m-Limestone, dark gray to black, very fine- to cryptocrystalline, splintery hard, conchoidal fracture; beds 10-85 cm thick. Some similar limestone argillaceous, softer. Interbedded with black shale, fissile, hard, non-calcareous.

10. 7 m - Cross-bedded, lenticular sequence of: Sandstone, light gray to white, very fine-grained, angular, well sorted, almost entirely quartz; most is finely laminated by argillaceous material, hard, slightly quartzitic, non-calcareous; lensing beds 1.5-Om thick, pinchouts within 2 m laterally; most beds 20-50 cm thick; slightly micaceous (muscovite). Shale, black, fissile, non-calcareous; and clay-silt-sand mixture types, slightly micaceous. Some plant remains (Middle to Upper Permian flora like the one published from the Hazro Anticline by Wagner, 1959 (D. W. Gossage of Shell, verbal communication).

9. 5 m-Shale, black, and thin-bedded limestone like unit 11.

8. 7.5 m-Limestone like unit 11, in 20-50 cm thick beds, with thin black shale interbeds and partings, slightly calcareous; some limestone is very sandy, contains fine, angular quartz grains; 1 m in lower part is organic-fragmental, containing abundant algae and small Foraminifera. *Mizzia* cf. *velebitana* Schubert, *Robuloides* sp., *Glomospira* sp.; brachiopods, *Schellwienella?.* (Determined by Miss Solmaz Erdoğan of Mobil.)

Interval No. *Lithology and Paleontology*

7. 3 in-Sandstone, light gray to white, very fine-grained, angular, well sorted, all quartz, micaceous, calcareous, hard, tight, weathers yellow; cross-bedded, wedging, ripple-marked. Shale, black, fissile, calcareous.

6. 2.4 m-Limestone, dark gray to black, very fine-crystalline, some is sandy and nodular; with worm feeding tracks. Shale, black, soft.

5. 3.5 m-Black shale filling pockets in limestone surface below; overlain by dark gray to black limestone as in unit 4, slightly sandy at top. Followed by sandstone, gray-white, very fine-grained, angular, well sorted, calcareous, hard, tight, evenly bedded, bottom slightly friable. Feeding tracks or worm burrows on bedding planes.

4. 3 m-At bottom sandstone, dark gray, very fine-grained, argillaceous, micaceous, slightly calcareous, tight. Overlain by limestone, dark gray to black, very fine- to cryptocrystalline, beds 10-30 cm thick. Overlying shale fills pockets in upper limestone surface.

3. 4.2 m-At bottom shale, black, non-calcareous, followed by limestone, dark gray to black, very fine- and cryptocrystalline, with slight sand content in places, 5 cm thick black shale interbeds; some wavy bedding.

2. 4 m-Limestone as in unit 3, even beds of 10-60 cm thickness, with 2-20 cm thick beds of black shale.

1. 6 m-Limestone, dark gray to black, very fine- and cryptocrystalline, splintery hard, mostly massive, some nodular, in lower part thin-bedded with dark gray to black shale interbeds, calcareous algae and Foraminifera. *Mizzia* sp., *Glomospira* sp., *Robuloides* sp. (Determined by Miss Solmaz Erdoğan of Mobil.) *Productus* sp. in float. Small nests of pyrite.

Lowest exposed bed, bottom of stream.

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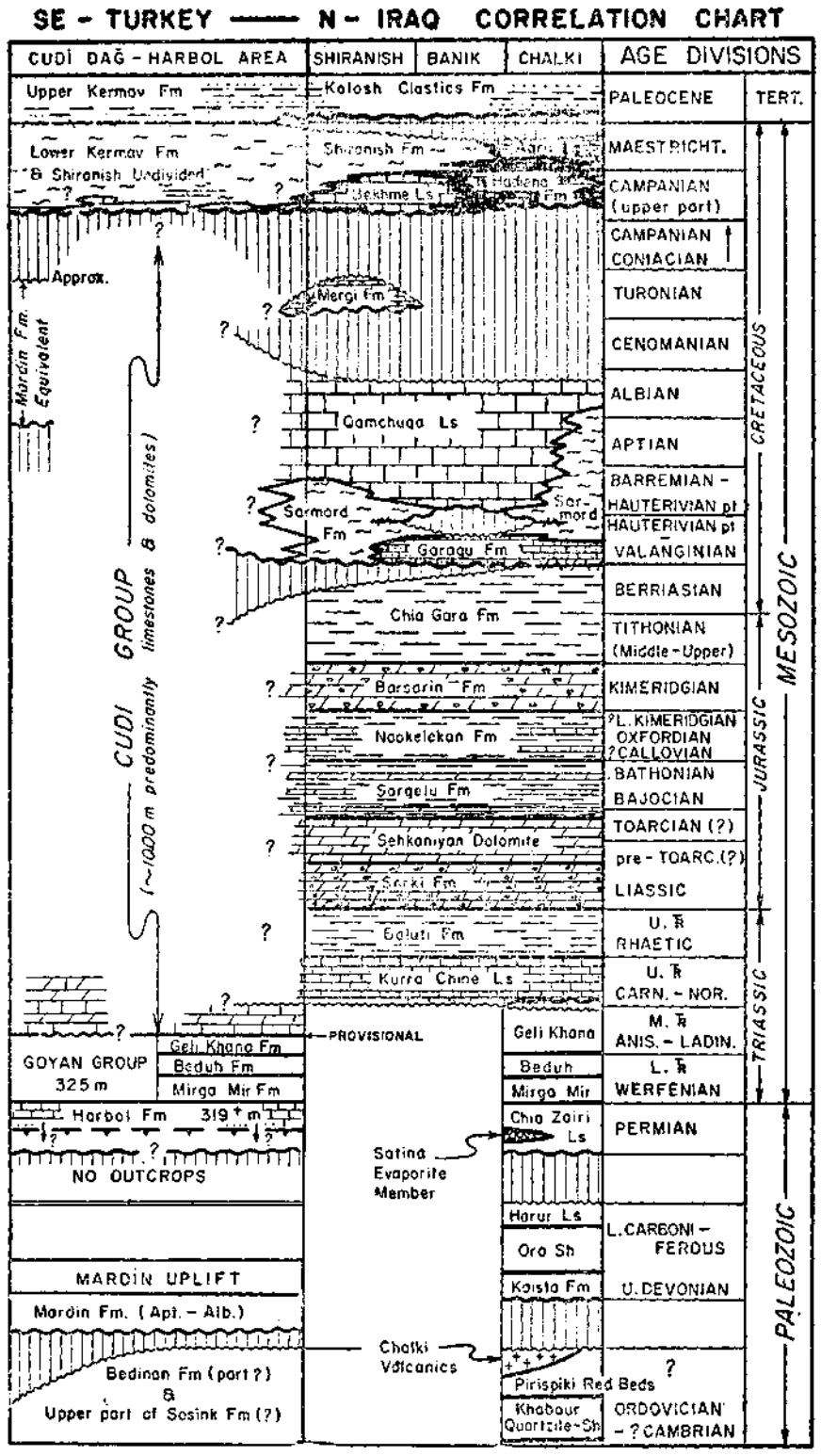
SE - TURKEY —— N - IRAQ CORRELATION CHART



LEGEND

- Shale
- Marl
- Limestone
- — " — , oolitic
- — " — , sandy; Garagu Fm : Oolites, sdy marls, marly detrital limestone, coralline limestone, sands.
- Dolomite / Limestone with residual solution breccias.
- Sandstone & shale
- Time plane
- Formation boundary
- Erosional and / or depositional break (where shown in direct contact with overlying formation indicates break of unknown or slight duration; where shown below a non-sequence indicates top of eroded lower formation).
- Base of transgressive formation following a non-sequence.
- Break of unknown or slight duration passing into non-sequence of assessed time value.
- Doubtful erosional or depositional break or condensation horizon, corresponding to a formation boundary.

NOTE : SHIRANISH - BANIK - CHALKI CORRELATION taken from PLATE II of LEX. STRAT. INT. - VOL. III, FASC 10 a (IRAQ)

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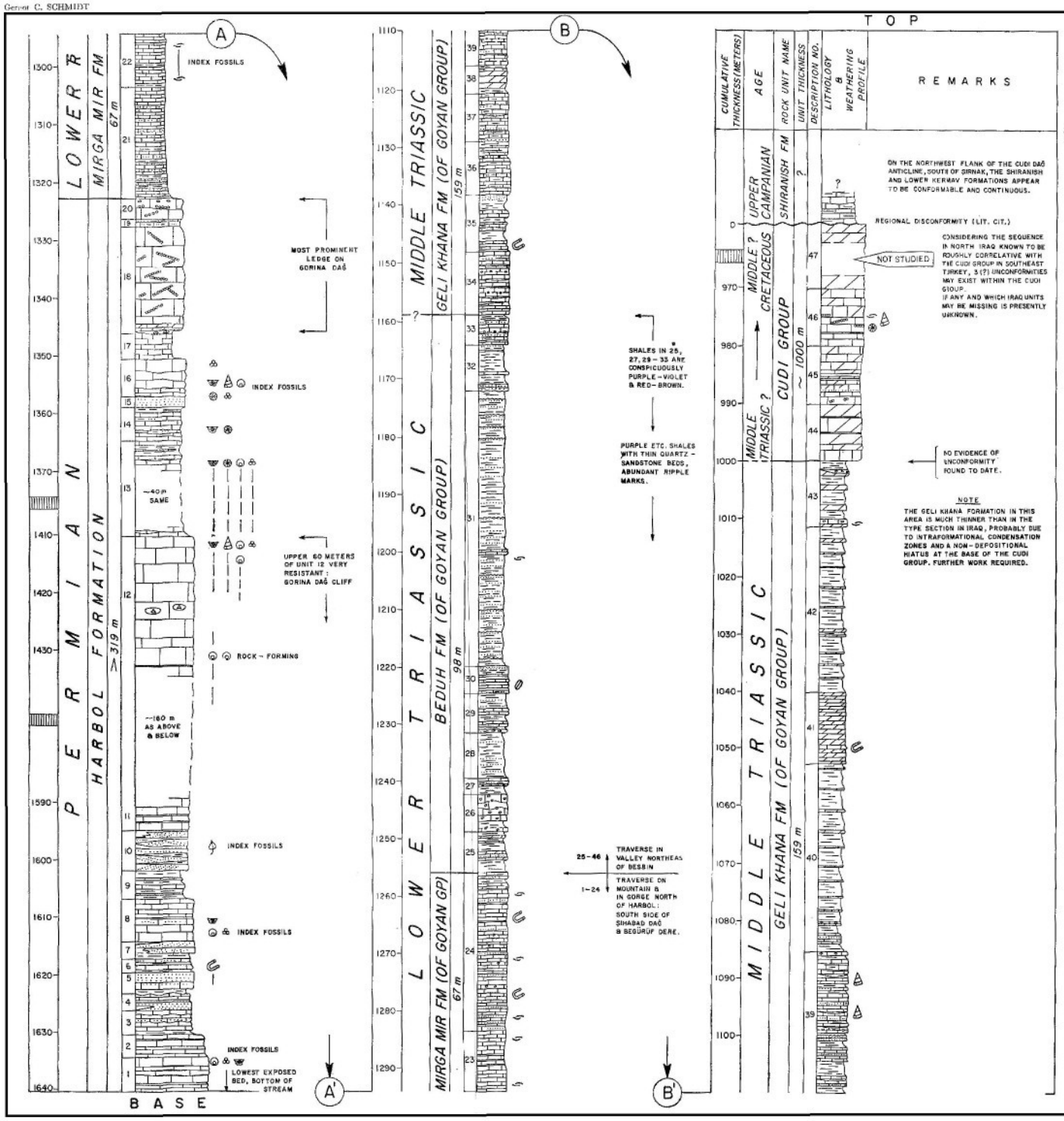

COLUMNAR SURFACE SECTION

COMPOSITE

EASTERN CUDI DAĞ - HARBOL AREA

PERMIAN TO CRETACEOUS

BY
G. C. SCHMIDT
1959/60

THICKNESSES OF DETAILED ROCK UNITS OBTAINED BY DIRECT TAPE MEASUREMENT AND ON COMPASS - TAPE TRAVERSES.
FIELD ASSISTANT: ÖZCAN YASA.

SEE PLATE 2 FOR LOCATION OF TRAVERSES.

LEGEND

- DOLOMITE
- LIMESTONE
  - dolomitic
  - oolitic (cross-bedded)
  - argillaceous - shaly
  - with chert concretions
  - with sand channel at top
- SHALE (incl. calcareous)
- SILTSTONE
- SANDSTONE
  - cross-bedded & ripple-marked
- CONGLOMERATE
- INTRAFORMATIONAL CONGL. & SOLUTION BRECCIAS

- PELECYPODS
- BRACHIOPODS
- GASTROPODS
- OSTRACODS
- FORAMINIFERA
- CRINOIDS
- LIME-SECRETING ALGAE
- WORM BURROWS AND TRACKS
- PLANTS

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