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The Mauddud-Wara contact in the Greater Burgan Oil Field—a possible unconformity surface

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ABSTRACT

The Mauddud Formation is one of the important reservoir rocks in Kuwait. It ranges in thickness from a few metres to about a hundred metres. The unconformity surface can be demarcated by using the following criteria: the variation in thickness of the Mauddud Formation in the study area as compared to that in other localities, the abrupt change from the Mauddud limestone to the Wara sandstone, the presence of dedolomitisation features near the top of the formation, and the effect of chemical weathering on glauconite which results in the precipitation of hydrated iron oxides and alunite.

INTRODUCTION

The early Middle Cretaceous Mauddud Formation is a widespread lithostratigraphic unit in the Arabian Gulf region. Its type section is Dukhan well No. 1, Qatar. In the Greater Burgan Oil Field (Burgan, Magwa and Ahmadi) (Fig. 1), the formation is conformably underlain by the Burgan Formation and is overlain by the Wara Formation.

Five hundred and fifty core samples representing the formation were collected from thirteen wells distributed throughout the Greater Burgan Oil Field. The cores were examined under a binocular microscope and samples were taken at equal intervals to get a fairly representative selection of the major lithologic changes. One hundred samples were chosen for thin sectioning and petrographic examination.

The purpose of this study is to throw some light on the Mauddud-Wara contact in the Greater Burgan Oil Field in Kuwait.

DISCUSSION

Based on the lithologic description, petrographic examination, and comparison of the Mauddud Formation in Kuwait and nearby areas, the following observations were made:

1. Thickness distribution of the Mauddud Formation. The Mauddud Formation can be traced in different countries of the Middle East. The average thickness of the formation in Kuwait and nearby countries is illustrated in Fig. 2. From this it is apparent that the

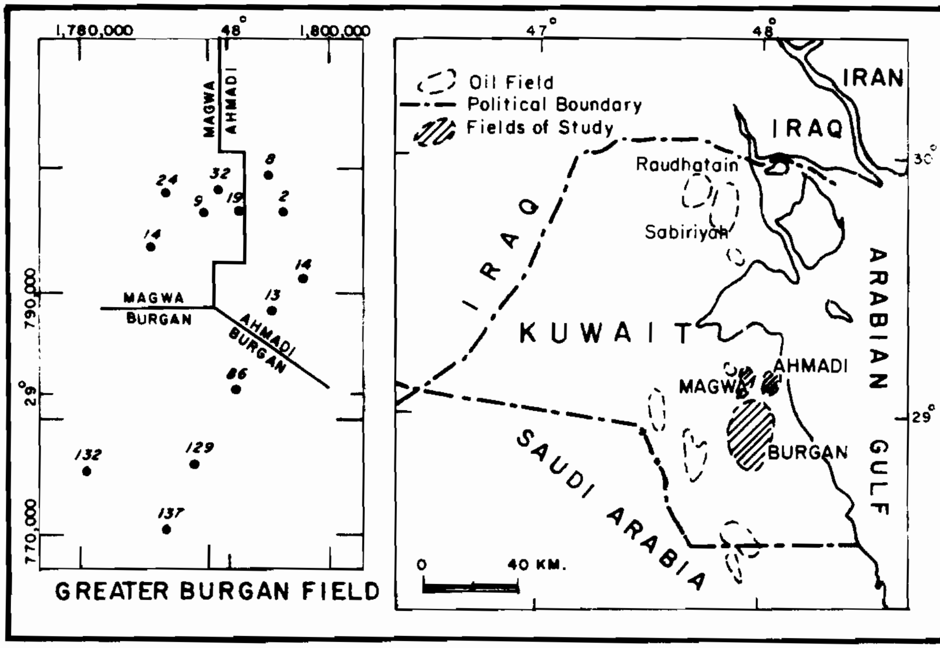

Fig. 1. Location map of studied fields and wells.

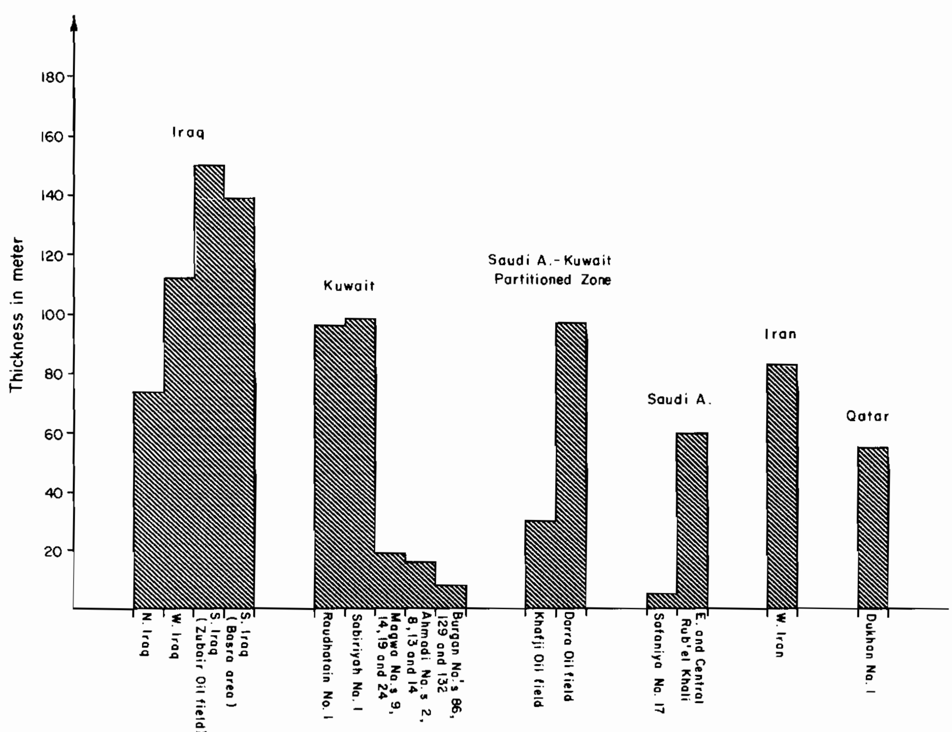

Fig. 2. Thickness distribution of the Mauddud Formation in Kuwait and nearby countries.

minimum average thickness is in the Greater Burgan Oil Field (BG., MG. and AH.). Moreover, a study of microfacies of the Mauddud Formation revealed that seven different microfacies are present in Raudhatain No. 1, and eight microfacies in Sabiriyah No. 1. The southern wells contain four microfacies in Burgan No. 129 and three microfacies in Magwa No. 26, while there are only two microfacies in Ahmadi No. 2. This is attributed to the obvious thickening of the Mauddud Formation in northern Kuwait (Al-Shamlan 1980). The noticeable thinning of the Mauddud Formation in southern Kuwait is due to either: (a) deposition over a pre-existing elevated area followed by a faster rate of erosion as evidenced by a high-energy environment which prevailed intermittently during the deposition of the formation (Al-Shamlan 1980). These deposits were in a shelf area and close to the basinal margin; (b) smaller subsidence during deposition in the south compared with greater subsidence in the north.

Because of the great difference in thickness between the Mauddud Formation in northern and southern Kuwait (about 84 m) in relation to the relatively short distance between them (about 80 km), the effect of erosion cannot be ignored.

2. Mauddud limestone and Wara sandstone. Prior to Mauddud deposition, the area of study was part of an extensive sea undergoing heavy regressive sedimentation represented by the Burgan sandstone (Al-Shamlan *et al.* 1981). This was followed by a marine transgression and the inundation of the shelf which gave rise to the Mauddud Formation in the northern Arabian Gulf. The Mauddud limestone is partly regressive as it gave way to the deposition of the regressive Wara sandstone.

The abrupt changes from transgressive Mauddud limestone to regressive Wara sandstone are also considered suggestive evidence for a hiatus either due to erosion or non-deposition at the contact between these two formations.

3. Dedolomitisation phenomena. Dedolomitisation is usually a surface phenomenon related to weathering surfaces and hence is commonly found below unconformities (Evamy 1967; Braun & Friedman 1969). De Groot (1967) has shown experimentally that the process of dedolomitisation requires a high rate of water flow to remove the Mg^{++} formed, and to keep the ratio of Ca^{++}/Mg^{++} in water constantly high. A carbon dioxide partial pressure considerably lower than 0·5 atm and a temperature not higher than 50°C are also needed. All of these conditions suggest that dedolomitisation is a 'near surface' process.

In the present study the term dedolomitisation is used to describe replacement of secondary dolomite by calcite to differentiate it from calcitisation which includes in part replacement of dolomite by calcite.

Dedolomitisation is observed in most of the studied wells at or near the top of the formation. It either occurs as a partial replacement of individual dolomite crystals (Figs 3 and 4), or a complete replacement of the dolomitised areas (Figs 5 and 6). Some of the remaining, irregularly shaped dolomite is scattered at random through the replaced crystals. Other secondary dolomite crystals are pseudomorphically replaced by calcite. The occurrence of relics of dolomite crystals which were not completely replaced, can also be observed.

There is no direct evidence as to when such a process might have taken place, but most investigators agree that it is a surface phenomenon related to periods of exposure (Goldberg 1967). The Dunkove-Lebedynsk beds are dedolomitised in boreholes at a

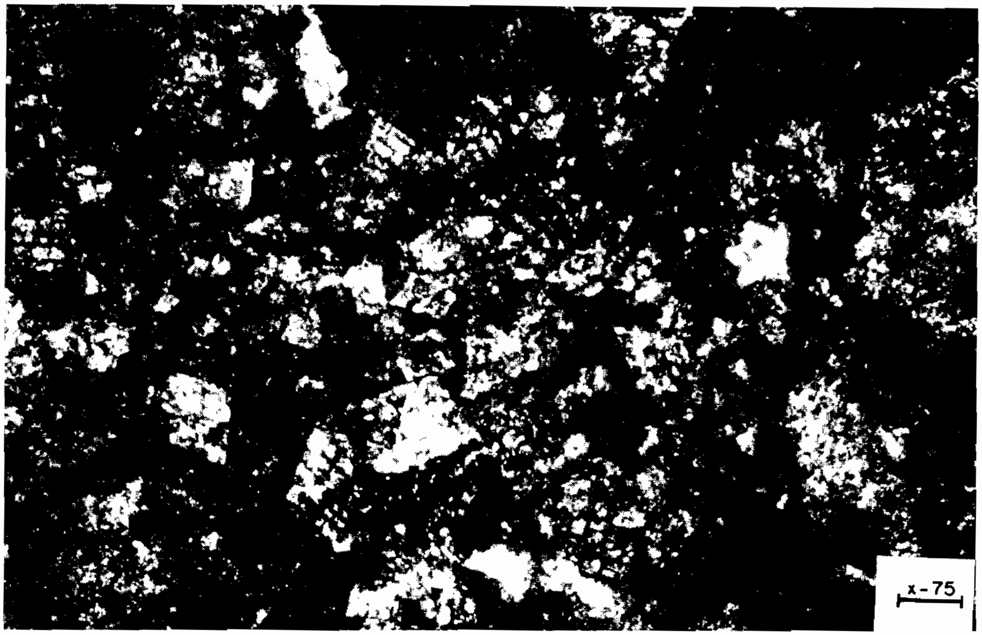

Fig. 3. Partial replacement of individual dolomite crystals (MG. 19, stained).

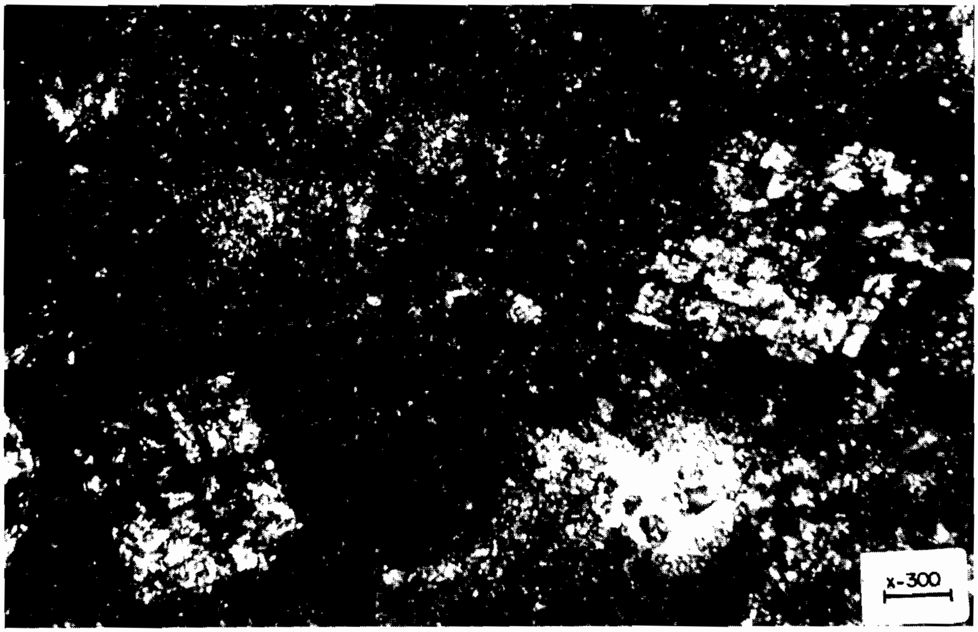

Fig. 4. Pseudomorphically replaced crystals of dolomite by calcite embedded in a micrite matrix (AH. 8, stained).

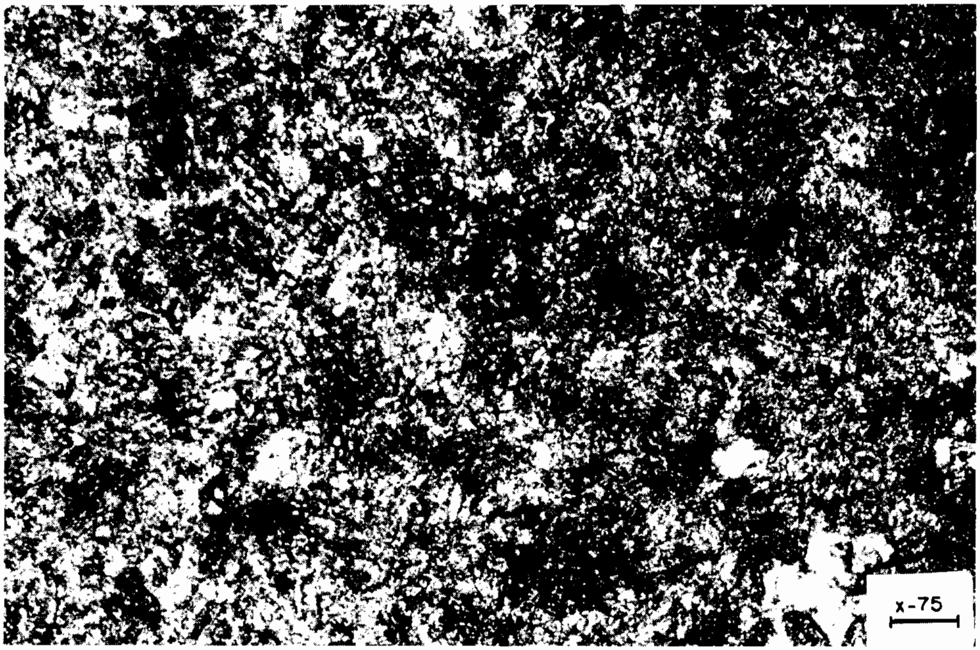

Fig. 5. Partial to complete replacement of the dolomitised area. The white patches represent pore-filling sparry calcite (AH. 8).

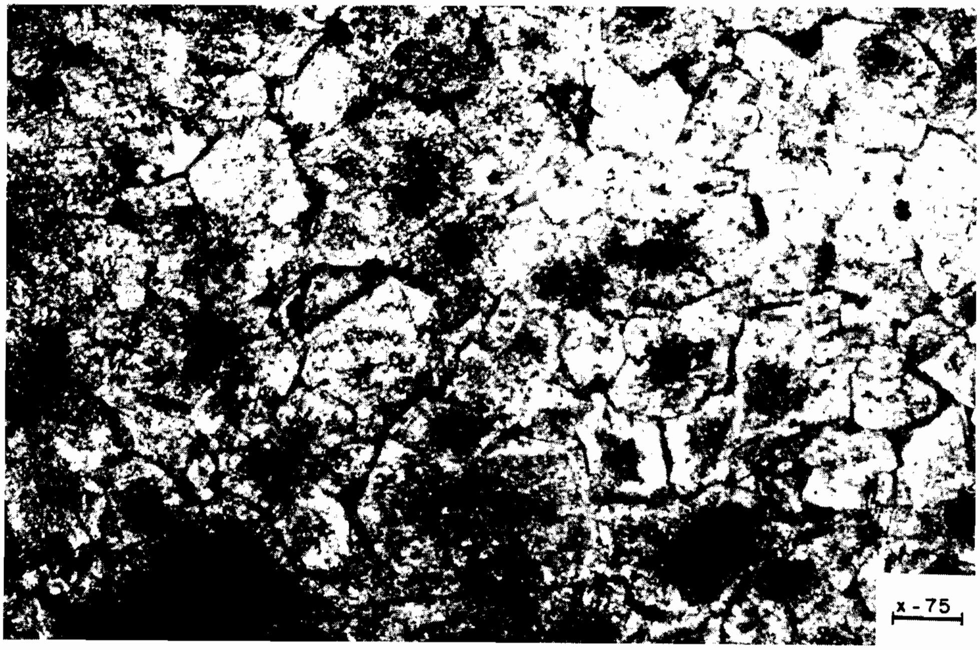

Fig. 6. Dark clots within some crystals of calcite are present. The clots are suggestive of original dolomite rhombohedra with dark centres, which are likely to be the product of dedolomitisation (MG. 19).

depth of several hundred metres, but only in areas where they are overlain unconformably by younger sediments (Mukhalaev 1957 in Goldberg 1967). Schmidt (1965) also found dedolomitisation in the Gigas beds (Upper Jurassic) in northwest Germany, where Lower Cretaceous shales transgressively overlie Jurassic beds, and that dedolomitisation in the Jurassic rocks increases as it approaches the unconformity.

The importance of the dedolomitisation mechanism in carbonate rocks at depth, as suggested by Al-Hashimi & Hemingway (1973), has been found to convert highly impermeable and impervious dolomitic rocks into a porous and permeable state. Consequently it may help in the prediction of potential oil or gas reservoirs in addition to the presence of the unconformity surface.

4. Distribution and alteration of glauconite. Subangular to subrounded glauconite grains cemented by sparry calcite are abundantly present. Other elements occasionally found are fine angular quartz grains and scattered pyrite crystals. The sequence of micrite, dolomite and glauconite at the top of the formation is characteristic of all the wells where glauconite is found (Fig. 7). Colour of glauconite varies from dark green for detrital grains to light green for diagenetic glauconite and greenish yellow for the chemically weathered glauconite (Fig. 8). During weathering the glauconite changes from dark green, smooth lustrous grains through a pale green less smooth and lustrous phase to a completely brown type of grain (Loveland 1981).

In the study area some glauconite grains are altered to limonite, alunite and α-quartz (El-Sharkawi & Al-Awadi, personal communication). The colour change of glauconite, the precipitation of brown limonitic material and the formation of alunite were regarded to be the ultimate outcome of surface weathering of glauconite (El-Sharkawi & Khalil 1977).

In advanced stages of alteration, glauconite may be completely leached, while limonite and alunite are preserved. The released silica can be traced in the underlying sediments as α-quartz.

The widespread presence of glauconite grains at the top of the formation in some wells and its absence in others (as indicated in Fig. 9) is also considered an indication of a lapse in time of erosion or non-deposition.

SUMMARY AND CONCLUSIONS

The authors hope that this study has thrown some light on the Wara-Mauddud contact in the Greater Burgan Oil Field. It is evident that the Mauddud Formation in the study area is disconformably overlain by the Wara Sandstone Formation. The minimum average thickness of the formation is in the area of study. Moreover, the microfacies study revealed that these facies are reduced in the south as compared to the north. The abrupt changes from transgressive Mauddud limestone to regressive Wara sandstone, the presence of dedolomitisation at or near the top of the formation and the distribution and alteration of glauconite grains due to chemical weathering, are considered as good evidence for a hiatus, either due to erosion or non-deposition at the contact between these two formations.

Intertonguing of sand and shale has been reported in the Mauddud Formation of the Greater Burgan Oil Field in Kuwait (El-Sayed 1978). Ibrahim (1981) attributed these tongues to the Nahr Umr and Wara Formations. The present investigation

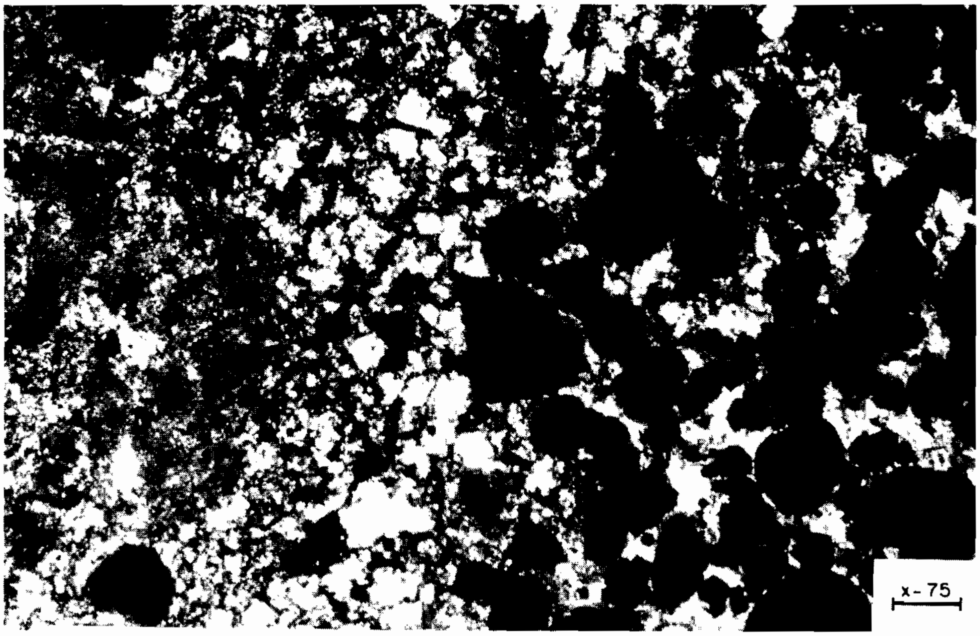

Fig. 7. Mauddud-Wara contact where micrite, dolomite and glauconite are present (MG. 9).

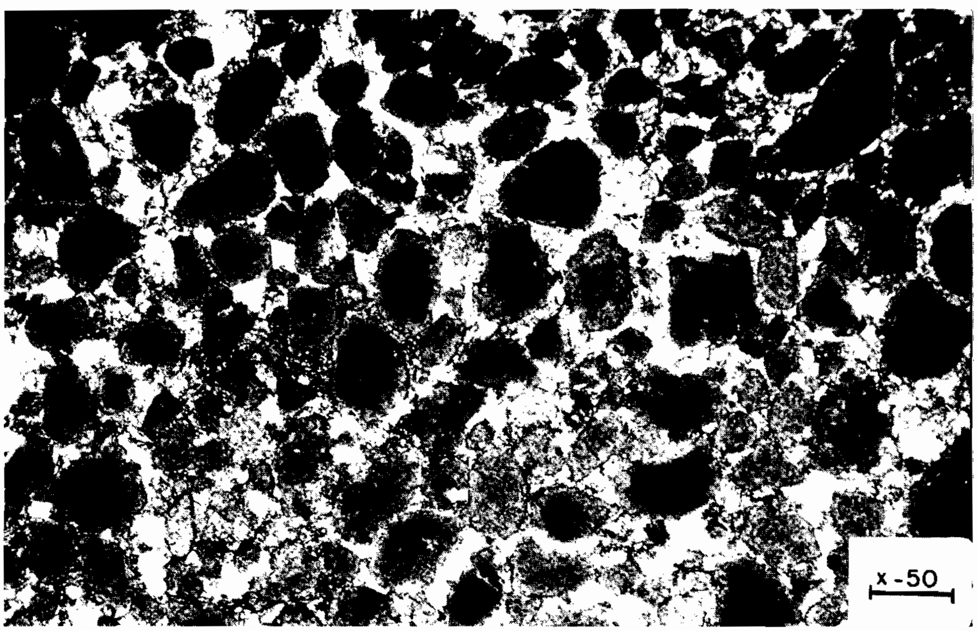

Fig. 8. Fine to coarse subangular to subrounded glauconite grains cemented by sparry calcite (MG. 19).

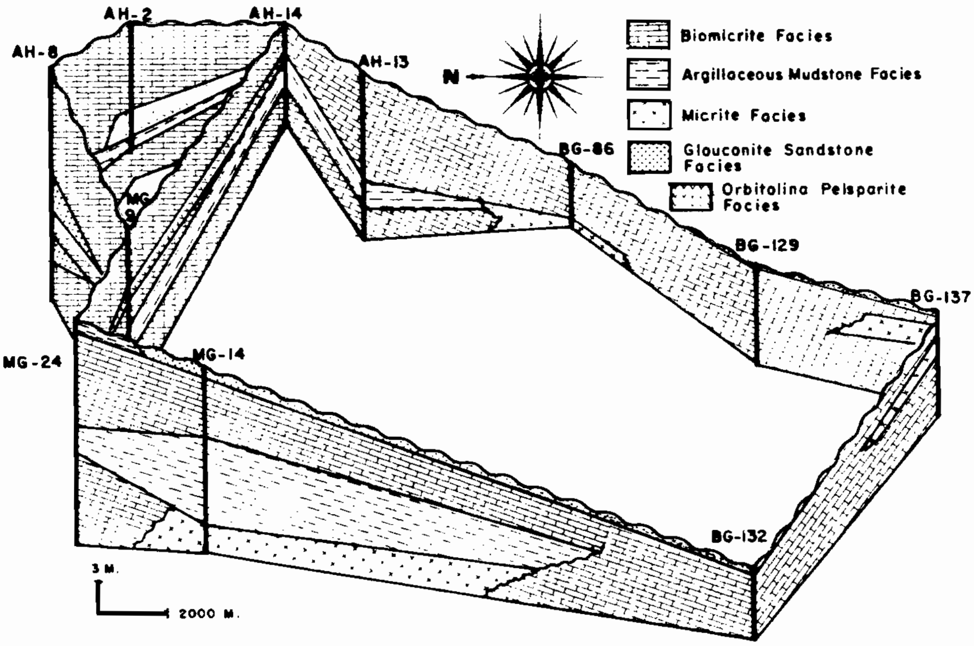

Fig. 9. Panel diagram showing distribution of the different microfacies in the study area (after Al-Shamlan *et al.* 1981, with modifications).

suggests that the Mauddud Formation in the study area is underlain by the Burgan Formation and overlain by an unconformity surface.

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تماس المودود والوارة في حقل البرقان النفطي الاكبر كاحتمال لسطح عدم توافق

على عبد الله الشملان
قسم الجيولوجيا بجامعة الكويت

محمد ابراهيم على السيد
معهد الكويت للابحاث العلمية

خلاصة

يتناول هذا البحث دراسة تلامس تكوين المودود والوارة في حقل البرقان النفطي الاكبر. وتشير الدراسة الى احتمال وجود سطح عدم توافق اعتمادا على الشواهد الاتية : ١ ـ الاختلاف في سمك تكوين المودود في منطقة الدراسة مقارنة بالمناطق المجاورة والتي تشمل السعودية والعراق وايران وقطر والمنطقة المحايدة ، بالاضافة الى حقول النفط الواقعة في شمال دولة الكويت . ٢ ـ التغير الفجائي في طبيعة الرواسب ما بين المودود الجيري والوارة الرملية . ٣ ـ وجود ظاهرة اعادة الدلمتة بالقرب من سطح تكوين المودود . ٤ ـ التجوية الكيميائية لمعدن الجلوكونيت والتي نتج عنها ترسيب أكسيد الحديد المائي ومعدن الالونيت .