TYPES OF STROMATOLITES IN THE BARSARIN FORMATION (LATE JURASSIC), BARZINJA AREA, NORTHEAST IRAQ

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ABSRTACT

The present study aims to record and describe, for the first time, the occurrence of Barsarin Formation in the Barzinja area (northeast of Iraq) and to provide more details on the limestone succession that contains both laminated and nodular massive beds. Sixty eight samples have been collected from this succession from which more than 68 thin sections have been prepared and studied under binocular and polarized microscopes. Based on the thin sections studies and field observations of outcrops, it is proved that both laminated and massive limestones belong to cryptalgal stromatolite. Morphologically, the examined stromatolites can be divided into four types: Planer, Wavy, Columnar and Spheroidal (oncoidal) stromatolites. The first two types occur as laminated limestone, (mat) while the other two types form more or less massive limestone beds. The formation, as a whole was deposited in a semi-closed lagoon (as a part of rimmed shelf) of an attached carbonate platform, which persisted in a low energy lagoon. The laminated and massive limestones were deposited in protected lagoon within intertidal and subtidal environments, respectively. The lower part suffered from short duration of wave agitation and bioturbation, which are represented by occurrence of rip-up clasts around which oncoids are grown.

أنواع الستروماتولايت في تكوين بارسرين (الجوراسي المتأخر) في منطقة برزنجة، شمال شرق العراق

هيام صالح داود و كمال حاجي كريم

المستخلص

إن الهدف من هذه الدراسة هو استكشاف ووصف تكوين بارسرين (للمرة الأولى) في منطقة برزنجة، شمال شرق العراق وكذلك محاولة الوصول إلى معلومات وافية حول تعاقب الحجر الجيري الرقائقي والعقدي. تم جمع ثمانية وستين عينة من المقطع وتم تحضير نفس العدد من الشرائح الرقيقة، حيث تمت دراستها تحت المجهر العادي والمجهر المستقطب.

استناداً إلى دراسة الشرائح والملاحظات الحقلية، فقد تم التوصل بأن كلا النوعين من الحجر الجيري الرقائقي والكتلي المتماسك ينتميان إلى الستروماتولايت الطحلبية التي تنقسم حسب شكلها الظاهري إلى أربعة أنواع: مستوية، تموجية، عمودية، عقدية. إن الستروماتولايت المستوية والتموجية تشكلان الحجر الجيري الرقائقي بينما العمودية والعقدية تشكلان الحجر الجيري الكتلي المتماسك. بيئياً، ترسب التكوين في بحيرة شاطئية شبه مغلقة (semi-closed lagoon) كجزء من الرف القاري الكاربوناتي. في هذه البيئة، ترسب كلا النوعين من الحجر الجيري (الرقائقي والكتلي المتماسك) في بيئتي: بين المدية وتحت المدية، وعلى التوالي. فالجزء السفلي من المقطع قد تعرض لفترات قصيرة للأمواج وكذلك التعكرات الحياتية، حيث يظهر ذلك واضحاً من قلع الحبيبات (بواسطة الأمواج) التي تشكلت حولها بعد ذلك الستروماتولايت العقدية.

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INTRODUCTION

This paper focuses on laminated and nodular limestones of Barsarin Formation (Late Jurassic) from northeast Iraq. The studied area is located 2 Km northeast of Chinara village, about 10 Km east of Barzinja Town (Fig.1). The Barsarin Formation was indicated in the field using available geological map (Sissakian, 2000) and its characteristic lithology.

According to the tectonic classification of Iraq (Buday and Jassim, 1987 and Jassim and Goff, 2006), this area is located in the Imbricated Zone and consists of large and small anticlines, which are overturned towards southwest (Fig.2). The Zagros Thrust boundary is no more than 5 Km far from the studied section. The sampled section runs along a road cut, which is located about 1 Km north of Bywak village (Figs.1 and 2). Where the terrain conditions permit, other sections were examined, such as the one located south and east of Chinara village but, they are partly exposed. A total number of 68 samples have been collected, and petrographically studied.

According to Bellen *et al*. (1959), the Barsarin Formation was defined by Wetzel in 1950 in unpublished report. The type section is located near the Barsarin village in Rawanduz area (Erbil Governorate), approximately 200 Km northwest of the studied area, along the same mountain chain.

The studied section has thickness of about 63 m (Fig.3), which increases and becomes more massive toward west, while in Ru Kuchuk River, the thickness reaches 60 m and consists of limestone, dolomitic limestone with laminated and fluffy textures with brecciated and folded beds. Jassim and Goff (2006) attributed the existence of breccia to dissolution of anhydrite, which was observed in some outcrops in Ser Amadiya and Kurrek Mountains (Bellen *et al*., 1959), they claimed that the environment of the formation is lagoonal often evaporitic. They have not found fossils due to strong recrystallization and dolomitization.

ORIGIN OF THE LAMINATIONS

Most of the studied section, except the lower part consists of very thinly laminated limestone with few meters of massive limestone beds (Figs.4 and 5). These laminations are the most diagnostic features of the limestone in the section and can be recognized in both hand specimens and in thin sections. The lamination consists of regular alternation of light and dark grey dolomitic and partially recrystalized limestone (Fig.4B and C). The thickness of these laminae ranges between 3 mm to several cm. The lamina are parallel and either planar or more or less crinkled (Fig.6).

The boundaries between the laminae are sharp, due to the pressure solution and formation of stylolites. The constituents of the laminae (as a whole) are highly modified by recrystallization, dolomitization and pressure solution. The dark and light laminae are only distinguishable in some thin sections due to recrystallization, while the stylolites are well observed in thin sections rather than in hand specimens. But, the laminae when seen by naked eye, seem to be well differentiated by surface weathering, by which the light lamina appear as granular (silty) zones, while the dark ones show smoother and clotty texture (Fig.6C).

The present appearance of the stromatolites and their modification are similar to what is shown by Park (1976) in Fig. (7). Therefore, there is no direct information that may show specific microbes that may have been responsible for this stromatolite. But, the microbial or bacterial origin is clear from columnar and oncoidal stromatolites that are shown in Figs. (7 and 8). The pressure solution generated low amplitudes and sharp peaked stylolites, which run parallel to the laminae (Fig.5A and B). In the lower part of the succession, the laminae consist of pure micritic carbonate, although now transformed to coarse crystals. This part has few massive beds, which contain ostracods and their fragments (Figs.5, 6D and 9B).

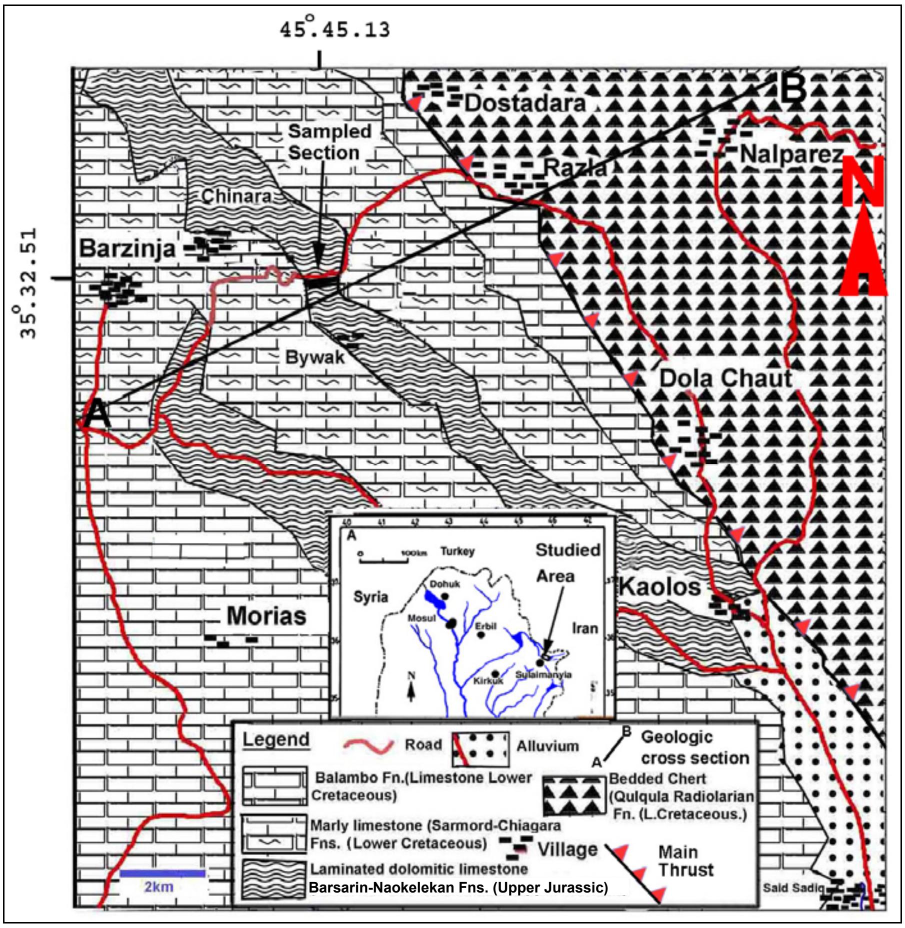

Fig.1: Geologic map of the study area showing location of the studied section (modified after Sissakian, 2000)

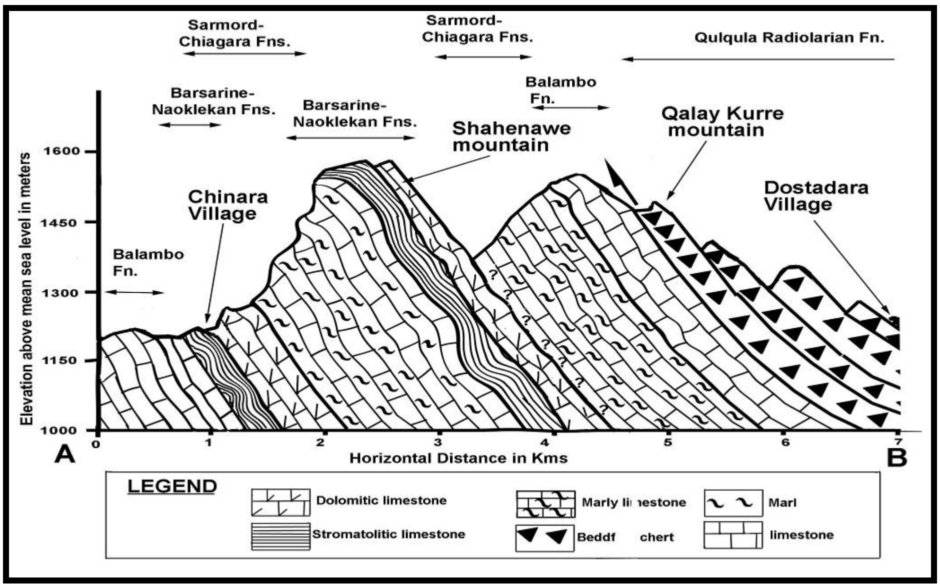

Fig.2: Geologic cross section, through the studied section (note the overturned beds; in the left side)

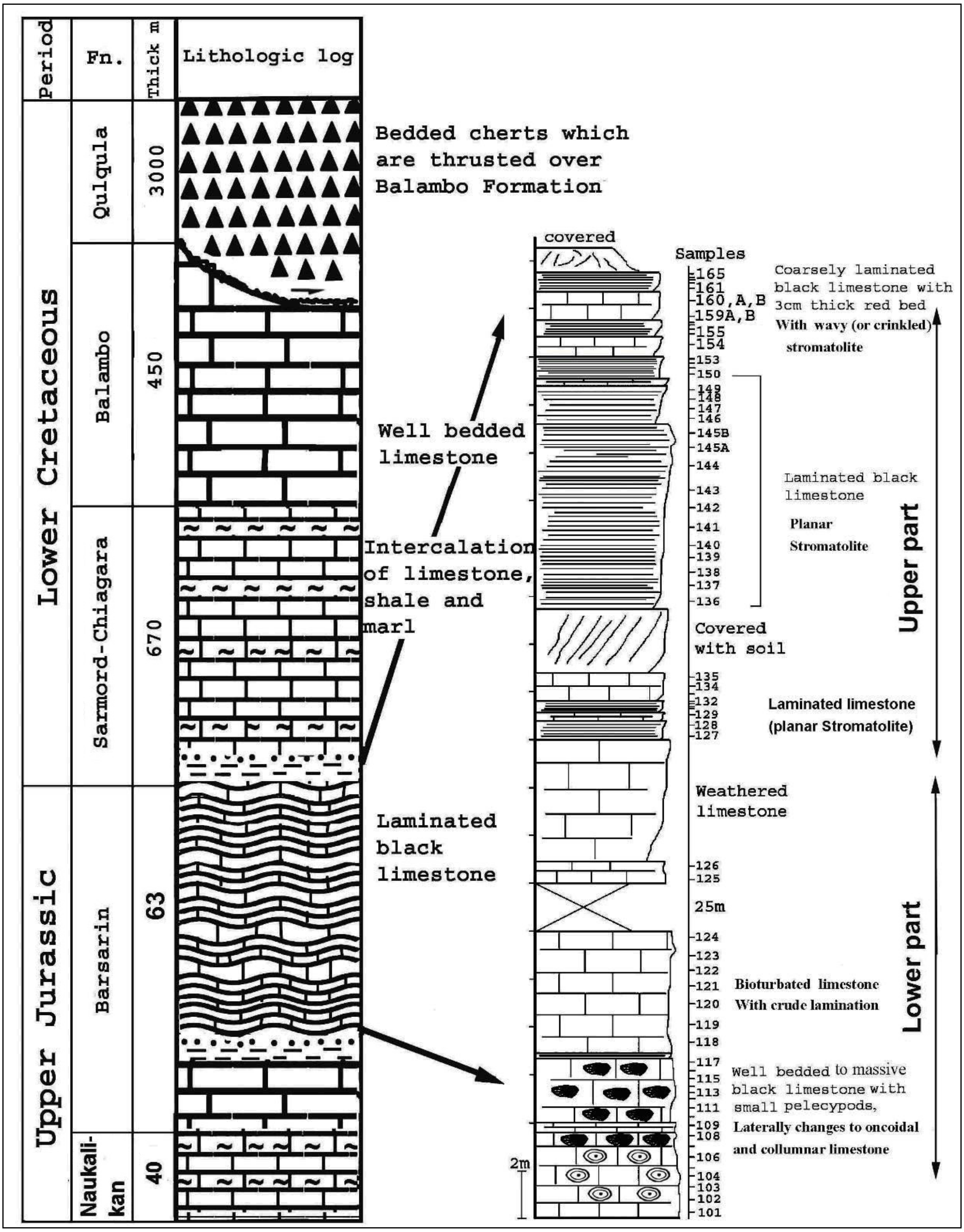

Fig.3: Stratigraphic column of the studied section with the location of the collected samples

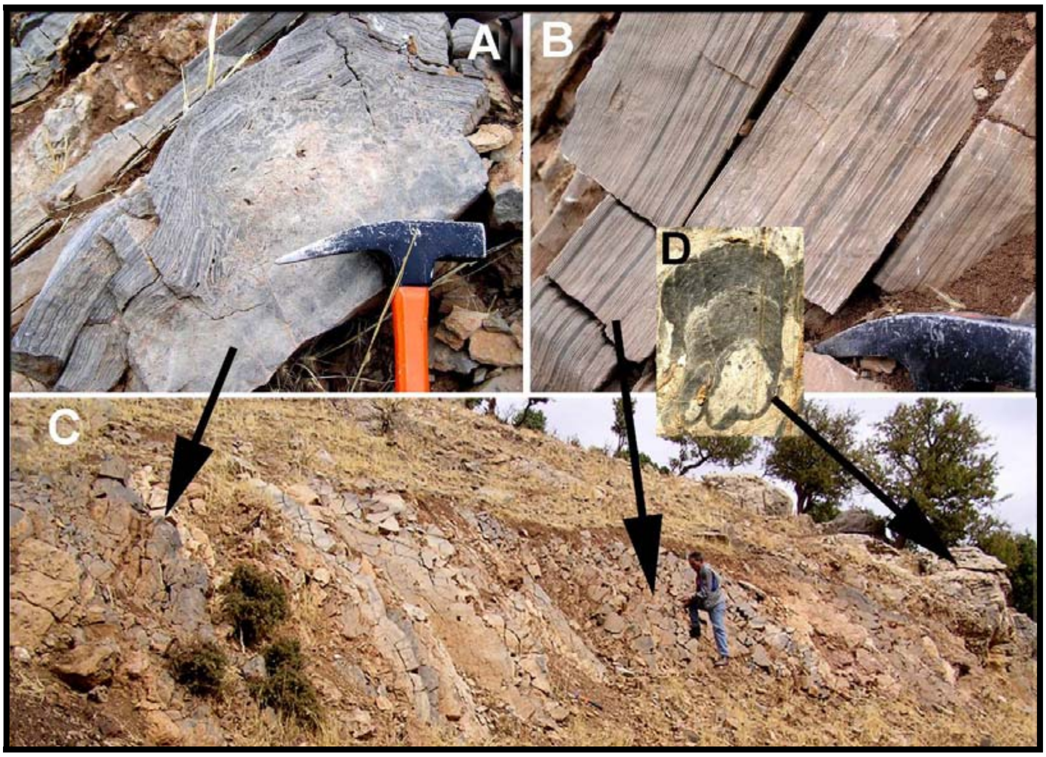

Fig.4: **A)** Disturbed and wavy stromatolite near the top of the Barsarin Formation
B) Planner stromatolite (laminated limestone) in the upper part of the formation
C) Part of the sampled section showing the planer and crinkled (wavey) stromatolite
D) Hemi-spheriodal stromatolite in the lower part of Barsarin Formation

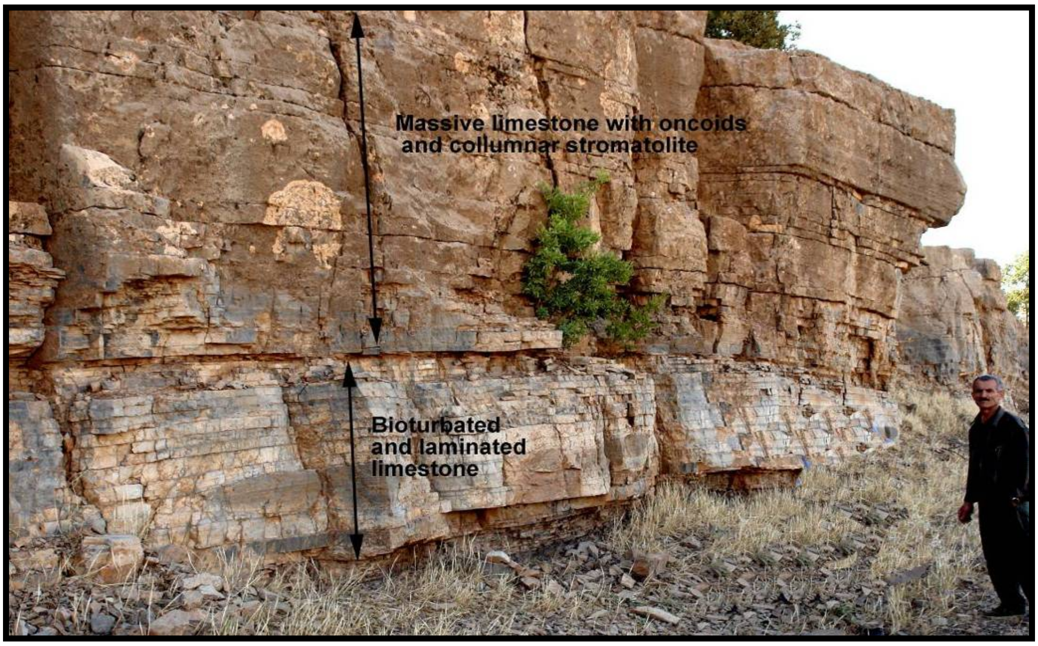

Fig.5: The lower part of a studied section showing the massive interval, which contains oncoids and columnar stromatolite
(It is located about 150 m to the west of the sampled section)

The massive beds change laterally at a distance of 150 m to nodular limestone and the thickness of the beds increases. The inspection of the nodules showed that they consist of oncoidal and columnar stromatolites. The oncoids were developed around white irregular rip-up limestone clasts. The laminae of the oncoids are dark grey or black. The asymmetrical growth of the oncoid forms columnar stromatolite (Fig.10). The microfacies of the formation belong to bindstone and sheetstone; when the classification of Dunham (1962) and Insalaco (1998) are considered, respectively. The possibility of some buffling exists too, especially in the lower part of the section, which contains some columnar stromatolite.

The laminated sediments show small corrugation and irregularities in thickness in the upper part, which serve to distinguish them from the laminae deposited purely by physical processes in the lower part of the succession (Tucker, 1996). The presence of two types of laminae implies changes of the nature or size of the carbonate material that are deposited through time. These changes in the types of the sediments may be achieved by currents or by variation in the types of the organisms that lived and accumulated at a given place (Blatt *et al*. 1980). The uppermost part of the section contains a red layer (5 cm thick) and gypsum pseudomorph in a form of displaced elongated calcite crystals, analogous to satin spar gypsum. In Ranya area, 140 Km to the northwest of the studied area, Salae (2001) studied stromatolite and attributed the origin of these laminations in Barsarin Formation to algal mat. He found many types of stromatolites such as flat type, blister and stratiform that are mainly grown in intertidal and shallow subtidal environments.

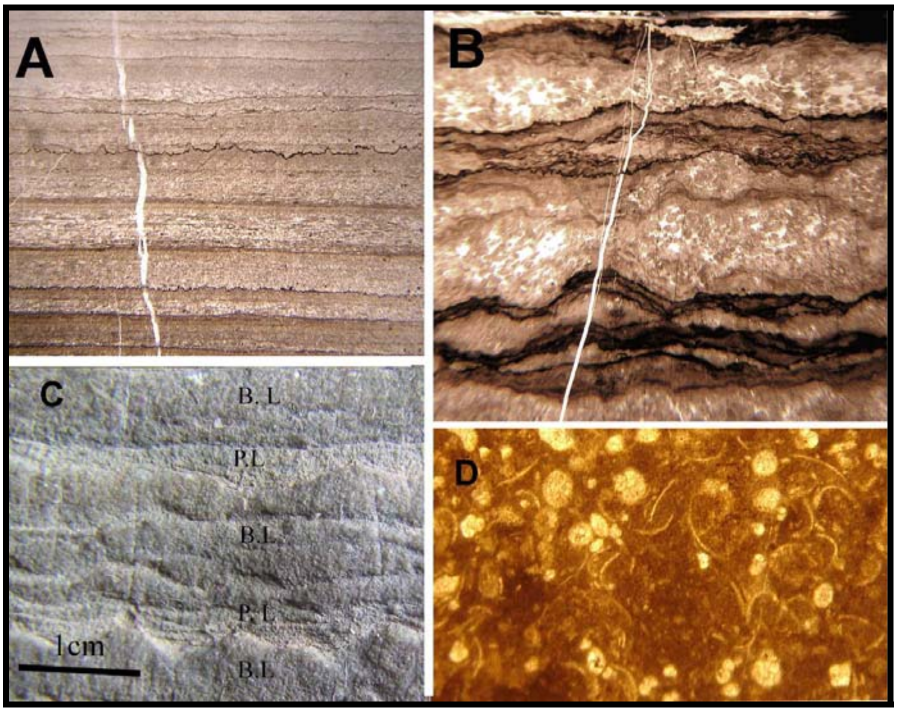

Fig.6: **A)** Planar stromatolite (laminated limestone) being dolomitized and changed into stylolaminated due to pressure solution (x 10 N.L)

B) Disrupted and amalgamated crinkled stromatolite with low amplitude stylolite (black lines), the white spots are deformed birdseye's structures (x 10 N.L)

C) Weathered hand specimen showing crinkled lamination and two types of laminae: The biogenic (B.L) and physically deposited laminae (x 10 P.L) can be distinguished

D) Bioclastic limestone consists of ostracods, bivalve fragments and gastropods

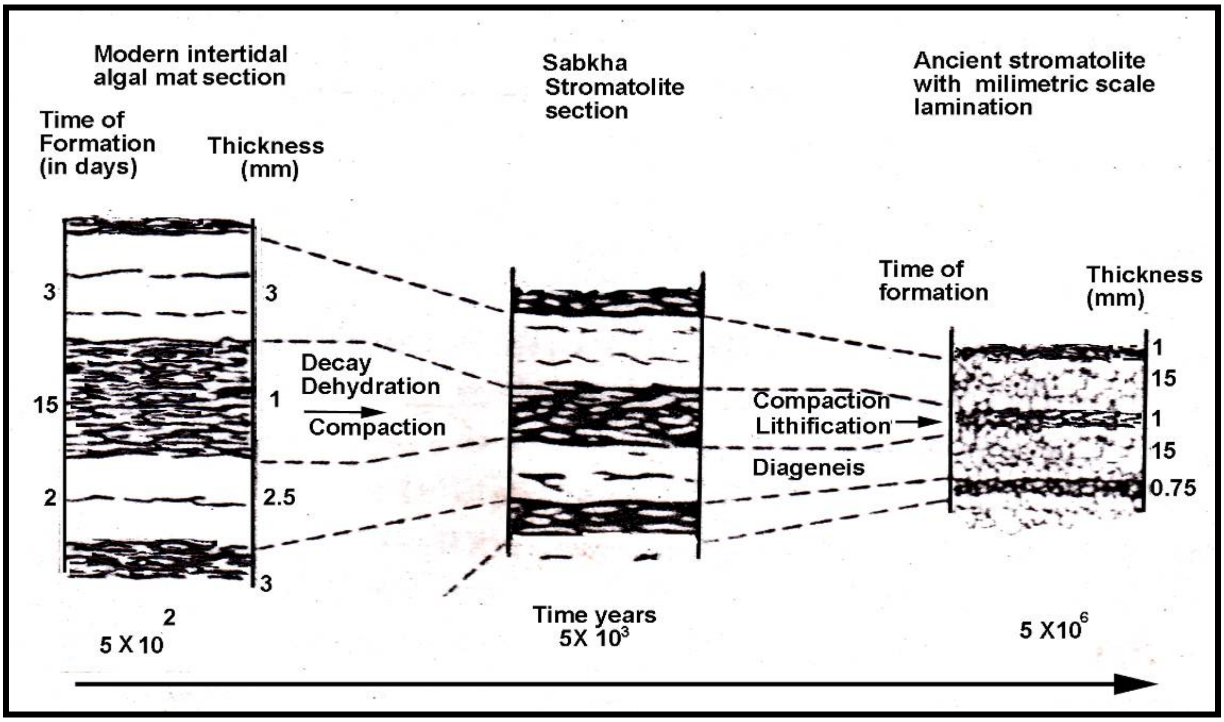

Fig.7: Modification of the stromatolite by diagenesis (Park, 1976) which is applicable for the present study

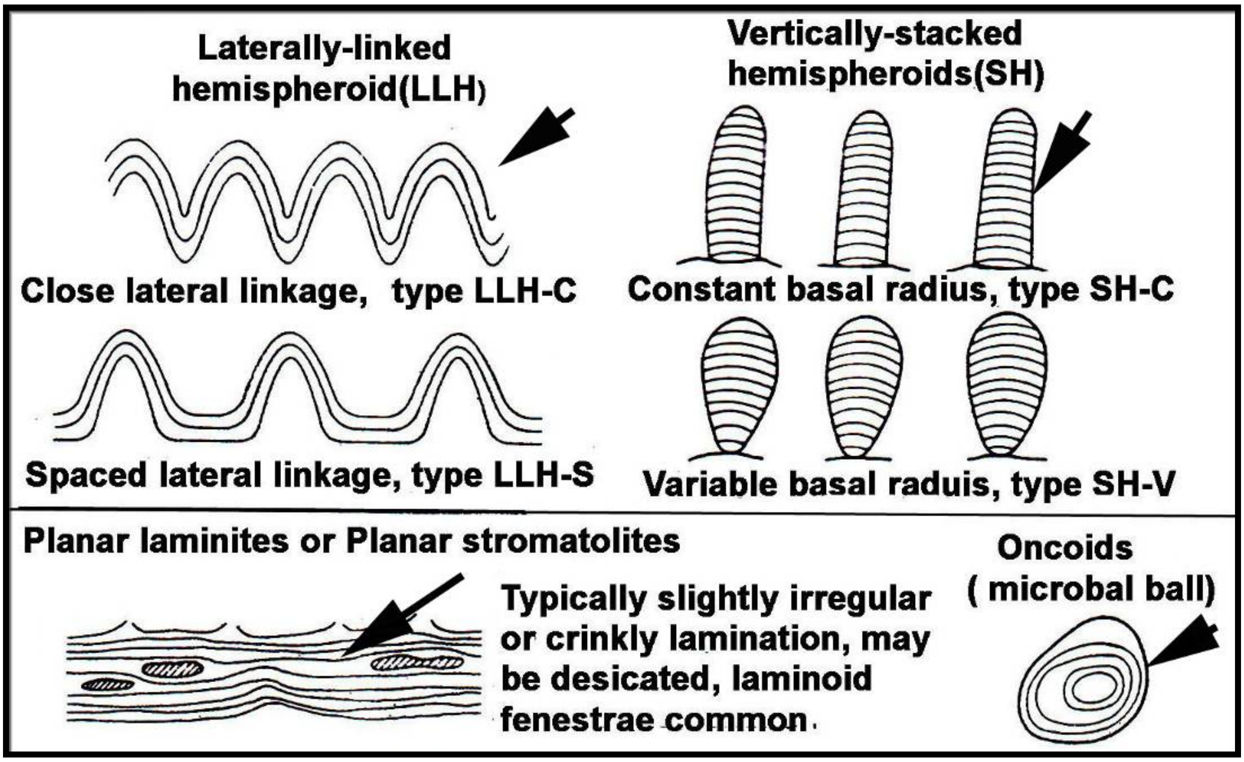

Fig.8: Morphotype of stromatolites (Logan *et al*., 1964 in Tucker, 1996) those that are indicated by black arrow are found in the present study

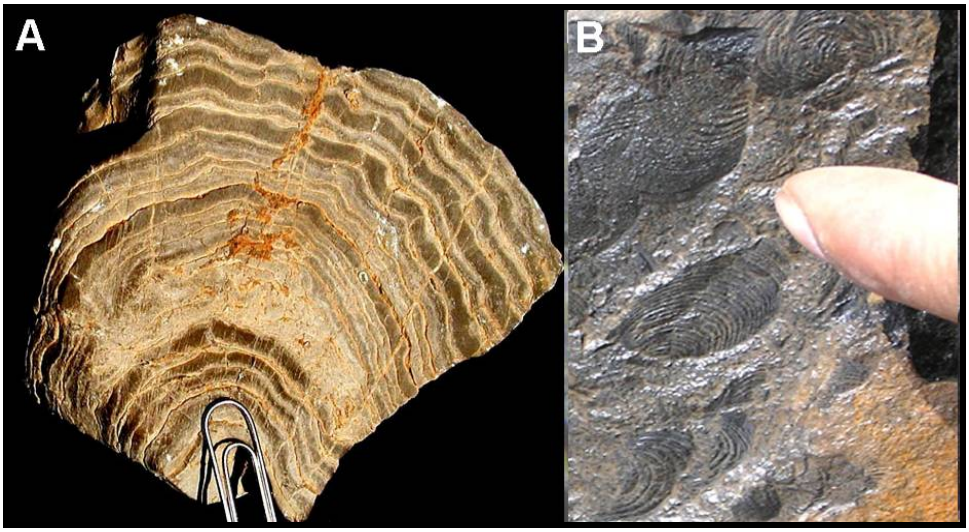

Fig.9: **A)** Wavy stromatolite, which is folded and formed hemi-spheriodal body in the upper part of the Barsarin Formation. **B)** Cast of small pelecypods in the lower part of the Barsarin Formation in the lower part of the studied section.

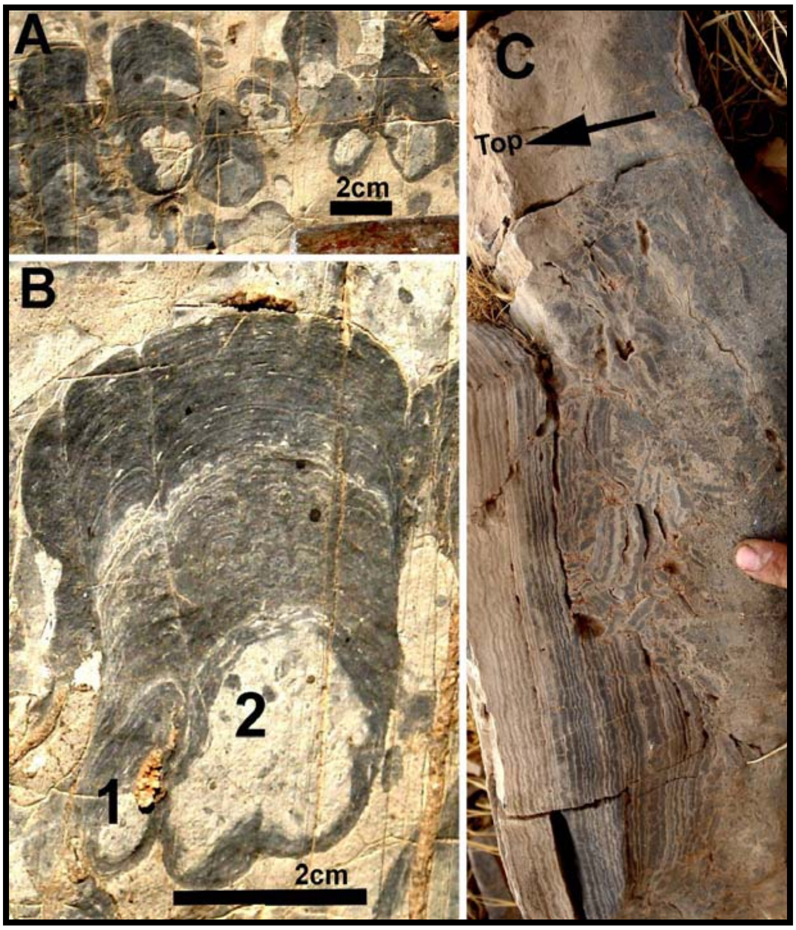

Fig.10: **A)** Several oncoids developed around rip-up clasts, on the oncoids a columnar stromatolite is developed in the lower part of the formation. **B)** Two oncoids (indicated by 1 and 2) grown on the irregular rip-up clasts (white). **C)** Parallel and crinkled stromatolite in the upper part of the Barsarin Formation.

DEPOSITIONAL ENVIRONMENTS

The stromatolites that are produced by algal and/ or cyanobacterial mats are deposited in the restricted circulation shelf and tidal flats, in addition to sabkha and salinas (Wilson, 1975). According to the classification of Hoffman (1976), planar stromatolites are formed in the intertidal zone. Based on our interpretations, the Barsarin Formation contains very well developed millimeteric laminations, which imply very specific depositional environments. The graving animals, such as pelecypods prevented the development of stromatolites (Browne *et al*., 2000). This is true for the upper part of the studied section, which is represented by restricted lagoon (intertidal zone) in which the graving animals were not survived. Therefore, well developed millimeteric lamination of microbal origin is developed.

The lower part of the studied section was deposited in shallow subtidal environment with less restriction in which pelecypods and ostracods were survived and grazed on microbes. This part shows some evidence of high energy during short times. This is represented by rip-up clasts (intraformational conglomerate or breecia) that are eroded from the bottom. On these clasts concentric laminae are developed as oncoids (Figs.9 and 10). In some cases, the microbial limestone (dark grey) is mixed with the non-biogenetic limestone (light grey), but it is not known if the mixing is generated by bioturbation or by wave activity (Fig.11). From all aforementioned citation, it is inferred that the formation is deposited on an attached platform. The evidence for attached platform is that the upper part of the formation contains several thin beds of red claystone and terrigeneous sandstone (Fig.12).

According to Tucker (1991), Nichols (1999) and Einsele (2000), ramp is gently sloping sea bottom (less than a degree) with generally high energy inner-ramp near shoreline, which passes off-shore to quiet and deep-water outer ramp. They added that large reefs are generally not present on ramps. When looking at the lateral and vertical distributions of carbonate facies and grain size, it could be realized that the platform topography that fits the carbonate successions of Barsarin Formation, in the studied area, is rimmed shelf (Fig.12). The formation shows rapid grains size and facies change both specially and temporarily. Another evidence of the rimmed platform is that no lithoclast and ooids are observed. But, the problem is that the clear barrier is not found in this study, although the massive limestone (with oncoidal and columnar stromatolite) of the lower part may represent the lagoon ward part of the barrier (back reef).

Fig.11: Mixture of biogenetic (possibly microbial) limestone and non-biogenetic (physical limestone) in the lower part of the section

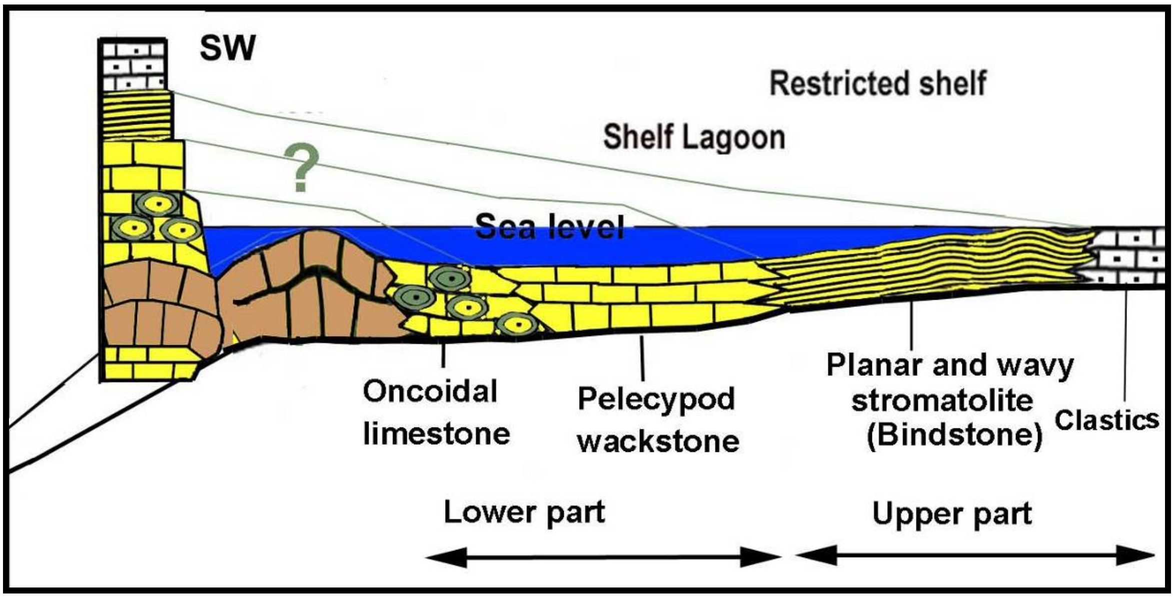

Fig.12: Proposed environmental model of the Barsarin Formation in the studied area

CONCLUSIONS

- For the first time the Barsarin Formation is recorded and described in the Barzinja area.
- Four types of stromatolites have been identified in the studied area.
- Two types of depositional environments have been identified: the intertidal, for the upper part and shallow subtidal, for the lower part of the succession.
- The recorded microfacies are bindstone and wackestone.

REFERENCES

Bellen, R.C. van, Dunnington, H.V., Wetzel, R. and Morton, D.M., 1959. Lexique Stratigraphique International. Asia, Fasc., 10a, Iraq, Paris, 333pp.

Blatt, H., Middleton, G. and Murray, R., 1980. Origin of Sedimentary Rocks. 2nd edit., Prentice Hall Pupl. Co., New Jersey, 782pp.

Buday, T. and Jassim, S.Z., 1987. The Regional Geology of Iraq, Vol.2, Tectonism, Magmatism and Metamorphism. In: M.J., Abbas and I.I., Kassab (Eds.), GEOSURV, Baghdad, 352pp.

Browne, K.M., Golubic, S., and Seong-Joo, L., 2000. Shallow marine microbial carbonate deposits. In: R., Riding and M., Awramik (Eds.), Microbial Sediments, Springer-Verlag, p. 233 – 249.

Dunham, R.J., 1962. Classification of carbonate rocks according to depositional texture. In: W.E., Ham (Ed.), Classification of rocks: a symposium, A.A.P.G, No.1, p. 108 – 121.

Einsele, G., 2000. Sedimentary Basins: evolution, facies and sedimentary budget, 2nd edit., Springer-Verlag, Berlin, 792pp.

Hoffman, P., 1976. Stromatolite morphogenesis in Shark bay, Western Australia. In: M.R., Walter (Ed.). Stromatolite. Development in Sedimentology, Vol.20, p. 261 – 271.

Insalaco, E., 1998. The descriptive nomenclature and classification of growth fabrics in fossil Scleractinian reef. Sediment. Geol., Vol.86, p. 118 – 159.

Jassim, S.Z. and Goff, J.C., 2006. Geology of Iraq. Dolin, Prague and Moravian Museum, Brno, 341pp.

Logan, B.W., Rezak, R. and Ginsburg, N., 1962. Classification and environmental significance of algal stromatolites. Jour. of Geol., Vol.72, p. 69 – 83

Nichols, G., 1999. Sedimentology and Stratigraphy. Blackwell Science, 354pp.

Park, R., 1976. A notes on the significance of lamination in stromatolites. Sedimentology, Vol.23, p. 379 – 393.

Reading, H.G. 1986. Sedimentary Environment and Facies, 2nd edit., Blackwell, 612pp.

Salae, A.T., 2001, Stratigraphy and sedimentology of the Upper Jurassic succession, NE Iraq. Unpub. M.Sc. Thesis, University of Salahaddin, Kurdistan Region, 105pp.

Tucker, M.E. 1991. Sequence stratigraphy of carbonate evaporite basins: models and application to the Upper Permian (Zechstein) of northeast England and adjoining North Sea. Jour. Geol. Soci., London, 148, p. 1019 – 1036.

Tucker, M.E, 1996. Sedimentary Petrology. Blackwell Science, 260pp.

Wilson, J.I., 1975. Carbonate Facies in Geological History. Springer-Verlag, Berlin, 471pp.