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Stratigraphy and Sedimentology of Organic-Rich Limestones of the Chia Gara Formation, Rania Area, Sulaimani, Kurdistan Region, NE Iraq.

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Abstract

The Chia Gara Formation (M.Tithonian-Berriasian) at Rania area is studied in detail stratigraphically and sedimentologically. The sequence is composed of organic-rich brown to dark shale and organic-rich argillaceous limestones. The shale is dominant in the lower part. The limestone layers becoming lighter in color upward. The upper contact is unconformable with the Balambo Formation. Four types of microfacies have been recognized. Radiolarian wackestone-packestone microfacies are the dominant facies, distributed through the section. The radiolarian moulds replaced by calcite, which indicate a major diagenetic process. The argillaceous limestone beds reveal interested white and dark bands; these structures are recorded for the first time. These bands are interpreted to be formed by diffusion process of organic matter-rich solutions through the porous limestone beds. The depositional environment reconstructed from the sedimentological evidences indicates to deep water environment, with warm, quiet water and euxinic condition.

Keywords: NE Iraq, Chia Gara Formation, radiolarians, diagenetic process, TOC%.

Introduction

The Chia Gara Formation (M.Tithonian-Berriasian) was first defined by Wetzel (1950) [1] at Chia Gara anticline, south of Amadia town in the High-Folded zone of north Iraq. The thickness of the formation, at its type locality, is 232m and is composed of unbroken succession of thin bedded limestone and shale, rich ammonite fauna, and grades upwards to yellowish marly limestone and shale with a zone of bullion beds, 21m thick at base [1]. The detailed study carried out by Spath [2] was done on the ammonites in this formation. One of the pioneer studies on this formation was carried out by Mc Carthy et al., (1955) [1]. They studied the formation in Zakho area, at this section the sequence generally consists of alternation of bituminous limestone and dark bituminous shale.

Dunnington [3] described the Tithonian-Berriasian sediments as basinal euxinic radiolarian shales-limestones. Buday [4], and Jassim and Goff [5] considered the sediments of Chia Gara Formation to represent the deep marine facies.The study of Total Company [6] mentioned that the average rate of deposition for Chia Gara Formation was high in the region of west of the Tigris River. Al-Qayim and Saadalla [7] studied the formation from Bekhma Gorge and Rawandoz area. They concluded that the formation reflects deep marine characters. The organic matters in the formation from different parts of Iraq ,surface and subsurface sections, studied by Al Habba [8], Al-Jubory[9], Al-Habba and Abdullah[10],Othman[11], Odisho and Othman[12] and Al-Beyati[13], they

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all agreed that the formation might represents good source rocks.

The upper boundary of the Chia Gara Formation remains difficult to recognize especially in the northeastern region from the type locality. Jassim and Goff [5] suggested that the Karimia Formation, which passes into Chia Gara Formation towards the NE, can be included in the Chia Gara Formation.The present study will focus on the problem of upper boundary of the formation in Rania area, as well as study the lithology of the organic – rich limestone in a surface section cropping out at Shawery valley, Hanjera Village, Rania area (Fig. 1). These beds are characterized by interesting phenomena which is a concentric light and dark bands distributed in the Chia Gara limestones. These structures are not recorded by the previous workers who studied the formation.

Stratigraphy

The Chia Gara Formation consists of a succession of laminated organic matter-rich limestone beds and brown to black fissile shale. The lower part is characterized by a dominant brown to black shale with thin to medium thickness of limestone lenses (Fig. 2). The limestone layers are rich in organic matter, which have formed structures in spherical and ellipsoidal shapes (Fig. 3). The lower contact is taken at the top of a stromatolitic limestone of Barsarin Formation. The stromatolite discussed for first time by Salae [14]. The sharp contact (changing from stromatolitic limestone to brown shale) indicates a rapid change in sea level and in sequence stratigarphy point of view means changing from LST to TST [15]. There is no clear evidence for unconformity surface between the two formations. However Jassim and Goff [5] considered the contact as conformable.

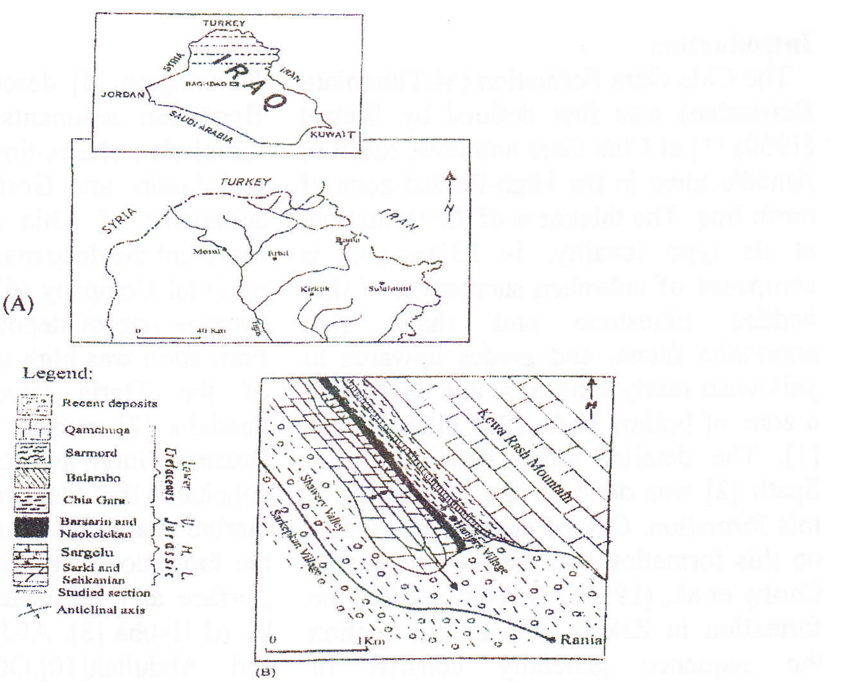
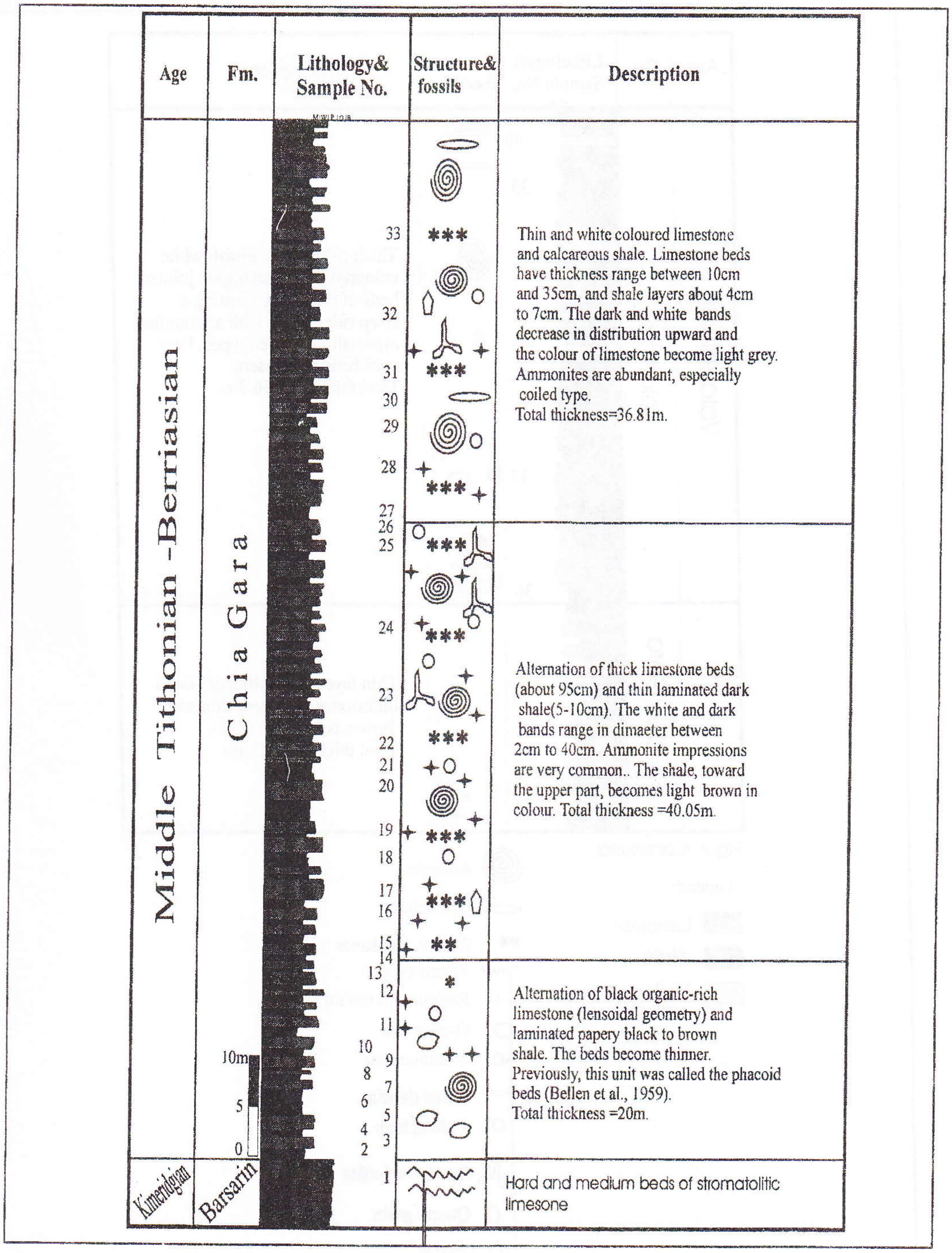


Fig.1 (A) Location map of the studied area, (B) Geological map of the Rania area (Modified after Salae, 2001).



Fig(2) Stratigraphic Column of the chia Gara Formation, Rania Section, Kurdistan, NE Iraq.

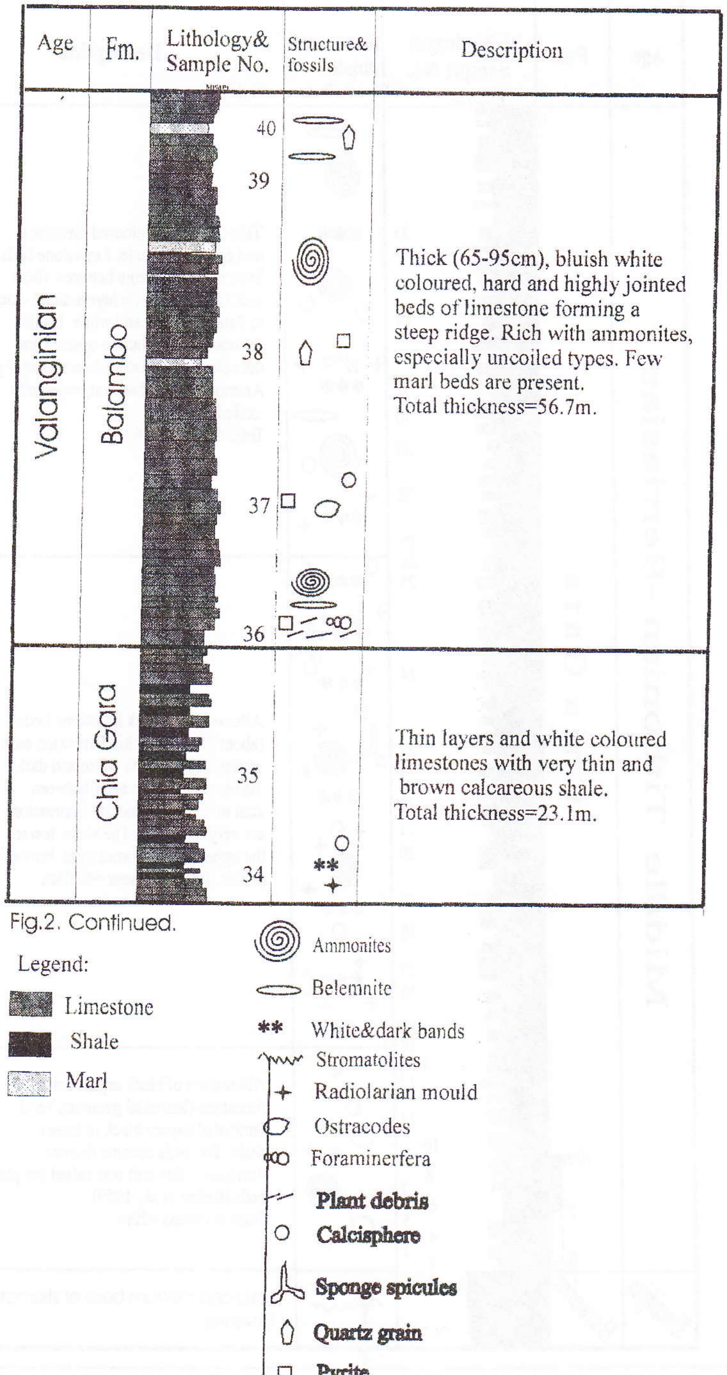


Fig.2. Continued.

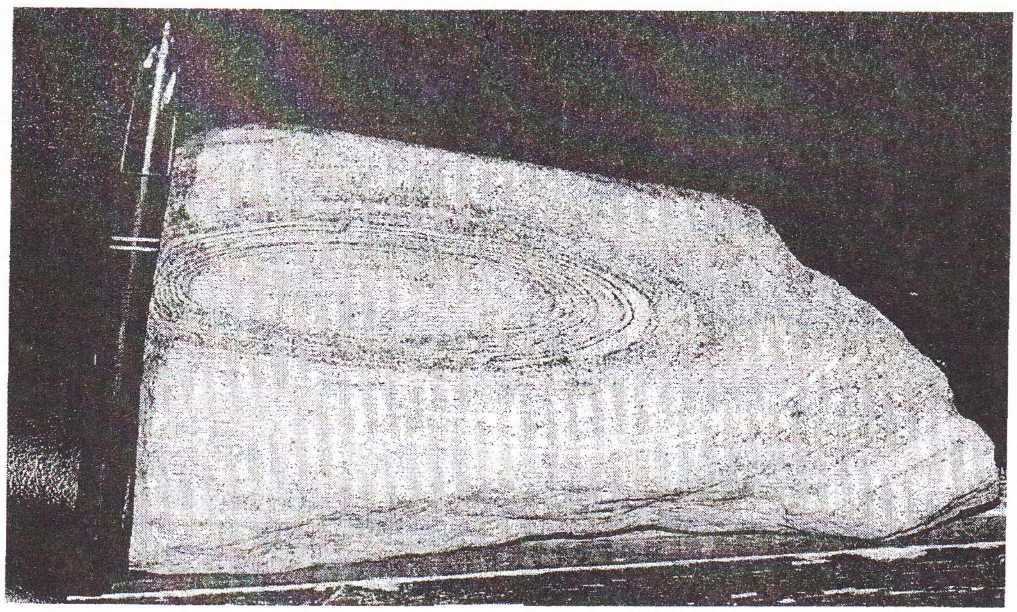
The upper contact, in contrast, is not sharp and needs accurate field work to be determined. This contact at the type locality is easily determined, because the overlying Garagu Formation begins with oolitic and ferruginous limestone which is not present in the Chia Gara Formation [1]. In Rania area, the study area, the upper boundary of the formation is with Balambo Formation, which is characterized by a succession of limestone and marl. The boundary is taken at the beginning of pinkish limestone (weathering color) and the abundance of uncoiled ammonites (Fig. 4A & 4B).

The appearance of these features represents the Balambo Formation [2, 1]. In addition to field work, the petrography indicates the presence of plant debris with benthic foraminifera (Genus *Dentalina*) without radiolaria (Fig.4C). The belemnites, which are abundant in Balambo Formation, prefers shallow, quiet and cool waters, and settled on mud bottoms, whereas the ammonites preferred deeper water [16]. Although the angular unconformity surface is not present between the Chia Gara and Balambo Formations, detailed petrographic study supports a period of non-deposition and/or erosion. The exact missing time could be determined using biostratigraphic study of ammonites.

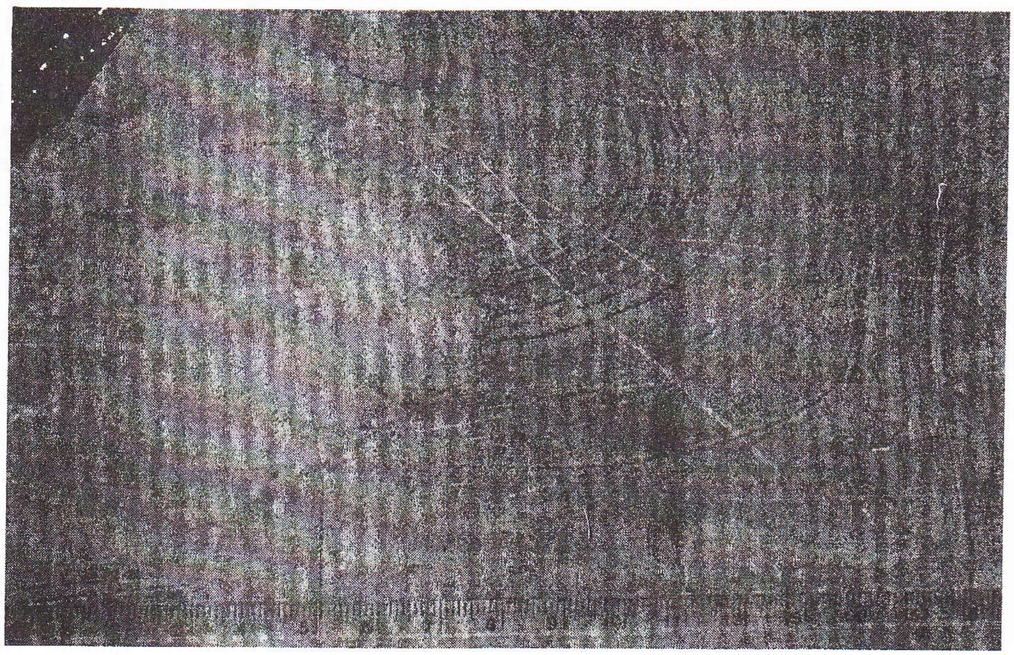
As described from field observations (Fig.2), the formation contains limestones and shale. The former is generally is bluish in weathering surface and dark in fresh surface. It is rich in ammonite impressions and thinly laminated sometimes papery. The shale is fissile, brown to black in color, predominant in the lower part and decrease towards the upper part. The limestone beds formed ridges in between the shale layers.Black shale-carbonate rhythms are common in Jurassic and Cretaceous Periods [17]. Periods of oxygenated deep waters usually produced lighter colored, biuturbated beds richer in carbonate than periods characterized by oxygen deficiency, resulting in dark, laminated interbeds [18].

Sedimentology

The limestone beds show homogeneity, as the case in the thin sections also, however the thickness may be slightly varied (Fig. 2). Most of the beds show organic-rich concentric bands (Fig. 3). These structures are different in size and shape. The diameter ranged between 5 cm to 50 cm with ellipsoidal to irregular shape. These structures can be seen in outcrops (Fig.3) and in thin sections also (Fig. 4D). Thin layers of organic matter and disseminated pyrite alternate with less organic and lighter layers, forming balls in three dimensions. These balls or ellipsoids occur one beside each other along the bed, sometimes bounded by joints and in other cases not.The fractures and micro faults are common. In particular, the outer boundary is sharp and the inner boundary is more diffuse. This is may be due to cement infilling of a rather porous layer (Charlotte Stockley, 2005, Natural History Museum, London, personal communication).Microscopic study shows the prevalence of fine grained sediments, micrite and microspar, as matrix and the grains are bioclasts, such as radiolarian moulds (50-250μ) (Fig.4E), calcisphers, ammonites, sponge spicules, rare foraminifera ,pelecepods and ostracods. The unwalled calsicphers are widely distributed in a micrite matrix. They are mostly alteration of radiolarians. Some fine and euhedral dolomite crystals and quartz grains are also present.The finely crystalline dolomite replacing mud-rich facies indicating synsedimentary dolomitisation forming at low temperature (ca.<50°C) [19].



(A)



(B)

Fig.3 The white and dark bands in the argillaceous limestone of Chia Gara Formation, Rania Section, Sulaimani, A-concentric bands without interruption, B-the bands cut by ammonite mold which causes termination of bands.

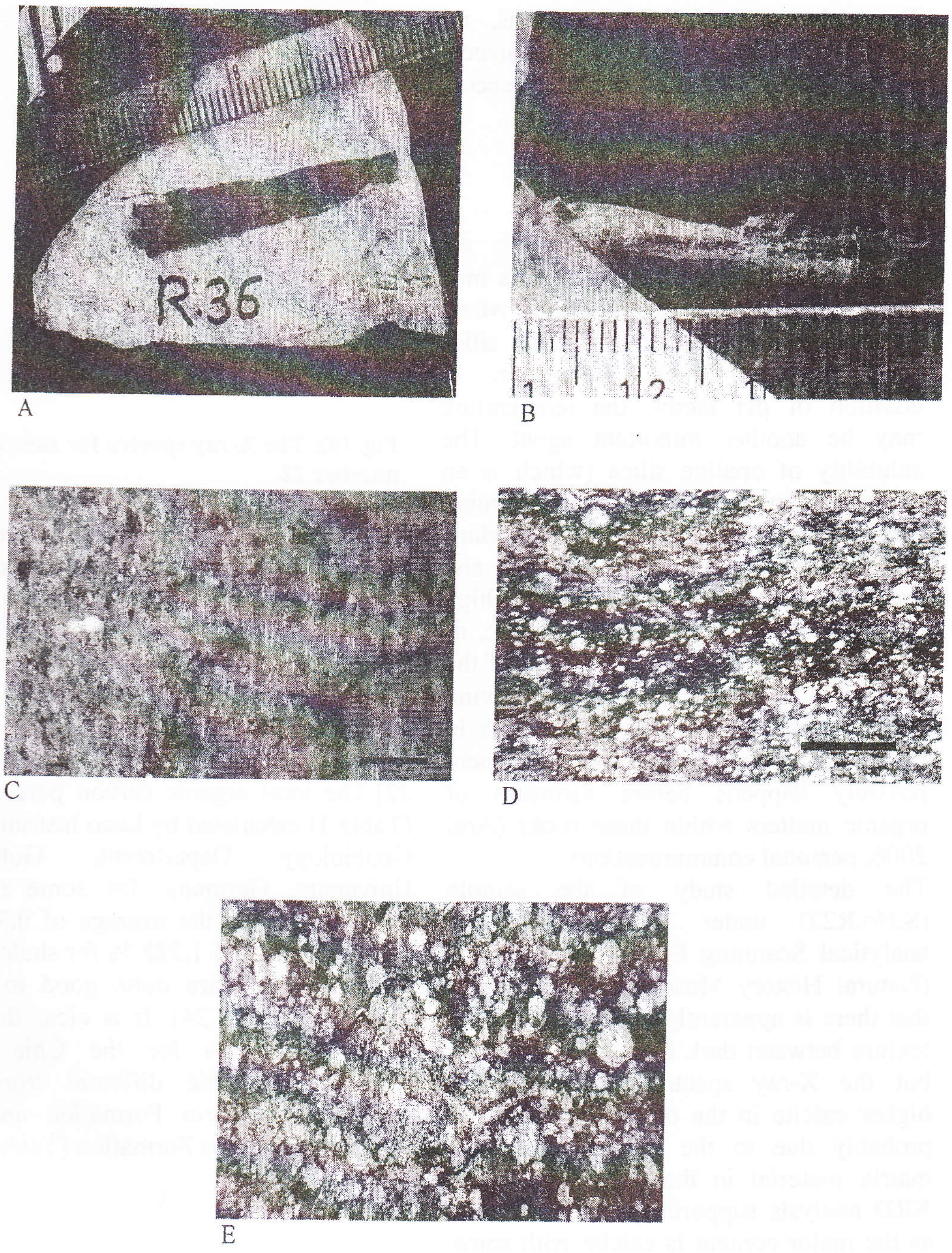


Figure 4. A: Pyritized belemnite from the Balambo Fm, Rania area, (S.No.R36), B: Belemnite from the Balambo Fm, Rania area(S.No.R39), C: Photomicrograph of plant debris rich mudstone(S. No.R36),Balambo Fm., PPL,400X,(Bar=400µ) D: Dark&white bands, Chia Gara Fm.,Rania area (S.No.R22), XP,400X, (Bar=650µ),and E: Radiolarian packestone microfacies rich with organic matter, sponge spicules and calcisphers, Chia Gara Fm (S.No. 23),PPL,400X(Bar=285µ).

From the study of thin sections, the following microfacies can be recognized:
1-Organic-rich wackestone (argillaceous limestone).
2-Radiolarian Packestone.
3-Radiolarian mudstone.
4-Calcareous shale.

Nearly all the radiolarian moulds are replaced by calcite (Fig.4E), this is may be due to change in pH condition, where in alkaline environment the silica dissolved and calcite precipitate. In addition of pH factor, the temperature may be another important agent. The solubility of opaline silica (which is an amorphous phase of high water content and porosity) in the tests of radiolarians increases with increasing temperature and pressure [20]. It is possible that the high temperature in the Late Jurassic time, as the region was a bout 2° - 3° south of the equator [17], was a factor for dissolving opaline silica and calcite replacement in the tests of radiolarians. This replacement possibly happens before diffusion of organic matters within these rocks (Arp, 2006, personal communication).

The detailed study of the sample (S.No.R22) under JEOL 5900 LV analytical Scanning Electron Microscope (Natural History Museum, UK) revealed that there is apparently little difference in texture between dark bands and the pale, but the X-ray spectra (Fig.5) showed higher calcite in the dark bands. This is probably due to the higher cement or matrix material in the dark bands. The XRD analysis supports the thin sections, as the major content is calcite with some quartz and rare dolomite.

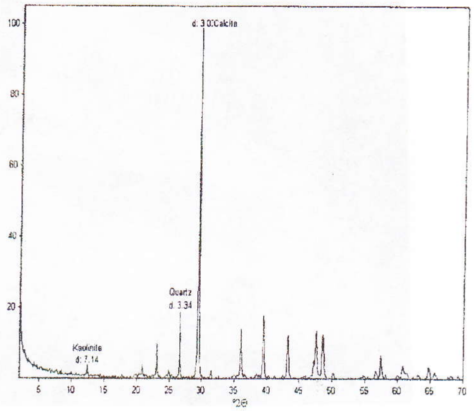


Fig. (5): The X-ray spectra for sample number 22.

The presence of these microfacies mudstone, wackestone and packestone indicate to warm water and current activity has been insufficient to remove the mud. The mudstone microfacies accumulate in quiet water where areas that are not affected by tidal and/or strong oceanic currents, deep basin areas [21, 22].The total organic carbon percentages (Table 1) calculated by Leco instrument at Geobiology Department, Gottingen University, Germany, for some of the samples showed the average of 0.766 % for limestone and 1.282 % for shale beds. These amounts are quite good to be a source rock [23, 24]. It is clear that the value of TOC% for the Chia Gara Formation is little different from the underlying Barsarin Formation and the overlying Balambo Formation (Table 1).

Table (1): The TOC% of the selected samples by LECO Instrument, Rania area, Sulaimani, NE Iraq.

Sample Number	Formation	Lithology	TOC%
R39	Balambo	Limestone	0.6124
R34	Chia Gara	Limestone	0.7775
R28	Chia Gara	Limestone	0.7944
R26	Chia Gara	Shale	0.6798
R21	Chia Gara	Shale	1.075
R20	Chia Gara	Limestone	0.7221
R18	Chia Gara	Shale	1.133
R16	Chia Gara	Limestone	1.127
R15	Chia Gara	Limestone	0.7250
R12	Chia Gara	Limestone	1.0713
R11	Chia Gara	Shale	2.0705
R9	Chia Gara	Shale	1.731
R7	Chia Gara	Limestone	1.059
R5a	Chia Gara	Limestone	0.5918
R2	Chia Gara	Shale	1.024
R1	Barsarin	Limestone	0.1597

The Origin of Dark and White Bands within Limestone Beds

As mentioned before the limestone beds of the Chia Gara Formation revealed an interesting phenomenon, which is the wide distribution of white and dark bands within limestone beds (Fig.2). At first these structures (Fig.3) were interpreted to be either stromatolitic or liesegang rings. After detailed investigation, the first suggestion was cancelled because of lacking characteristics of stromatolites. The second origin, liesegang rings, suggested by Professor D. Stow, Southampton Oceanography Center, UK (2004, personal communication). The liesegang rings are concentration of minerals in specific patterns. Currently there are two theories describing how patterns emerge, electrochemical and laser light scattering experiments [25].

In contrast of liesegang rings, these structures are rich with organic matter rather than other minerals, which are why the liesegang origin is also not accepted.

These structures are secondary features caused by fluid migration through the formation leaving a chemical banding (Stow, 2004, pers. com.).

The dark bands were more porous, which helped in more calcite, organic matter and pyrite to precipitate.

The role of joints and fractures is not limited, as in many cases they are the main control of distribution of these structures, and they are the pathways of fluid migration. Later, differential weathering played a role of giving them as spherical or ellipsoidal shapes.

The distribution of pyrite (framboidal) is mostly related to migration of oxygen-rich fluids which cause formation of sulfides or pyrite.

The framboidal pyrite has formed in early diagenetic process [26].

Depositional Environment

The lithology of Barsarin Formation, stromatolitic limestone and dolomites, indicates shallow depositional environment [14]. Changing from this unit to brown shale and black limestone rich in ammonites indicate deepening and or rising of sea level, the late Jurassic transgression. This unit represents quiet and euxinic marine depositional environment.

The absence of bioturbation in these sediments supports the euxinic condition [18]. Petrographically the limestones lack peloids, i.e. no active burrowing [22].

The radiolarian is the best biota live in a stenohaline water with salinity more than 30part/cm^3 [27, 28]. Toward the upper part of the formation the limestones are lighter in color and the shale layers also decrease, this may be due to less anoxic environment.The Chia Gara sediments deposited in a deep marine environment on the Passive Arabian Continental Margin as indicated by the presence of pelagic limestones (organic rich wackestone-packestone microfacies), also the wide distribution of radiolarians, thin walled pelecypods and sponge spicules. The late Tithonian time was the beginning of subduction of the Arabian shelf underneath the Turkish and Iranian plates [29].This caused the formation of listric normal faults [29]. These faults formed sub basins like half graben in shape, in which possibly the Chia Gara Formation was deposit.

Conclusions

1-The Chia Gara Formation in Rania area consists of alternations of brown to dark shale rich in organic matter and thinly bedded argillaceous limestones. Shale layers are thinned upward as well as the limestones becomes lighter in color.

2-The upper contact of the Chia Gara Formation with the Balambo Formation is probably unconformable.

3-The Balambo Formation is documented in geological map of the area, for the first time.

4-The interested white and dark bands within argillaceous limestone beds are interpreted to be formed by diffusion of organic matter- rich solutions through the porous limestones, succeeding differential weathering display them as concentric bands.

5-The TOC% results indicate the difference values for the Chia Gara Formation from the overlying Balambo Formation and the underlying Barsarin Formation, i.e. these analyses support the petrographical outputs.

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چینزانی ونیشتەنی بەردە کلسییە کانی دەوڵەمەند بە مەوادی ئەندامی لە پێکهاتوی چیاگارا دا، ناوچەی ڕانیە ، هەرێمی کوردستان، باکوری ڕۆژهەلاتی عێراق.

ئیبراهیم محەمەد جەزا محێدین، بەشی زەویناسی، کۆلیجی زانست، زانکۆی سلێمانی، هەرێمی کوردستان، عێراق

پوختە

لەم توێژینەوەیەدا هەوڵدراوە بەردە کلسییە کانی دەوڵەمەند بە مەوادی ئەندامی لە پێکهاتوی چیاگارا دا، ناوچەی ڕانیە ، هەرێمی کوردستان، باکوری ڕۆژهەلاتی عێراق بکۆڵرێتەوە لە ڕووی چینزانی و کەڤرزانییەوە. تواناراوە سەرکەوتووانە پێکهاتویچیاگارا لە پێکهاتوی سەروخۆی(بالامبۆ) جیابکرێتەوە و بۆ ئەم مەبەستەش دیاردە کەڤریی و بوونی بەبەردبووی دیار بەکاربهێنرێت. پێکهاتوی بارسەرین دەکەوێتە ژێر پێکهاتوی چیاگارا لەم ناوچەیەدا. لەڕووی جۆری بەردە کلسییەکان وەك لە برگەی تەنك دا دەردەکەون، دەگرێنەوە بۆ جۆرەکانی بەردی کلسی قوڕیی و پاکستۆن و واکستۆن، کە گشتیان دەوڵەمەندن بەڕادیۆلاریا و دڕکی ئیسفەنج و کالسیسفیر و ئوستراکۆدوهەندێك پاشماوەی بەبەردبووی وورد بوو. چینەکلسییە قوڕییەکان دەوڵەمەندن بە بوونی دیاردەی پشتێنەی تۆخ وکاڵ، کەبەشێوەی بازنەیی یان هێلکەیی دەبینرێن. هەوڵدراوە شیبکرێنەوە لەڕووی پێکهاتنیان ووا بڕوا دەکرێت کە ئە نجامی بڵاوبوونەوەی مەوادی ئەندامی وورد بەناوبۆشاییەکانی نێوبەردەکەدا دروست بوو بێت. لەڕووی دروست بوونەوە ئەم جۆرە بەردانە لەحەوزێکی قووڵدا نیشتوون کە تیایدا ئاوەکەی وەستاو بووەو ئۆکسجینی کەمبووە، واتە ژەهراوی بووە.

طباقية و رسوبية الاحجار الكلسية الغنية بالمواد العضوية لتكوين جياكارا في منطقة رانية، السليمانية، اقليم كوردستان، شمال شرق العراق.

ابراهيم محمد جزا محى الدين، قسم الجيولوجى، كلية العلوم، جامعة السليمانية، اقليم كردستان ، العراق

الخلاصة

هدف هذه الدراسة هووصف وتحديد طباقية و رسوبية الطبقات الكلسية الغنية بالمواد العضوية لتكوين جياكارا(التيثونيان- بيرياسيان) في منطقة رانية، السليمانية ، شمال شرق العراق. من ناحية الطباقية تم تحديد الحد العلوى للتكوين مع تكوين بالامبو اعتمادا على ادلة طباقية وصخارية و وجود البلمنايت بكثرة وبقايا النباتات في الشرائح الرقيقة. صخارية الطبقات الكلسية بشكل عام هي تواجد السحنات الحجر الجيرى الطينى و المرصوص والغنى ببقايا متحجرات الراديولاريا، كالسيسفير، اشواك الاسفنج و الاوستراكودا. كل القوالب للراديولاريا مذابة و حل الكالسايت محل السليكا بفعل العمليات التحويرية نتيجة لتغير الظروف الترسيبية. ان هذه الطبقات الكلسية الغنية بالمواد العضوية تحتوي على ظاهرة الحلقات الغامقة و الفاتحة بشكل واسع. تكون هذه الاشكال كروية وبيضوية اي ثلاثية الابعاد، وقد فسرت هذه البنيات على انها تكونت نتيجة دخول محاليل غنية بالمواد العضوية وانتشارها داخل الصخور. من خلال ملاحظة جميع الصفات الصخارية و الطباقية تبين بان البيئة لترسيبية لهذه الصخور هي الحوض العميق الذي يتميز بوجودمياه هادئة و ظروف انعدام الاوكسين(ظروف سامة).

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