BLACK CHERT, AN INTERESTING PETROGRAPHIC COMPONENT WITHIN THE UPPER PART OF SARGELU FORMATION (MIDDLE JURASSIC) – NORTH AND NORTHEASTERN IRAQI KURDISTAN

Govand H. Sherwani[*] and Sardar M. Balaky[**]

ABSTRACT

Three surface sections of Sargelu Formation were chosen for the purpose of this study, Naokelekan village (near Rowanduz), Gara mountain (southern Amadia), and Banik village (northeast of Zakho) Northern Iraqi Kurdistan. At all these localities, the upper part of Sargelu Formation is characterized by interesting black chert beds.

The petrographic study of chert beds was based on 25 thin sections. This study revealed fossils similar to those described in limestone units of the same formation, but with clear signs of silicification. By combination of field observations and petrographic studies, it can be concluded that chert beds are formed by diagenetic reorganization of silica, which is mostly of biogenic origin, mostly from radiolarians. Complete replacement of some thin limestone beds(or thin parts of them) by silica resulted in the development of chert beds. Dissolution of radiolarians, either within chert beds or in neighboring limestone beds, provides a major source of silica for this process.

الصوان الأسود، مكون بتروغرافي جدير بالاهتمام ضمن الجزء العلوي من تكوين ساركلو (الجوراسي الاوسط) – شمال وشمال شرق كوردستان العراق

كوفند حسين شيرواني و سردار محى الدين بالكي

المستخلص

تم اختيار ثلاثة مقاطع سطحية لتكوين ساركلو لغرض الدراسة، تتوزع في شمال وشمال شرق إقليم كردستان العراق: مقطع ناوكليكان (قرب راوندوز)، مقطع جبل كاره (جنوب العمادية) ومقطع بانك (شمال شرق زاخو).

يظهر الصوان في الأجزاء العليا من التكوين بشكل طبقات أو حزم رقيقة مع قليل من العدسات أو عقد ذات استطالة. اعتمدت الدراسة البتروغرافية لطبقات الصوان على (25) شريحة رقيقة. وبينت البتروغرافية احتواء طبقات الصوان على متحجرات مماثلة لما وصف فى الحجر الجيرى لنفس التكوين مع دلائل واضحة على التأثر بعملية السلكتة. وبالاعتماد على جمع الملاحظات الحقلية مع الدراسات المختبرية، يمكن الاستنتاج بان طبقات الصوان تكونت بعمليات تحويرية تمثلت فى إعادة توزيع السليكا والتي هي على الأغلب عضوية الأصل وتحديدا" من الراديولاريا. إن الإحلال الكامل لبعض الطبقات الرقيقة من الحجر الجيري (أو أجزاء منها) بالسليكا كان وراء تكوين طبقات الصوان. ويمكن ان يكون ذوبان الراديولاريا، سواء ضمن طبقات الصوان أو من طبقات الحجر الجيري المجاورة قد شكل المصدر الرئيس للسليكا اللازمة لهذه العملية.

INTRODUCTION

The Sargelu Formation was first recognized and described from Surdash anticline, Sulaimaniya district, of the High Folded Zone, Northeastern Iraq by

[*] Director General, Ministry of Higher Education and Scientific Affairs, Erbil, Iraq.

[**] Dept. of Geology, College of Science, University of Salahaddin –Erbil, Iraq.

Wetzel (1948) in Bellen et al. (1959). Based on the evidence of fossils, the age of Sargelu Formation has been determined as Bathonian, at top, to uppermost Liassic, at base (Bellen et al., 1959). Sargelu consists lithologically of thin to medium bedded black bituminous limestone, dolomitic limestone, black papery shale, with characteristic black chert at its upper part. The study aims to clarify the origin of cherts and the possible sources of silica required for the chert formation.

LOCATION AND METHODS

Three locations were chosen for the present study (Fig. 1), these are:

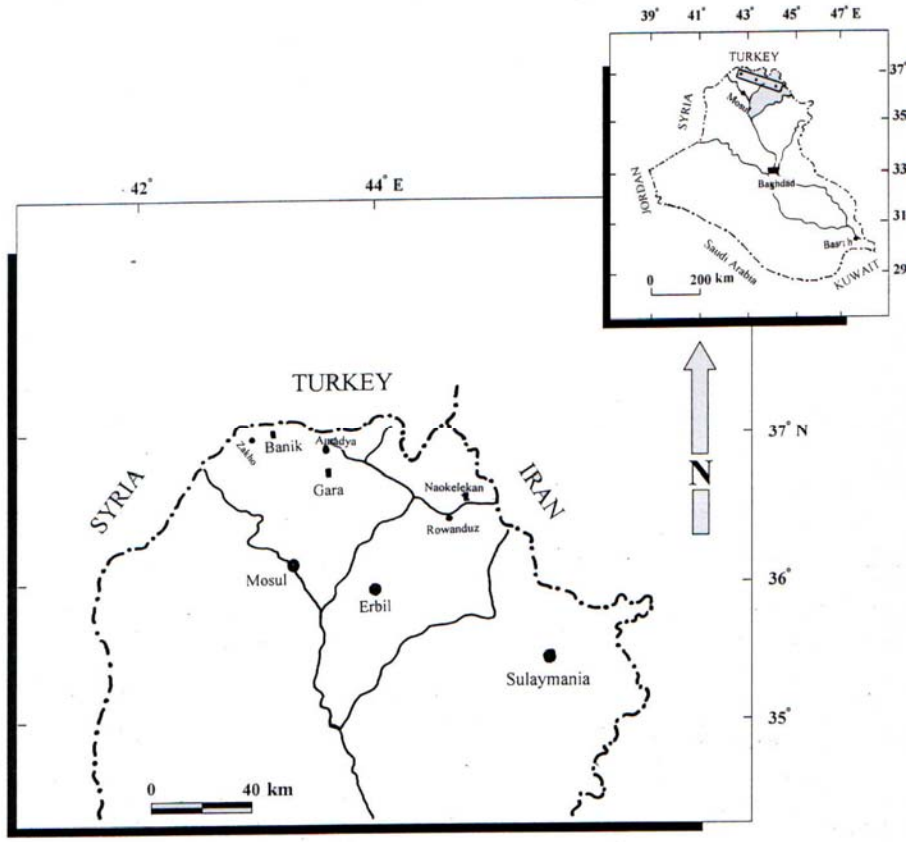

Fig (1): Location map of the study area

1-Naokelekan village, near Rowanduz in Balak valley about 500 meters northwest of Naokelekan village, Northeastern Iraqi Kurdistan (Lat. 36° 36' 00" N; Long. 44° 44' 10" E).

2-Gara mountain, south of Amadia, in Gali-Zewki, Northern Iraqi Kurdistan (Lat.36° 59' 38" N; Long. 43° 28' 16" E).

3-Banik village, about 25 km to NE of Zakho town, Northern Iraqi Kurdistan (Lat. 37° 13' 33.4" N, Long. 42° 58' 26" E), nearly 100 meters to the west of the village.

The sum of (25) thin sections, cut from chert samples, were examined during the present study. These samples uniformly cover all studied sections. Detailed petrographic description was handled by polarizing binocular microscope.

GEOLOGIC SETTING

Jurassic rocks are commonly exposed as isolated patches at some eroded cores and limbs of anticlines in the High-Folded, Imbricated, and Thrust Zones of Northern Iraq. The three studied sections, Naokelekan, Gara, and Banik, were intentionally chosen at two different tectonic units (Zones) (Fig. 2) (Numan, 2000). These sections are as follow:

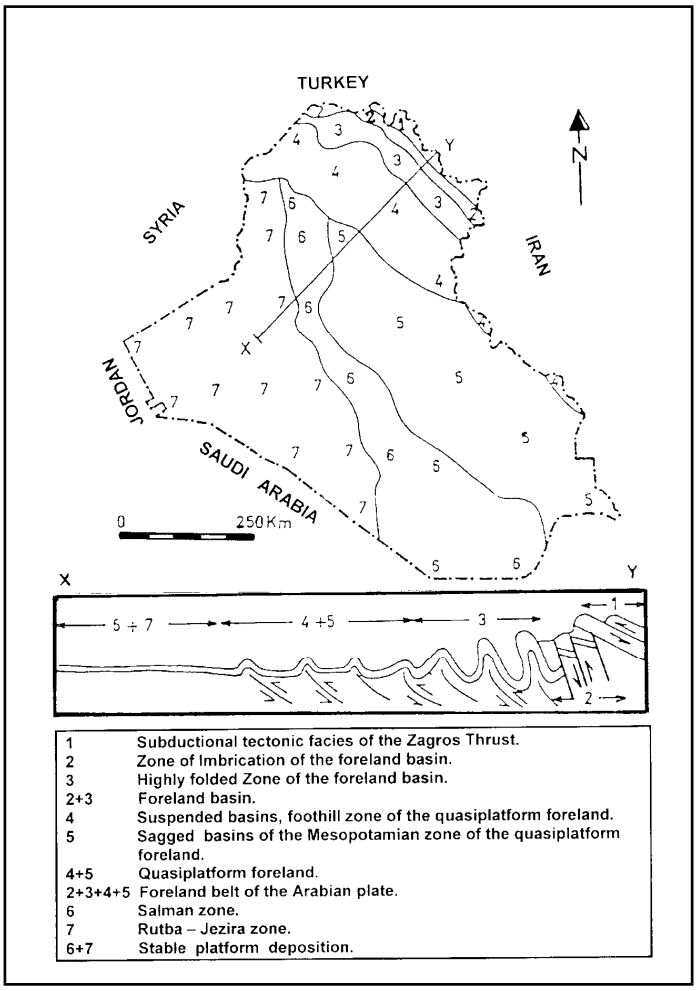

Fig (2): Major tectonic divisions in Iraq (after Numan, 2000)

1- Naokelekan village section, located within the zone of Imbrications of the Foreland basin.
2- Gara Mountain and Banik village sections are located within Highly Folded Zone of the Foreland basin.

Stratigraphically, Sargelu Formation, at all sections, is underlain by Sehkaniyan Formation (Early Jurassic) and overlain by Naokelekan Formation (Late Jurassic). The nature of boundaries are uniform conformable and gradational.

GEOLOGIC OCCURRENCE OF CHERTS

Chert is a general term for fine-grained siliceous sediments of chemical, biochemical, or biogenic origin (Tucker, 1981). It is a dense very hard rock composed of one or several forms of silica – opal, chalcedony (microcrystalline quartz), with splintery to conchoidal fracture (Pettijohn, 1975). Such rocks have many various names based on impurities that change color, the more common ones being jasper (red), flint (grey to black), novaculite (white) and porcellanite (porcellaneous) (Blatt et al., 1980).

In the geologic literature, there are several theories pointing that chert beds are of several origins (some depositional and others diagenetic) as shown in the Table(1):

Table 1: Theories explaining origin of chert beds

Theories of bedded chert origin			
Theory		**Authors (Year)**	**Characteristics**
Depositional origin	**Volcanogenic origin**	Wise and Weaver (1974)	- Associated with volcanic rocks. - Within / above pillow lava. - Radiolaria entrapped within lavas.
	Turbidity current origin	Nisbet and Price (1974); Iijima et al. (1985)	- Have sedimentary structures: (graded bedding + lamination). - Derived from nearby highs. - Rhythmic bedding.
	Pelagic "rain" theory	Price (1977)	- Depositional below CCD. - Uniform "rain" of radiolarians. - Slow and steady deposition cause massive chert beds. - No internal sedimentary structures.
Diagenetic origin		McBride and Folk (1979); Coniglio (1978)	- Caused by diagenetic organization of silica. - Result from complete replacement of limestone beds.

CHERT OF SARGELU FORMATION

The upper part of Sargelu Formation is characterized by the presence of thin beds with rare lenses and elongated nodules of cherts. These cherts are characterized by black color, dense, high fracturing with common veins of calcite. The black color is attributed to the content of organic matter. The bedding planes of chert beds are parallel and rarely well-exposed at all sections. The upper and lower contacts of each chert bed within limestones are rather gradational, with thin transition in color between black chert and gray limestone (Figs. 3-1,3-2,3-3).

PETROGRAPHIC CONSTITUENTS OF CHERT UNITS

The examined thin sections had clearly demonstrated that cherts, in all sections, consist of equant microcrystalline quartz matrix, which is brownish in color due to included organic matter (Fig. 4-2).

The following are observed petrographic constituents in chert units:

i- Fossils

Fossils, present in chert beds, include the following:

1-Silicified thin-shelled pelagic pelecypod (*Posidonia*) (Figs. 4-2, 4-5, 4-7, 4-8).
2-Radiolarians, some of them are pyrite-filled (Figs. 4-2, 4-5).
3-Calcispheres (Fig. 4-8).
4-Silicified ammonites.
5-Unsilicified phosphatic shells of uncertain origin (Fig. 4-6).

ii- Dolomite

Scattered dolomite crystals are observed within the cherts, particularly at Naokelekan section. Some of the crystals are euhedral, others are anhedral. Some of these crystals possess corroded edges (Fig. 4-8).

iii- Calcite

The cherts are highly fractured, and some of their beds are penetrated by veins, which are filled by spary calcite (blocky cement) (Fig. 4-3).

iv- Silica cement

Some megaquartz and chalcedonic quartz are seen within the cherts as cementing material filling the intraparticle vacuoles (Fig. 4-1), or in veins similar to drusy calcite cement (Fig. 4-6).

v- Other features

In addition to previous constituents, some notable features are described, as in follow:

1-Sutured seam stylolites (Fig. 4-4). These may represent relics of pre-existing carbonate rocks, removed by replacing silica.
2-Micro-faults (Fig. 4-3). These small structures stand as reflection of compactional effect.

Fig. (3)
Chert

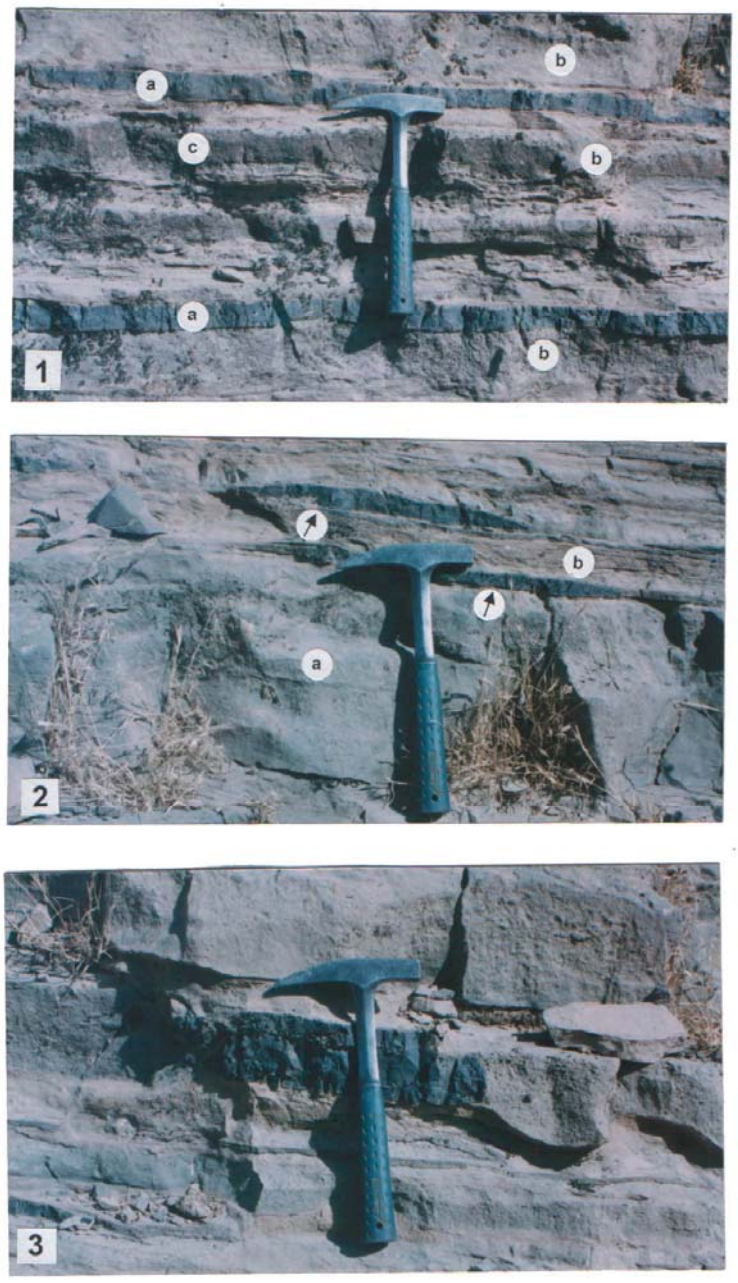

Fig. (3): Chert units in the outcrops

3-1 Thinly bedded, black, highly fractured cherts (a) alternating with thin to medium bedded, grey, bituminous limestones (b). Thin partly silicified limestone beds (c) are also present. Upper Sargelu Formation, Naokelekan section.

3-2 Two lenses of black cherts (arrows), within an interval of medium bedded limestone (a) with frequently papery shale beds (b). Upper Sargelu Formation, Naokelekan section.

3-3 An elongated nodule of black chert in bituminous limestone host rock. Upper Sargelu Formation, Naokelekan section.

Fig. (4)
Petrographic - Chert

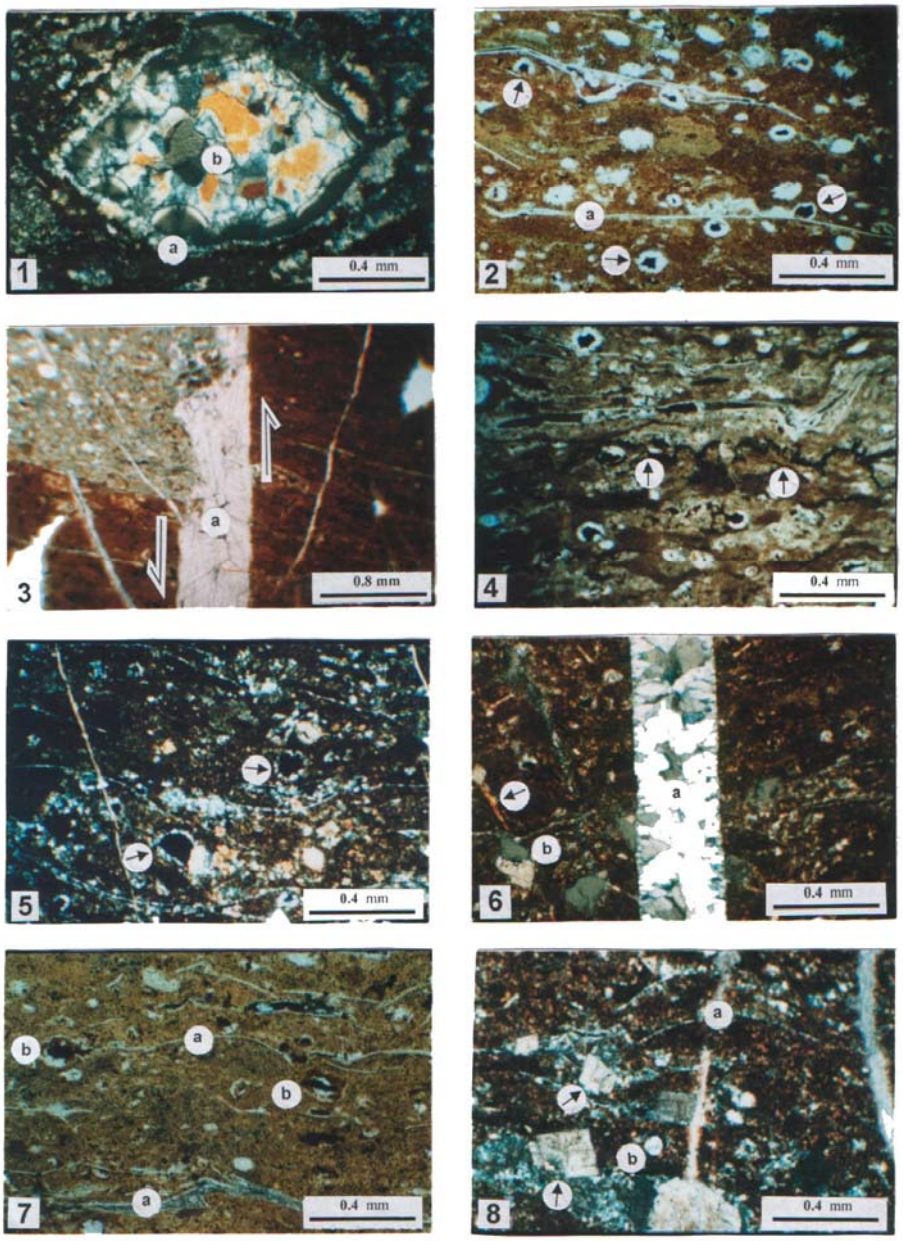

Fig. (4): Petrography – Chert

4-1 Silicified articulated *Posidonia* filled by silica cement with two generations: First with chalcedonic quartz (a), Later with polycrystalline quartz (b) inward. B. 9, X.N.

4-2 Radiolarian preserved as molds, some of them pyrite filled (arrows), accompanied by rare thin shelled *Posidonia* (a), the brownish color of matrix reflects organic content. B.23, P.P.

4-3 Microfault within chert, creating a vein filled with spary calcite (blocky cement) (a). (arrows indicate displacement). N. 55, P.P. A.S.

4-4 Sutured seam stylolite (arrows) within chert. This may indicate preservation of pre – existing compactional effect on original limestone. N. 45, P.P.

4-5 Silicified thin shelled *Posidonia* and radiolarian molds fringed by microquartz (arrows) coarser than host matrix, molds interior is filled with pyrite. N. 27, X.N.

4-6 A vein within the chert, filled by silica cement (a) similar to (drusy cement). Dolomite crystal (b) and unsilicified phosphatic shell (arrow) are also present. N. 31, X.N.

4-7 Thin – shelled *Posidonia* valves (silicified) (a) with radiolarian molds (b). Radiolarians are flattened due to compactional effect. G. 45, P.P.

4-8 Dolomite rhombs (arrows) with corroded edge within microcrystalline quartz matrix. Note silicified *Posidonia* valves (a) and calcisphere (b). N. 31, X.N.

Key Words

N. : Naokelekan
G. : Gara
B. : Banik
P.P. : Plane Polarized
X.N. : Crossed Nicols
A.S. : Alizarin Stained

ORIGIN OF CHERT IN SARGELU FORMATION

There are two scenarios for interpretation of the origin of chert beds found within the upper part of Sargelu Formation. These are related to:

1- Depositional origin
2- Diagenetic origin

1-Depositional origin

The evidences supporting depositional origin of silica are:

a-The bedded form of chert units (Figs. 3-1, 3-2, 3-3).

b-The cyclic appearance of successive chert (beds) may indicate rhythmic sedimentation.

c-The deep environment of Sargelu Formation (Balaky, 2004), which is favorable for silica deposition. But the depositional origin is tied to limited sources of silica that are not available within Sargelu's environment. While, some other evidences are against depositional origin:

1-The absence of pillow lavas and volcanoclastic sediments beneath the chert beds, which is implied in the volcanogenic origin theory.

2-The lack of parallel and cross lamination, and basal scour structures, would exclude the turbidity current deposition theory.

3-The petrography has shown that inspite of the available radiolarian, Sargelu cherts contain considerable amount of *Posidonia* shells (Figs. 4-1, 4-2, 4-5). This would lead to conclude that chert beds were not resultant of direct precipitation of silica bellow CCD. This conclusion would weaken the "pelagic rain" theory.

2-Diagenetic origin

The evidences for diagenetic origin are:

1-Fossils; the petrographic study shows that fossils, present within the chert beds, are similar to those described in limestones by Balaky (2004), such as; (*Posidonia*, radiolarian, calcispheres, and ammonites) (Figs. 4-1, 4-2, 4-5, 4-7, 4-8).

2-Presence of dolomite crystals, some of which have corroded edges (Fig. 4-8).

3-Stylolites (Fig. 4-4).

4-Replacing quartz crystals. After replacing calcite, these quartz crystals become scattered within cement-filled veins that penetrated the chert beds.

5-Gradational contact of chert with the overlying and underlying limestone beds (Figs. 3-1, 3-2).

6-Source of silica present in the Sargelu condition, is more likely to come from either the radiolarian or from clay mineral diagenesis, or both.

In viewing of all these evidences, the diagenetic origin of silica will be regarded the most acceptable for interpretation of chert beds in upper parts of Sargelu Formation. Moreover, the presence of silicified calcareous allochems and dolomite crystals, some with corroded edges, may all support the replacement origin of these chert beds (Price, 1977). Having dolomite crystals with corroded edges, would indicate that silicification postdated dolomitization.

In most chert beds, moderately preserved ghost textures and components of replaced limestones can be observed (Figs. 4-2, 4-5, 4-8). During replacement, some radiolarians and small carbonate skeletal grains (that become later silicified) lose their identity, causing difficulties in their recognition.

All the above evidences support the diagenetic origin of Sargelu cherts.

Complete replacement of some thin limestone beds or thin parts of them by silica resulted in the development of chert beds. The most likely mean of silicification that produced these chert beds, was by precipitation as cement around remaining radiolarian molds (Fig. 4-5), and also as fillings of the articulated *Posidonia* in form of chalcedonic and polycrytstalline quartz inward (Fig. 4-1).

SOURCES OF SILICA

There are three possible sources of silica for replacing original limestone beds (McBride and Folk, 1979):

1- Dissolution of radiolaria.
2- Clay mineral diagenesis.
3- Other probable source of silica may come from radiolarian in neighboring beds (limestone and shale interbeds) Additionally, considerable radiolarians are undoubtedly dissolved before being buried, because sea water at any depth over (CCD) is very undersaturated relative to silica (Brasier, 1980).

Lastly, from combining the field and petrographic evidences, we may state that the bedded cherts in the upper Sargelu Formation are formed by the diagenetic reorganization of silica, almost entirely of biogeneic origin, namely from radiolaria.

SUMMARY AND CONCLUSIONS

- The lithologic composition of Sargelu Formation (Middle Jurassic) consists of thin to medium bedded, black bituminous limestone, dolomitic limestone, and black papery shale with characteristic black cherts.
- Chert, the interesting petrographic component, is common within the upper part of Sargelu Formation in the form of thin beds, rare lenses, or elongated nodules.

- Sargelu's chert beds had shown homogenous petrographic contents, and revealed fossils similar to those described in limestone units. But, with clear signs of silicification that extended to the micritic matrix.
- By combination of field observations and petrographic studies, it is concluded that chert is formed by diagenetic reorganization of silica, which is of biogenetic (mostly radiolarian) origin.
- Complete replacement of some thin limestone beds or parts of them by silica, resulted in the development of chert beds. Dissolution of radiolarians either within chert beds or in neighboring limestone beds provided a major source of silica for this process.

REFERENCES

Balaky, S.M.H., 2004. Stratigraphy and Sedimentology of Sargelu Formation (Middle Jurassic) in Selected Sections in Erbil and Duhok Governorates – Iraqi Kurdistan. M.Sc. Thesis (unpub.), Salahaddin Univ., 110 pp.

Bellen, R.C., Van, Dunnigton, H.V., Wetzel, R. and Morton, D.M., 1959. Lexique Stratigraphique International. V. III, Asie, Fasc., 10a Iraq. Paris, 333 pp.

Blatt, H., Middletone, G. and Murray, R., 1980. Origin of Sedimentary Rocks. Prentice – Hall, USA. , 782 pp.

Brasier, M.D., 1980. Microfossils, George Allen and Unwin. London, 193 pp.

Iijima, A., Matsumoto, R. and Tado, R., 1985. Mechanism of sedimentation of rhythmically bedded chert. Jour. Sed. Geology, Vol. 41, No. 2/4, p. 221-233.

McBride, E.F. and Folk, R.L., 1979. Features and origin of Italian Jurassic radiolarites deposited on continental crust. Jour. Sed. Pet., Vol. 49, No. 3, p. 837-868.

Nisbet, E.G. and Price, I., 1974. Siliceous turbidites: bedded cherts as redeposited ocean-ridge derived sediments. In : Hus, K.J., and Jenkyns, H.C., eds., Pelagic sediments on land and under the sea : Int. Assoc. Sedimentologists Spec. Pub., No. 1, p. 351-366.

Numan, N.M.S., 2000. Major Cretaceous tectonic events in Iraq. Rafidain Jour. Sci., Vol. 11, No.3, p. 32-54.

Pettijohn, E.J., 1975. Sedimentary Rocks, 3rd edition. Harper and Roq Publishers. New York, 628pp.

Price, I., 1977. Facies distinction and interpretation of primary cherts in a Mesozoic continental margin succession, Othris, Greece. Jour. Sed. Geology, Vol. 18, p. 321-335.

Tucker, M.E., 1981. Sedimentary Petrology, an Introduction. Blackwell Scientific publications, 252 pp.

Wise, S.W. and Weaver, F.M., 1974, Chertification of oceanic sediments. In: Hsu, K.J. and Jenkyns, H.C. edts., Pelagic sediments on land and under the sea: Int. Assoc. Sedimentologists, Spec. Pub., No. 1, p. 301-326.