IASJ المجلات الاكاديمية العراقية

Tikrit Journal of Pure Science

ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: http://tjps.tu.edu.iq/index.php/j

Hydrocarbon Potentiality and Depositional Environment of Naokelekan Formation in Binari Serwan-1 Well, NE-Iraq Using Infrared Factors and Palynological Analysis Evidence

Rzger A. Abdula[1, 2], Maryam I. Abdulla[1], Nabaz A. Salih[3], Sazan A. Isa[1], Hedayat Hashmi[2]

[1]*Department of Petroleum Geosciences, Soran University, Soran, Kurdistan Region, Iraq*

[2]*Department of Petroleum Engineering and Mining, Tishik University, Erbil, Kurdistan Region, Iraq,*

[3]*Department of Chemistry, Soran University, Soran, Kurdistan Region, Iraq*

https://doi.org/10.25130/tjps.v25i2.236

ARTICLE INFO.

Article history:

-Received: 16 / 12 / 2019

-Accepted: 24 / 2 / 2020

-Available online: / / 2020

Keywords: Naokelekan, Palynology, Infrared spectrometry, kerogen, amorphous organic matter

Corresponding Author:

Name: **Rzger A. Abdula**

E-mail:

rzger.abdulkarim@tiu.edu.iq

Tel:

ABSTRACT

The cuttings from the Jurassic Naokelekan Formation have been studied in the oil exploratory Binari-Serwan-1 Well in Dokan Town, Iraqi Kurdistan Region, NE Iraq. Both infrared spectrometry techniques and microscopic study were used for determining hydrocarbon generation potentiality. The prepared strewn slides have been studied under polarizing microscope. The Naokelekan Formation has revealed an excellent total organic carbon (TOC) wt. % content, ranging from 4.20 to 5.88 wt. %. The palynomorphs as well as phytoclasts are totally absent and only the amorphous organic matter (AOM) was identified. The concentrated kerogens of selected samples were analyzed by the Infrared Spectrometer. The results of these samples analysis show existence of kerogen types II and III, which coincides with the microscopic study. This organic matter is of gas and oil prone types. This study suggests that the sediments were deposited in a marine, suboxic to anoxic environment.

Introduction

The sediments of Jurassic Period in general and Middle Jurassic especially contain substantial source rock in Iraq. They encompass the high percentage of organic matter viz. Sargelu, Naokelekan, and Najmah formations [1, 2, 3, 4, 5].

The Naokelakan Formation was first described by Wetzel and Morton in 1950 [6] from the Imbricated Zone of northeastern Iraq, near Rowanduz Town. The Naokelakan Formation consists of dark, carbonaceous limestone, calcareous, fissile, black to brown shale, and thin-to medium dolomitic limestone. The thickness of the formation is approximately between 7 to 48 meters in Banik and RuKuchuk, respectively [6]. According to Buday [7], the Naokelekan Formation has been renamed Najmah Formation in the Mesopotamian wells in the middle and southern parts of Iraq.

In Iran and southeastern Turkey, the correlative units are Surmeh Formation of the east Zagros Mountain and the shaly horizons in the Cudi Group, respectively [8,7]. In most of the Arabian countries, Tuwaiq Mountain, Hanifa, Jubaila, and Najmah formations are equivalent formations for Naokelakan Formation [7].

The Naokelekan Formation was deposited in an euxinic environment in a slow subsiding basin [7, 9]. On the contrary, Salae [10] decided that the formation was deposited in brackish lagoon.

Balaky [11,12] studied the facies association of Naokelekan Formation in northeastern Iraq and recognized two lithofacies associations: subtidal and open marine. Kabeer [13] created a geological cross section traversing the northern limb of Gara anticline.

Stratigraphy and geochemistry of Jurassic formations in Banik and Galy Derash sections, north Iraq were investigated by Al-Badry [14] and stated that depositional setting for Naokelekan Formation was salty swamps, marshes, and restricted tidal flat and lagoons.

The existence of *Cyclagelosphaera deflandrei* sp. and *lotharingius* sp. within the upper part of this formation signifies Callovian-Upper Oxfordian age [15].

The organic matter found in various inlayers of Naokelekan Formation belongs to types II and III kerogens [2]. Odisho and Othman [16] evaluated the source rock capability within the both well samples and outcrop samples of the Sargelu, Naokelekan, Chia Gara, and Sarmord formations in northern Iraq, over the Mosul block. They showed that the Sargelu, Naokelekan, and Chia Gara formations are source rocks despite the fact that with variable hydrocarbon capability. Al-Beyati, [17] used the infrared method with AOM classification on Chia Gara Formation and he agreed that the formation might represent a good source rock. The quality of organic matter of Naokelekan Formation is good and thermally matures[5].

Dunnington [18] assessed the petroleum system processes and lithofacies of Jurassic succession in northern Iraq and concluded that Jurassic units produced hydrocarbons that migrated upward. Outcomes from a basin modeling that performed by Pitman et al. [19] showed that oil was generated from Naokelekan Formation during Late Eocene to Oligocene.

The aim of this study is to interpret depositional environment, kerogen type, and hydrocarbon potentiality of the Naokelekan Formation using infraded factors and palynological analysis in the Binari-Serwan-1 Well. This well is located approximately 20 km east of Dokan Town (Fig. 1) in the High Folded Zone. The studied section lies on longitude 45º 14′ 35″ E and latitude 35º 44′ 02″ E.

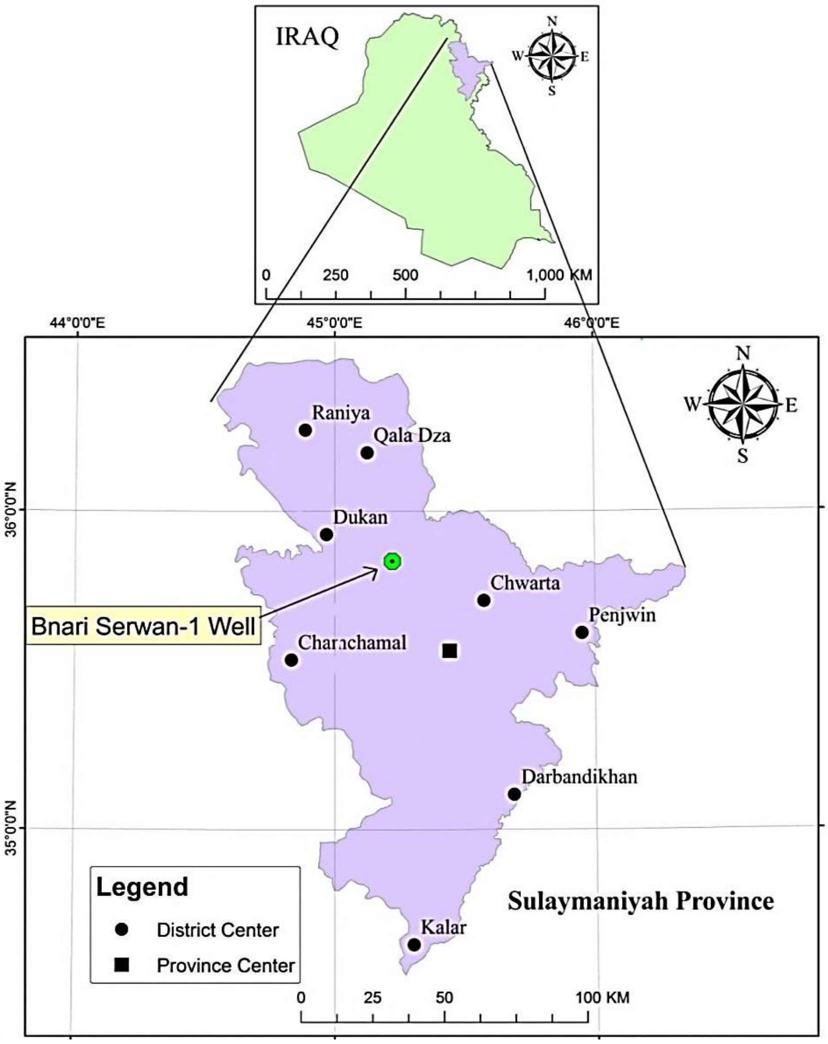


Figure 1: map of the studied well, Binari Serwan-1, which is located in Dokan area, Sulaymaniyah Governorate.

Methodology

The five samples from the Naokelekan Formation were collected from Erbil Geological Survey Storage in Erbil, Iraqi Kurdistan Region in October, 2015 (Table 1).

The laboratory work performed at University of Sulaymaniyah and included the following actions:

The samples were grinded and sieved by nylon mesh 10µ. After that, 30 ml H_2O and 30 ml HCl were mixed in a glass beaker and next mixed with the 30 g of 2 mm of sieved samples. Then, they were left for a whole day. During the day the samples were shaken by a rod to speed the reaction. For five times the above reaction were repeated. When the reaction finished in the following day, the samples were washed by water four times and left them for three hours each time.

Next step, the washed samples mixed with the 60 ml of HF in a plastic beaker until the silica bonds were dissolved. When the samples deposited, the HF were separated from the samples and washed them four times with water.

The samples mixed with 30 ml of HCl four times again and heated to remove the matter, which formed during mixing the samples with HF. Then the acid dispensed off and purified water added and left overnight. Samples were then washed several times with distilled water until being neutral. The residues are sieved with 10 µm nylon mesh. These residues were mounted by cellusize on cover slip and sticker on the slide by a small amount of mounting medium (Canada balsam).

The prepared slides studied under transmitted light using microscope and the AOM kerogen was identified under reflected lights. The rock samples were analyzed by Infrared. The Infrared technique can be used to determine the kerogen type and maturity. It can offer a quantifiable ration of bond types viz. aliphatic and aromatic bonds.

The concentrated kerogens of selected samples were analyzed by Infrared instrument (IR) at Department of Chemistry, University of Sulaymaniyah. The pellets made through mixing with Potassium Bromide (KBr) and pressed under 20 Kb pressure. The IR Spectra were recorded on a Perkin-Elmer FT/IR spectrometer using KBr pellets (vmax in cm^{-1}). The intensity of important peaks at wave numbers such 1630 cm^{-1}, 1710^{-1}, 2860^{-1}, and 2930^{-1} have been measured.

Table 1: The studied samples number, depth of samples, and TOC for samples selected from the Naokelekan Formation at Binari Serwan-1 Well, Sulaymaniyah Governorate, Kurdistan Region - Iraq.

Location	Formation	Sample No.	Depth (m)	TOC wt. %
Binari Serwan-1	Naokelekan	BS-12	840-843	4.38
Binari Serwan-1	Naokelekan	BS-13	843-846	4.52
Binari Serwan-1	Naokelekan	BS-14	846-849	1.23
Binari Serwan-1	Naokelekan	BS-15	1915-1918	5.01
Binari Serwan-1	Naokelekan	BS-23	1939-1942	5.88

The Naokelekan Formation occurs between 1916 and 1951 m and occurs again between 779 and 849 m. The repetition is due to existence of thrust fault [20].

Geological and structural setting

Iraq situated in the northeastern part of the Arabian Plate. Iraq divided into several tectonic zones include: (1) Geosyncline subdivision (Northern Thrust Zone, Zagros Thrust Zone, Imbricated Zone); (2) Unstable Shelf (High Folded Zone, Foot Hill Zone, Mesopotamian Zone); and (3) Stable Shelf (Block Faulted Zone).

The Mesozoic sequence of Iraq represents the sediments that belong to passive margin of the Arabian Plate [21]. This plate margin developed from rift to drift in the Permian- Triassic and Jurassic-Early Cretaceous, respectively. Later during Late Cretaceous- Early Tertiary was sutured [22].

The Naokelekan and Barsarin formations were deposited in the developed foreland basin during Late Jurassic at the edge of the Arabian Plate [23, 24]. The exposure of Jurassic formations can be seen as sequestered spots in several structures in the High Folded, Imbricated, and Thrust zones of Iraq.

In the studied well, Naokelekan Formation conformably occurs above Sargelu Formation and conformably also under Barsarin Formation (Fig. 2). The formation is 70 m thick and occurs between the 1916-1951 m under the surface. It occurs again between 779-849 m under the surface with the thickness of 35 m due to the existence of thrust fault. The formation consists of laminated shaly limestone, dark grey or bluish limestones, extremely bituminous limestones, and dolomites with black bituminous shales.

Results and discussion

Total Organic Carbon

The TOC values were obtained from the Naokelakan Formation samples (Table 1) by weighting the remained amount of organic matter after mixing the samples with HCl and HF. The TOC values are different from lower, middle, and upper parts of the formation. At the lower part, the TOC is higher than the upper and middle part samples. The average TOC is 4.20 wt. % which is comparatively a moderate amount as this formation has 18.8 wt. % TOC in average in the well Ajeel-12 and 0.4 wt. % TOC in average in Barzinja locality [25].

Visual Kerogen

The prepared five strewn slides have been studied under polarizing microscope. The palynomorphs as well as phytoclasts are totally absent, and only the AOM kerogen was identified under polarizing lights.

The amorphous organic matter is originated principally from marine organism viz. phytoplankton which has formless shape and quickly decomposed in oxic conditions [26].

According to Thompson and Dembicki [27], there are four diverse forms of amorphous organic matter based on texture: Type A is a dense with spotted connection or delicate polygonal; Type B is a very small, solid, stretch, ellipsoid, or smooth-edged distinct grains; Type C is clumps with gritty, fragmental or spherical textures; and Type D is tinny, platy, or quadrilateral particles.

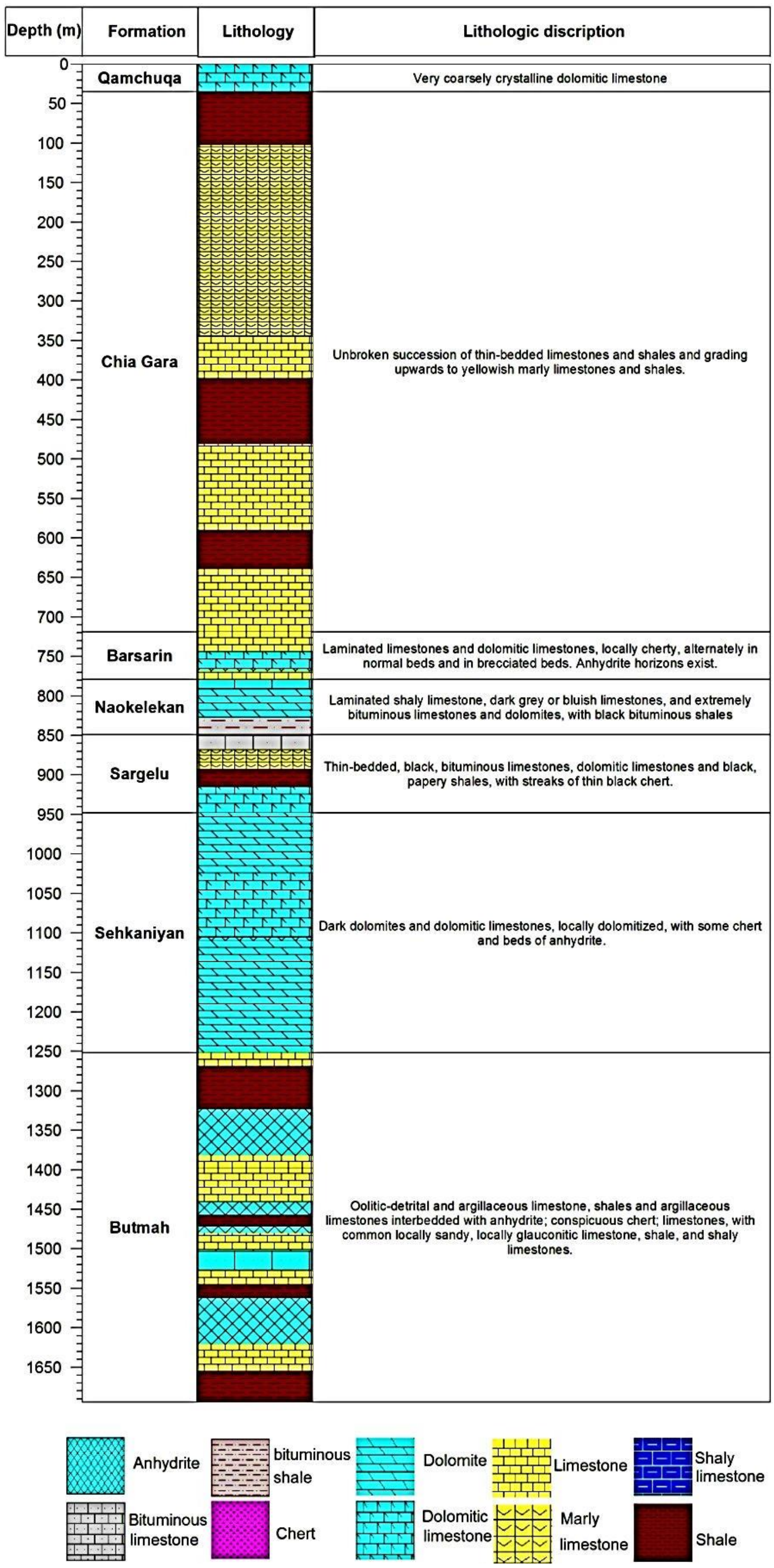


Figure 2: Stratigraphic column shows the distribution of the formations in the studied well.

Oil-prone organic matter is commonly encompassing types A and/or D individually or non-individually, while gas-prone organic matter comprises Type A and differs in quantities of Types B, C, and/or D.

The classification of Thompson and Dembicki [27] was used for naming the type of kerogen for the studied samples. This classification has been used successfully in Kurdistan by many authors, such as Mohialdeen [28], Ranyayi [29], and Mohialdeen et al. [30].

The AOM within the studied samples were classified into three major types: a) small and elongated dark grains less than 20 micron in diameter (Type B) and a small amount of very fine rectangular grains (Type D). Both types are dominant in samples BS-14 (Fig. 3C) and BS-15 (Fig. 3D); b) represents dark brown grains with large diameters (≈ 200 micron), which are mostly Type C, this type seen in (BS-13) sample (Fig. 3B); c) represents compact mass with spotted connection or delicate polygonal, which is mostly Type A. This type was seen in samples BS-12 (Fig. 3A) and BS-23 (Fig. 3E) [27].

The studied organic matter is mostly Type A and varies in quantities of types B, C and/or D depending on Thompson and Dembicki [27] classification. All the studied samples are grey under reflected light. Using the ternary diagram of Tyson [31] for classification of organic matter within sedimentary rocks, all the studied samples are located very close to the left lower corner of AOM (Fig. 4). This field (IX) is characterized by sediments that deposited in suboxic to anoxic marine environment. Thus, this part considered as highly oil prone organic matter.

Infrared Spectrometry

The infrared spectroscopy has been done for selected five samples from the rocks of Naokelekan Formation. The organic matter of Naokelekan Formation was investigated by FTIR for wave numbers ranging between (400–4000) Cm^{-1} (Figs. 5, 6, 7, 8, and 9). This technique depends on the relevant intensity of the absorption bands associated with aliphatic CH_2, CH_3 assemblages (active part of organic matter) and to polyaroamtic nuclei (benzene) (inactive part of organic matter; therefore, kerogen type and maturity can be inferred. The information provided by this technique when utilized along supplementary data can offer a numerical measure of aliphatic and aromatic bonds in the range of: 1) 3100–2900 cm^{-1} for C–H bonds; 2) 1800–1650 cm^{-1} for C=O groups 3) 3600–3200 cm^{-1} for O–H and N–H groups [32, 33, 34].

After comparison the spectrographs with those of Thompson and Dembicki [27], it is clear that the studied samples: BS-23 and BS-12 are belonging to Type C; samples BS-14 and BS-15 are belonging to Type B, which is totally gas prone; and sample BS-13 is belonging to Type A, which is oil prone.

The strength of discrete peaks at 2860 cm^{-1} and 2930 cm^{-1} (CH_2 and CH_3 aliphatic groups), at 1710 cm^{-1} (Carboxyl and Carbonyl groups), and at 1630 cm^{-1} (aromatic C=C bonds) on the spectrographs were determined to compute A and C Factors suggested by Ganz and Kalkreuth [35] (Table 2) and plotted on the A and C factors diagram (Fig. 10). The samples BS-13, BS-14, and BS-15 are Type II kerogen; however, samples BS-12 and BS-23 are containing Type III kerogen.

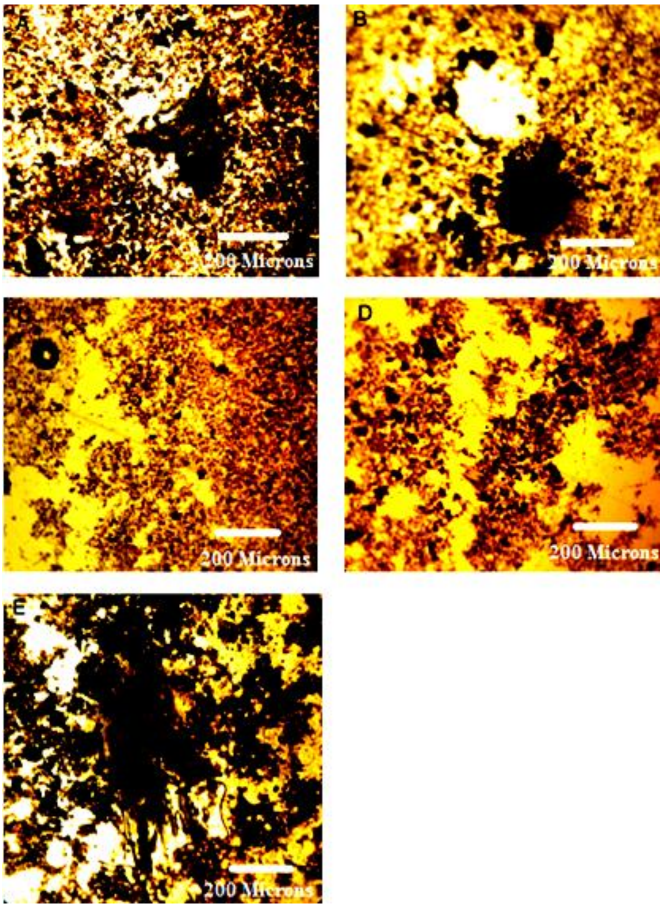
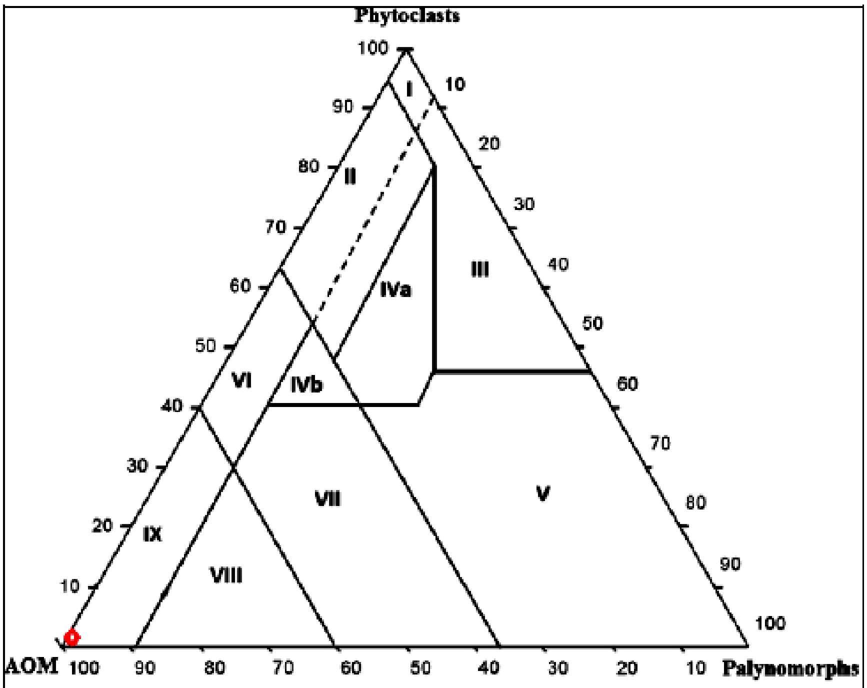


Figure 3: Photomicrographs of Late Jurassic Naokelekan Formation depicting different types of organic matter (BS-12 (A), X100) sample, (BS-13 (B), X100) sample, (BS-14 (C), BS-15 (D), X100) samples, and (BS-23 (E), X100) sample, Binari Serwan-1 Well, Sulaymaniyah, Iraqi Kurdistan Region.



Palynofacies Fields	Environment	Kerogen Type
I	Highly proximal shelf or basin	III (gas prone)
II	Marginal dysoxic –oxic basin	III (gas prone)
III	Heterolithic oxic shelf ("proximal shelf")	III or IV (gas prone)
IV	Shelf to basin transition	III or II (mainly gas prone)
V	Mud-dominated oxic shelf ("distal shelf")	III > IV(gas prone)
VI	Proximal suboxic-anoxic shelf	II (oil prone)
VII	Distal dysoxic-anoxic "shelf"	II (oil prone)
VIII	Distal dysoxic-anoxic shelf	II >> I (oil prone)
IX	Distal suboxic-anoxic basin	II ≥ I (highly oil prone)

Figure 4: Ternary diagram of amorphous organic matter (AOM) –phytoclast –palynomorphs. All the studied samples located in the lower left corner of the diagram, exactly on AOM corner due to high abundance of AOM. The diagram demonstrates that the upper Jurassic sediments were deposited in marine, suboxic-anoxic marine depositional setting (adapted from [31]).

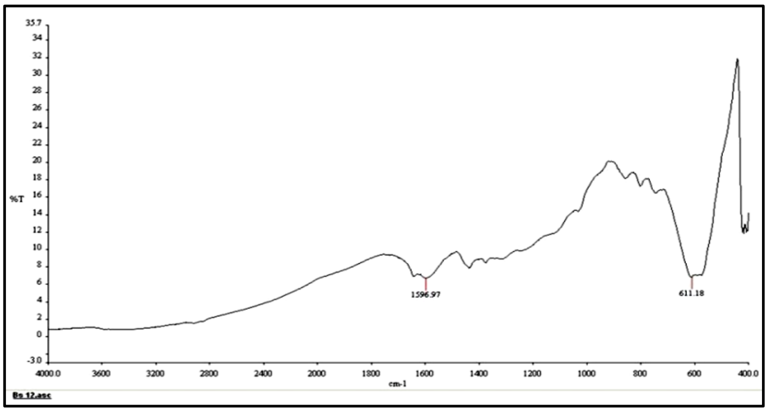


Figure 5: The Infrared spectra (transmittance) for sample BS-12 (Type C). An IR spectrum's X-axis represents the intensity of distinct peaks (1/cm) marked as "Wave number" and ranges between 400-4,000. The horizontal axis shows the absorption values. The Y-axis is marked as "Percent Transmittance" (T %) and sorts between-3.00 -35.70.

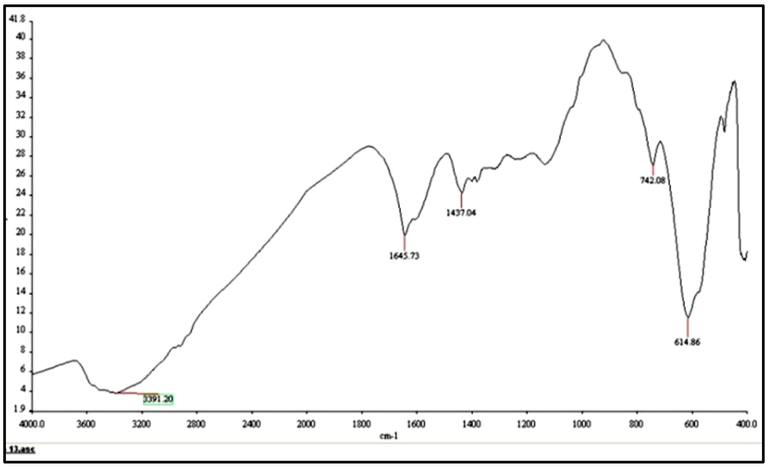


Figure 6: The Infrared spectra (transmittance) for sample BS-13 (Type A). An IR spectrum's X-axis represents the intensity of distinct peaks (1/cm) marked as "Wave number" and ranges between 400 - 4,000. The horizontal axis shows the absorption values. The Y-axis is marked as "Percent Transmittance" (T %) and sorts between 1.90 -41.80.

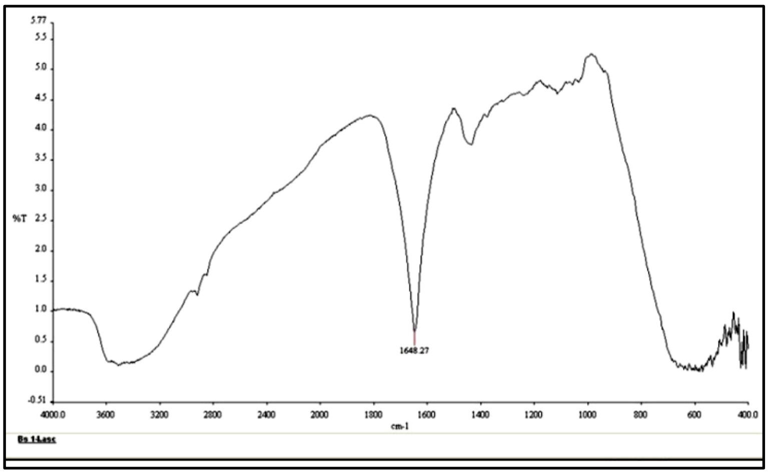


Figure 7: The Infrared spectra (transmittance) for sample BS-14 (Type B). An IR spectrum's X-axis represents the intensity of distinct peaks (1/cm) marked as "Wave number" and ranges between 400 - 4,000. The horizontal axis shows the absorption values. The Y-axis is marked as "Percent Transmittance" (T %) and sorts between 0.51 -5.77.

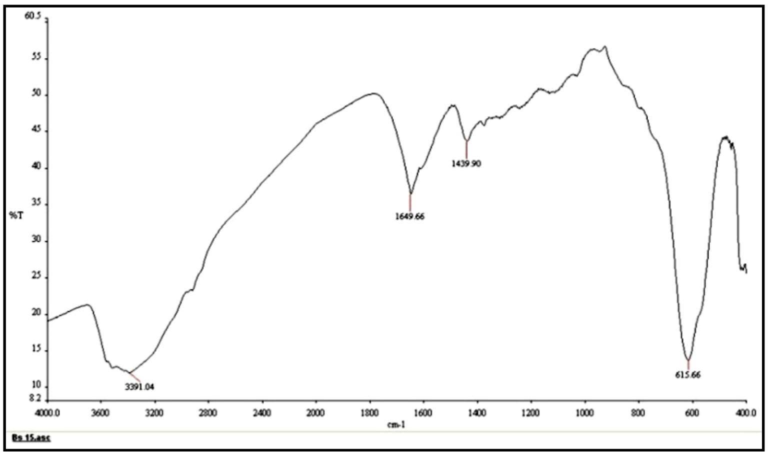


Figure 8: The Infrared spectra (transmittance) for sample BS-15 (Type B). An IR spectrum's X-axis represents the intensity of distinct peaks (1/cm) marked as "Wave number" and ranges between 400 - 4,000. The horizontal axis shows the absorption values. The Y-axis is marked as "Percent Transmittance" (T %) and sorts between 8.20 -60.50.

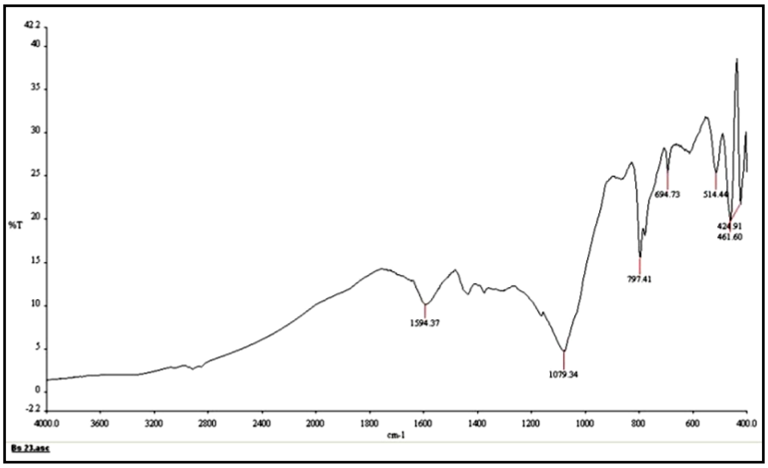


Figure 9: The Infrared spectra (transmittance) for sample BS-23 (Type C). An IR spectrum's X-axis represents the intensity of distinct peaks (1/cm) marked as "Wave number" and ranges between 400 - 4,000. The horizontal axis shows the absorption values. The Y-axis is marked as "Percent Transmittance" (T %) and sorts between -2.20 -42.20.

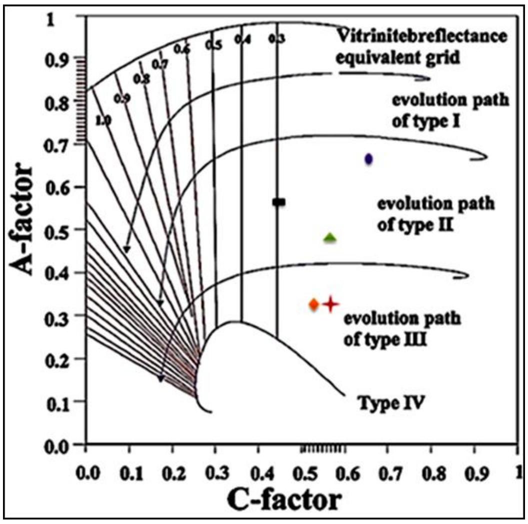


Figure 10: The results of Infrared spectroscopy as plotted on the A-Factor versus C-Factor. The samples BS-14 , BS-15, and BS-13 are containing Type II kerogen. The samples BS-12 and BS-23 are containing Type III kerogen [35].

Table 2: Sample number, range of Infrared spectra (transmittance), A and C factors.

Sample No.	2930 c^{-1}	2860 c^{-1}	1710 c^{-1}	1630 c^{-1}	A factor	C factor
BS-12	1.57	1.74	9.26	7.17	0.32	0.56
BS-13	8.65	9.80	27.17	21.00	0.47	0.56
BS-14	1.29	1.61	2.92	1.51	0.66	0.66
BS-15	23.35	25.87	31.83	38.47	0.56	0.45
BS-23	2.79	2.94	13.92	12.26	0.32	0.53

A Factor = 2860 cm^{-1} + 2930 cm^{-1} / 2860 cm^{-1} + 2930 cm^{-1} + 1630 cm^{-1}
C Factor = 1710 cm^{-1} / 1710 cm^{-1} + 1630 cm^{-1} [35].

Conclusions

The results of the studied samples from Late Jurassic Naokelekan Formation in well Binari Serwan-1 indicated the following points:

- The samples BS-12, BS-13, BS-15, and BS-23 contain high TOC percentage (considered as excellent), while the sample BS-14 contains moderate TOC percentage (considered as good). Therefore, The Naokelekan Formation can be considered a potential source rock.
- The organic matter is totally amorphous with no indication to any palynomorphs and phytoclasts.
- The microscopic study data indicate the presence of kerogen types II and III. This was confirmed also by the study of prepared pellets by Infrared Spectrometer shows the presence of kerogen type II within the samples BS-13, BS-14, and BS-15, while samples BS-12 and BS-23 are kerogen type III.
- This study suggests that the sediments were deposited in a marine, suboxic to anoxic environment.

Acknowledgments

Many thanks are to the Ministry of Natural Resources in Erbil for providing samples in Binari-Serwan-1 Well. We would like to recognize the Department of Chemistry, Sulaymaniyah University for analyzing samples by Infrared Spectrometry. Special thanks to Dr. Ibrahim Mohialdeen and Ms. Razawa Sarraj from Geology Department, Sulaymaniyah University, and Nahida Mohammed Azo from Soran University for their technical help.

References

[1] Al-Omari, F.S. and Sadiq, A., (1977). Geology of northern Iraq. Mosul University Press, Mosul, Iraq, 198p.

[2] Othman, R.S., (1990). Generation, migration, and maturation of the hydrocarbons, Northern Iraq (Upper Jurassic-Lower Cretaceous). M.Sc. thesis (unpublished), University of Salahaddin, 208p.

[3] Jassim, S.Z. and Al-Gailani, M., (2006). Hydrocarbons, chapter 18.In: Jassim, S.Z. and Goff, J.C. (eds.), Geology of Iraq. First edition, Prague and Moravian Museum, Brno, Czech Republic, pp. 232−250.

[4] Ahmed, Sh.M., (2007). Source rock evaluation of Naokelekan and Barsarin Formations (Upper Jurassic), Kurdistan Region/ N. Iraq. M.Sc. thesis(unpublished), University of Sulaymaniyah, 228p.

[5] Al-Ameri, T.K. and Zumberge, J., (2012). Middle and Upper Jurassic hydrocarbon potential of the Zagros Fold Belt, North Iraq. Marine and Petroleum Geology, 36(1), pp. 13−34.

[6] Bellen, R.C. Dunnington, van, H.V., Wetzel, R., and Morton, D.M., (1959). Lexique stratigraphic international.
Paris, Vol. III, Asie, Fascicule 10a Iraq, 333p.

[7] Buday, T., (1980). The regional geology of Iraq, Vol. 1, stratigraphy and paleogeography. Dar Al-Kutub Publishing House, University of Mosul, Mosul, Iraq, 445p.

[8] Altinli, I.E., (1966). Geology of eastern and southeastern Anatolia, Turkey. Bulletin of Mineral Research Exploration Institute of Turkey, Foreign Edition, Ankara, 60, pp. 35−76.

[9] Al-Sayyab, A., Al-Ansari, N., Al-Rawi, D., Al-Jassim, J., Al-Omari, F., and Al-Shaikh, Z., (1982). Geology of Iraq. Mosul University Press, Mosul, Iraq, 280p.

[10] Salae, A.T.S. (2001). Stratigraphy and sedimentology of the Upper Jurassic succession, northern Iraq. Master's thesis (unpublished), Science College, University of Baghdad, Baghdad, Iraq, 95p.

[11] Balaky, S.M., (2008). Facies associations and depositional environments of Naokelekan Formation (late Jurassic), Northeastern Iraq—Kurdistan region. Zanko, the scientific journal of pure and applied sciences, pp. 167−180.

[12] Balaky, S.M.H., (2015). Sequence stratigraphic analyses of Naokelekan Formation (Late Jurassic), Barsarin area, Kurdistan region—northeast Iraq. Arabian Journal of Geosciences, 8(8), pp. 5869−5878.

[13] Kabeer, A., 2019, Pers. Com., Geological cross section traversing the northern limb of Gara anticline. Norwegian Oil and Gas Operator (DNO), Erbil, Kurdistan Region, Iraq.

[14] Al-Badry, A.M.S., (2012). Stratigraphy and geochemistry of Jurassic formations in selected sections – north Iraq. Ph.D. dissertation (unpublished), Science College, University of Baghdad, Baghdad, Iraq, 183p.

[15] Abdula, R.A., (2016). Stratigraphy and lithology of Naokelekan Formation in Iraqi Kurdistan-Review. The International Journal Of Engineering And Science, 5(8), pp. 2319−1805.

[16] Odisho, K.Y and Othman, R.S. (1992). Preliminary geochemical evaluation of hydrocarbon source rocks in northern part of Iraq. Iraqi Geological Journal, 25, pp. 136−153.

[17] Al Beyati, F.M., (1998). Organic geochemical and environmental evaluation study of Chia Gara Formation from selected boreholes in middle Iraq, Ph.D. dissertation (unpublished), University of Baghdad, 172p.

[18] Dunnington, H.V., (1958). Generation, migration, accumulation and dissipation of oil in Northern Iraq. In: Wecks, G.L. (ed.), Habitat of oil, a symposium. AAPG, Tulsa, pp. 1194−1251.

[19] Pitman, J.K., Steinshouer, D., and Lewan, M.D., (2004). Petroleum generation and migration in the Mesopotamian basin and Zagros Fold Belt of Iraq, results from a basin-modeling study. GeoArabia, Gulf PetroLink, Bahrain, 9(4), pp. 41−72.

[20] Gas Plus, 2019, pers. Comm.

[21] Numan, N.M.S., (1997). A plate tectonic scenario for the Phanerozoic succession in Iraq. Iraqi Geological JournalSociety of Iraq, 30(2), pp. 85−110.

[22] Burchette, T.P., (1993). Mishrif Formation (Cenomanian-Turonian), southern Arabian Gulf: carbonate platform growth along a cratonic basin margin. In: Simo, J.A., Scott, R.W., and Masse, J.P. (eds.), Cretaceous Carbonate Platforms. AAPG Memoir, 56, pp. 185−199.

[23] Murris, R.J., (1980). Middle East: Stratigraphic Evolution and oil Habitat. AAPG Bulletin, 64(5), pp. 597−618.

[24] Numan, N.M.S., (2000). Major Cretaceous tectonic events in Iraq. Rafidain Journal Society, 11(3), pp. 32−54.

[25] Abdula, R.A., (2017). Source rock assessment of Naokelekan Formation in Iraqi Kurdistan. Journal of Zankoi Sulaimani, 19 (1), pp. 103–124.

[26] Pacton, M., Gorin, G.E., and Vasconcelos, C., (2011). Amorphous organic matter — Experimental data on formation and the role of microbes. Review of Palaeobotany and Palynology, 166 (3-4), pp. 253−267.

[27] Thompson, C.L. and Dembicki, H., (1986). Optical characteristics of amorphous kerogens and the hydrocarbon generating potential of source rocks. International Journal of Coal Geology, 6, pp. 229−249.
[28] Mohialdeen, I.M.J., (2008). Source rock appraisal and oil/source rock correlation for the Chia Gara Formation, Kurdistan, N Iraq. Ph.D. dissertation (unpublished), University of Sulaymaniyah, 140p.
[29] Ranyayi, K.S.M., (2009). Source rock evaluation of lower Tertiary Formations in northeast Iraq. Master's thesis (unpublished), Science College, University of Sulaymaniyah, Iraq, 171p.
[30] Mohialdeen, I.M.J., Hakimi, M.H. and Al-Beyati, F.M., (2013). Geochemical and petrographic characterization of Late Jurassic – Early Cretaceous Chia Gara Formation in Northern Iraq: Palaeoenvironment and oil generation potential. Marine and Petroleum Geology, 43, pp. 166−177.
[31] Tyson, R.V., (1995). Sedimentary organic matter: Organic facies and palynofacies. Chapman and Hall, London, 615p.
[32] Farmer, V.C., (1974). The Infrared Spectra of Minerals. Mineralogical Society. London, 527p.
[33] Gionis, V., Kacandes, G., Kastritis, I., and Chryssikosi, G., (2006). Palygorskite exhibits low amounts of etrahedral substitution on the structure of palygorskite by mid-and near-infrared spectroscopy. American Mineralogist, 91, pp. 1125−1133.
[34] Myriam, M., Suarez, M., and Martin-Pozas, J.M., (1998). Structural and textural modifications of palygorskite andsepiolite under acid treatment. Clays and Clay Minerals,46(3), pp. 225−231.
[35] Ganz, H. and Kalkreuth, W., (1987). Application of infrared spectroscopy to the classification of kerogen-types and the evaluation of source rock and oil shale potentials. Fuel, 66(5), pp. 708−711.

البيئة الترسيبية لتكوين ناوكييلكان في بئر بناري سيروان – 1، شمال شرق العراق باستخدام كل من تقنيات الطيف بالأشعة تحت الحمراء ودليل التحليل البالينوجي

رزگار عبد الكريم عبدالله[2،1] ، مريم اسماعيل عبدالله[1]، نبز عبدالحميد صالح [3] ، سازان عارف عيسى[1] ، هيدايت هاشمي[1]
[1]قسم علوم الارض البترولية ، جامعة سوران، اربيل ، العراق
[2]قسم الهندسة النفط و المناجم، جامعة تيشك ، اربيل ، العراق
[3]قسم الكيمياء ، جامعة سوران ، اربيل ، العراق

الملخص

تمت دراسة صخور تكوين ناوكيليكان الجوراسي ضمن البئر الٱستكشافى بنارى سيروان-١ فى مدينة دوكان، كوردستان العراق. واستخدمت كل من تقنيات الطيف بالأشعة تحت الحمراء و الدراسة المجهرية لتحديد إمكانات توليد الهيدروكربون. يحتوي تكوين ناوكيليكان على نسبة ممتازة من إجمالي محتوى الكربون العضوي، والتي تتراوح من 4.20 إلى 5.88٪ بالوزن. تمت دراسة الشرائح المحضرة المعدة تحت المجهر المستقطب. الأشكال البالينولوجية و كذلك الخلايا النباتية المكسرة غائبة تمامًا وتم تحديد الكيروجين عديم الشكل فقط. تم تحليل المادة العضوية المركزة للعينات المختارة بواسطة مطياف الأشعة تحت الحمراء. تظهر نتائج هذه العينات نوعين من الكيروجين الثاني والثالث، والذي يتلائم مع نتائج الدراسة المجهرية. هذه المادة العضوية معظمها من النوع المكون للغاز و النفط. ترسبت صخور تكوين ناوكيليكان في بيئة بحرية سامة اختزالية عديمة الاوكسجين.