1* Masoud Khajavi

Investigation of Palynofacies Potential and Sedimentary Environment on One of the Fields in Southwest Iran

Journal of Electrical Systems

Abstract: - The purpose of this study is to investigate palynofacies potential and sedimentary environment in one of the fields in Southwest Iran. After palynological slides were prepared, the palynological elements of samples were detected among 200-400 grains for each sample under the microscope with a magnification of 16. The groups of palynological elements (amorphous organic matter (AOM), marine palynomorph, phytoclasts, spore, and pollen) were calculated using their sample percentages. The results showed that samples studied in wells 50 and 70 are classified into palynofacies groups VI and IX regarding the organic matters and palynological elements existing in them, while samples in wells 62 and 26 are placed in the palynofacies groups VI and II. Regarding the Tyson Diagram, the palynofacies VI contains abundant AOM and average phytoclast content, representing an offshore environment and a recovery existing in an oil window with high hydrocarbon generation power, and IX has abundant AOM with very low rate of palynomorph, representing a semi-oxygenated to low-oxygen and offshore environment and in an oil window with very high production power. The palynofacies II contains high phytoclast and low AOM, indicating a basin margin environment with recovery conditions in the gas generation window with minor oil. In palynofacies IX group, a high amount of clear and bright amorphous organic matter (80-100) exists. The amount of amorphous organic matter in palynofacies VI is decreased (40-70%) rather than IX, while phytoclast usually varies between 10% and 30%. There is a considerable decline in the amount of AOM in the palynofacies group reaching around 15-35%..

Keywords: Mansouri Oilfield, Palynofacies, Sedimentary Environment, Fields of Southwest Iran

I. INTRODUCTION

Palynology plays a highly important role in the low-cost exploration and extraction of hydrocarbons, which includes studying pollens, spores, radiolaria, diatoms, algae, and other organic remains [1]. Palynofacies are defined as the process that leads to the removal of resistant organic matter from the rock substrate through acid washing. The concept of palynofacies was introduced by Combaz for the first time in 1964 who used this term to find the origin and understand the transport of organic particles in the soil [2]. The start point and success of palynofacies are observed in the natural relationship between sedimentology palynology and organic geochemistry, in which organic geochemistry is the base for hydrocarbon evaluation to its objective and quantitative matures. Jones further developed the concept of palynofacies in 1987 and asserted that the base and action of organic facies is the decomposition of elements or pyrolysis, and continued that the concept of palynofacies may also be detected through Transmitted Light Microscopy [3]. Tyson (1995) and Batten (1996) classified the palynological elements into three main groups of organic matter (marine palynomorphs, phytoclasts, and amorphous organic matters) to achieve better performance of palynofacies. The mentioned matters are elaborated herein [4].

Palynomorphs have a significant role in environment interpretations. Acritarchs, scolocodonts, and dinoflagellates usually make up a high percentage of marine palynomorphs [4]. As mentioned, palynomorphs are effective in renovating and identifying ancient environments. For instance, results obtained by some researchers have found that the ratio of dinoflagellates to pollens, spores, and nannofossils would determine the distance between the sedimentary environment and the coast (Tyson, 1998) (Figures 1-4). When the basin is far from the shore and moderate oxygen conditions exist, the kerogen density percentage of marine palynomorphs rises, and the farther the distance from the shore, the higher the percentage of dinocysts will be [4]. Assessment of palynological slides allowed to detection of some structures with different components related to remains and animal remains and particles (scolecodonts, graptolites, chitinozoa) [4].

Phytoclasts include all particles entering from the shore to the basin. Those phytoclasts of land origin include pollen, plant spores, leaf fragments, cuticles, and wood fragments. Those plants that produce pollen provide more environmental compatibility rather those plants that produce spores [4]. This group consists of two isomorphic and blade-shaped groups in terms of shape and size, and dark and brown phytoclasts in terms of transparency, in which the brown one represents the environment near the coast and the dark one indicates a semi-calm and offshore environment [4].

[1] Oil Exploration Engineering, Department of Mining, Isfahan University of Technology, Iran

* Corresponding author

Tabaei and Tabrizi (2011) carried out a study to evaluate the oil-generating potential of tertiary deposits of the Pabdeh Formation in the Kabir Zone of Lorestan Mountain [5]. Beyranvand (2013) conducted a study on biostratigraphy and paleoecology of Gurpi and Pabdeh Formations in an area of the Izeh Zone and used them in basin analysis under the title of Ph.D. Thesis [6]. Tarjani Salehani (2014) studied palynostratigraphy, palynofacies, and paleoecology of Sanganeh Formation in the Toos Well 1 of Kopeh Dagh as an MA Thesis at Tehran University [7]. Hashemi Yazdi (2015) conducted a study on palynology and paleoecology of the Delichay Formation in the central-eastern Alborz basin and the Hajdak Formation in the east of Central Iran as a Ph.D. Thesis in Tehran University [8]. Yousefi (2017) carried out palynostratigraphy, palynofacies, and paleoecologic studies on the Sarcheshmeh Formation in the section of Khemari Village in the east of Kopeh Dagh sedimentary basin [9].

Zagros zone, which has the highest area in Iran is one of the most important oil areas in the world where rock sources are provided using stratigraphy and organic geochemistry [10]. In the southwest of Iran, oil accumulation in the Kertaseh oil system occurs due to oil migration from multiple layers of source rock with different specific grades, which are based on the deposition time of Govdan (Barmian), Kajdomi (Albian), Goro (Neocumian), Ahmadi (Lower Cenomanian), Pabdeh and Gurpi (Eosen, Campanian, Maastrichtian) [10 & 11].

Geographical features and location of Mansouri Oilfield

The Mansouri Oilfield is one of the oilfields of Iran that is located in Khuzestan Province. This field is in the neighborhood of Ahvaz Oilfield from the northwest, of Ab Teimour Field from the west, and next to Shadegan Oilfield from the northeast (Figure 1) [12].

Figure 1. Geographical location of Mansouri Field [12]

The Mansouri Oilfield was discovered in 1963 by the Iran Oil Exploration and Production Company, and its exploitation began in 1974. The volume of in-situ storage of crude oil of Mansouri Oilfield is estimated at over 3 billion barrels. In terms of geography, this field is 39km and 5km in length and width, respectively [12 & 13]. Mansouri Oilfield is one of the fields managed by the National Iranian South Oil Company, and its production operations are done by Karoon Oil and Gas Production Company. In this research, studies, and assessments were done based on the sample of drilling debris harvested from wells 26, 62, 70, and 50 in Mansouri Oilfield to evaluate the hydrocarbon generation potential in these four wells (Figure 2).

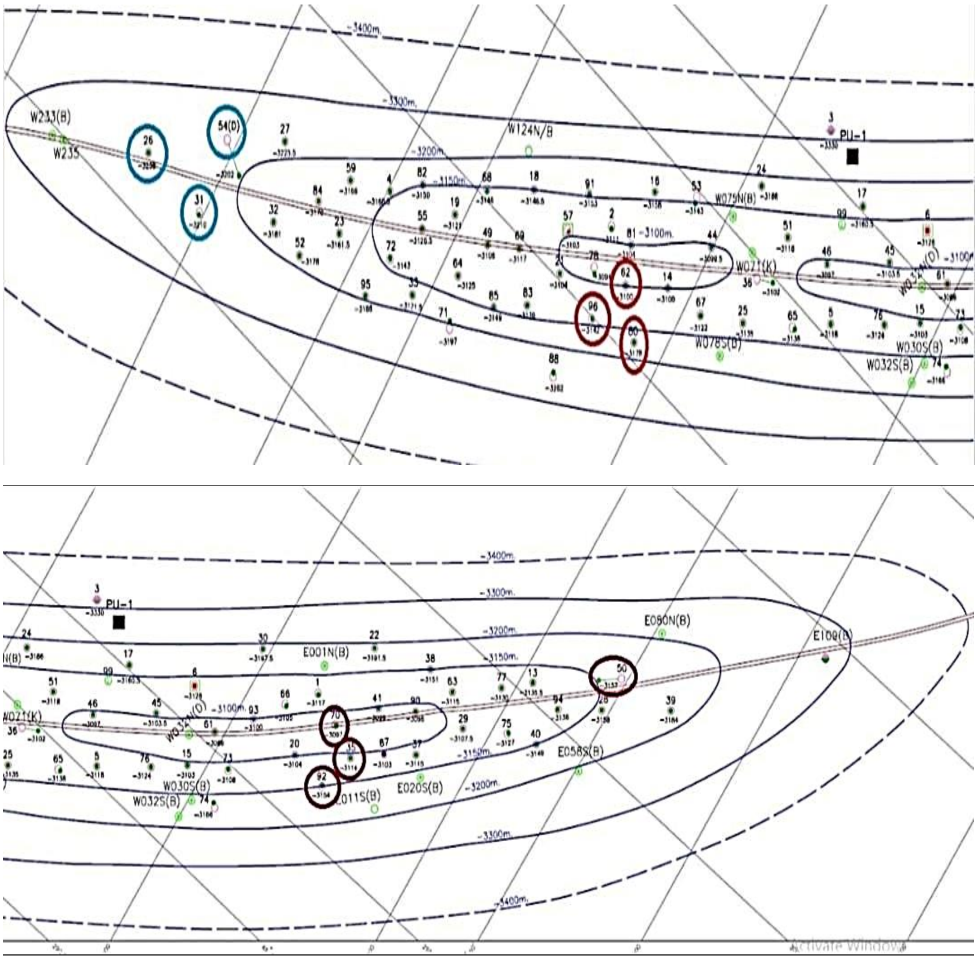


Figure 2. Location of wells 50, 62, 26, and 70 in Mansouri Oilfield [12]

Geographical location and geology of formations

Pabdeh Formation is located in Tang Pabdeh and the anticline of Gurpi Mountain at a 34 km distance from the north of Lali County (northeast of Kuzestan Province). The lower border of the Pabdeh Formation is different in various borders of Zagros, so in some areas of this border, the upper limit of this formation has continuous Asmari limestones while is noncontinuous in some zones with an absence during the previous Paleocene. It is worth noting that there is a direct link between Tale Zang and Pabdeh formations, so some zones of this formation are observed in the Pabdeh Formation (Figure 3) [14]. The lower area of the Pabdeh Formation contains thin to medium-layered bluish-gray marls, shale, and interlayers of clay limestones with purple shales and cherty limes. The middle layer of it contains dark gray marls with thin layers of clay limes and shale [14]. The upper zone also contains a sequence of thin layered clay limes, marl, and shale. Also. The dominant microfacies of this formation is biomicrite [14]. Gurpi formation contains gray marl stones with thin layers of clay limestones and thin to medium-layered marl and shale between these layers. The row of this formation is not resistant to erosion and creates a gentle topography. In general, the Gurpi Formation consists of two lime areas of Emam Hasan and Simreh [14]. This formation has been created on the Ilam lime formation with an erosive heterogeneity. The upper bound of this formation in the sample cut is the Pabdeh Formation, and the lower bound of this formation consists of Bagestan group formations [14].

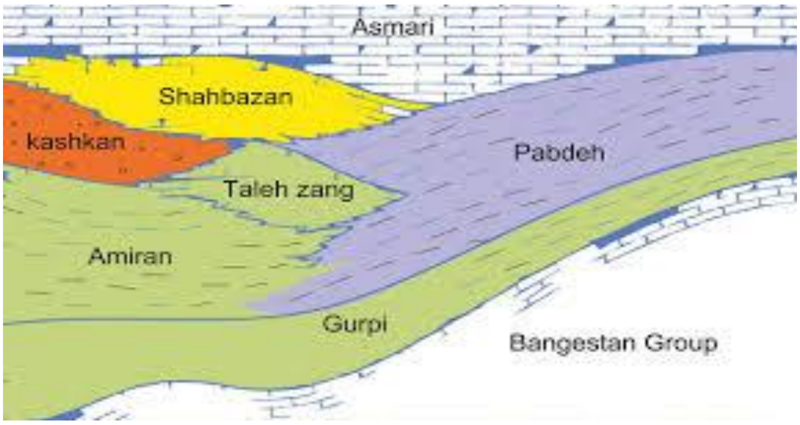


Figure 3. Lithological comparison between Mesozoic and Cenozoic formations in Zagros [14]

II. MATERIALS AND METHODS

The acquired drilling debris samples include 22 debris from various depths used in 4 Mansouri Oilfield, which are elaborated herein. Forty-four palynological slides were prepared in the palynology lab of the Geology and Mineral Explorations Organization of Iran, by using the Traverse Method. In the Traverse method, about 100g of sample were isolated, washed, and cleansed then added to acid chloric 30%. After 25 hours, samples were washed several times to be completely neutralized then acid hydrofluoric was added to the samples. The obtained solution was boiled in a distilled acid chloric 5% and centrifuged using the solution, the isolated phases were filtered through considered filters, and organic matter on each filter was kept in the special sample container with a lid [15]. Palynological slides of the isolated samples above were prepared. The prepared slides were tested under the Microscope BH2 OLYMPUS with 10-100 magnification in the microscopical lab of Mine Faculty of the Industrial University of Isfahan, and the type of palynofacies and amounts of palynological elements in them were detected.

After the type of palynofacies was determined and studied, 10 samples out of the previous 22 samples were selected by considering a change in the type of palynofacy and their organic matter contents in different depths of considered wells, and then rock-oil pyrolysis analysis was done on them in the lab of Tehran Oil Industry Research Center. This is an important case for examining geochemical features, hydrocarbon-generation potential, and production power of samples. Now, the rock-oil pyrolysis analysis device is widely used in the world, including for information related to quantity, quality, maturity, and type of organic matter in sedimentary rock for describing hydrocarbon-generation potential in the old industry. After samples were cleansed, a low amount of sample (about 100mg) was powdered and put in special capsules after being homogenized, and then heated under helium atmosphere conditions under 300 degrees for 3 minutes. The heating degree is then increased up to 600 per 25 degrees per minute, and the obtained results are expressed in form of a geochemical log graph.

Epidermal tissues (cuticle)

Cellular structure does not destroy this part because the cuticle has an outer resistant layer that protects the epiderm of organic plants. To see them through the transient light, the color of mots cuticles is bright yellow to brown and orange, which of course their colors depend on the durability and maturity degree [16]. Generally, cuticles are observable in deltas and rivers, alluvial cones close to the coast and marshes, and have good durability in these environments [16].

Sabrinite (root tissues)

This category shows less fluorescence alteration in the oxygen-containing soil, and their colors vary between yellow and dark brown, which is composed of woody plant debris [16].

Vitrinite (woody tissues)

The woody tissues are observed in gray to black color by the xylem or cellular structure [16]. Most woody structures used in preparing palynological pieces are of this kind and highly depend on the closeness to the source, which is highly common in nonmarine basins and palynological pieces. These pieces are also found in sand and silt components and deltas near the source (Figure 4) [16 & 17].

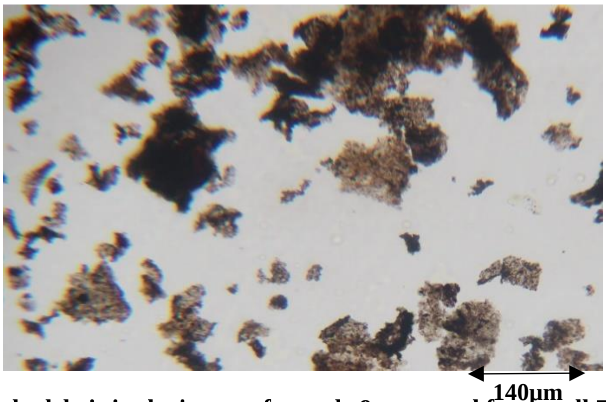


Figure 4. Some woody debris in the image of sample 9 extracted from well 70 with 140µm scale

Woody tissues include several groups:

1) Woody tissues with mass and curved structures
2) Gymnosperm tissues with concentric round holes
3) Angiosperm tissues with thick strips

These tissues are found in the phytoclasts existing in a marshy environment and an onshore rich in sediments. Their densities and frequencies depend on the plant composition, short distance to the coast, marine flows, and their shapes. These tissues have lower to ordinary densities in the environments of delta sediments, delta opening, and lake sediments [16 & 17].

Charcoal woody tissues (black opaque particles, inertinite, and fusinite)

The particles observable in inertinite macerals are unstructured black opaque particles that usually have similar shapes with stretched and angular surfaces which are broken in displacements and convert to smaller opaque particles. Fusinites are seen as an opaque shape within the transient light with the color varying between brown and black occurring in high-energy oxidated environments and intertidal zones [17]. Inertinites are abundant in river sediments and lakes and are important parts of organic matter's constituents, and appear when the wood is decomposed under moderate or normal temperatures in oxidant environments. The high percentage of phytoclasts indicates the environment near the coast and their high durability powers [31].

Amorphous Organic Matter (AOM)

The high percent of amorphous kerogens found as organic matter in the source rock is of this kind. This group does not have a certain structure and is found in abundance in offshore environments that are regenerating and have high durability caused by plankton. AOM usually has a good relationship with clay minerals [17]. Organic matters become amorphous in the light penetration area during deposition; it means that recrystallization and consumption of organic masses occur in a zone near the sediment-water surface, some scientists define this as organic matter coagulation in the clay particles suspending in the water [17]. This group is divided into two dark and transparent groups:

Dark AOM

They usually contain some minerals such as pyrite and clay minerals, and their particles are big and spherical, which appear in flows with higher oxygen percentages [17]. This category does not have high durability and becomes decomposed by aerobic bacteria. Aerobic bacteria decompose the palynomorphs using the available oxygens, and if the activity of these bacteria is severe, they will lose all of their organic matter and oxygen and only carbon remains, so it shows its dark color. The frequency of AOM containing pyrite is a good characteristic for detecting environments with low and limited oxygen (Figure 5) [17].

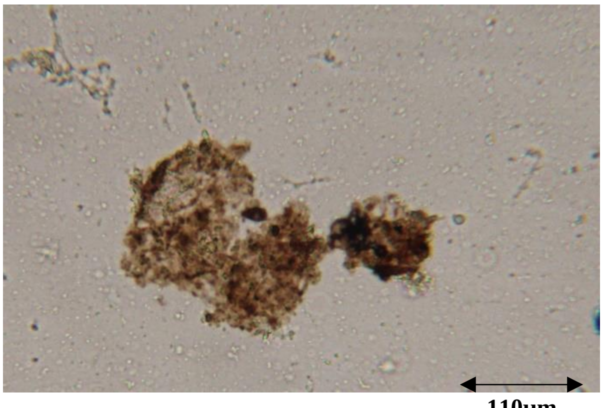


Figure 5. Sample of a dark amorph in the image of sample 17 from well 50 with 110μm scale

Transparent or bright AOM

This kind of AOM provides weak fluorescence generation, and its dimensions vary between 2 and 22 microns and rarely contain pyrite [18]. These matters appear in an oxygen-free and low-energy sedimentary environment of stagnant waters where anaerobic bacteria are active. Under regeneration conditions, the activity of these bacteria converts and decomposes organic matter to nitrate and sulfate., so these bacteria do not have a considerable effect on organic matter decomposition in case of high sedimentation rate (Figure 6) [18].

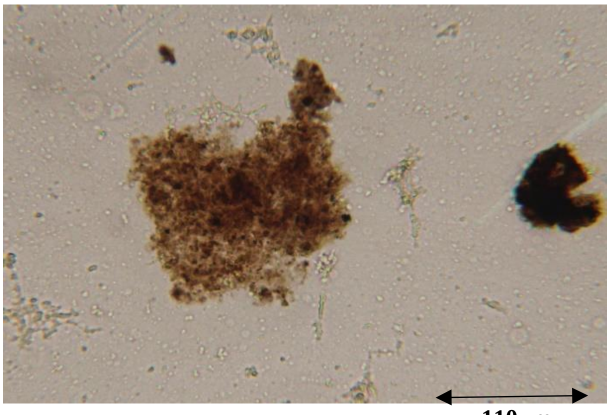


Figure 6. Sample of a bright amorph in the image of sample 16 from well 50 with 110μm scale

Paleoecology

Paleoecology is the relationship between the environment and fossil organisms in the time related to them. A paleoecologic interpretation depends on several effects and important factors, which along with other results and evidence highly contribute to the detection of ancient environments. This part of the study reviews these factors [18].

Lability (instability) factor

This factor is measured based on the ratio of brown phytoclasts to opaque ones. Terrestrial plants are the origins of brown phytoclasts, representing an environment near the coast [19]. In environments with high sedimentation rates, the durability of these particles will be increased in palynological slides [19 & 20]. Opaque phytoclasts are generated from oxidation and erosion of brown phytoclasts due to recarrying in the coasts and indicate an offshore and semi-oxidant environment. The frequency of this factor with decreased AOM and increased marine palynomorphs shows the very good durability of organic matter [19 & 20]. In general, the varying process of liability factor in a few samples indicates the almost unstable conditions during sedimentation.

Ratio of dark to bright AOM

As mentioned before, the ratio of transparent to dark AOM indicates the oxygen rate of the environment [20]. Transparent AOM appears on the surface lower than sediment due to the activity of anaerobic bacteria in the oxygen-free environment, which causes the decomposition of organic particles to sulfate and nitrate releasing methane, water, and CO2 [20]. On the other hand, dark particles appear in an oxygenated environment due to the activity of aerobic bacteria. Marine palynomorphs especially dinoflagellates with good durability rates are increased in oxygen-free and high sedimentation conditions, in which bacteria do not have enough time for the decomposition of organic matter due to high sedimentation. Hence, the amount of AOM is a great indicator for examining oxygen and sedimentation rates in ancient environments [20]. If an environment has a low oxygen and sedimentation rate, anaerobic bacteria would compose the palynomorphs to organic matter, and if exist in an environment with high oxygen and low sedimentation rates, the aerobic bacteria would decompose palynomorphs to dark AOM [20].

Ratio of AOM to marine palynomorphs

This ratio can complete the results of oxygen and sedimentation rates in case of consistency. The frequency of transparent AOM relative to marine palynomorphs indicates the sedimentary environment with low oxygen and sedimentation rates [21]. A higher density of dark AOM rather than marine palynomorphs represents an environment with high oxygen and a lower rate of marine palynomorphs indicates an environment with low oxygen or without oxygen with a high sedimentation rate [21].

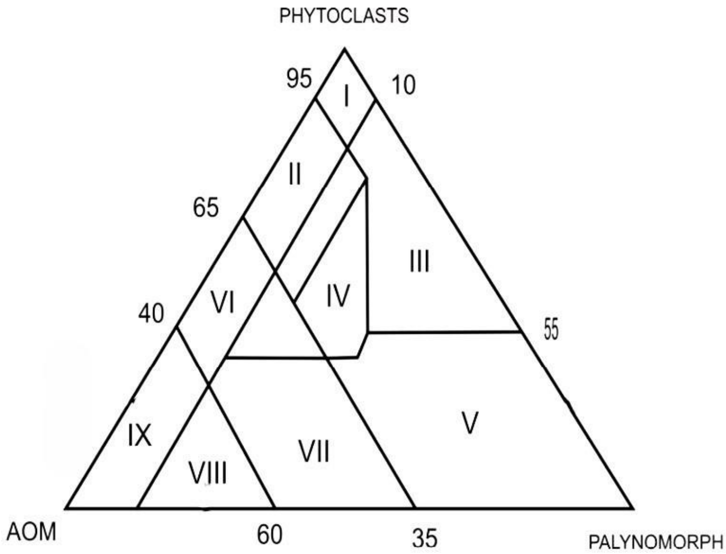
III. RESULTS

After palynological slides were prepared, the palynological elements of samples were found equal to 200-400 grains for each sample under a microscope with a magnification of 16. Groups of palynological elements (AOM, marine palynomorphs, phytoclasts, spore, and pollen) were then measured with their percentage in the samples (Table 1). This classification and its values were examined and analyzed to detect the type of environment, separate palynofacies, and determine the type of their kerogens using the Tyson Diagram (Figure 7) [4].

Table 1. Palynological elements percent in samples

Palynological Elements Percent					
Well	**Samples**	**PHYTOCLAST%**	**AOM%**	**PALYNOMORPH%**	**SPORE-POLLEN%**
62	1	55	35	5	5
62	2	50	45	3	2
62	3	50	40	5	5
1* 62	4	30	60	5	5
2* 70	5	5	90	2	3
70	6	35	55	5	5
70	7	45	45	5	5
70	8	45	50	3	2
3* 70	9	20	70	7	3
4* 26	10	65	35	-	-
5* 26	11	75	25	-	-
26	12	75	15	10	-
26	13	70	20	10	-
26	14	75	15	5	5
26	15	75	20	5	-
6* 50	16	5	85	5	5
7* 50	17	25	60	10	5
8* 50	18	20	65	5	10
9* 50	19	40	45	10	5
10*50	20	40	50	5	5
50	21	35	50	10	5
50	22	30	55	10	5

In the table above, the samples were selected for testing the Oil-Rock based on the percentage of organic matter with the sign * and were then tested. Figure 7 depicts the defined palynofacies of Tyson, which each represents a different sedimentary environment.



I: Highly proximal shelf or basin , II: Marginal disoxic-anoxic basin , III: Proximal shelf - Heterolithic oxic shelf , IV: Shelf to basin transition , V: Mud-dominated oxic shelf (distal shelf) , VI:Proximal suboxic-anoxic shelf , VII: Distal dysoxic-anoxic shelf , VIII: Distal dysoxic-oxic , IX: Distal suboxic-anoxic basin. shelf.

Figure 7. Various palynofacies on the triangular Tryson Diagram [4]

According to results shown in Figure 8, the studied samples in wells 50 and 70 are placed in the palynofacies groups VI and IX regarding the organic matters and palynological elements existing in them, while samples in wells 62 and 26 were classified to palynofacies group VI and II. According to the Tyson Diagram, the palynofacies VI contains abundant AOM and moderate phytoclast content, representing an offshore and recovery environment placed in an oil window with high hydrocarbon generation and IX has abundant AOM with very low palynomorph, indicating semi-oxygenated to the low-oxygen offshore environment in an oil window with very high generation power. Palynofacies II contains high phytoclasts and low AOM, indicating the basin margin environment with recovery conditions in the gas production window with minor oil.

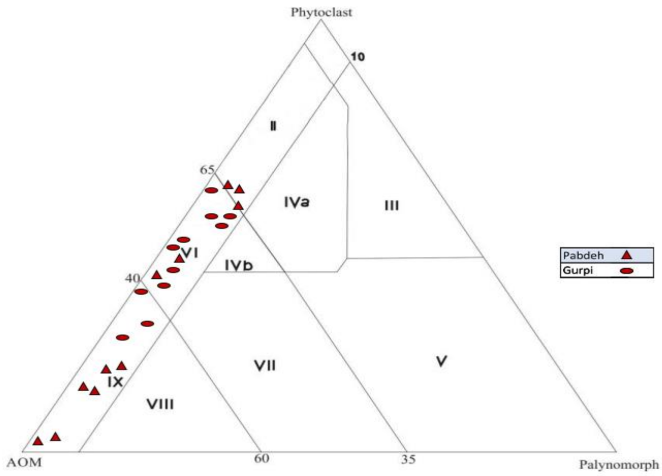


Figure 8. Palynological profiles available in the studied samples

The following paragraphs fully examine these three groups of palynofacies.

Table 2. Types of palynofacies and their relevant sedimentary environments [4]

Palynofacies	Ancient environment	Characteristic	Spore and pollen	Microplankton	Type or kerogen
I	Highly proximal shelf or basin	Abundant phytoclast	High	Very low	III Gas prone
II	Marginal dysoxic-anoxic basin	Abundant Phytoclast, low AOM	High	Very low	III Gas prone

III	Heterolithic oxic shelf (proximal shelf)	Abundant Phytoclast, low AOM	High	Moderate to abundant	III or IV Gas-prone
IV	Shelf-to-basin transition	Frequency of phytoclast in the environment near the source.	Moderate to high	Low to very low	III or II Mainly gas-prone
V	Distal shelf	Low to moderate AOM and abundant palynomorph	Usually low	Common to abundant	III>IV Gas prone
VI	Proximal suboxic-anoxic shelf	Abundant AOM. Moderate to high phytoclast content	Low to moderate	Low to common	II Oil prone
VII	Distal dysoxic shelf	Moderate to good AOM durability. Moderate to low palynomorph	Low	Moderate to common	II Oil prone
VIII	Distant anoxic shelf	Abundant AOM with perfect durability. Moderate to low palynomorph	Low	Low to moderate	II>I Oil prone
IX	Distal suboxic-anoxic basin	Abundant AOM. Low palynomorph	Low	Very low	II>=I Highly oil-prone

In the group of **Palynofacies IX**, transparent and bright AOM is abundant (80-100%) (Figure 9). There are very low phytoclasts (1-3%) in this group. The Tyson Diagram's triangle has considered palynofacies IX as a semi-oxygenated offshore environment for this group. The determined kerogen is of I and II types in which, oil production is very high [4]. This environment is usually deeper than the rest of the environments, which indicates an open marine environment with stagnant depth conditions and an abundance of AOM also confirms the topic (Table 2) [4].

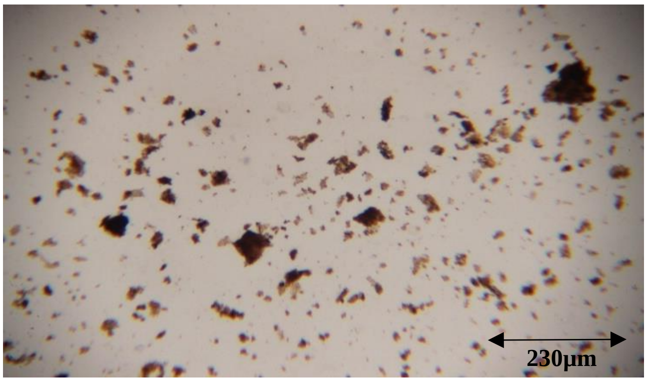


Figure 9. Palynological IX containing 80-100% organic matter in the image of sample 5 from well 70 with 230μm scale

The number of organic matters of amorphous **palynofacies VI** has decreased (40-70%) compared to IX and the phytoclast rate usually varies between 10 and 30% (Figure 10). The Tyson Diagram's triangle has considered palynofacies VI as an offshore environment for this group. Its kerogen is of type II, which is oil-prone (Table 2) [4].

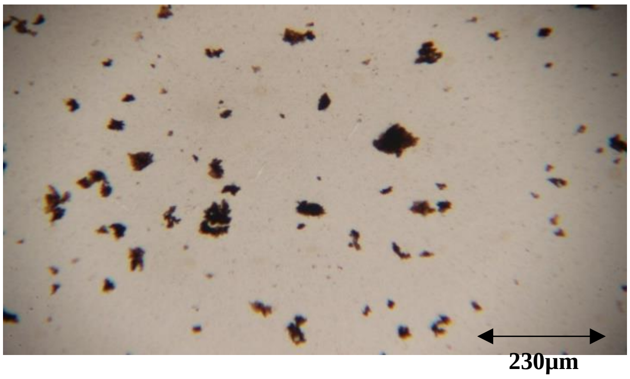


Figure 10. Palynological VI containing 40-70% organic matter in the image of sample 17 from well 50 with 230µm scale

In the group of **Palynofacies II**, a dramatic decline has occurred in AOM (about 15-35%) (Figure 11). Except for the minor amount of AOM, other elements (phytoclast, palynomorph) were not observed. This group can be considered equal to type 11 Tyson indicating a basin margin environment with low or without oxygen [4]. Its relevant kerogen is of II type with very low percent, which can produce gas with a minor amount of oil (Table 2) [4].

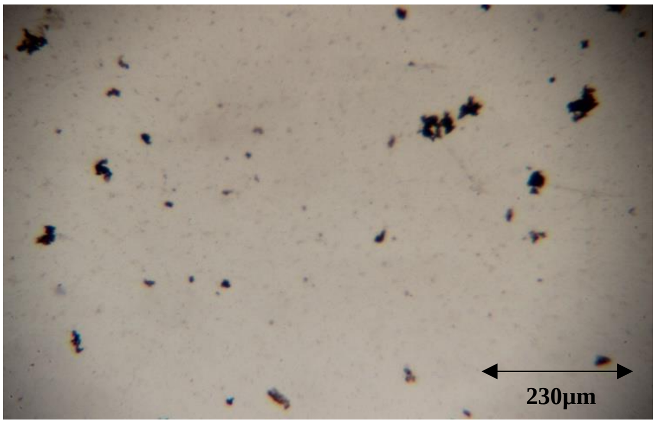


Figure 11. Palynological II containing 15-35% organic matter in the image of sample 10 from well 26 with 230µm scale

IV. DISCUSSION

Assessment of palynological slides led to the identification of three palynofacies groups for the considered wells. The identified palynofacies regarding the triple Tyson Diagram indicate the low-depth or semi-depth to deep environments. A high percentage of AOM in wells 50 and 70 indicates good durability under recovery conditions, and the amount of AOM is reduced in wells 26 and 62, which shows an environment with low depth in the basin margin. Also, high amounts of AOM in oxygenated environments are matched with the environments where the percent of organic matter generation is high. The AOM includes substances that are rapidly decomposed and are mostly found in places with low aerobic decomposition. The high percentage of AOM indicates offshore low-oxygenate environments. Low oxygen rate in sedimentation phases and recovery conditions imply a high percent of organic and algae marine matter as raw materials for the creation of hydrocarbon and thin lithology of the shale layer, which makes the formation suitable for hydrocarbon generation.

V. REFERENCES

[1] Hudson, W.E. & Nicholas, C.J. (2014). The Pindiro Group (Triassic to Early Jurassic Mandawa Basin, southern coastal Tanzania): Definition, palaeoenvironment, and stratigraphy. Journal of African Earth Sciences, 92, 55-67.

[2] Combaz, A. (1980). Kes kerogens vus au microscope, In: Bombardier, L., Gorin, G.E. (2000). Stratigraphical and lateral distribution of sedimentary organic matter in Upper Jurassic carbonate of SE France, Sedimentary Geology,132,177-203.

[3] Jones, R.W. (1987). Organic Facies, in Brook J. Welte D. eds. Advances in petroleum geochemistry, Academic Press, New york. 1-90.

[4] Tyson, R.V. (1995). Sedimentary organic matter, organic facies, and palynofacies. Chapman and Hall, London, 616 pp. Batten, D.J. (1996). Palynofacies and petroleum potential., Palynology: principles and application. AASP Foundation, 3: 1065-1084.

[5] Tabaei, M, and Tabrizi, J,. (2011). Evaluation of the oil-generation potential of deposits from three periods of Pabdeh Formation in Kabir Kooh Zone of Lorestan, MA Thesis.

[6] Beyranvand, (2013) Biostratigraphy and paleoecology of Gurpi and Pabdeh formations in an area of Izeh Zone and using them for basin analysis, Ph.D. Thesis, Tehran University.

[7] Tarjani Salehani, M,. (2014) Palynostratigraphy, palynofacies, and paleoecology of Sanganeh Formation in Toos Well 1 of Kopeh Dagh, MA Thesis, Tehran University, Geology School.

[8] Hashemi Yazdi, F. (2015) Palynology and paleoecology of Delichay Formation in Central-Eastern Alborz Basin and Hajdak Formation in the East of Central Iran, Ph.D. Thesis, Tehran University.

[9] Yousefi, M. (2017), Palynostratigraphy, palynofacies and paleoecology of Sarcheshmeh Formation in the section of Khemari Village in the east of Kopeh Dagh sedimentary basin, MA Thesis, Tehran University.

[10] Alizadeh, B. Opera, A. Kalani, M. Alipour, M. (2020), Source rock and shale oil potential of the Pabdeh Formation (Middle-Late Eocene) in the Dezful Embayment**,** southwest Iran: Geologica Acta, 18, 1-22. https://doi.org/10.1344/GeologicaActa2020.18.15

[11] Scheeder, G. Weniger, P. Blumenberg, M. (2020), Geochemical implications from direct Rock-Eval pyrolysis of petroleum: Organic Geochemistry, 146, 104051. https://doi.org/10.1016/j.orggeochem.2020.104051

[12] Aghanabati, A, (2014). Iran's geology, Geology Organization Press, P. 586.

[13] Busk, H.G. and Mayo, H.T. (1918) Some Notes on the Geology of the Persian Oil Fields. Institution of Petroleum Technologists, 5, 5-26.

[14] Darvishzadeh, A, (2004). Iran's geology, Amir Kabir Press, P. 901.

[15] Traverse, A. (1988). Palaeopalynology. Academic Division of Unwihyman Ltd, London, UK, 600 pp

[16] Liu, B., Schieber, J., Mastalerz, M. (2019). Petrographic and micro-FTIR study of organic matter in the Upper Devonian New Albany Shale during thermal maturation: Implications for kerogen transformation. In Camp, W., Milliken, K., Taylor, K., Fishman, N., Hackley, P., Macquaker, J., (Eds.), Mudstone diagenesis: research perspectives for shale hydrocarbon reservoirs, seals, and source rocks. American Association of Petroleum Geologists Memoir 120, 165-188. https://doi.org/10.1306/AAPG120.

[17] Pacton, M., Gorin, G.E., Vasconcelos, C. (2011). Amorphous organic matter - Experimental data on formation and the role of microbes: Review of Palaeobotany and Palynology 166, 253-267. https://doi.org/10.1016/j.revpalbo.2011.05.011.

[18] Paleoecology: a window into the past". Exploring the Past to Understand the Future. Retrieved (2018)-03-20.

[19] Rabbani, J., Ghasemi-Nejad, E., Ashori, A., Vahidinia, M.(2013).Quantitative palynostratigraphy and palaeoecology of Tethyan Paleocene–Eocene red beds in the north of Zagros sedimentary basin, Iran. Arabian Journal of Geosciences DOI 10.1007/s12517-013- 1164-2

[20] Alizadeh, B., Opera, A., Kalani, M., Alipour, M. (2020), Source rock and shale oil potential of the Pabdeh Formation (Middle-Late Eocene) in the Dezful Embayment, southwest Iran: Geologica Acta, 18, 1-22. https://doi.org/10.1344/GeologicaActa2020.18.15

[21] Hosseini, A. and Alizadeh, B, (2015). Evaluation of geology of Kajdomi Formation in Azadegan Oilfields' wells using Rock-Oil Pyrolysis method. Geology, 4(3), 231-240.