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# ROCK-EVAL ANALYSIS OF SOURCE ROCK PARAMETERS IN THE ARYSKUM DEPRESSION OF THE SOUTH TURGAY BASIN, KAZAKHSTAN

*The study is aimed at identifying potential oil and gas source strata at the Upper–Middle Jurassic clay deposits based on Rock-Eval pyrolysis data on samples taken at the East and Central Akshabulak deposits (Aryskum depression, South Turgay Basin, Kazakhstan). The data on the total organic carbon content (TOC), residual generation potential of organic matter ($S_2$) on the pyrogram, productivity index (PI), oxygen and hydrogen indicators (HI & OI) and maximum pyrolysis temperature ($T_{max}$) are summarized. However, only the East Akshabulak samples were used to assess hydrocarbon potential as the TOC of the Central Akshabulak rocks was less than 0.3%. The analysis results of the East Akshabulak rocks show that the $S_2$ parameter of generation potential varied from satisfactory (0.58 and 2.48 mg HC/g) to very good (3.84 mg HC/g). In addition, it was found that the concentration of TOC 0.78 has a satisfactory generation potential, and the samples taken at the depths of 1960.9 and 1967.65 m have a very good oil and gas generation potential. The type of organic matter was also evaluated using the HI and the $T_{max}$, which allowed concluding that the test samples contained type III kerogen, characterized by the release of mostly gaseous hydrocarbons. The thermal maturity of organic matter was also determined based on the values of $T_{max}$ and PI: by PI the test rocks were classified as immature, however the temperature values of the samples taken at the depths of 1960.9 and 1965.98 m pointed at their early stage of maturity.*

***Keywords:*** *organic geochemistry, oil and gas content, oil generation, Rock-Eval pyrolysis, Aryskum depression, South Turgay Basin*
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## Introduction

In recent years, geochemical studies of oils play an important role in addressing problems in petroleum geology. The interpretation of these results contributes to a better understanding of the geochemical conditions for the accumulation and transformation of oils in nature, as well as for the formation of oil deposits [1]. The South Turgay sedimentary basin, based on the thickness of its sedimentary cover and the features of its tectonic and lithostratigraphic characteristics, belongs to an intracontinental basin and is located on the young Scythian–Turan platform (**Fig. 1**). The heterogeneous basement of the Scythian–Turan platform consists of several microcontinents which are the fragments of the East European platform or Pangaea [3, 4]. The basin structure consists of three formations: the Zhilanshik depression in the north, the Aryskum depression in the south, and the Mynbulak saddle in-between. All commercial-value fields (over 50) are discovered in the Aryskum depression [5]. The oil and gas potential is associated with the lithostratigraphic Jurassic–Cretaceous units, Devonian–lower Carboniferous quasi-platform units, and disintegrated basement outcrops. Generation and displacement of hydrocarbons are the critical properties of oil source rocks [6]. Geochemical studies of sedimentary cover show that the Jurassic–Cretaceous formations contain high concentrations of various types of organic matter, predominantly sapropelic. The most probable sources of hydrocarbons are identified as the lower and middle Jurassic formations, which, in combination with the thermobaric conditions in the basins, governed generation of liquid hydrocarbons [7].

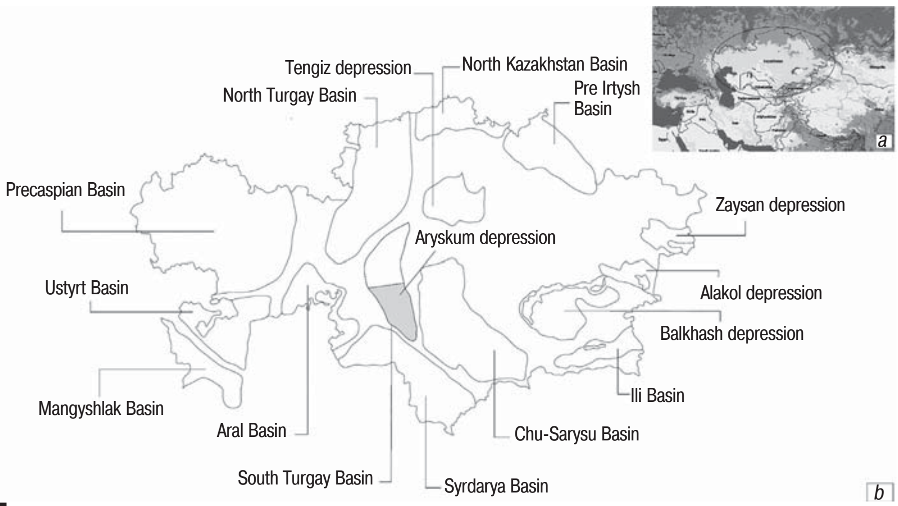


**Fig. 1. The Google Earth map of Kazakhstan (*a*); map of sedimentary basins and Aryskum depression in Kazakhstan (*b*) [2]**

The goal of this study is to supplement the understanding of the geochemical characteristics of the Aryskum depression with new geochemical research, which can significantly enhance accuracy of the resource appraisal and hydrocarbon exploration and development strategies.

In petroleum geochemistry Rock Eval pyrolysis is the critical method of the fast, routine analysis of a large number of samples [8, 9]. Since its discovery, pyrolysis has always been used to assess the generation potential of oil-bearing rocks and the degree of categenetic maturation of organic matter [10, 11]. The method was successfully applied to studying oil-producing strata, for example, the Bakken formations (North Dakota, USA, and Canada), Eagle Ford (South-West Texas), Monterey (California, USA), Permian Bazin (Texas and New Mexico, USA), Bazhenov formation (Western Siberia).

The purpose of this work is to assess the oil and gas generation potential of the Upper-to-Middle Jurassic clay deposits of the Aryskum depression in the South Turgay basin (STB) based on the results of the pyrolytic core analysis.

To meet the purpose, the study estimated:

The generation potential of parent rocks;

The types of organic matter;

The thermal maturity of organic matter.

When assessing oil and gas potential, the organic matter maturity is an important parameter. In this study, the geochemical analysis was used to determine the maturity and hydrocarbon potential of rocks of the Kumkol and Akshabulak formations in the STB.

The analytical studies determined the values of the parameters (HI, OI, PI, $S_1$, $S_2$ and $S_1 + S_2$) to assess the thermal maturity of organic material at the initial stage of thermal maturation. In addition, this study aims to characterize concatenation of organic material and thermal maturity [12].

## Geological setting

Regionally, the STB represents the southern part of the large Turgay mega-trough, confined to the area between the Ulytau mountain range and the Lower Syr Darya uplift.

In paleotectonic terms, the formation of the modern structure of the STB was most significantly influenced by intense tectonic movements during collision of the East European and Kazakh paleoplates [13]. In this regard, the STB represents a large linear structure of horizontal extension in the Earth's crust, expressed in its upper part by a graben-like depression limited by faulted and folded dislocations filled with terrigenous sediments of the Jurassic age.

In its turn, the STB is structurally represented by the Zhilanshik and Aryskum depressions and the Mynbulak saddle separating them.

The development and formation of the Mesozoic sediments was characterized by the isolation of grabens extended in the NW-SE and NNW-SSE directions (Aryskum, Akshabulak, Sarylan and Bozingen) and horsts (Aksai, Ashisai, Tabakbulak and Bozingen) (**Fig. 2**). The main feature of the Jurassic lithological and stratigraphic units is exclusively the intracontinental conditions of formation (**Table 1**). The massive sedimentation was the result of the activity of Mesozoic rifting, which experienced a stratigraphic "slide" in time in a southerly direction.

As a result, the sectional position of the basement formations and the Jurassic–Cretaceous sedimentary filling of the grabens is reflective of the amplitude of Mesozoic rifting. The structure formation units (hereinafter, SFU) are characterized and isolated by a wide hypsometric tinting of their uplift and subsidence (**Fig. 3**). In the development of the basin, along with the tensile tectonic stresses, the horizontal compression stresses also actively show up.

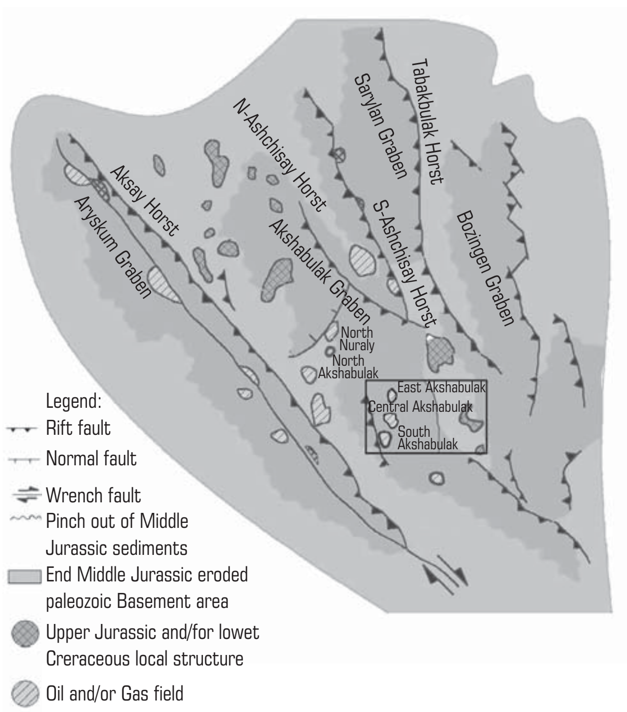


**Fig. 2. Tectonic diagram of the South Turgay Basin [13]**

Based on the previous prospecting results on the STB section, a more detailed study characterizes the Jurassic–Cretaceous part of the section, with the developed oil and gas traps of various types, both structural and non-anticlinal. The development of structural traps is usually associated with the locks of inherited anticlines and zones complicated by tectonic faulting. In addition, mixed-type structural traps may be encountered, associated with the zones of stratigraphic unconformity and lithological pinch-out or replacement. The non-anticlinal type of traps is very characteristic6 and is associated with the peculiarities of individual stages of sedimentation, most often confined to the zones of formation of paleochannel flows and alluvial fans.

At the contact of the pre-Jurassic and Jurassic–Cretaceous units, most local structures are traps covering buried hills against the background of basement protrusions. Partially developed structures are anticlines formed as a result of the influence of faulting and horizontal displacement, as well as dislocated anticlines formed under the influence of fault tectonics processes. Local structures, taking into account active growth and uplift, are characterized by multi-stage development. Presumably, this is especially characteristic of traps developed at the Early–Middle Jurassic and Upper Jurassic–Lower Cretaceous ages [14].

Most of the identified hydrocarbon deposits are confined to zones with a pronounced structural factor and, in regional terms, are determined by the position in terms of bedrock ledges (basement blocks).

The majority of the revealed hydrocarbon reservoirs adjoin the zones with the pronounced structural factor and are regionally governed by the horizontal positions of basement blocks. Taking into account the available collected information and based on the results of a comprehensive study and preliminary modeling of hydrocarbon systems, a temporary relationship is determined between structural tectonics and geodynamics, on the one hand, the ability to accumulate and preserve oil and gas source rock before the stage of hydrocarbon generation, on the other hand.

According to drilling and seismic exploration data, the main structural formation units in the sediment section of the STB are: pre-rift Upper Paleozoic, syn-rift Jurassic filling, post-rift platform. The SFUs define the main stages of the development of the STB and the formation of various lithological and stratigraphic sequences of sediments. The nature and main trends in the regional sedimentation are associated with the influx of volcanogenic sedimentary material resulting from the activation and collision of large tectonic plates [15].

**Table 1. Sequence and characteristics of the Jurassic–Cretaceous sediments in the South Turgay basin**

| System | Series | Stage | | Formation | | Notation |
|---|---|---|---|---|---|---|
| Cretaceous | Upper | Turonian | | Balapan | | |
| | | Cenomanian | | Kyzylkyia | | |
| | Lower | Aptinian | | Karachetau | | |
| | | Barremian | | Daul | Up | |
| | | Neocomian | Hauterivian | | Down | |
| | | | Vanlanginian | | | |
| | | | Berriasian | Aryskum | | $K_1nc_1ar$ |
| Jurassic | Upper | Tithonian | | Akshabulak | | $J_3ak$ |
| | | Kimmeridian | | | | |
| | | Oxfordian | | Kumkol | | $J_3km$ |
| | | Callovian | | | | |
| | Middle | Bathonian | | Karagansai | | $J_2kr$ |
| | | Bajocian | | | | |
| | | Aalenian | | Doshan | | $J_2ds$ |
| | Lower | Toarcian | | Aybolin | | $J_1ab$ |
| | | Pliensbachian | | Sazymbai | | $J_1sb$ |
| | | Sinemurian | | | | |
| | | Hettangian | | Bozyngen | | $J_1bg$ |
| Paleozoic | | | | | | |

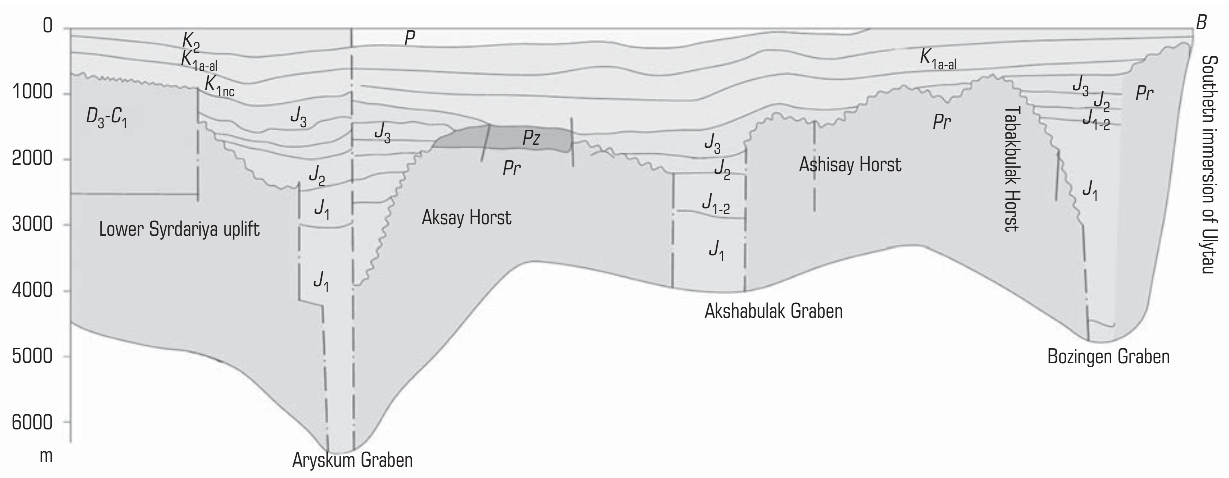


**Fig. 3. Latitudinal regional geological profile of the Aryskum depression along the line Lower Syr Darya uplift–Ulytau Massif:**
$D_3$-$C_1$ – quasi-platform sediments (Devonian–Carboniferous), $J_1$, $J_2$, $J_3$ – Jurassic organogenic sediments (upper-platform graben fill sediments), $K_{1a\text{-}al}$, $K_{1nc}$, $K_2$ – Cretaceous–Quaternary layers (sheet-like), *Pz* – Paleozoic, Pr – Proterozoic, P – Permian system [2]

**Table 2. Stratigraphic logs and thickness of the Jurassic–Cretaceous rift fill [15]**

| Stratigraphic unit, suite | P-1 Bozingen | P-1 Bektas | P-2 Akshabulak North |
|---|---|---|---|
| | Bottom, m | Bottom, m | Bottom, m |
| Paleogene | | 150 | 140 |
| Upper Cretaceous, Turon-senon | 235 | 478 | 380 |
| Upper Cretaceous, Cenomanian | 330 | 638 | 492 |
| Lower Cretaceous, apt-alb | 520 | 874 | 1087 |
| Lower Chalk, Neocombe | 711 | 1169 | 1630 |
| Upper Jurassic | 1655 | 2016 | 2690 |
| Middle Jurassic | 2440 | 2778 | 2927 |
| Lower Jurassic | 3722 (bottomhole) | 4036 (bottomhole) | 4774 (bottomhole) |
| Total thickness of the Jurassic–Cretaceous filling, (m) | 3011 | 2867 | 3144 |

The main feature of the Jurassic lithological and stratigraphic units is their exclusively intracontinental conditions of formation and powerful sedimentation as a result of the active stage Mesozoic rifting. Intracontinental sedimentation was characterized by the formation of elongated depressions, which were filled predominantly with terrigenous rocks. At the same time, the rifting processes caused accumulation of sediments of significant thickness; individual sedimentation cycles are quite clearly distinguished in the section along the marker formations in the Lower, Middle and Upper Jurassic. In turn, each formation features its own characteristics in the lithological composition of sediments. According to the latest new data, the characteristic feature of the Lower Jurassic is clayey strata, which condition the main oil- and gas-bearing horizons in it. The facies composition of sediments is characterized by the formation of eluvial (weathering crust deposits), proluvial-deluvial and alluvial (alluvial fans, temporary flows and paleoruvial complexes) deposits. Paleorecious complexes, taking into account the nature of the terrain, are differentiated and represented by facies of riverbed, floodplain and lake-marsh accumulation environments. Alluvial deposits compose the Aryskum horizon (Lower Cretaceous, Upper Daul sub-formation). Facies of alluvial cones, riverbed and floodplain formations are areally distributed within the western and eastern periphery of the Aryskum depression (Doschan, Aryskum, Konys, etc.).

By the end of the rifting stage, the area under consideration experienced a general sinking due to high-rate sedimentation. The Pre-Jurassic protrusions (pre-Paleozoic basement and Upper Paleozoic) in places towered above the water surface. This led to the formation of a powerful weathering crust on ancient outcrops of bedrock. By the end of the Jurassic, deep grabens formed, filled with terrigenous-coal-bearing, terrigenous-clay and carbonate-terrigenous shallow-water sediments [15]. In the deflections, the thickness of the rift Jurassic filling reached 3.0 km and more **(Table 2).**

The contours of the STB begin to be outlined by the beginning of the Jurassic sedimentation. The contours of the basin appear more clearly at the beginning of the accumulation of the Middle Jurassic Karagansai formation. Rifting processes had more intense amplitude and stratigraphic depth in the south–easterly direction. As part of the uplift filling, three stable rhythms are distinguished, reflecting the main stages of rifting: deposition initiation (Sazymbai and Aybalin formations), subsidence (Doschan and Karagansai formations) and completion (Kumkol and Akshabulak formations) [3].

## Materials and methods

In the studies, 5 core samples were examined using the Rock-Eval method, which allowed thermal modeling of source rock evolution.

To do this, a rock sample 10 to 100 mg in weight is subjected to stepwise heating in an inert gas current (pyrolysis). Free hydrocarbons first evaporate at a given temperature in the pyrolysis furnace, forming the $S_1$ peak. Then, as the temperature increases, the thermal destruction of kerogen (insoluble organic matter) occurs, accompanied by the release of both gaseous and liquid degradation products (peak $S_2$). An inert gas current feeds the released hydrocarbons into the flame ionization detector of the pyrolyzer, which records their amount. The thermocouple located in the pyrolysis furnace records the maximum temperature of the peak $S_2$ — $T_{max}$. Thus, this allows judging on the amount of free hydrocarbons contained in the pore space ($S_1$) and the remaining generation potential of the organic matter of the rock ($S_2$) [16].

To study the oil/gas generation properties and the thermal maturity of the organic matter of sedimentary rocks, the samples were analyzed in the Bulk-Rock cycle. The temperature program of this cycle is shown in **Table 3**.

**Table 3. Temperature profile for the Bulk-Rock cycle**

| Stage | Initial temperature, °C | Final temperature, °C | Heating speed, °C/min | Exposure time at the initial temperature, min | Exposure time at the final temperature, min |
|---|---|---|---|---|---|
| Pyrolysis | 300 | 650 | 25 | 3 | 0 |
| Oxidation | 300 | 850 | 20 | 1 | 5 |

**Table 4. Geochemical data from pyrolysis analysis of core**

| Deposits | Horizon | Well | Depth | $S_1$ | $S_2$ | $S_1+S_2$ | PI | $T_{max}$ | TOC | HI | OI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| East Akshabulak | *J-I* | 70 | 1960.9 | 0.12 | 2.36 | 2.48 | 0.05 | 438 | 2.22 | 106 | 11 |
| East Akshabulak | *J-I* | 70 | 1967.65 | 0.14 | 3.84 | 3.98 | 0.03 | 434 | 3.37 | 114 | 18 |
| East Akshabulak | *J-I* | 70 | 1965.98 | 0.05 | 0.58 | 0.63 | 0.08 | 436 | 0.78 | 74 | 41 |
| Central Akshabulak | *J-II* | 480 | 1738.9 | 0.06 | 0.35 | 0.41 | 0.14 | 450 | 0.23 | 152 | 135 |
| Central Akshabulak | *J-II* | 480 | 1742.55 | 0.03 | 0.18 | 0.21 | 0.14 | 608 | 0.05 | 360 | 180 |

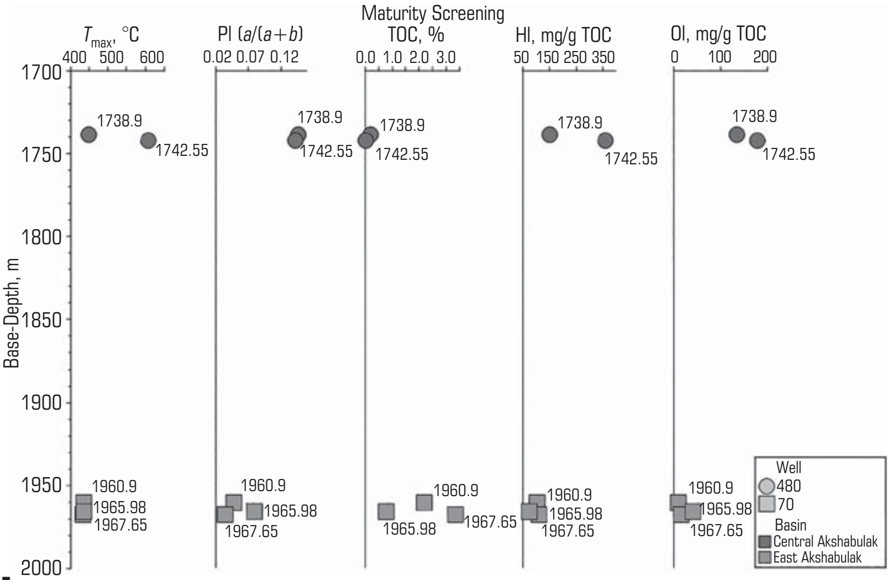


**Fig. 4. Geochemical log of Jurassic deposits in the Aryskum depression**

**Table 5. Criteria for ranking source rock by hydrocarbon generation potential [19]**

| Class | TOC, % | $S_1$, mg HC/g of rock | $S_2$, mg HC/g of rock |
|---|---|---|---|
| Poor | <0.5 | <0.5 | <2.5 |
| Fair | 0.5–1 | 0.5–1 | 2.5–5 |
| Good | 1–2 | 1–2 | 5–10 |
| Very good | 2–4 | 2–4 | 10–20 |
| Excellent | >4 | >4 | >20 |

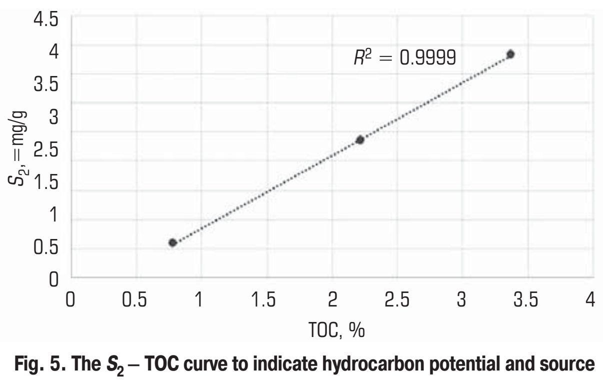


**Fig. 5. The $S_2$ – TOC curve to indicate hydrocarbon potential and source rock efficiency**

### Results

As a result of the conducted research, potentially oil and gas source rock strata were identified based on such RE parameters as the amount of free hydrocarbons ($S_1$) contained in the pore space, the residual generation potential of the organic matter of the rock ($S_2$), the temperature ($T_{max}$) at which the maximum release of hydrocarbons from kerogen cracks occurs, as well as the total organic carbon content (TOC).

Rocks with a TOC content less than 0.3% and a HC yield at the $S_2$ peak less than 0.09 mg of HC/g were not used to assess oil and gas generation properties [17], including samples nos. 4 and 5 from the Central Akshabulak.

The data of the test core samples of the Upper–Middle Jurassic clay deposits from wells No. 70 East Akshabulak and No. 480 Central Akshabulak of the Aryskum depression are given in **Table 4**. **Figure 4** shows the geochemical parameters (TOC, PI, $T_{max}$, HI, OI) of the test core samples taken at the depths of 1738.9 m and 1742.55 m in the Central Akshabulak, as well as at the depths of 1960.9, 1965.98 and 1967.75 m in the East Akshabulak. However, only the East Akshabulak samples were used to assess the hydrocarbon potential, the stage of maturity of organic matter and the type of kerogen [18].

### Discussion

The amount of organic matter in a rock sample, kerogen, as well as the hydrocarbons present in the sample are determined by the parameter of Total Organic Carbon — TOC [19]. High concentrations of organic matter or TOC and the amount of hydrocarbons released during thermal pyrolysis (parameter $S_2$) indicate the ability of the rock to generate hydrocarbons (**Table 5**) [18].

The values of the total organic carbon (TOC) for the studied samples range from 0.05 to 3.37 mg HC/g of rock, with a tendency for higher concentrations of organic matter from 0.78 to 3.37 mg HC/g of rock in the J–I deposits.

According to the source rock classification, the samples with TOC below 0.5 are not source rocks, the sample from the depth of 1965.98 m with TOC 0.78 has a satisfactory generation potential. The East Akshabulak samples from the depths of 1960.9 and 1967.65 m have a very good oil and gas generation potential [18, 20].

The rocks with the summed values of $S_1$ and $S_2$ higher than 2 kg/t have an average generation potential (depths1960.9 and 1967.65 m), while the value of $S_1+S_2$ less than 2 kg/t indicates a low generation potential (depth 1965.98 m). However, $S_1$ values can be affected by drilling fluids and petroleum migration [18], which may be indicated by low PI values in indicated depth intervals.

Since a high correlation coefficient between the amount of generated hydrocarbons released during thermal pyrolysis ($S_2$) and TOC is important for determining the oil and gas content of a rock, a linear relationship was plotted for these parameters and it had a high correlation coefficient — $R^2 = 0.9999$ (**Fig. 5**).

In the analyzed samples from the East Akshabulak, taken at the depths of 1965.98 and 1960.9 m, he values of $S_2$ below 2.5 indicate a poor potential (0.58 and 2.48 mg HC/g of rock, respectively), and only the Upper Jurassic sample from the depth of 1967.65 m with $S_2$ of 3.84 mg HC/g has a very good potential [21, 22].

Since the value of $S_1$ represents the proportion of the initial genetic potential, that was effectively transformed into hydrocarbons, and the value of $S_2$ characterizes the residual oil and gas source potential that would not be used in generation of hydrocarbons, the sum of these parameters ($S_1+S_2$) represents the total generation potential [23].

According to the results obtained, the low $S_1$ values (less than 0.5) of the East Akshabulak rocks allow us to assess the generation potential of the studied samples as poor, however, the $S_2$ value of 3.84 from the depth of 1967.65 m indicates a satisfactory generation potential of this sample.

The second important parameter for evaluating an oil source rock is the type of kerogen. In particular, type I and type II kerogens usually have initial organic matter(s) of lake and marine origin and mainly generate liquid hydrocarbons. Type III kerogen, as a rule, is formed from woody and vegetable matter and generates mainly gas. Type IV kerogen usually consists of inert materials and has no oil/gas-generating potential.

In this work, the characterization of kerogen and organic matter was also carried out by analyzing the core samples material and plotting the dependence of the Hydrogen Index (HI) and the temperature of maximum generation of hydrocarbons ($T_{max}$) [24].

**Figure 6** shows that all samples studied concentrate near type III kerogen (gas-generating). To characterize the type of kerogen in the pyrolytic analysis of rocks, two composite indicators are also used — the hydrogen index HI and the oxygen index OI, which lead to the same conclusion [19].

According to the modified Van Krevelen diagram, which allows determining the type of kerogen, the test rock samples belong to kerogen type III (well-70, East Akshabulak) (**Fig. 7**).

The HI values in the range of 74–114 mg HC/g TOC also classify the test East Akshabulak samples as type III kerogen [25]. This implies that the organic matter in the studied samples accumulated under sub-oxic conditions [26, 27].

**Figure 8** presents the dependence of $S_2$ on TOC, which allows concluding on type III kerogen of the test samples.

To characterize the degree of evolution of organic matter, two indicators are used: the ratio $S_1/(S_1+S_2)$ and the temperature $T_{max}$, which allow an assessment of the thermal maturity of organic matter in relation to the ability of oil and gas generation of rocks [28].

The range of $T_{max}$ values of the studied samples varies from 434 to 438 °C (**Fig. 9**). According to Fig. 9, *b*, the samples from the depths of 1965.98 and 1960.9 m are acceptable for the conditions of the very beginning of the oil window, i.e. oil generation, and can be classified as immature to early mature [29].

PI (Production Index) = $S_1/(S_1+S_2)$ — the degree of kerogen depletion, is taken into account in the coefficient, the values of which 0.1–0.4 correspond to the conditions of the main oil formation zone in the source rocks (in the absence of migration) and, therefore, serve as a relative measure of catagenesis (**Table 6**).

The productivity index (PI) in the test rock samples from the East Akshabulak varies from 0.03 to 0.08. According to Table 6 [25], rocks with PI up to 0.1 are classified as immature, however, the temperature values at the depths of 1960.9 and 1965.98 m (438 and 436 °C, respectively) indicate an early stage of maturity.

A graph of the temperature dependence of the maximum hydrocarbon generation ($T_{max}$) and Productivity Index was used to determine the thermal maturity of the studied rocks. This graph demonstrates that all test samples of the East Akshabulak rocks are immature in terms of the productivity

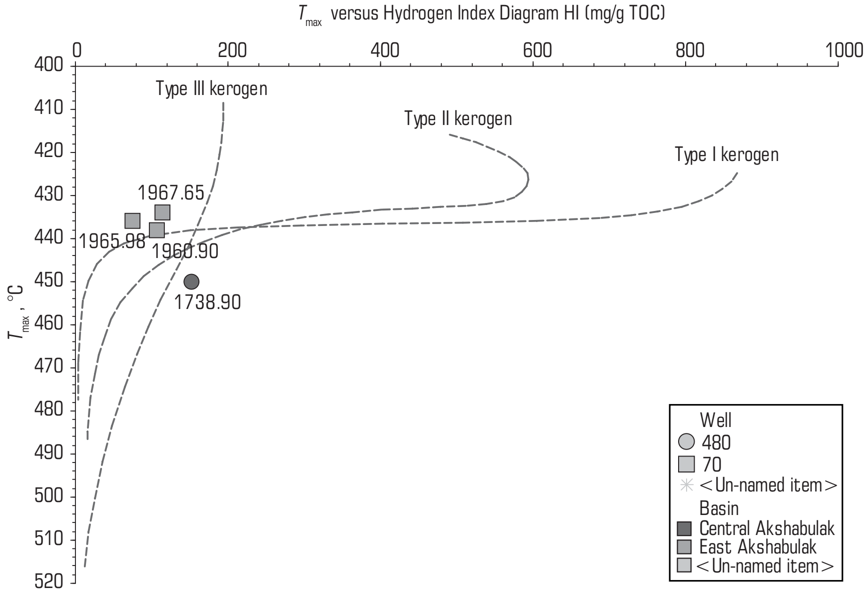


**Fig. 6. Graph of HI versus $T_{max}$ showing kerogen quality and thermal maturity stages**

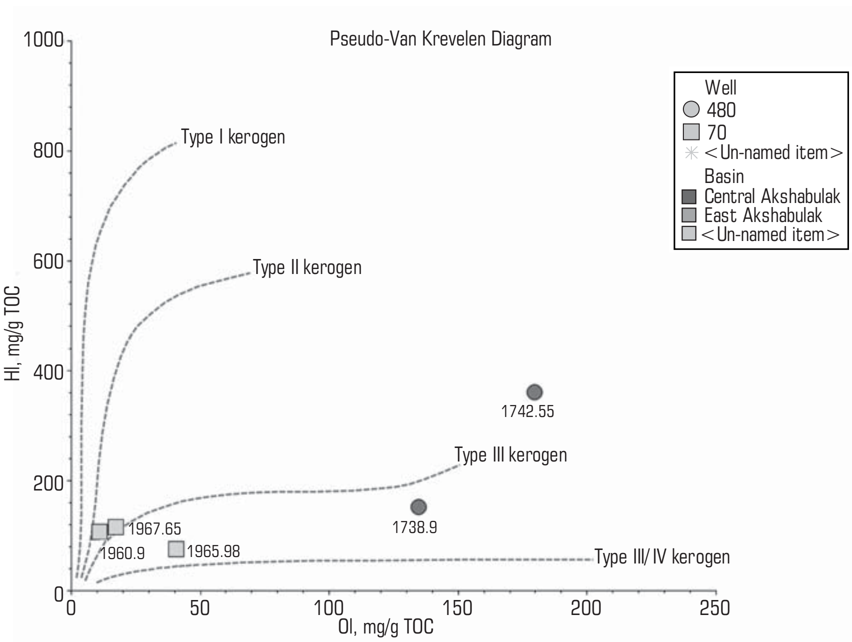


**Fig. 7. Modified Van Kravelen diagram of kerogen types of test samples**

**Table 6. Stages of thermal maturity of organic matter with respect to oil and gas generation ability according to Rock-Eval pyrolysis data [25]**

| Stages of maturity | | $T_{max}$, °C | PI | Dominant generation products |
|---|---|---|---|---|
| Immature | | <435 | < 0.10 | Early generation gases |
| Mature | Early maturity | 435–445 | 0.10–0.15 | Heavy oil |
| | Peak of oil generation | 445–450 | 0.2–0.40 | Oil |
| | Late maturity | 450–470 | >0.40 | Light oils, condensates, fat gases |
| Over mature | | >470 | – | Gases |

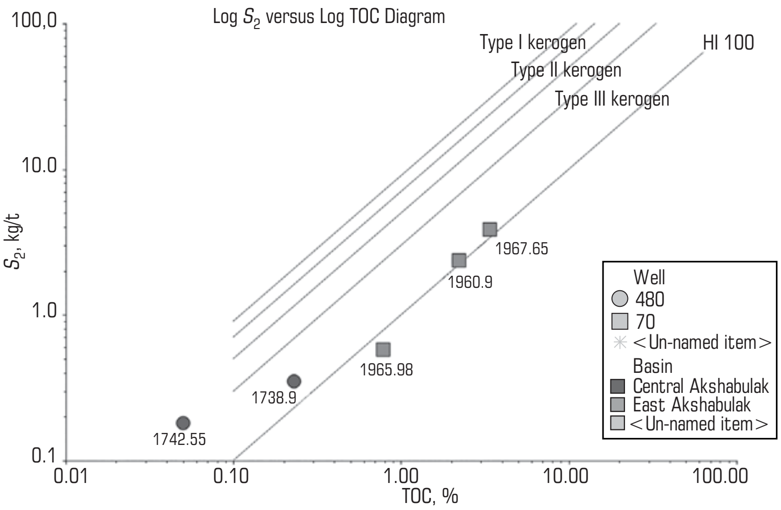


**Fig. 8. TOC versus hydrocarbon potential in test core samples**

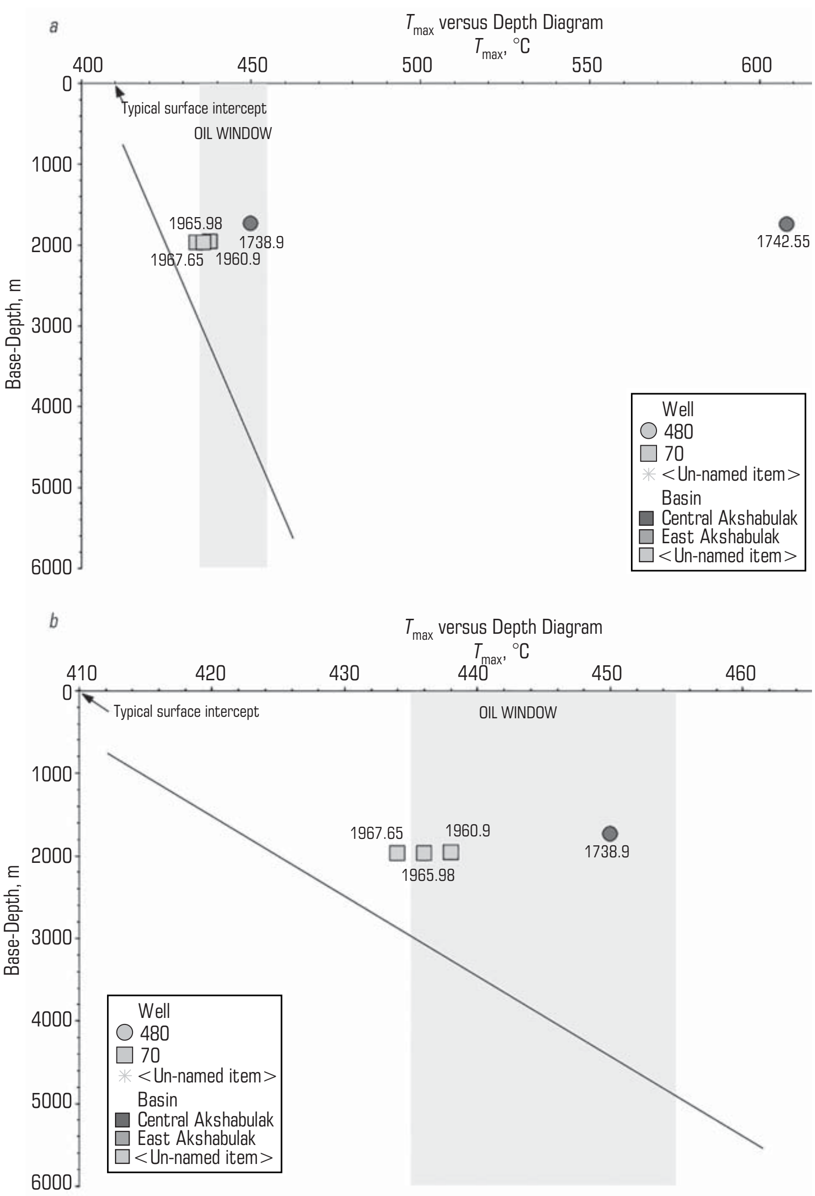


**Fig. 9. Depth dependence of $T_{max}$**

index and early-matured in terms of $T_{max}$ (**Fig. 10**). In this work, the $T_{max}$ values of the East Akshabulak samples can be considered reliable since $S_2$ is more than 0.2 kg/t and TOC is higher than 0.5 [29, 30].

## Conclusion

Geochemical evaluation of potential source rocks in the Aryskum depression is carried out based on Rock-Eval pyrolysis. The conducted analytical studies of RE made it possible to study the following parameters: TOC, $S_1$, $S_2$, $T_{max}$ and HI, OI, PI, which were used to assess the thermal maturity of organic material at the initial stage of thermal maturation.

To assess the oil and gas generation properties of the studied samples, the rocks of Central Akshabulak were withdrawn from the analysis since their TOC content was less than 0.3%.

Based on the geochemical analysis of the core samples from the Upper Jurassic formations of the East Akshabulak deposit in the Aryskum depression, the RE data were obtained, which allowed drawing conclusions about the generation potential, the type of organic matter and thermal maturity of organic matter.

The generation potential of the test samples, determined from the geochemical studies, varies from satisfactory to very good: a sample from the depth of 1965.98 m with TOC 0.78 has a satisfactory generation potential. The samples of the East Akshabulak from the depths of 1960.9 and 1967.65 m have a very good oil and gas generation potential. Also, these conclusions are confirmed by the value of $S_2$ correlated with TOC at the correlation coefficient of 0.9999.

The observed low HI values in the samples indicate the absence of a noticeable concentration of organic matter in the rocks, which confirms their proximity to type III kerogen, characterized by the release of mainly gaseous hydrocarbons. The reliability of the data obtained is proved by the results of the hydrogen (HI) and oxygen (OI) indicators.

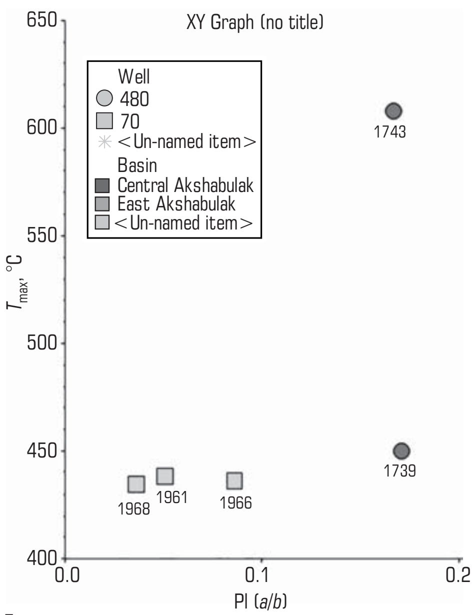


**Fig. 10. $T_{max}$ versus Production Index showing hydrocarbon generation zone**

Thermal maturity of organic matter of the source rocks was determined by studying their geochemical parameters such as the pyrolysis temperature $T_{max}$ and the productive index PI. The test samples of the East Akshabulak deposit are classified by PI as immature, however, the temperature values from the depths of 1960.9 and 1965.98 m point at the early stage of maturity.

To determine the degree of evolution of organic matter, the $S_1/(S_1+S_2)$ ratio and $T_{max}$ temperature were used, according to which the test samples are acceptable for the conditions of the very beginning of the oil window, i.e. oil generation, which allows classifying them as immature to early mature. This implies that the investigated source intervals have poor to satisfactory source potential.

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