

FLUCTUATIONS IN THE WORLD OCEAN LEVEL IN THE SOUTHEASTERN CASPIAN BASIN DURING THE JURASSIC-CRETACEOUS PERIOD

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Summary. The study of sea-level fluctuations in the southeastern Caspian Basin during the Jurassic-Cretaceous transition provides critical insights into the region's paleogeographic evolution and hydrocarbon potential. By analyzing detailed core samples from key oil and gas fields, researchers identified distinct lithological sequences, including sandstones, shales, limestones, and evaporites, reflecting dynamic depositional environments – from shallow marine shelves to sabkha-like evaporitic basins and fluvio-deltaic systems. These variations were driven by a combination of large-scale global factors, such as the breakup of Pangaea, intensified mid-ocean ridge activity, and climatic shifts (e.g., greenhouse conditions in the Cretaceous), as well as regional influences like subsidence, halokinesis (salt dome movement), and episodic influxes of clastic material from nearby uplifted areas. Sequence stratigraphy revealed high-resolution transgressive-regressive cycles, highlighting stark differences between the Jurassic and Cretaceous periods. The Jurassic was characterized by non-marine, lacustrine, and alluvial plain conditions, with occasional short-lived marine incursions, while the Cretaceous experienced a prolonged marine transgression, leading to widespread carbonate platform development. However, localized regressive episodes suggest intermittent basin restriction, possibly due to tectonic barriers or eustatic sea-level drops, complicating paleoenvironmental reconstructions. The study underscores the critical interplay between global eustasy and regional tectonics when modeling ancient sea-level changes. Such integrated models improve the accuracy of paleogeographic reconstructions and enhance the prediction of reservoir quality and seal rock distribution. These findings are particularly valuable for hydrocarbon exploration, as they help pinpoint stratigraphic traps and optimize drilling targets in the Tengiz-Kashagan region. Further research incorporating biostratigraphic zonation and isotopic dating could refine chronostratigraphic frameworks, reducing uncertainties in resource assessments for analogous basins.

Keywords: *The Caspian Basin, Jurassic-Cretaceous period, global ocean fluctuations, transgressions-regressions, sedimentation, paleogeography, collectors*

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Introduction

Fluctuations in global sea levels during the geological past are a key factor influencing the formation of sedimentary basins, the evolution of ecosystems, and the distribution of natural resources. Studying these processes during the Jurassic-Cretaceous period is particularly important, as this era was characterized by global climate changes, tectonic activity, and ocean transgressions and regressions (Haq, 2014; Snedden and Liu, 2010). Its southeastern sector exhibits a complex geological history marked by repeated sea level variations, making it an ideal area for refining paleogeographic reconstructions and deciphering the mechanisms behind these fluctuations (Gamkrelidze, 1986; Ruban et al., 2007).

It is necessary to refine paleogeographic reconstructions and understand the mechanisms

controlling sea level fluctuations in the region. This has not only scientific but also practical significance, as it allows for more accurate forecasting of the distribution of hydrocarbon resources and other mineral deposits (Catuneanu, 2006).

Despite a significant number of studies devoted to the geological evolution of the Caspian Depression, many aspects related to global sea level fluctuations during the Jurassic-Cretaceous period remain insufficiently studied.

The object of the study is the Jurassic-Cretaceous deposits of the Tengiz-Kashagan oil and gas region, located in the southeastern part of the Caspian Syncline. The reconstruction of global sea level fluctuations in the southeastern part of the Caspian Depression during the Jurassic-Cretaceous period was carried out by analyzing lithological-stratigraphic data, results of lithological-

sedimentological studies of core material, identification of key stages of transgressions and regressions, and comparison of the obtained data with existing results.

The conducted work included lithological-sedimentological analysis of cores with macro-descriptions of textures, structures, rock composition, and facies interpretation, integration with a suite of standard laboratory studies, and results of well-logging data interpretation (geophysical well logging, GWI). Statistical analysis of the spatial distribution of facies was used to verify the conclusions.

The study of fluctuations of the World Ocean level in the investigated region raises a number of important questions that require further research. One of the key aspects is the precise determination of factors influencing sea level changes, including tectonic processes, climatic changes, and eustatic fluctuations (Miller et al., 2005). Despite significant progress in understanding the paleogeographic evolution of the region, questions remain unresolved regarding the role of local tectonic movements in the formation of sedimentary basins (Popov et al., 2010). Additionally, the connection between Global Ocean level changes and the regional characteristics of the Caspian Basin has not been sufficiently studied,

necessitating a more detailed analysis of stratigraphic and paleontological data.

Geological background

The study area covers key structural elements of the region: The Karaton-Tengiz uplift system, the Prorva uplifted zone, and the down warped block south of the Sagiz uplift (Fig. 2). This region has context of diverse and complex tectonic settings, where the sedimentary cover is divided into three major successions: the subsalt, salt, and suprasalt complexes, reflecting different stages of tectonic evolution. The salt deposits played a key role in the formation of reservoirs, hydrocarbon traps, and fault systems. Major hydrocarbon fields, including those in the Jurassic and Cretaceous suprasalt deposits, are located near the study area (Volozh et al., 2003).

The lithological composition of the studied well sections is predominantly represented by terrigenous deposits, including sandstones with clayey and carbonate cement, siltstones, clays, as well as coal interbeds and bioturbation textures. The Valanginian deposits are dominated by carbonate rocks: limestones, dolomites, and anhydrites. In the Upper Cretaceous section, an increase in the proportion of carbonate rocks is observed, reflecting changes in sedimentation conditions.

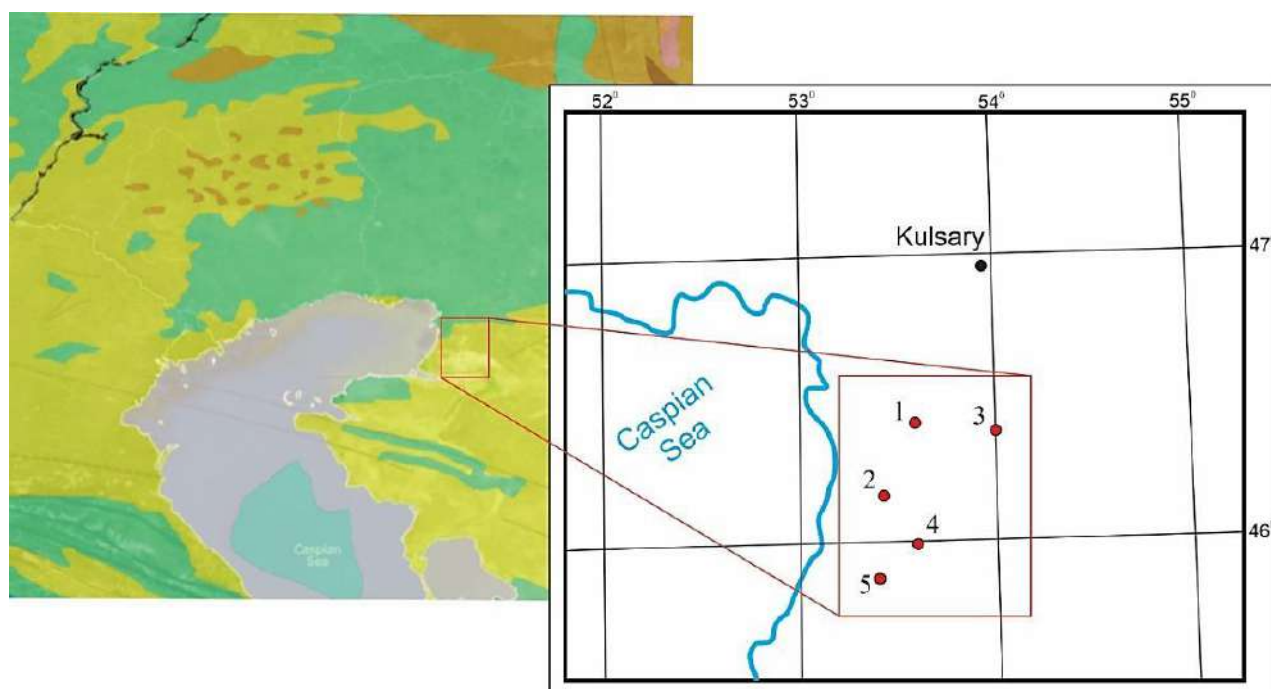


Fig. 1. Overview map of the region indicating the location of the studied fields: 1. Karaton; 2. Karasor; 3. Akkuduk; 4. Dosmukhambetovskoye; 5. S. Nurzhanov

Based on lithological and sedimentological analysis of core samples, four main depositional environments were identified in the studied well sections: marine environment, marine carbonate environment, arid coastal zones and evaporites, and deltas. These environments include a range of facies associated with wetlands, shallow and deep shelf, evaporites, delta plains, delta channels, delta fronts, and prodelta. All identified facies are characterized by relationships based on lithological and textural features of the core (Pronin, 2023).

Sea level fluctuations in the studied region were influenced by factors that determined the complex sedimentation dynamics and paleogeographic evolution of the region.

Global factors:

During the Jurassic-Cretaceous period, global transgressions and regressions occurred, associated with the breakup of the supercontinent Pangaea, the formation of new oceanic basins, and changes in ocean water volume (Haq et al., 1987).

Massive emissions of carbon dioxide into the atmosphere (volcanic activity, mantle degassing) caused a greenhouse effect, contributing to polar ice melting and rising sea levels (Hallam, 1992).

In the Jurassic and Cretaceous periods, the climate was predominantly warm and humid, promoting intense weathering and increased sediment supply to basins (Skelton et al., 2003).

The movement of lithospheric plates and the formation of new oceanic ridges (e.g., the Atlantic) led to changes in the volume of oceanic basins and, consequently, eustatic sea level fluctuations (Miller et al., 2005).

Regional factors:

Intense subsidence and uplift within the basin, associated with fault activation and salt tectonics, influenced local changes in basin level (Баренбаум, 2002).

The formation of the Karaton-Tengiz uplift system and the Prorva zone created barriers to sedimentation, leading to the differentiation of the basin into sub-basins with varying sedimentation regimes (Волкова и др., 2010).

The influx of large amounts of terrigenous material from surrounding highlands (e.g., the Ural orogen) contributed to basin filling and local sea level changes (Габдуллин и др., 2008).

Carbonate sedimentation in shallow marine environments (e.g., on uplifts) created marker horizons reflecting periods of sea level stabilization (Зорина, 2016).

Changes in river discharge and erosional activity, depending on climate, influenced the volume of sediment supply and, consequently, basin dynamics (Alsharhan, Nairn, 1997).

Materials and Methods

The study was based on core material from 15 wells across five fields (Karaton, Karasor, Akkuduk, Dosmukhambetovskoye, and S.Nurzhanov) with a total length of 1,331.81 meters (Fig. 1).

Periodic salinization or freshening of the basin, related to changes in connectivity with the Global Ocean, could also affect water levels.

For the reconstruction of transgressive-regressive and progradational-retrogradational cycles, data from lithological core analysis, facies interpretation, and well-logging (geophysical well logging, GWI) were used. Based on sequence stratigraphy methods (Габдуллин и др., 2008), the following patterns were identified:

- Changes in grain size upward through the section, reflecting sedimentation cyclicity.

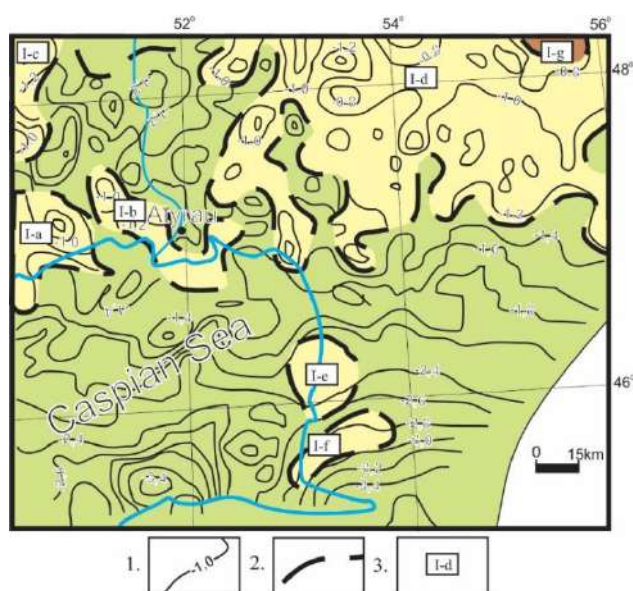


Fig. 2. Part of the scheme of structural and tectonic zoning of the Mesozoic complex (Воцалевский и др., 2002) 1. Isohypses of the base of the Jurassic complex (V reflecting horizon); 2. Boundaries of structural elements; 3. Structural relatively elevated zones: **I-a** – Martyshinskaya, **I-b** – Nizhneuralskaya, **I-c** – Karagayskaya, **I-d** – Sagizkaya; **I-e** – Karaton-Tengizskaya, **I-f** – Prorvinskaya, **I-g** – Shubarkuduk-Akzharskaya

- The nature of well-logging curves (gamma ray, spontaneous potential) showing trends of decreasing or increasing environmental energy.

- The presence of marker horizons, such as coals (indicators of regression) and carbonate rocks (indicators of marine transgressions).

Based on these data, transgressive-regressive cycles were identified and summarized, allowing for the reconstruction of sea level changes during the Jurassic-Cretaceous period. Zones of local

sea level fluctuations leading to aggradational cyclicity were established (Зорина, 2016). A composite section of cycles for the studied fields was constructed, reflecting the spatiotemporal variability of sedimentation (Fig. 3).

Based on the identified relative changes in shoreline levels from well sections, using well-logging curves and core data, the Mesozoic-Cenozoic cycle diagram was compared with the generalized results, as shown in Fig. 4.

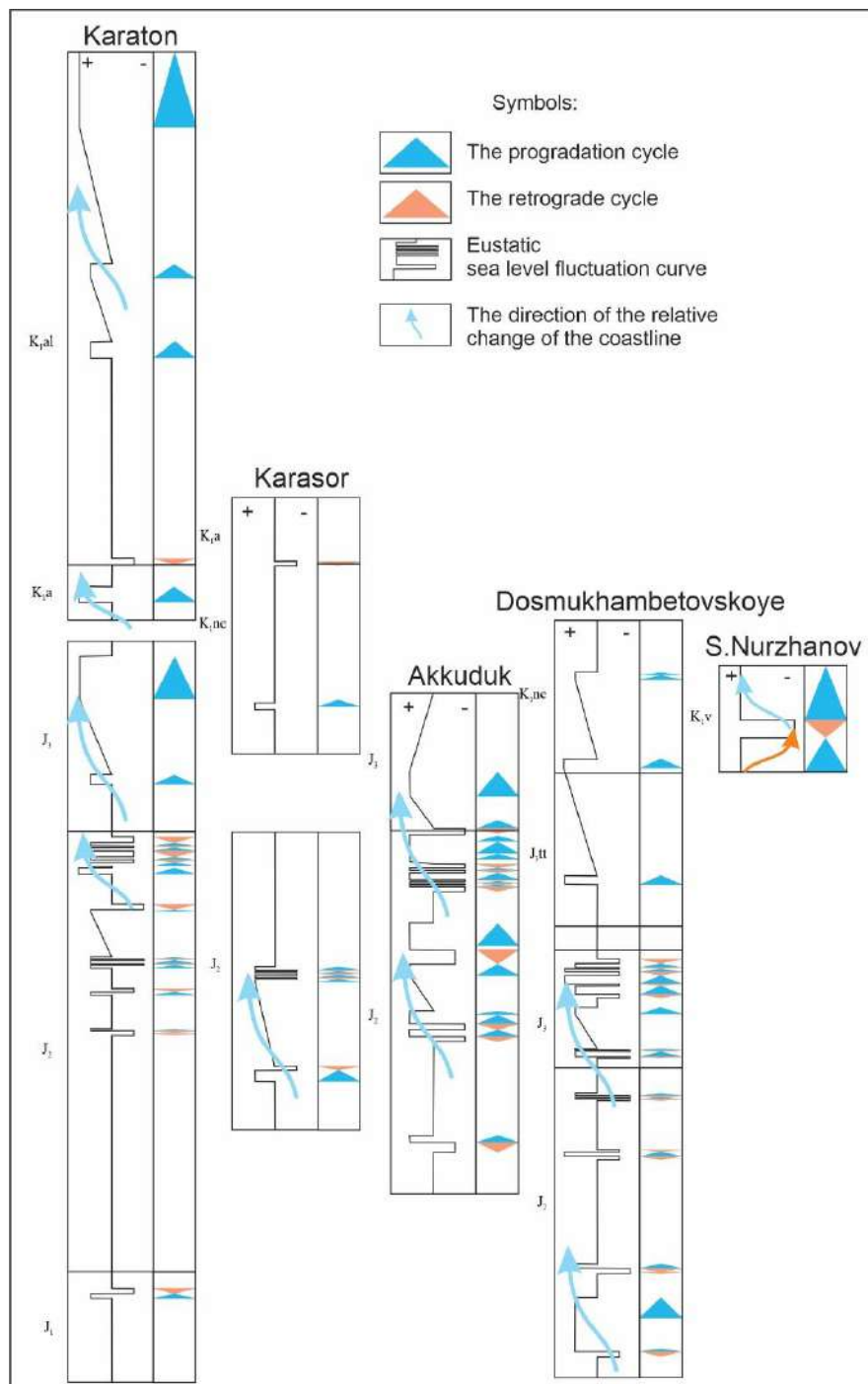


Fig. 3. Transgressive-regressive cycles and identified directions of relative shoreline displacement in the Jurassic-Cretaceous periods in the studied deposits

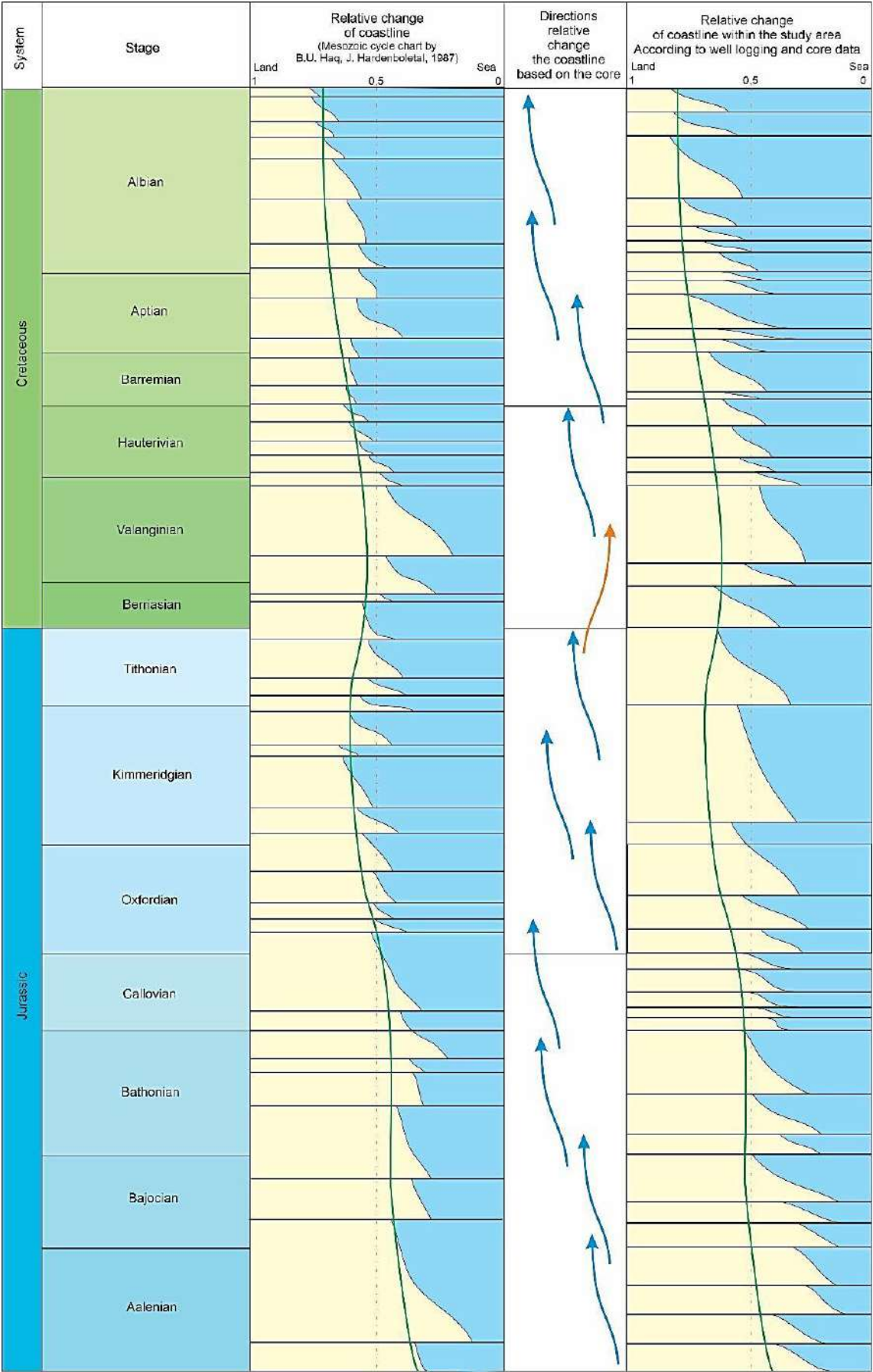


Fig. 4. Comparison of the data from the Mesozoic-Cenozoic cycle diagram fragment and the information obtained on the relative change of the coastline by deposits

The analysis of the obtained data allows us to conclude that significant fluctuations in global sea levels occurred in the studied area during the Jurassic-Cretaceous period. Frequent changes in transgressive-regressive cycles in certain intervals indicate the presence of aggradation cyclicity, driven by local factors that may deviate from global sea level trends. The comparison of cycles and relative sea level changes suggests that the main trend of sea level changes in the studied area generally aligns with global patterns.

Results and Discussion

Paleogeographic conditions in the Jurassic period were characterized by arid climates and continental settings, while during the Cretaceous period a significant marine transgression was recorded. However, the frequent sea level fluctu-

ations in certain intervals may indicate the presence of an isolated or semi-enclosed water body whose level changed independently of the Global Ocean. Particular attention should be paid to the sharp sea level fall during the Valanginian, leading to the establishment of evaporitic conditions, as confirmed by available data.

The heterogeneity of Jurassic-Cretaceous reservoir architecture in the study area is due to frequent fluctuations of the level of a semi-enclosed water body, causing multiple facies variations. The most favorable conditions for reservoir rock formation were observed in proximal facies, demonstrating high sedimentation rate. These findings highlight the importance of considering local factors in reconstructing paleogeographic and paleoclimatic conditions, as well as in predicting the distribution of reservoir properties in the section.

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КОЛЕБАНИЯ УРОВНЯ МИРОВОГО ОКЕАНА ЮГО-ВОСТОЧНОЙ ЧАСТИ ПРИКАСПИЙСКОЙ ВПАДИНЫ В ЮРСКО-МЕЛОВОЙ ПЕРИОД

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Резюме. Исследование колебаний уровня моря в юго-восточной части Каспийского бассейна на рубеже юрского и мелового периодов дает ключевое представление о палеогеографической эволюции региона и его нефтегазовом потенциале. Анализ кернового материала из месторождений исследуемого региона, позволил выявить четкие литологические последовательности, включающие песчаники, глинистые сланцы, известняки и эвапориты, которые отражают динамичные условия осадконакопления — от мелководных шельфов до эвапоритовых бассейнов и дельтовых систем. Эти изменения были обусловлены сочетанием глобальных факторов, таких как распад Пангеи, усиление активности срединно-океанических хребтов и климатические колебания (например, парниковые условия мелового периода), а также региональных процессов — тектонического погружения, движения соляных куполов и периодический привнос обломочного материала с прилегающих регионов. Последовательность указывает на высокоразрешающие трансгрессивно-регрессивные циклы, подчеркивающие резкие различия между юрским и меловым периодами. В юре преобладали континентальные, озерные и аллювиальные равнинные условия с кратковременными морскими вторжениями, тогда как в мелу произошла продолжительная морская трансгрессия, приведшая к формированию карбонатных платформ. Однако локальные регрессивные эпизоды указывают на периодическую изоляцию бассейна, возможно, из-за тектонических барьеров или эвстатических понижений уровня моря, что усложняет реконструкции палеосред. Исследование подчеркивает важное взаимодействие глобальной эвстатики и региональной тектоники при моделировании древних изменений уровня моря. Такой комплексный подход к модели, повышает точность палеогеографических реконструкций и улучшает прогнозирование качества коллекторов и распределения флюидоупоров. Эти результаты особенно ценны для нефтегазовой разведки, поскольку помогают выявлять стратиграфические ловушки и оптимизировать бурения в исследуемом регионе. Дальнейшие исследования, дополненные биостратиграфией и изотопное датирование, позволят уточнить хроностратиграфические схемы и снизить неопределенности при оценке ресурсов в аналогичных бассейнах.

Ключевые слова: Прикаспийская впадина, юрско-меловой период, колебания мирового океана, трансгрессии-регрессии, осадконакопление, палеогеография, коллекторы

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Xülasə. Yura-Təbaşir dövrünün keçidində Cənub-Şərqi Xəzər hövzəsində baş verən dəniz səviyyəsinin dəyişkənliyinin araşdırılması regionun paleocoğrafi təkamülünə və karbohidrogen potensialına dair mühüm məlumatları ehtiva edir. Həmin hövzənin əsas neft və qaz yataqlarından götürülmüş kern nümunələri ətraflı təhlil edilərək, dayaz dəniz şelflərindən başlamış səbxa tipli evaporit hövzələrinə və fluvio-delta sistemlərinə qədər dinamik çöküntü mühitlərini əks etdirən qumdaşlarından, gilli şistlərdən, əhəngdaşlarından və evaporitlərdən ibarət fərqli litoloji sekvenslər müəyyən edilmişdir. Belə variyasiyalar Pangeyanın parçalanması, orta okean silsilələrinin fəaliyyətinin güclənməsi və iqlim dəyişiklikləri (məsələn, Təbaşir dövründə istixana şəraiti) kimi genişmiqyaslı global amillərin, həmçinin çökmə, halokinez (duz günbəzlərinin hərəkəti) və yaxınlıqdakı qalxmış ərazilərdən epizodik olaraq klastik materialların daxil olması kimi regional təsirlərin kombinasiyası nəticəsində baş vermişdir. Sekvens stratigrafiyası Yura və Təbaşir dövrləri arasında kəskin fərqləri vurğulayan yüksək rezolyusiyalı transqressiv-reqressiv dövrləri aşkar edir. Belə ki, Yura dövrü qısa müddətli dəniz transqressiyaları ilə müşayiət olunan qeyri-dəniz, göl və allüvial düzənlik şəraiti ilə xarakterizə olunsada, Təbaşir dövründə uzunmüddətli dəniz transqressiyası baş vermiş və geniş karbonat platformalarının inkişafına səbəb olmuşdur. Lakin, lokal reqressiv epizodlar, ehtimal ki, tektonik məhdudiyyətlər və ya evstatik dəniz səviyyəsinin enməsi nəticəsində hövzənin aralıqlarla məhdudlaşdığını göstərir ki, bu da paleohövzə mühitinin rekonstruksiyasını çətinləşdirir. Tədqiqatımız qədim dəniz səviyyəsinin dəyişikliklərinin modelləşdirilməsində global evstaziya və regional tektonikanın kritik qarşılıqlı əlaqəsini ön plana çıxardır. Bu cür integrasiya olunmuş modellər paleocoğrafi rekonstruksiyaların dəqiqliyini artırır və kollektor keyfiyyətinin və örtük süxurlarının paylanması proqnozlaşdırılmasını yaxşılaşdırır. Belə tapıntılar, xüsusən də Tənqiz-Kaşağan regionunda stratigrafik tələlərin müəyyənləşdirilməsinə və qazma ilə bağlı hədəflərin optimallaşdırılmasına imkan yaratdığı üçün karbohidrogenlərin axtarışında xüsusilə əlverişlidir. Biostratigrafik zonalaşdırma və izotop kimi əlavə tədqiqatlar analoji hövzələr üçün resurs qiymətləndirilməsindəki qeyri-müəyyənlikləri azaldaraq, xronostratigrafik mənzərəni təkmilləşdirə bilər.

Açar sözlər: Xəzəryanı çökəklik, yura-təbaşir dövrü, dünya okeanının dəyişməsi, transqressiya-reqressiya, çöküntü-toplanma, paleocoğrafiya, kollektor