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Research Article

THE ROLE OF SALT TECTONICS IN THE FORMATION OF STRUCTURAL MODELS AND PROSPECTIVE RESERVOIRS OF THE SURKHANDARYA MEGASYNCLINE

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ABSTRACT
This study investigates the role of salt tectonics in the formation of structural models and prospective reservoirs within the Surkhandarya megasyncline, located in the Afghan-Tajik Basin. A paleotectonic analysis of the region's geological structure is presented, along with a detailed description of the main structural-tectonic zones, including the influence of salt formations on geological horizon distribution and the development of potential hydrocarbon traps. Special attention is given to processes occurring within suprasalt and subsalt layers, as well as structural characteristics shaped by the movement of Upper Jurassic salts and thrust zones. The identified patterns in salt complex formations and their correlation with Paleogene and Cretaceous deposits confirm the critical importance of accounting for salt tectonics when evaluating hydrocarbon field prospects. The findings have practical significance for geological exploration in the Surkhandarya zone and other analogous regions.

Keywords: *Salt Tectonics, Structural Models, Geology Of The Surkhandarya Megasyncline, Mesozoic Cover, Geophysical Data, Prospective Reservoirs, Tectogenesis, Platform Cover*

INTRODUCTION
The Surkhandarya megasyncline, located within the Afghan-Tajik Basin, is a complex structure formed through prolonged tectonic processes. One of the key factors influencing the development and distribution of geological layers in this region is salt tectonics. Salt deposits, formed through isostatic movements and associated displacements, play a critical role in shaping structural models, which, in turn, determine the potential for hydrocarbon exploration and production. The significance of this research lies in the need for a deeper understanding of the mechanisms underlying salt structure formation and their impact on the geological structure of the region as a whole. Salt tectonics can serve as a decisive factor in forecasting prospective reservoirs and in determining the location of hydrocarbon fields in complex geological settings like those found in the Surkhandarya megasyncline. (Abidov *et al*.,1987)
This study aims to analyze the role of salt tectonics in forming structural models and to assess its impact on the hydrocarbon potential of the region's reservoirs. To achieve this objective, the article examines the main geological and tectonic features of the Surkhandarya zone, the characteristics of salt formations, and the relationship between salt tectonics and the formation of hydrocarbon traps.

MATERIALS AND METHODS
To investigate the role of salt tectonics in the formation of structural models of the Surkhandarya megasyncline, a paleotectonic analysis was conducted to study the historical tectonic changes in the region, allowing an understanding of salt tectonic processes over an extended time period and their impact on the distribution of prospective hydrocarbon reservoirs. The geophysical data analysis includes the processing of seismic and magnetic survey data to identify disharmonic rock complexes and their influence on the formation of hydrocarbon traps. These methods enable the mapping of subsurface salt structures, including their thickness and conFigureuration. Structural modeling was employed to build structural models assessing the impact of salt movements on subsalt and suprasalt complexes. These models help identify

deformation mechanisms and predict promising areas for geological exploration. The sedimentary complex analysis involved examining the sedimentary characteristics of Jurassic-Paleogene deposits to determine depositional conditions and their role in the formation of potential traps. (Abdullaev, G.S *et al*.,2020)
The Kognysay area is located within the Afghan-Tajik Basin in the eastern part of the Baysun Depression, within the Surkhandarya Monocline (Figure 1). **(**Wendelstein *et al.,* 1978)
In the geological structure of the Surkhandarya Megasyncline, the pre-Jurassic folded basement, which is buried at a great depth, and the Mesozoic-Cenozoic sedimentary complex, which forms two structural levels, stand out. The Jurassic-Paleogene level serves as the platform cover, formed during the post-Hercynian period, while the Neogene-Quaternary level is orogenic, formed during the Alpine tectogenetic stage. In the basement section, Paleozoic geosynclinal formations and Permian and Triassic epigeosynclinal formations are distinguished, which are identified as an intermediate structural level. A characteristic feature of the deep structure of the platform cover is the presence of two discordant rock complexes: the subsalt complex, composed of Lower, Middle, and Upper Jurassic formations, and the supersalt complex, consisting of Cretaceous-Paleogene deposits.The modern structure of the Surkhandarya Megasyncline was finally shaped during the Neogene-Anthropogene tectogenetic period. Within it, the Baysun, Kelif-Sarykamysh, Western Surkhan, and Eastern Surkhan structural-tectonic zones are identified (Figure 2) (Abidov, 2010)

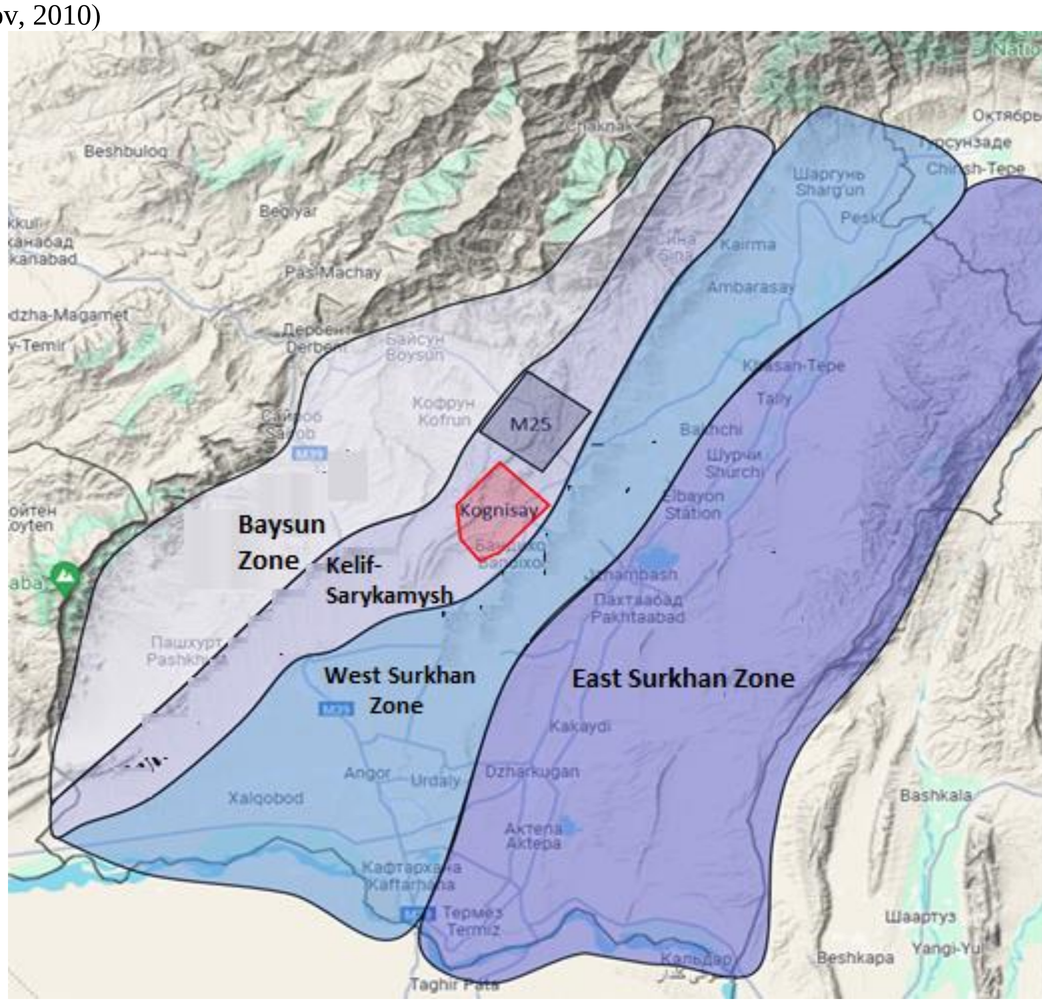

Figure 1 Structural-Tectonic Zones of the Surkhandarya Megasyncline

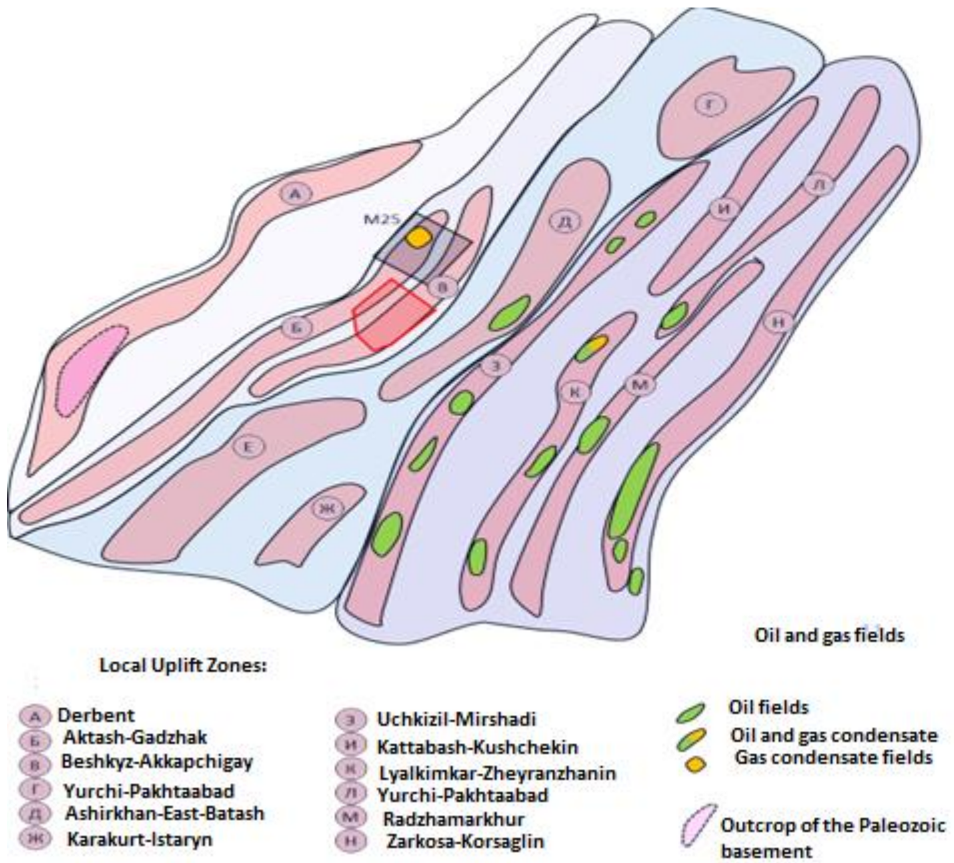

Figure 2 Main Structural Elements of the Surkhandarya Region

The Baysun Structural-Tectonic Zone is located in the western part of the Surkhandarya Megasyncline. To the northwest, it is bounded by the Kugitang-Baysun Deep Fault, to the east by the Surkhantau-Kelif Deep Fault, and to the south by a series of strike-slip faults. Tectonically, the zone represents a trough, with dimensions in the Paleogene horizons of 65x15 km. In the northwestern part of the trough, the Derbent Zone of local uplifts is located. The Baysun Zone is characterized by anticlinorial folds, complicated by submeridional and sublatitudinal tectonic faults.

RESULTS AND DISCUSSION

The results of paleotectonic analysis and salt tectonics studies in the Surkhandarya megasyncline confirm the crucial role of salt formations in shaping tectonic structures and their impact on hydrocarbon distribution. Specifically, it was established that the influence of salt pillows and the movement of Upper Jurassic salts has a significant effect on the development of both suprasalt and subsalt horizons, creating numerous tectonic traps for hydrocarbons.

A key finding of the study is that salt tectonics in this region leads to the formation of disharmonic rock complexes, characterized by complex structures and varied sedimentation conditions. The subsalt complex, represented by Lower, Middle, and Upper Jurassic deposits, and the suprasalt complex, consisting of Cretaceous-Paleogene deposits, exhibit different sedimentary conditions—ranging from continental to lagoonal. These characteristics create favorable conditions for trap formation, which may be promising for oil and gas exploration.

Special attention should be given to the maximum thickness of salt deposits observed near thrust zones. In these areas, salt pillows form robust structural noses that can act as potential hydrocarbon traps. Salt formations located near well sites (e.g., Kog-1J) influence the geological structure and may serve as a basis for developing more precise models of hydrocarbon deposit distribution.

The analysis of thickness and continuity of structural complexes confirms that the geological layers in the region form a stable structure, which can serve as a crucial basis for further exploration. However, due to the complex structure of salt layers and their interactions with other geological formations, studying salt tectonics requires the use of integrated methods, including geophysical surveys and modeling approaches for more accurate prediction. Thus, the results of salt tectonics analysis and structural modeling demonstrate that salt formations play a key role in the formation of geological traps, making this region promising for further hydrocarbon exploration.

The Kelif-Sarykamysh Structural-Tectonic Zone is located between the Baysun and Western Surkhan Zones. It includes the Akhtash-Gadzhak and Beshkiz-Akkapchigay Zones of local uplifts, in the salt complex of which morphologically diverse folds related to thrusts of various amplitudes and directions of dip are developed. Salt tectonics significantly complicates the structural plan of the supra-salt horizons in the under-thrust.

The Western Surkhan Structural-Tectonic Zone is located east of the Kelif-Sarykamysh Zone and borders the Eastern Surkhan Zone along the Western Khoudag Fault. The Western Surkhan Zone represents a deep trough composed of Neogene-Quaternary deposits, with the basement depth ranging from 9.5 to 11.2 km. The Upper Jurassic formation lies at depths of 6-7 km, with a north-to-south and west-to-east dip.

Within the Western Surkhan Structural-Tectonic Zone, the Sangardak, Karakurti-Istarinsk, Ashirkhan-Eastern-Batash, Angor, and Yurchi-Pakhtaabad Zones of local uplifts are distinguished, which are further complicated by folds. Additionally, the Surkhantau Ridge and the Shirabad Depression are present.

The Eastern Surkhan Structural-Tectonic Zone lies to the east of the Western Surkhan Zone. To the east, it is bounded by the Western Babatag Thrust. The basement depth within the zone ranges from 7.3 to 11.2 km, with the carbonate formation in the central part of the southern half of the zone reaching 5.5 km.

The Afghan-Tajik Basin was deformed by the northwestern displacement of the Pamir Block, which created a series of complex anticlines and synclines with northeastern strike, supported by faults with main separating surfaces along the upper Jurassic salts and Paleozoic basement. The synclines were filled with orogenic molasse clastic rocks ranging from 1000 to 6000 meters in thickness. In the Baysun Block, their thickness ranges from 0 to 4000 meters.

The Kognysay area is located directly in the thrust zone. The main fault of the fold extends from the southwest to the northeast, with the western block located in the allochthonous (overhanging) region (Figures 3 and 4). Following subsequent erosion, the Lower and Upper Cretaceous deposits are exposed on the surface.

A characteristic feature of the deep structure of the platform cover is the presence of two discordant rock complexes: the subsalt complex, composed of Lower, Middle, and Upper Jurassic formations, and the supersalt complex, consisting of Cretaceous-Paleogene deposits. The thickness of the Mesozoic cover (Figure4) is generally constant across the area, ranging from 3200 to 3600 meters. Major uplifts are formed due to the thrust (duplicated section in the northeast) and the movement of Upper Jurassic salts. The maximum salt thickness is found in areas near the thrust zone, where a salt pillow is formed at the location of the Kog-1J well, creating a structural nose in the Cretaceous and Paleogene deposits. The analysis of the thicknesses of the structural complexes of the supersalt and subsalt deposits also confirms the uniformity of the thicknesses, with sedimentation conditions changing from continental to lagoonal. The data reviewed confirms the complexity of the geological structure of the region and the importance of considering the peculiarities of salt tectonics when identifying promising sites for geological exploration. Salt formations near thrust zones can form structural noses and serve as potential traps for hydrocarbons, which increases the research interest in this area.

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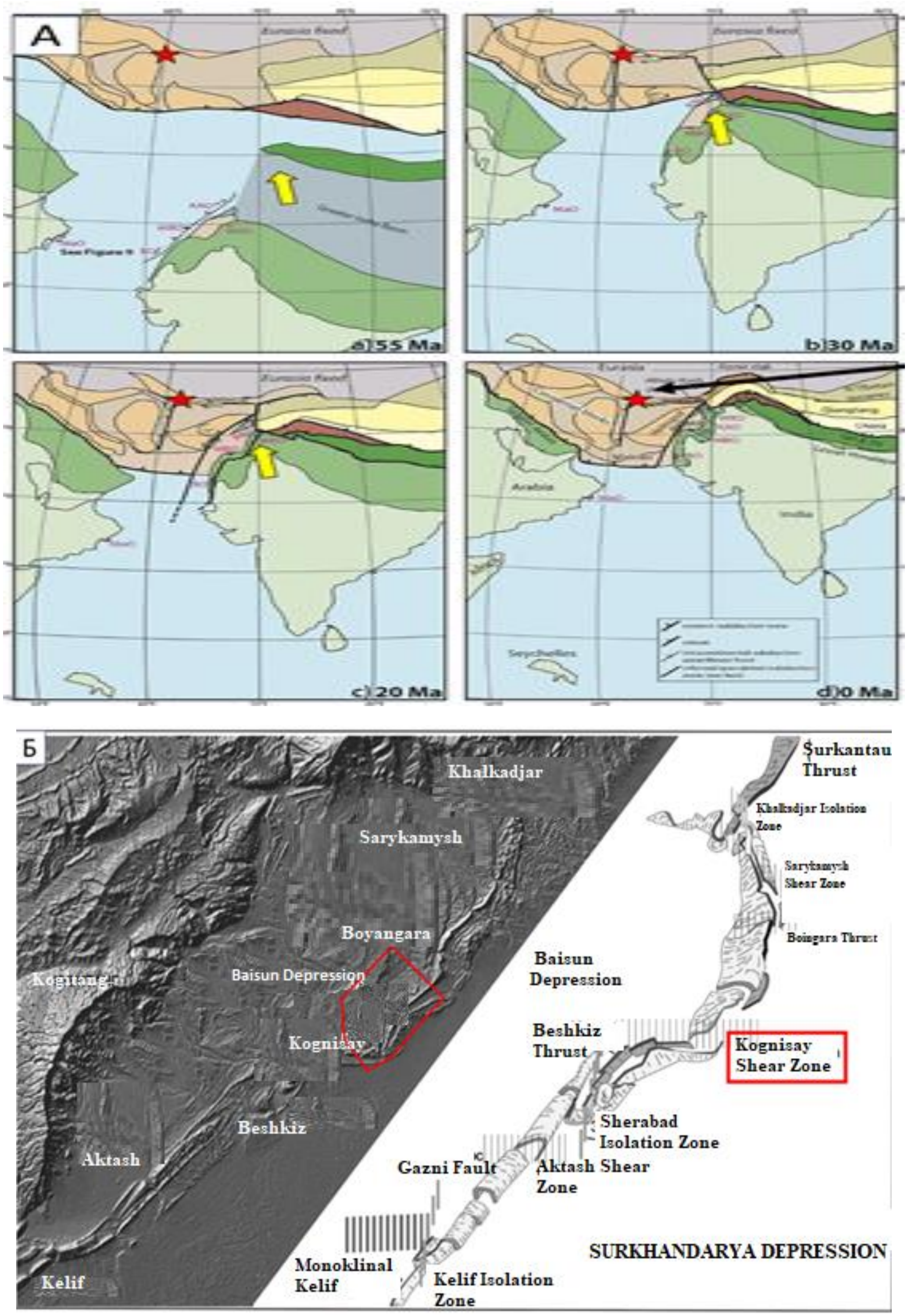


Figure 3:
A) Evolution of Indostan in the Cenozoic.
B) Topography and deformation model of Paleocene deposits of the edge of the Akhtash-Surkhantau Anticline Uplift [9].

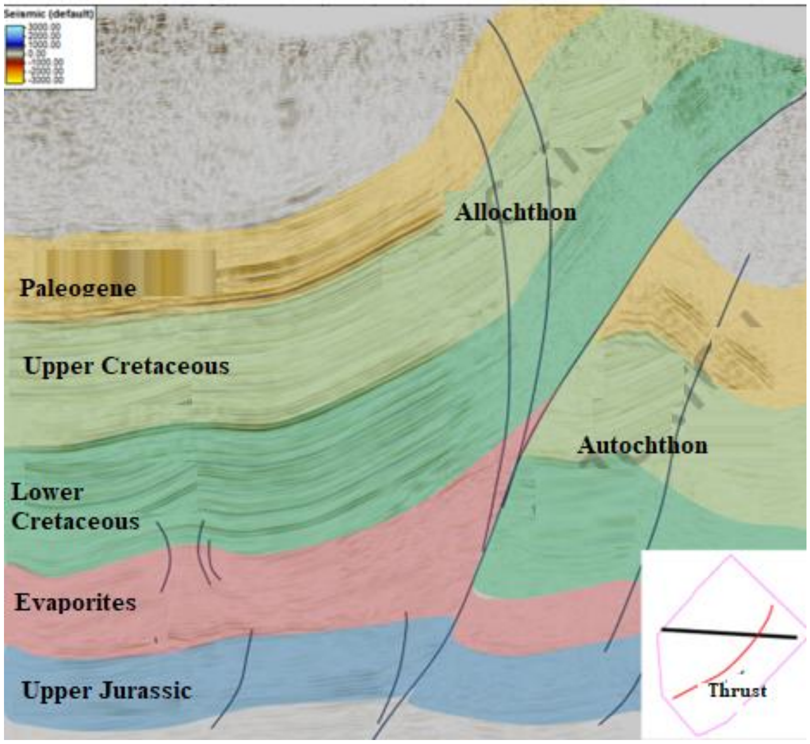


Figure 4: Structure of the Thrust Zone in the Kognysay Area.

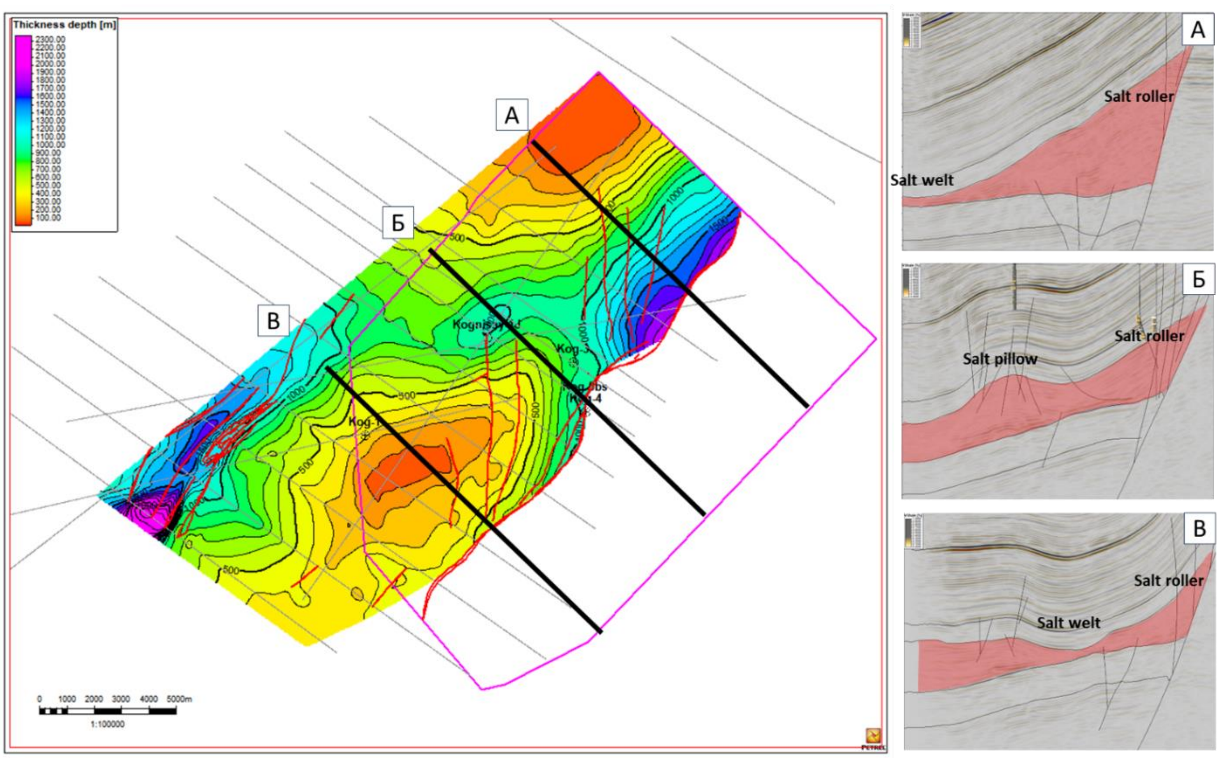
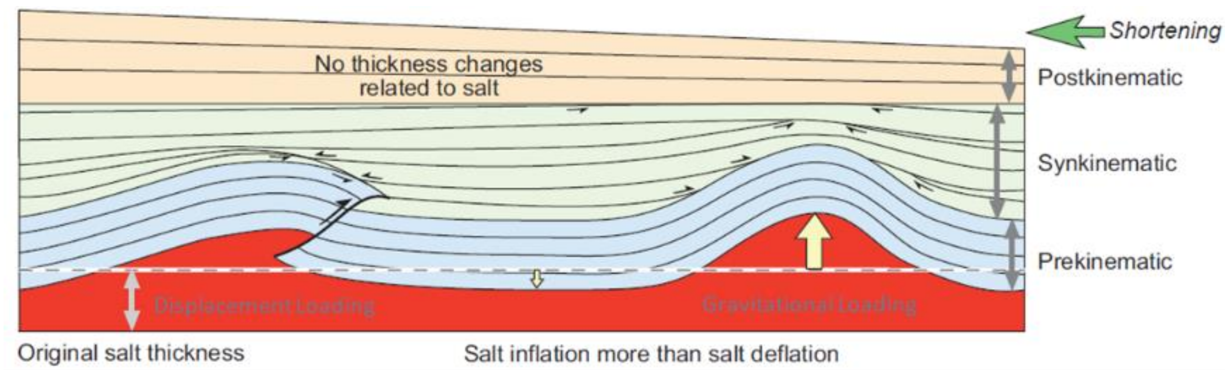


Figure 5: Structure of the Evaporite Complex and Its Main Structural Elements. Map of Salt Thickness and Sections.

In the development of thrust deformations, the structural position of the evaporite layers can also vary depending on the stage and degree of deformation. When a major slip develops with a progressively increasing dip in the direction of movement of the thrust front, the advancement of the salt layers occurs simultaneously with the penetration of the detachment, but with a smaller amplitude.The conFigureuration of the evaporite body is also controlled by local decompression conditions, under which the advancement of the salt layers occurs due to the density differentiation effect (Figure 5).



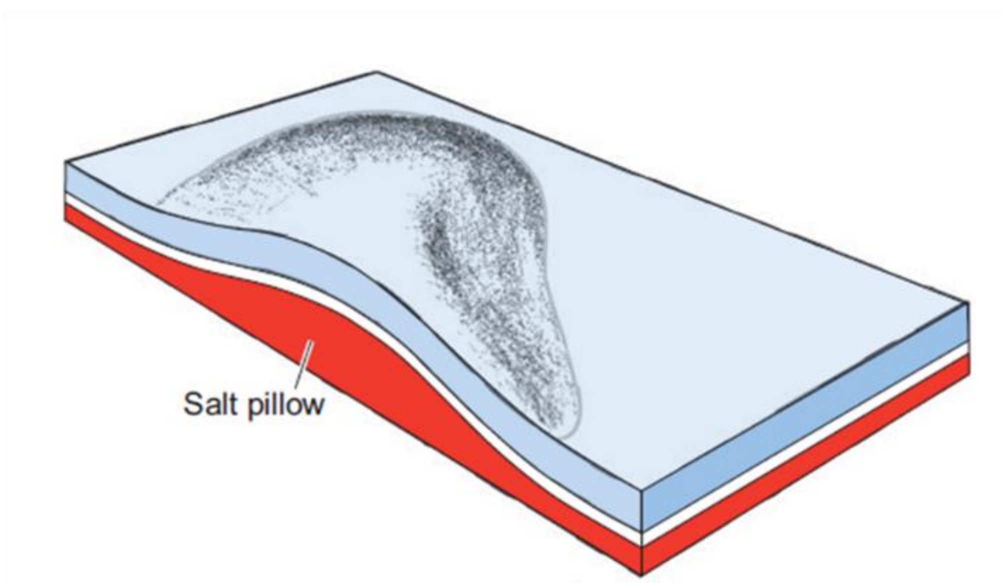


Figure 6: Schematic Structure of the Salt Pillow [13].

For the onset of salt tectonics (Figure6), gravitational driving forces must overcome the strength and weight of the cap rock above the crest of the structure (Figure 7 A, B, C). Thus, halokinetic pillows grow most effectively when the roof is thin and weak; growth tends to slow down as the overburden becomes thicker and stronger. The growth of halokinetic pillows and anticline covers at a later stage may also slow down due to the reduced salt influx from the thinning source layer. However, if salt is imported from the plane of the section, these folds with a salt core can continue to increase even after the adjacent source layer has become lithified.The overall diagram illustrating the development of the area and the formation of the main structural elements (the eastern thrust and the salt anticline) is presented in Figure 7.

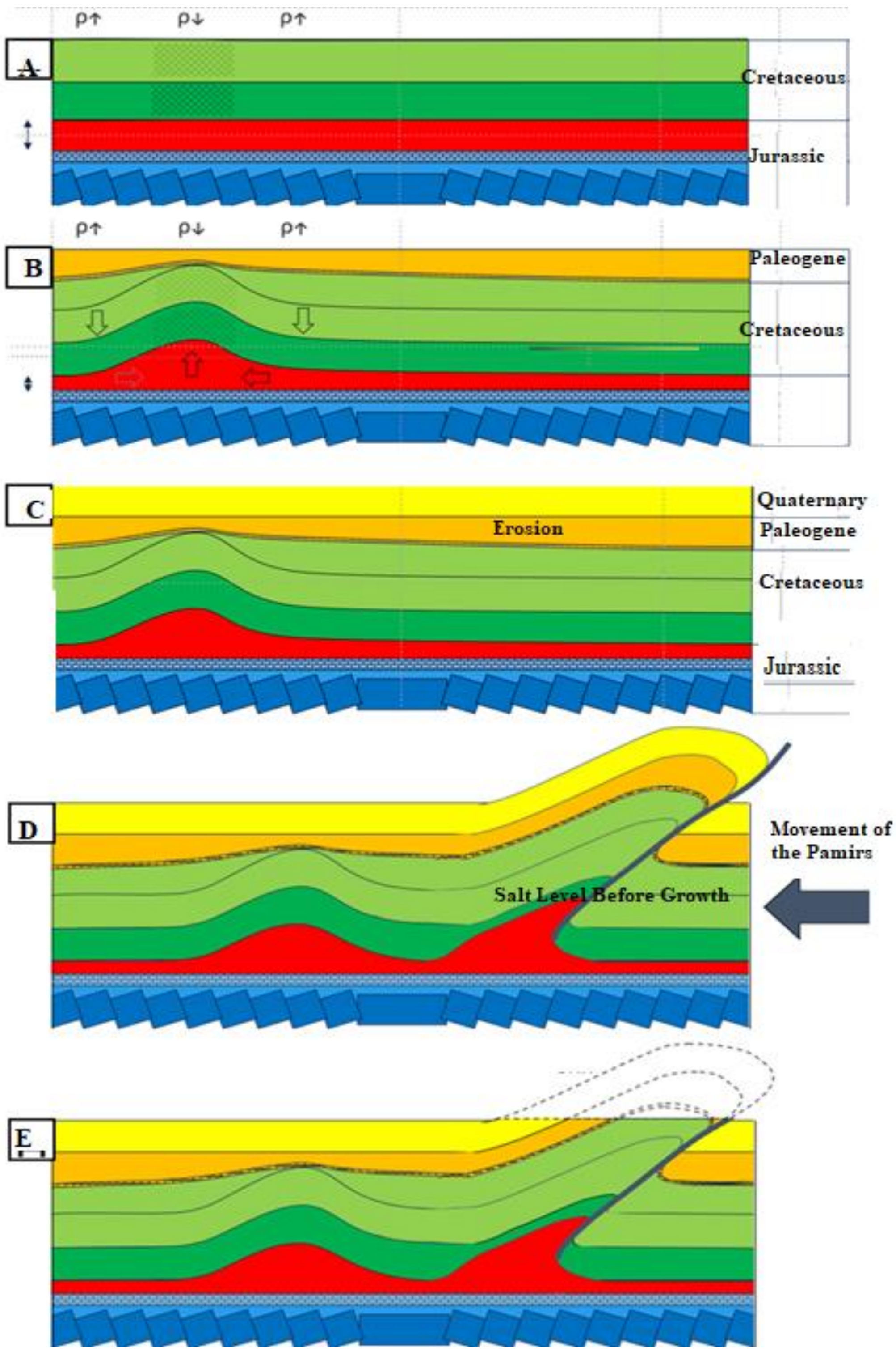


Figure 7: Mechanism of Formation of the Salt Pillow and Salt Thrust.

The features of salt tectonics are reflected in the analysis of the thicknesses of the subsalt and supersalt complexes. If the thickness of the evaporite complex is subtracted from the structural plan of the supersalt deposits, it will repeat the uplifts of the subsalt carbonate complex of the Jurassic (Figure8, Figure9). This may indicate a direct influence of salt movement on the structural plan of the supersalt horizons. This aspect increases the confidence in the structural mapping of the central part of the area.

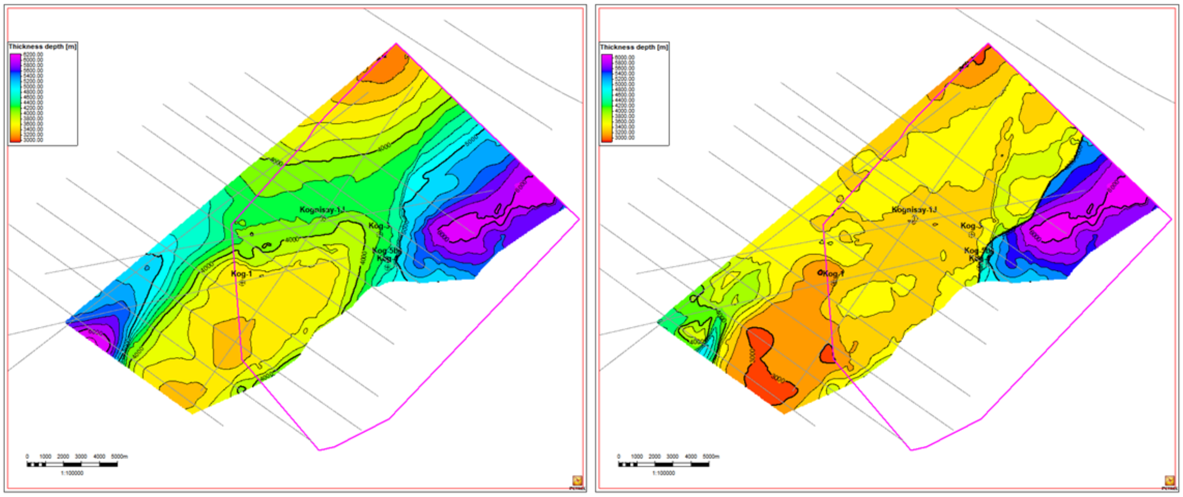


Figure 8: Thickness of the Mesozoic Cover
a) Including Salt Deposits;
b) Excluding Salt Deposits.

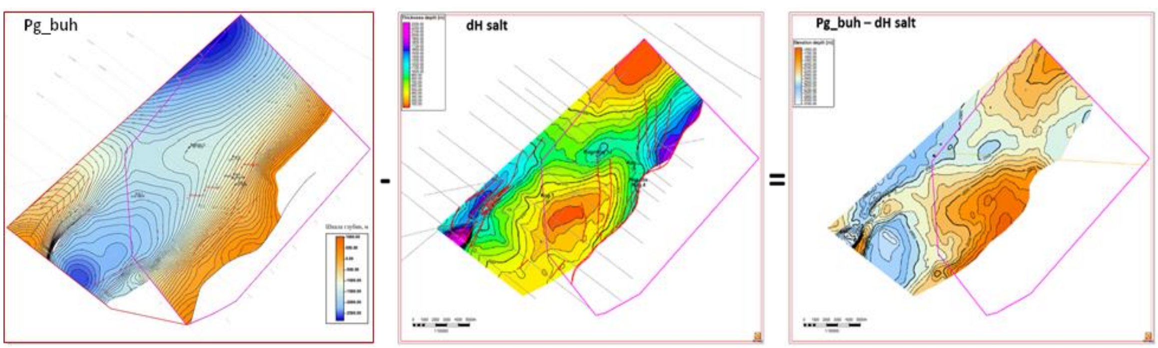


Figure 9: Analysis of the Influence of the Evaporite Complex on Overlying Deposits.

Salt tectonics played a crucial role in the formation of fracture zones. When salt pillows and diapirs form, stretching occurs in the arch of the salt structure and compression on the flanks, eventually leading to shear (Figure 10). High-amplitude extension faults are observed in the area of the western salt structure, while faults with lower amplitudes (difficult to map) are observed near the structural nose of Kognysay. Such faults may have high conductivity, as fractures can form along them, allowing salt movement that fills void spaces outside the Jurassic interval.

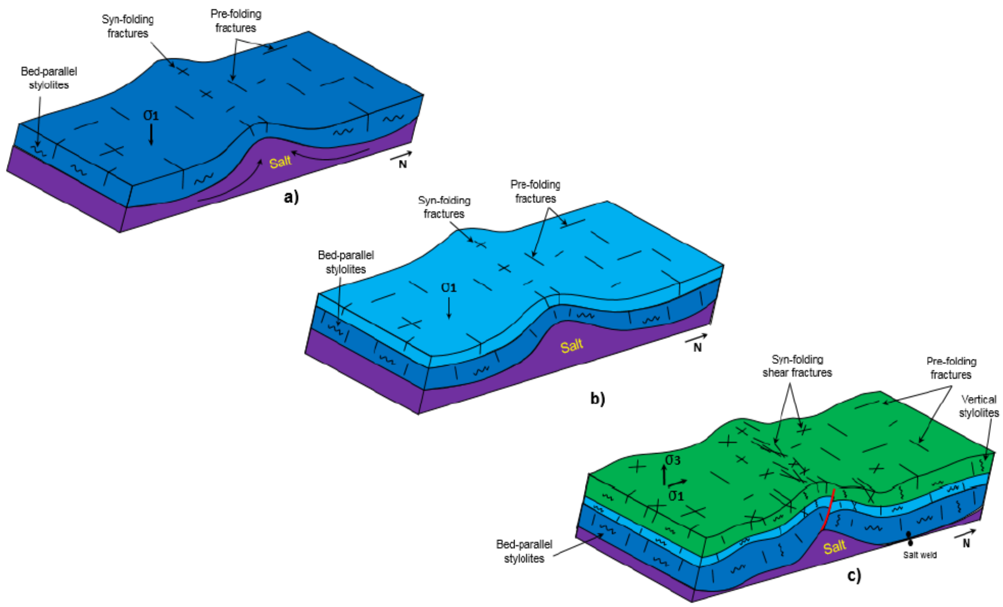


Figure 10: Diagram of Fault Formation in Deposits Above the Salt Pillow Arch [Ulises de Jesus Rodriguez del Angel, 2021]

The Surkhandarya Megasyncline consists of a pre-Jurassic folded foundation, submerged at great depth, and a Mesozoic-Cenozoic sequence of deposits, forming two structural levels: the Jurassic-Paleogene (platform cover) and the Neogene-Quaternary (orogenic). In the foundation section, Paleozoic and Permo-Triassic formations are distinguished, with a characteristic disharmony between the Lower Jurassic and Upper Cretaceous deposits. Within the Surkhandarya Megasyncline, four main structural-tectonic zones are identified: the Baysun, Kelif-Sarykamysh, Western Surkhan, and Eastern Surkhan zones. The Western Surkhan zone represents a deep depression, with the foundation reaching depths of 9.5 to 11.2 km. The Upper Jurassic formation lies at depths of 6-7 km in some areas. The Eastern Surkhan zone is characterized by foundation depths from 7.3 to 11.2 km, with carbonate formations in the central part of the zone lying at depths of up to 5.5 km. In the Kognysay area, located in the thrust zone, the main fault extends from the southwest to the northeast. The western block is located in the allochthonous (overhanging) area, which leads to the exposure of Lower and Upper Cretaceous deposits on the surface. Salt tectonics has a significant impact on the structural plan of the supersalt horizons in the under-thrust zones, complicating their tectonic forms. The Afghan-Tajik Basin was deformed by the northwestward movement of the Pamir Block, which resulted in the formation of complex anticlines and synclines. These structures are supported by faults and are filled with orogenetic molasse clastic deposits with thicknesses ranging from 1000 to 6000 meters. In the Baysun Block, the thickness of these deposits ranges from 0 to 4000 meters.

CONCLUSIONS

The following conclusions can be drawn from the above:

1.The movement and distribution of salt deposits create various types of structural traps, especially near thrust zones, where large salt pillows form structural noses. These noses and structural faults can serve as effective traps for hydrocarbons.

2.Salt deposits divide the region into subsalt and supersalt complexes, which differ in their sedimentation conditions. Subsalt complexes formed by Jurassic rocks and supersalt complexes of Cretaceous and

Paleogene age have distinct geological features, creating conditions for the formation of prospective reservoirs.
3.The obtained results are valuable for geological exploration in the Surkhandarya Megasyncline, as they confirm that accounting for the specifics of salt tectonics allows for more accurate prediction of the location and volume of hydrocarbon deposits.
4.To improve the understanding of the structural features of the region and enhance the accuracy of hydrocarbon reservoir forecasting, further research is required using more detailed modeling methods and geophysical surveys.

REFERENCES

Abidov, A.A. (2010). *Genesis of Oil and Gas and Methodology for Prospecting Their Deposits*. Tashkent: Fan, pp. 97–100.
Abidov, A.A., Ubaikhodzhaev, T.I., Absadykov, A.A., & Yuldashev, Z.Yu. (1987). Prospects for Oil and Gas Potential in the Surkhandarya Synclinorium. *Geology of Oil and Gas*, Moscow, 20–23.
Abdullaev, G.S., Bogdanov, A.N., & Eidelman, N.K. (2020). Current State and Prospects for the Development of Geological Exploration for Oil and Gas in the Surkhandarya Region of the Republic of Uzbekistan. *Oil and Gas Geology. Theory and Practice*, 15(4). DOI: 10.17353/2070-5379/40_2020.
Wendelstein, B.Yu., & Rezvakov, R.A (1978). *Geophysical Methods for Determining Parameters of Oil and Gas Reservoirs. Moscow*: *Nedr*, 316p.