Caspian Without Borders

International Cooperation to Help Create a Geological and Geodynamic Model of the Entire Caspian Region

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Many problems in studying the Caspian stem from the fact that its offshore belongs to different countries and hence geological information is broken into fragments not mating one another. Lack of scientific cooperation among coastal states along with not infrequent utilization of outdated regional-scale geological information results in emergence of contradictory geological models of the region. The Caspian states have to work together to develop a holistic picture of geological structure of the Caspian.

Keywords: Caspian Sea, offshore, regional geology, geological model, association.

For all the years of investigations in the Caspian Sea off-shore, more than 380,000 km of regional, prospecting and detailed offshore seismic surveys have been acquired with average observation density of about 1 km/km2, more than 90 promising structures have been studied by drilling, about 60 hydrocarbon accumulations of different scales have been discovered.

Large oil and gas accumulations are discovered in the Caspian offshore in the recent decades, among them such fields as Shah Deniz, Kashagan, Filanovsky, Korchagin, Tsentralnoye, and others, a number of new promising areas are revealed. Not only Russian oil and gas companies work in the region by also more than 30 foreign and international companies and consortiums who realize about 50 offshore oil and gas projects.

Taking into account recent hydrocarbon discoveries in the North Caspian, it ranks among the regions of world im-portance in terms of both explored reserves and forecasted potential. Analysis of different sources (publications, re-ports, etc.) shows that total recoverable reserves of the en-tire Caspian Sea may count 18.8 billion to 35.0 billion tons of oil equivalent (Table 1).

Right now production is underway in the South Caspian (Azerbaijan) and in the Middle Caspian (Russia). Start of commercial development of offshore fields of Kazakhstan and Turkmenistan is expected in the nearest future. New major centers of offshore oil and gas production operate and appear in the region.

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CASPIAN WITHOUT BORDERS

INTERNATIONAL COOPERATION TO HELP CREATE GEOLOGICAL AND GEODYNAMIC MODEL FOR REGION Many problems with studying the Caspian lie In the fact that Its territory lies In various states, so geo-logical information has become disconnected. The lack of scientific cooperation between the littoral states and the frequent use of outdated geological Information on a regional scale leads to the emergence of contradictory geological models for the region. The Caspian states have to work together in order to establish an integral picture of the Caspian's structure.

Key words: Caspian Sea, water zone, regional geology, geological model, association.

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"Patchwork Quilt"

According to the existing perceptions of the structur-al-tectonic model of the region [1], the North, Middle and South Caspian provide space for continuation of structur-al-tectonic zones of the East European Precambrian plat-form, the Scythian-Turanian "young" mobile platform, and the Alpine orogenic-folded belt. The East European Plat-form that was formed on the Precambrian (Karelian and Early Baikalian) basement is presented by its southeastern element – the Precaspian Depression and in its composition – the

Table 1

*Results of geoexploration operations for oil and gas in offshore sectors of the Caspian states**

Offshore sector of state	Number of local structures in the studied part of the offshore	Number structures of drilled	Number of commercially significant discoveries (fields)	Success ratio of prospecting drilling	Initial total recoverable reserves, billion t oil equivalent
Russia	76	15	11	0.73	3.2 - 6.7
Kazakhstan	141	15	7	0.47	8.1 - 15.0
Turkmenistan	81	12	8	0.67	2.2 - 3.9
Iran	48	-	-	-	1.5 - 4.4
Azerbaijan	138	50	32	0.64	3.8 - 5.0
TOTAL	484	92	58	0.63	18.8 - 35.0

** by data from publications and report materials as of 2013 year start.*

southern submergence of the Astrakhan-Caspian and Novobogatinsky-Shukat zones of arched uplifts, the South Emba trough zone, and other elements expressed in the ancient basement relief of the North Caspian.

The Scythian-Turanian Platform presented mainly in the Middle Caspian was formed on the Baikalian basement reactivated in the Hercynian and Cimmerian tectonogenesis epochs in connection with both rifting-related and fold-ing-orogenic movements in the Tethys region. In the south-ern part of the Caspian, the South Caspian Depression en-tering into composition of the Alpine folded-orogenic belt is situated.

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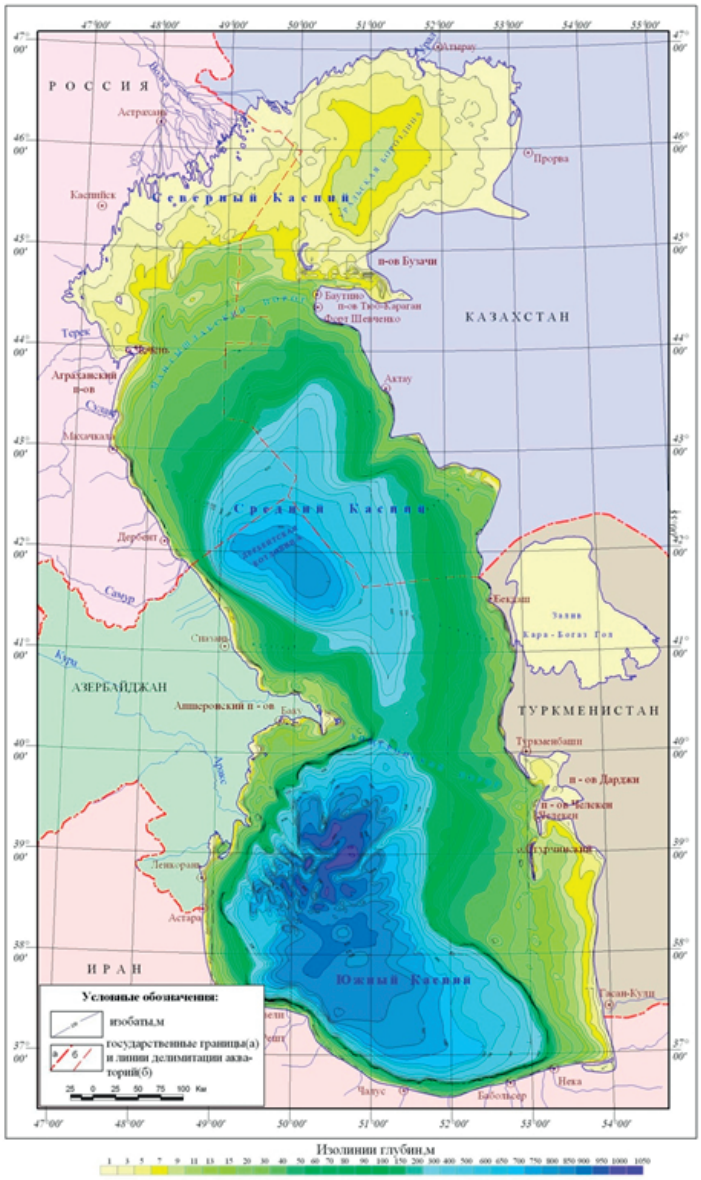
Sedimentary cover of the South Caspian Depression having Mesozoic-Quaternary age may reach up to 25 km thickness by seismic data (deep seismic sounding, refraction seismic). It is presented by rather well studied productive Middle Pliocene red-bed rock mass underlain by heter-ochronous Paleogene and Miocene deposits and overlain by Upper Pliocene clay-sand complexes and Quaternary de-posits. Deep-lying deposits of supposedly Mesozo-ic-Paleogene age are singled out conditionally, based on correlation of seismic data for the offshore and sections of the adjacent onshore, and analysis of clastic material in blowouts

Figure 1

Bathymetry map of the Caspian Sea



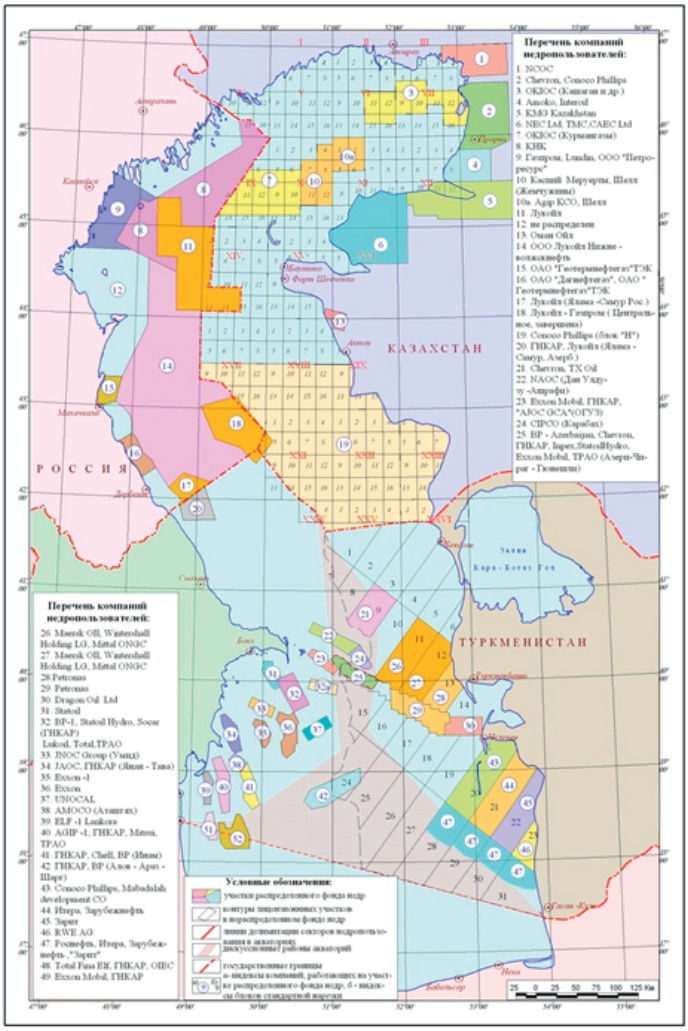


Figure 2

Present-day licensing condition of the Caspian Sea

Subsurface user companies: 1. NCOC; 2. Chevron, ConocoPhilllps; 3. OKIOC (Kashagan and others); 4. Amoko, Interoil; 5. KMG Kazakhstan; 6. NEC Ltd, TMC, CAEC Ltd; 7. OKIOC (Kurman-gazy); 8. Caspian Oil Company; 9. Gazprom, Lunfing, Petroresurs; 10. Caspian Meruerty, Shell (Pearls); 10a. Agip KCO, Shell; 11. LUKOIL; 12. Not distributed; 13. Oman Oil; 14. LU-KOIL-Nizhnevolzhskneft; 15-16. NEL Geotermneftegaz; 15a. Not distributed (Dimitrovsky); 16a. Not distributed (Derbentsky); 17. LUKOIL (Yalama-Samur, Russia); 18. LUKOIL, Gazprom (Tcentralnoye, completed); 19. ConocoPhilllps (Block H); 20. SOCAR, LUKOIL (Yalama-Samur, Azerbaijan); 21. Chevron, TX Oil; 22. NAOC (Dan-Ulduzu-Ashrafi); 23. ExxonMobil, SOCAR, AJOC GCA (OGUZ); 24. CIPCO (Karabakh); 25. BP-Azerbaijan, Chevron, SOCAR, Inpex, Statoil, ExxonMobil, TPAO (Azeri-Chirag-Gyuneshli); 26. Maersk Oil, WIntershall, Mittal ONGC; 27.Maersk Oil, Wintershall, Mittal ONGC; 28-29. Petronas; 30. Dragon Oil Ltd; 31. Statoll; 32. BP, Statoil, SOCAR, LUKOIL, TPAO; 33. JNOC Group (Umid); 34. JAOC, SOCAR (Yanan-Tava); 35-36. ExxonMobil; 37. UN-OCAL; 38.AMOCO (Ashtagyakh); 39. ELF -1 Lankora; 40. AGIP, SOCAR, Mitsui, TPAO; 41. SOCAR, Shell, BP (Inam); 42 SOCAR, BP (Alov-Araz-Sharg); 43.Conoco Phillips, Mabadalah development CO; 44. Itera, Zarubezhneftl 45. Zarit; 46. RWE AG; 47. Rasneft, Itera, Zarubezhneft, Zarit; 48. TotalFinaElf, SOCAR, OIEC; 49.ExxonMobll, SOCAR.

of numerous mud volcanoes.

The characteristic feature of the South Caspioan De-pression is wide development of mud volcanism. The biggest volume of regional studies was performed in the Caspian in the 70-80ies of the 20th century. At that, the main share of studies of that period fell upon the upper structural stages of the sedimentary section of the South Caspian and to some lesser extent – that of the Middle Cas-pian. The North Caspian and the zone of the Mangyshlak Threshold remained studied by individual lines only for a long period – almost till late 80ies – early 90ies. It was start-ing from the 90-es that regions of the North and Middle Caspian were subjected to intense study that was conducted in the national subsurface use sectors by different state-owned and private organizations and enterprises.

The obvious weakness of the studies is that the Caspian has been never covered by a single network of regional ob-servations with the use of a single technique which would make it possible to understand not only upper but also the deepest portions of the section. Without this it is also impos-sible to establish true-to-fact structural and genetic relations among individual formational complexes and major tec-tonic units of the offshore and the adjacent onshore.

Due to the fact that geophysical surveys were conducted as long ago as in the last century and by different states, knowledge of regional geology, tectonics and geodynamics of the Caspian as a matter of fact rest upon summaries of not always accurate and trustworthy data. That is, in geoinformation terms, the concepts of the Caspian geology are just a “patchwork quilt” stitched together of extremely heterogeneous information.

The available results of geological and geophysical studies require refinement both with respect to morphology, mutual arrangement and internal structure of the singled out structural-tectonic zones, including structure of the earth crust and upper mantle, and with respect to studying peculi-arities of sedimentary complexes characteristic of different regions of the Caspian (salt and subsalt units, mud volcan-ism, deltaic complexes, etc.), this requiring acquisition of a state-of-the-art integrated geological and geophysical survey along a series of reference survey lines crossing the entire offshore of the sea, on the “from shore to shore” principle.

In the old fashion

One of the essential regional problems is study of deep ge-ology of the Caspian. Without understanding structure and properties of the Moho discontinuity, crystalline basement and transitional complex, bottom of the sedimentary sec-tion, it is

impossible to create a tectono-geodynamic model of the Caspian balanced for the entire offshore.
Interrelationships of heterochronous platform and orogenic structural-formational complexes within the Caspian offshore remain not quite clear.
Ambiguities in the concepts of deep geology of the re-gion, role and significance of deep crustal horizons and sub-crustal mantle in structure formation at the basement and the sedimentary cover level, quality and direction of pro-cesses at the said levels result in constructing perhaps erro-neous historical geological, geodynamic and petroleum ge-ological models.
Such uncertainty leads to disagreements in evaluations of prospectivity and economic value of the resource poten-tial of not only the Caspian as the whole but of individual national subsurface use regions, that in turn hindering the solving of the problems in delimitation of the offshore areas that exist among the coastal states. It became possible to solve this problem among Russia, Kazakhstan and Azer-baijan only. In the period of 1998-2003, after a series of consultations and negotiations, these countries came to agreement concerning division of the North and Middle Caspian on the “bottom is divided – water is common” principle enshrined by interstate agreements.
Performance of regional study requires complete cover-age of the entire Caspian Sea basin by a regular network of geophysical observations because acquisition of survey within a part of the offshore adjoining the territory of a sin-gle country does not make it possible to solve regional geo-logical problems. Acquiring conceptually, qualitatively new data also requires utilization of state-of-the-art equipment and technologies, a significant amount of finance.
After breakup of the Soviet Union, the new states that originated in the Caspian Region did not pay proper atten-tion to regional studies within their subsurface use areas for a number of economic and political reasons, having put this problem onto subsurface users. However the companies were interested in obtaining new information mainly in the zone of their corporate interests – within particular fields or promising areas.
A huge gap exists nowadays between technologies of geoexploration operations utilized for studying fields by oil and gas companies in local offshore areas and regional studies conducted by geological institutions.

CASPIAN HAS NEVER BEEN COVERED BY A SINGLE NETWORK OF REGIONAL OBSERVATIONS WHICH WOULD MAKE IT POSSIBLE TO UNDERSTAND GEOLOGICAL STRUCTURE OF NOT ONLY UPPER BU ALSO OF THE LOWER PORTIONS OF THE SECTION

Oil companies use most advanced technologies allowing to obtain maximum informative data about the geological medium in horizontal and vertical dimensions, i.e. areally and depthwise. High costs of new equipment and technolo-gies compel the state institutions to use technologies of the previous or even the one before previous generation. This results in the situation where data on structure of local areas and individual fields not always match information ob-tained with the use of more modern equipment and tech-nologies.

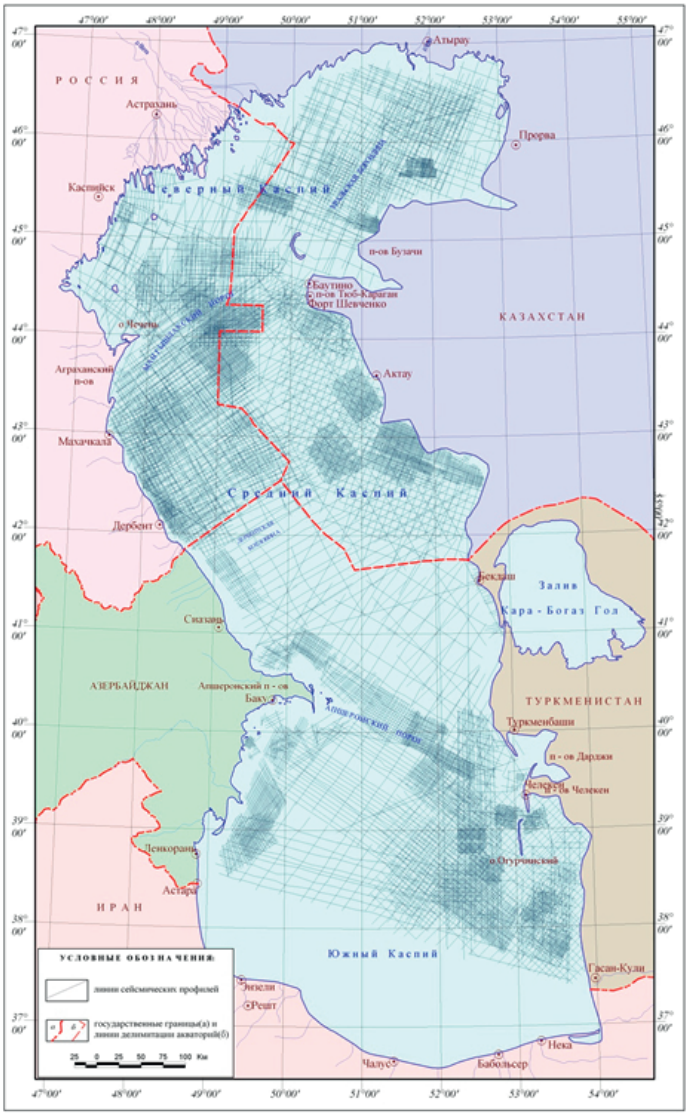
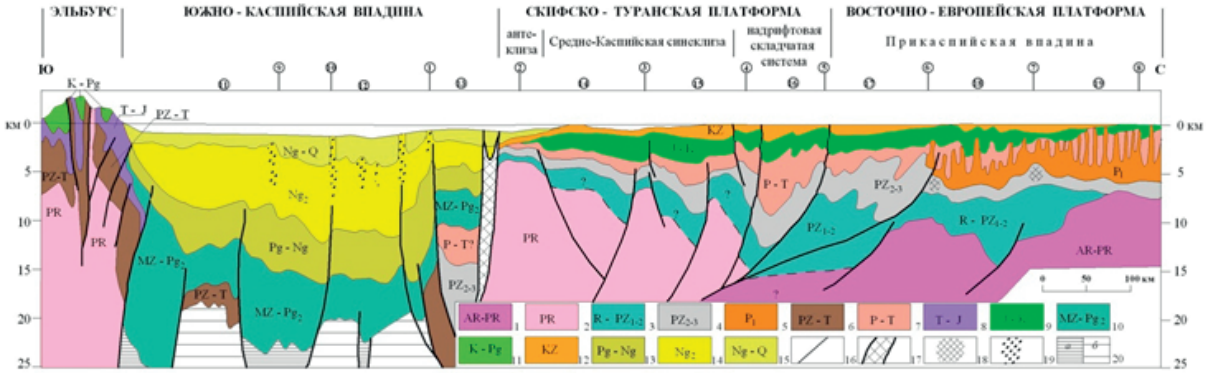


Figure 3

Map of seismic and drilling study of the Caspian Sea

Figure 4

*Conceptual geological section of the Caspian Sea along a submeridional line **



1 – Pre Baikalian crystalline basement; 2. – Baikalian crystalline and folded-metamorphic basement, sedimentary and volcanoclastic complexes, in particular transitional ones; 3 – Pre Devonian; 4 – subsalt, Middle-Upper Paleozoic of the Precaspian Depression and synchronous complexes of the Scythian-Turanian Platform; 5 – saliferous Lower Permian comples; 6 – Paleozoic-Triassic complex of the Alpine belt; 7 – post-salt complex of the Precaspian Depression and the synchronous transitional complex of the Scyhian-Turanian Platform; 8 – Triassic-Jurassic complex of the Alpine belt; Mesozoic-Cenozoic complexes: 9 – Jurassic-Cretaceous; 10 – Mesozoic-Eocene; 11 – Cretaceous-Eocene; 12 – Cenozoic, non-fragmented; 13 – Paleogene-Neogene (Maikopian series including); 14 – productive red-bed member of the Middle Pliocene; 15 – Pliocene-Quaternary deposits; 16 – faults; 17 – Turkmenian formation; 18 – bioherms; 19 – clay diapirs and mud volcanoes; 20 – complexes of the basement of the South Caspian Depression: a – zones of newly formed suboceanic or subsontinental earth crust; b – zone of deep tectono-magmatic reworking of ancient Precambrian or Paleozoic basement.

** After B.V. Senin, L.E. Levin, Yu.A. Vislkovsky, 2002 and [1].*

Exchange of new geological materials among first-rate geological institutions of the Caspian states practically stopped. Lack of scientific cooperation among the coastal states, along with use of outdated geological information, inconsistencies and non-coordination of geological and ge-ophysical information, also causes construction of contra-dictory geological models.

Common Interest

We see the way to solve problems of the Caspian in acquiring regional integrated geological and geophysical studies in close cooperation with geological services of the countries interested in obtaining modern geological and geophysical information for the region, first of all of the Caspian coastal states.

The experience in conducting such studies is already available. In 2010 the international scientific association Geology Without Limits was created in Russia, it comprises several major scientific and scientific-and-production cen-ters and enterprises. Its main goal is initiation and realization of international scientific projects aimed at studying and developing the understanding of major sedimentary basins of the world and structural elements of the earth crust. The first projects of the association became study of regional deep geology of the Black Sea in 2011 and of the Russian Arctic in 2011 – 2013.

TO OBTAIN A HOLISTIC PICTURE OF GEOLOGICAL STRUCTURE OF THE CASPIAN, THE CASPIAN STATES SHOULD WORK TOGETHER

The project in the Black Sea offshore became most res-onant, it covered economic zones of almost all coastal states [2]. Within its framework, 9000 lin.km of new in-creased-depth seismic data were acquired. The significant results became obtaining unique information on structure of the bottom of the earth crust, basement surface and lower complexes of the sedimentary cover, revealing main events in the pre Cenozoic geological history of the basin evolution in the system of Paratethys, peculiarities of the recent geo-dynamics of the Black Sea Basin.

Now the association Geology Without Limits comes up with the suggestion to develop a similar research project in the Caspian Basin whose purpose is development of a new geological and geodynamic model of the region. At the stage of field acquisition, it is supposed to acquire a considerable amount of new regional geophysical data covering and in-terconnecting with each other all sedimentary basins of the present-day Caspian. In the studies, utilization of state-of-the-art techniques is planned for obtaining a single network of geophysical data both in shallow-water and deepwater regions. Analysis of obtained data will be made by a group of scientists including representatives of all countries participating in the project. On the basis of results of the project, a new geological-geodynamic model of the region should be constructed in which peculiarities of its deep and near-surface geology will be interrelated both structurally and geodynamically. This model will make it possible to reconstruct fuller and more substantiated history of geological evolution of the Caspian, to detect new prom-ising areas and depositional complexes, and will also help solving many environmental problems connected with fluc-tuations of the Caspian Sea level and seismic hazard of its bottom and shores.