

## ANNOTATION

of thesis for the degree of Doctor of Philosophy (PhD) in the specialty  
"6D070600 - Geology and Exploration of Mineral Deposits"

AIGUL ISSAGALIYEVA

### **Geophysical criteria for geodynamic zonation of oil and gas bearing regions of the South Caspian depression**

**Topicality.** Connection between the structure of the Earth crust's upper layers, the location of minerals there with the subsurface structures has been proven in numerous geological-geophysical studies. Accumulated in the last 30 years, new geological-geophysical materials clarify the geological structure of some areas of the Caspian Basin. Modern methods of geophysical surveys and powerful computational modelling complexes allowed obtaining information of high quality and of required reliability. Evidently, new geophysical materials, produced by modern geological concepts of formation of sedimentary basins and their oil-gas content, required re-adjusting the existing views on the regional deep structure.

**Research objective.** Development of a scientific-methodological basis for study of the deep structure and geodynamics of the Earth's crust lithosphere based on geophysical data of the southern part of the Caspian Basin, identification of its main deep heterogeneities related to oil-gas content of the region.

**Research objectives.** Generalization and analysis of original geological-geophysical information; analysis of physical fields, models of the Earth's crust and the mantle along the lines of the DSS, CWM-DSS regional profiles; methodological and complex result interpretation of geophysical, structural-geological and petrophysical data for physical-geological cross-sections of the Earth's crust on the geodynamic basis of the region; the relationship between the regional oil-gas content and the depth structure and the geodynamic regime of the main geological structures on the basis of the developed geophysical criteria.

**Object of study.** The lithosphere of the Kazakhstan's southern part of the Caspian Basin and adjacent geostructures.

**Subject of research.** Analysis and interpretation of the geological-geophysical data accumulated to date, refracting them in the light of the latest tectonic concepts of the Earth evolution, development of a model of the lithosphere and the formation of oil-gas-bearing systems.

**Factual material.** The work is based on results of physical field interpretation, construction of crustal and mantle models along the DSS, CWM-DSS profiles in combination with gravel and magnetic surveys, taking into account the existing concepts of geodynamics of the region development.

**Relation of the thesis work to thematic research plans.** The work is based on materials of fundamental and applied researches of the Seismology Institute at the RK MES and the K.I. Satpayev KazNITU on study and evaluation of natural and man-made seismic and geotectonic vulnerability of the region and development of a database of geological-geophysical information of the Caspian region, obtained under direct participation of the dissertant as one of the main performers.

**Research Methodology.** Reconstruction of deep structures of lower parts of the earth's crust is based on petrodensity and velocity modelling linked to main parameters of the gravitational and thermal fields. Study of the basement of the sedimentary cover is based on interpretation of regional seismic surveys by the RW, CDP methods and the potential field analysis with extensive use of modern geoinformation systems.

***The main defence points***

1. Complex interpretation of structural-geological, geophysical and petrophysical data allowed to develop principles of formation of physical-geological models of tectonic structures of earth crust on a geodynamic basis with increased accuracy and reliability;

2. Relief and thickness maps of the southern Caspian Basin at a scale of 1:1,500,000, constructed as a result of P-velocity and density modelling along regional profile lines, reflect the heterogeneity of deep crustal horizons and complex structural relationships of dissimilar blocks of the lower sedimentary cover of the southern Caspian Basin.

3. Under deep conditions, the character of the magnetic field reflects zones confined to the roof topography fractures of magnetically active boundaries associated with contacts of rock blocks with different magnetization of lower horizons of the sedimentary cover, confirming and clarifying the geotectonic zoning of the base of sedimentary complexes of the southern Caspian Basin;

4. The established dependencies of seismic data and drilling, consideration of positive gravimetric anomalies against the background of areas of reduced anomalous magnetic field value, are geophysical criteria for identifying zones of Middle and Upper Devonian accumulation in relatively elevated deposits, possibly associated with oil and gas bearing capacity of the region.

***Scientific novelty of the research.*** A new scientific-methodological approach has been developed to form the geophysical basis required for studying the deep structure of the lithosphere and geodynamic zoning of sedimentary basins, and for identifying and predicting new oil-and-gas bearing areas.

***Practical meaning***

1. These studies have shown that geophysical methods can be used to study the deep structure of the lower horizons of the Earth's crust, the surface of the basement, the pre-Devonian complexes and the sedimentary cover of large sedimentary basins;

2. Features of the deep structure of the southern Caspian depression have been revealed. Diagrammes of relief and thickness of the deep boundaries of the southern Caspian Basin were compiled, showing the heterogeneity of the structure of different layers of the Earth's crust and complex structural relationships of heterogeneous blocks of the lower sedimentary cover. The territory has been zoned as per relation of its individual layers by type of earth crust (continental, relict paleo-oceanic, transitional crust).

3. Geophysical criteria have been established for predicting a number of new prospective Paleozoic structures formed in the lower sedimentary cover, mainly in the Middle to Upper Devonian and Lower Carboniferous.

***Work approbation.*** The research results were published in 12 scientific papers,

in the periodicals of Kazakhstan, CIS and foreign countries, recommended by "The RK MES Control Committee", two handwritten reports, 3 articles in a journal with non-zero impact factor (quartiles Q2, Q3), 2 articles in MES-recommended journals, 7 articles in the collections of proceedings from scientific international and republican conferences.

***Structure and scope of the thesis.*** The work was carried out in the Department of Geophysics of the Kazakh National Research Technical University named after K.I. Satpayev, Almaty, Republic of Kazakhstan. Scientific consultants: Istekova S.A., Doctor of Geological-Mineralogical Sc., Isaev V.I., Doctor of Geological-Mineralogical Sc., professor of the Tomsk Polytechnic University (Russia).

The thesis text contains 179 printed pages and consists of 5 sections, supplied with an introduction and a conclusion, as well as a list of 183 reference titles, 80 figures and 2 tables.

**Chapter 1.** *Analysis of completeness and quality of results collected in the geological-geophysical surveys.* The south of the Caspian Basin is characterised by the high degree of geological-geophysical information acquired by regional methods, therefore the deep structures are sufficiently provided with geophysical materials. To date, results of generalisation and analysis of the studies of deep horizons of the Earth's crust, include mainly regional constructions on gravimetric and magnetometer data. Results of the studies on regional geotraverses as well as on space and thermal survey data were practically not used.

**Chapter 2:** *A review of understanding of the deep tectonic structure and of geodynamic development of the Caspian Basin study area* has provided information on the history of geological development of the whole region and its elements, as well as zones of junction with adjacent geological structures.

**Chapter 3.** *Research Methodology.* Representations of the structure of deepest layers of the earth crust and the upper mantle are based on results of data processing of complex geophysical works for building the layered depth maps of the crust and the complex geological-geophysical modelling of the regional deep structure. The results of deep geophysical surveys along geotraverses contributed decisively, permitting the identification of structural heterogeneities in the crust and the upper mantle, critical in the study of geological structure of the region. The following were analyzed: seismological boundaries of the earth crust (surfaces of crystalline basement, intracrustal, M, etc.); depths to refractive and reflective boundaries obtained from longitudinal and transverse wave data; depths to exchange boundaries; values of longitudinal and transverse wave velocities and their ratios. The presence of a reference deep seismic section according to the DSS data and application of modern tools of division and separation of gravity field components allowed to reveal geological heterogeneities at the level of deep horizons of the earth's crust vertically and laterally. Velocity parameters were recalculated into density sections and corrected with actually observed gravity data based on the forward and inverse problem-solving using modern computer technologies. A comprehensive analysis of detailed gravity-magnetic data was carried out to study the internal structure of the crystalline basement and the geological heterogeneity of the basement of the sedimentary cover.

**Chapter 4:** *Characterisation of geophysical fields.* Zoning of regional geophysical anomalies was carried out; zones differing in amplitude, size in plan, configuration and other characteristics of physical fields were identified. Analysis of the gravity field structure allowed to draw up a zoning diagramme of local gravity anomalies. The magnetic field in most of the central territory of the southern Caspian depression is of reduced values in the form of a complex large latitudinally oriented anomalous zone.

The analysis of the volumetric digital model of velocity parameters permitted obtaining the velocity slices at characteristic hypsometric levels of the earth's crust; constructed were a series of alternating sections in any required direction, structural diagrams of characteristic velocity levels and thickness maps of layers between them. Maps and diagrams of depth structures showing the internal structure of the region's crust were produced, showing the elevated and depressed blocks of the basement and sedimentary cover. The territory has been zoned upon correlation of its individual layers by type of crust: continental, relict paleo-oceanic, and transitional crust.

**Chapter 5.** *The role of geophysical surveys in studying the deep structure and identifying the oil and gas promising structures.* Patterns of physical fields are established:

- associated with latent uplifts of rigid carbonate blocks, characterised by clear contours of positive gravity anomalies and zones of elevated velocity values;
- a band of a geomagnetic stage, spatially confined to large uplifts of the Devonian-Lower Carboniferous complexes;
- spatial relationship of negative magnetic field anomalies to subsalt oil and gas fields;
- presence of narrow sub-vertical low-velocity zones in areas where large hydrocarbon fields are located.

Features of wave fields, consideration of positive gravimetric anomalies and areas of reduced anomalous magnetic field value, individuated as a geomagnetic step, are geophysical criteria identifying the accumulation zones of Middle and Upper Devonian deposits, in a relatively elevated setting. These blocks are characterised by inheritance of large uplifts in the lower crustal horizons, possibly associated with oil and gas accumulation zones.

The conducted research allowed us to create a geophysical basis for studying the deep structure of the lower horizons of the Earth's crust, the basement surface, pre-Devonian complexes and the sedimentary cover of large sedimentary basins and can be used for geodynamic zoning and assessment of oil-and-gas content of the region. The established patterns of distribution of geophysical fields may become the basis for the prospecting strategy in the region.