Technical science and innovation

Volume 2021 | Issue 1 Article 5

3-27-2021

Determination Of Structural-Geomorphological And Neotectonic Elements Controlling The Oil And Gas Performance Of The Ferghana Region Using Digital Space Images

S Nesmeyanov
Sergeev Institute of Environmental Geoscience RAS (IEG RAS), Moscow, Ulansky lane, house 13, building 2, 101000, Moscow, Russian

Rakhimjan Umurzakov
Tashkent state technical university, Tashkent, Uzbekistan, umrah@mail.ru

Samariddin Rabbimkulov
Tashkent state technical university, Tashkent, Uzbekistan, mr.geolog.88@mail.ru

O Voeykova
Sergeev Institute of Environmental Geoscience RAS (IEG RAS), Moscow, Ulansky lane, house 13, building 2, 101000, Moscow, Russian, voa49@mail.ru

Follow this and additional works at: https://btstu.researchcommons.org/journal

 Part of the Geological Engineering Commons

Recommended Citation

Nesmeyanov, S; Umurzakov, Rakhimjan; Rabbimkulov, Samariddin; and Voeykova, O (2021) "Determination Of Structural-Geomorphological And Neotectonic Elements Controlling The Oil And Gas Performance Of The Ferghana Region Using Digital Space Images," *Technical science and innovation*: Vol. 2021: Iss. 1, Article 5.
DOI: https://doi.org/10.51346/tstu-01.21.1-77-0101
Available at: https://btstu.researchcommons.org/journal/vol2021/iss1/5

This Article is brought to you for free and open access by Technical Science and Innovation. It has been accepted for inclusion in Technical science and innovation by an authorized editor of Technical Science and Innovation.

UDC 528+551.2./4+553.9

DETERMINATION OF STRUCTURAL-GEOMORPHOLOGICAL AND NEOTECTONIC ELEMENTS CONTROLLING THE OIL AND GAS PERFORMANCE OF THE FERGHANA REGION USING DIGITAL SPACE IMAGES

S.A.Nesmeyanov*, R. A. Umurzakov, S. A. Rabbimkulov**, O.A.Voeykova***
** Sergeev Institute of Environmental Geoscience RAS (IEG RAS), Moscow, Ulansky lane, house 13, building 2, 101000, Russian. voa49@mail.ru*
***Tashkent State Technical University named after Islam Karimov, Tashkent, University St. 2A, 100095, Uzbekistan. raxim.umurzakov@tdtu.uz; umrah@mail.ru; mr.geolog.88@mail.ru*

Annotation. *The article describes the results of studies carried out with the aim of identifying the main structural-geomorphological and neotectonic elements that control oil and gas content within the Fergana depression using materials from remote sensing of the Earth. To date, cosmogeological maps have been compiled for the western part of Uzbekistan. In the Fergana region, the use of remote sensing photographs dates back to the 60-80 of the last century. Therefore, studies based on space images are relevant. Based on a quantitative analysis of the distribution of oil and gas fields, the main structures that control the oil and gas content of the territory have established stepped zones (31% of the total number of fields), monoclines (22%), near-side slopes and fault zones (10-15%). Possibilities of identifying such areas using Landsat 8 satellite images were considered. In addition, various published geological materials, including cartographic ones, were used. When processing satellite images, the software packages Envi, Erdas Imagine, QGIS, etc. were used. The research was carried out on the basis of the software-integrated environment ArcGis. Based on the identification of deciphering signs (by the degree of brightness and the photon of the images) of geomorphological relief elements and structures within the Fergana depression, the main morphostructural elements have been identified - uplifts and depressions, fault zones, monoclines, near-side slopes, folded blocks. It is shown that the technique used allows the operational study of large territories, and the results obtained can be used to identify promising areas for performing top-priority prospecting and exploration works.*

Key words: *Remote sensing of the Earth, GIS-technologies, digital model, structural-geomorphological, neotectonics, oil and gas potential, Fergana depression.*

INTRODUCTION. The use of remote sensing data and GIS technology currently directly or indirectly serves to increase the efficiency of geological exploration. One of the most pressing issues today is the involvement of Earth remote sensing data in geological research, especially in the creation of a scientific geological basis for prospecting for mineral deposits with the isolation of geological material and structural elements [1,2,3]. To date, a technique has already been developed and cosmogeological maps of the territory of Uzbekistan [4,5] have been compiled - a cosmogeological basis, which is successfully used in practice. However, these maps were compiled in relation to the geological conditions of Western Uzbekistan and are intended for prospecting for solid minerals. Developments related to tasks for oil and gas fields were carried out mainly in the Bukhara-Khiva region. For the Fergana oil and gas region, the use of remote sensing dates back to the distant 60-80 years of the last century, and new studies based on new data were not carried out.

The purpose of this work is to eliminate this serious shortcoming and to identify the possibilities of using digital remote sensing (ERS) data to identify structural-geomorphological

and neotectonic structures that control oil and gas content. An overview map of the location of the study area is shown in Figure 1. Identification of geological-structural and geomorphological elements, which are reflected in digital satellite images of the Earth taken from a long distance, is important for the integrated solution of prospecting and exploration tasks.

The fact that neotectonic structures have important oil and gas control significance was noted by many scientists, and in relation to the territory of Uzbekistan in recent decades - by B.B.Sitdikov (1985, 2006), N.Kh. Nugmanov (2010), A.I. Timurziev (2006) and other.

The last tectonic movements, which made the main contribution to the formation of the modern relief of the Earth, are distinguished as "neotectonic" according to the works of N.I. Nikolaev. In the western part of the described region, there are also known works on the quantitative assessment of recent movements and neotectonic zoning [6]. Currently, new methods have appeared for identifying the latest tectonic structures based on an integrated approach to studying the features of the relief and sedimentary complexes [7]. These works repeatedly emphasize the key role of structural and geomorphological studies in identifying the structural features of neotectonic elements.

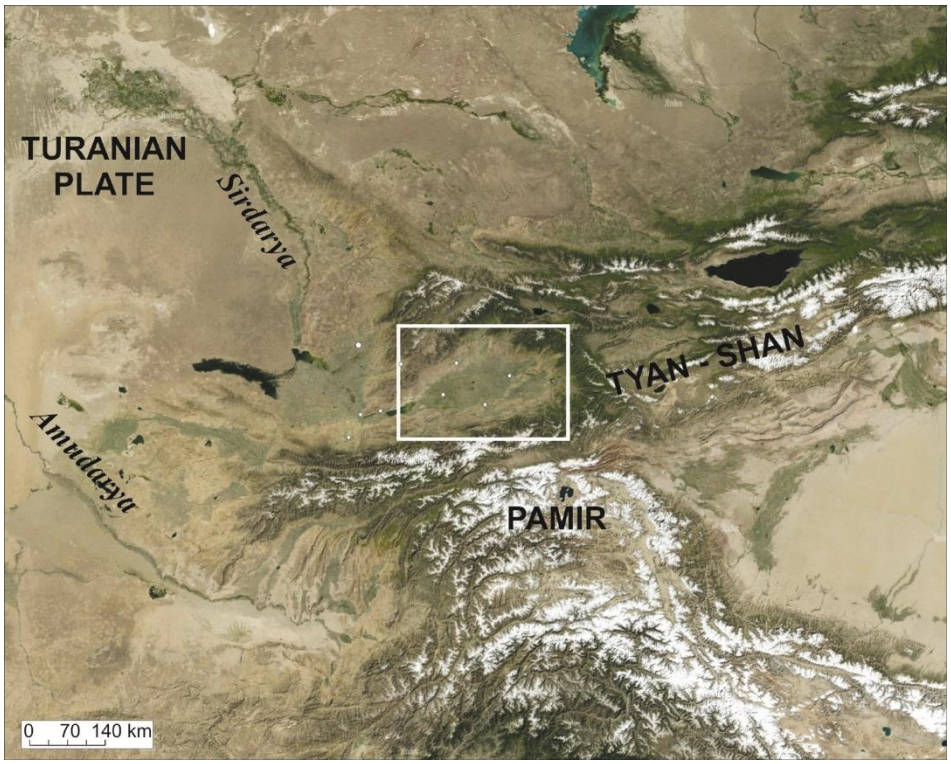

Fig. 1. Overview map of the location of the study area
(based on snippet from https://opentopography.org)

These problematic issues, as applied to the orogenic Fergana depression, were first studied by O.M. Borisov with colleagues [8,9], a structural-tectonic map was compiled. In addition, on the basis of the use of structural - geomorphological maps, elements of neotectonic development of the Fergana orogenic region were identified [10]. A schematic map of the terrain was compiled using cosmophotographic materials, reflecting not only the structure of mountainous and near-edge sections of the depression, but also along the sections of the Central Graben and troughs. On the basis of satellite images, large linear zones were identified that intersect the central part of the depression. On the basis of satellite images, zones of thermal anomalies were identified in connection with the search for deep heat and mass transfer channels [11, 12], as well as linear zones intersecting the central part of the depression.

For various oil and gas regions of the world on the basis of structural-geomorphological and cosmological-geological studies, digital models of the corresponding territories have been developed [13, 14, 15]. At the same time, various elements obeying the laws of formation of the modern relief of the Earth, the results of plicative and disjunctive movements, and fault zones were taken as deciphering signs in space images [16,17]. This article presents the results obtained on the basis of analysis and generalization of previous works [4,5,7, 10-13, 18], using modern GIS technologies (geographic information systems) and new remote sensing data for the Fergana depression.

MATERIALS AND METHODS. Currently, large-scale satellite images of Landsat 7, Landsat 8, Aster (TERRA), Quick Bird, DEM, SRTM, Open Topography, ALOS-2 and other images of the Japan Aerospace Research Agency (JAXA) are used in geological research.

The processing of space images is carried out using the ERDAS Imagine and ENVI software [19,20]. Research is aimed at creating a unified cosmogeological structural-geomorphological basis with reference to nomenclature topographic maps using the above-mentioned ERS materials. At the same time, in addition to traditional methods of visual decryption, automated processing systems using GIS technologies were used, as well as landscape geoindication methods. To identify the interpretation results with geological objects, data on the outcrops of rocks of the territory were used. At the same time, materials of the Geological Map of Uzbekistan (scale 1: 500,000), published by the State Committee for Geology of the Republic of Uzbekistan, were widely used, as well as published and fund materials obtained by various employees of scientific geological organizations (Institute of Geology and Geophysics, Institute of Geology and Exploration of Oil and Gas Fields, Institute “Gidiroingeo”, JSC "Uzbekgeophizica").

We will not describe in detail the geological structure of the region, we will focus only on certain basic indicators of the geological structure of the depression In the geological section of the Fergana depression, the Mesoic-Cenozoic sedimentary deposits take part, under which the dislocated formations of the Paleozoic lie. Most of the depression is overlain by Quaternary sediments, which are represented by conglomerates, loess, pebble, sand and gravel and clay formations. Neogene and Paleogene deposits are exposed on the day surface, within the near-edge parts of the depression. Their lithological differences are shown in Figure 2. Neogene deposits in the Fergana depression are subdivided into two complexes: Miocene-Lower Pliocene and Upper Pliocene. The Miocene-Lower Pliocene are represented by alternation of various pebble conglomerates, sandstones, gravelstones and clays, combined into a pale pink suite.

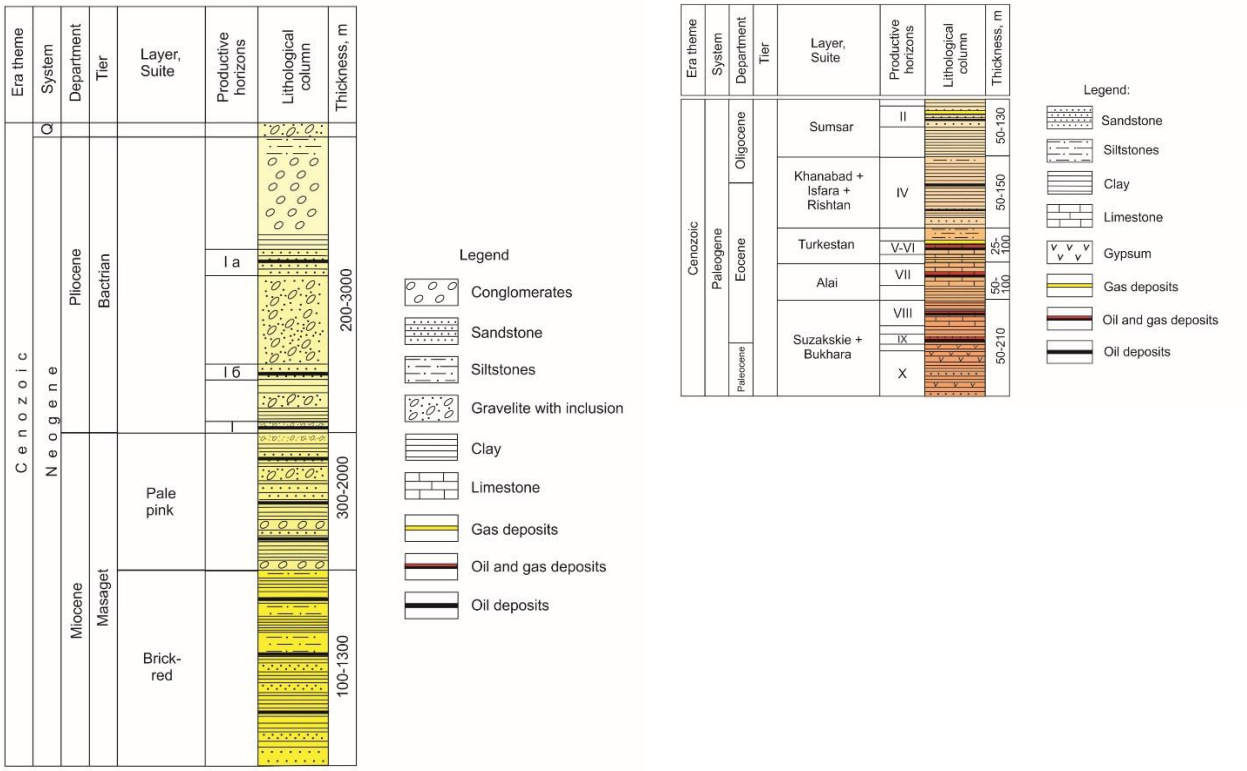

Fig. 2. Consolidated geological sections of Neogene and Paleogene sediments of the Fergana depression

In some areas, they occur with angular unconformity. The thickness of the suite varies widely: within the southern flank of the depression it is 140-160 m, in the Andijan group of folds it is about 70-150 m. In addition, it is known from published materials that terrigenous and carbonate deposits are considered to be the main oil and gas bearing deposits, which have high values of porosity and other filtration-volumetric parameters - mainly limestones and sandstones.

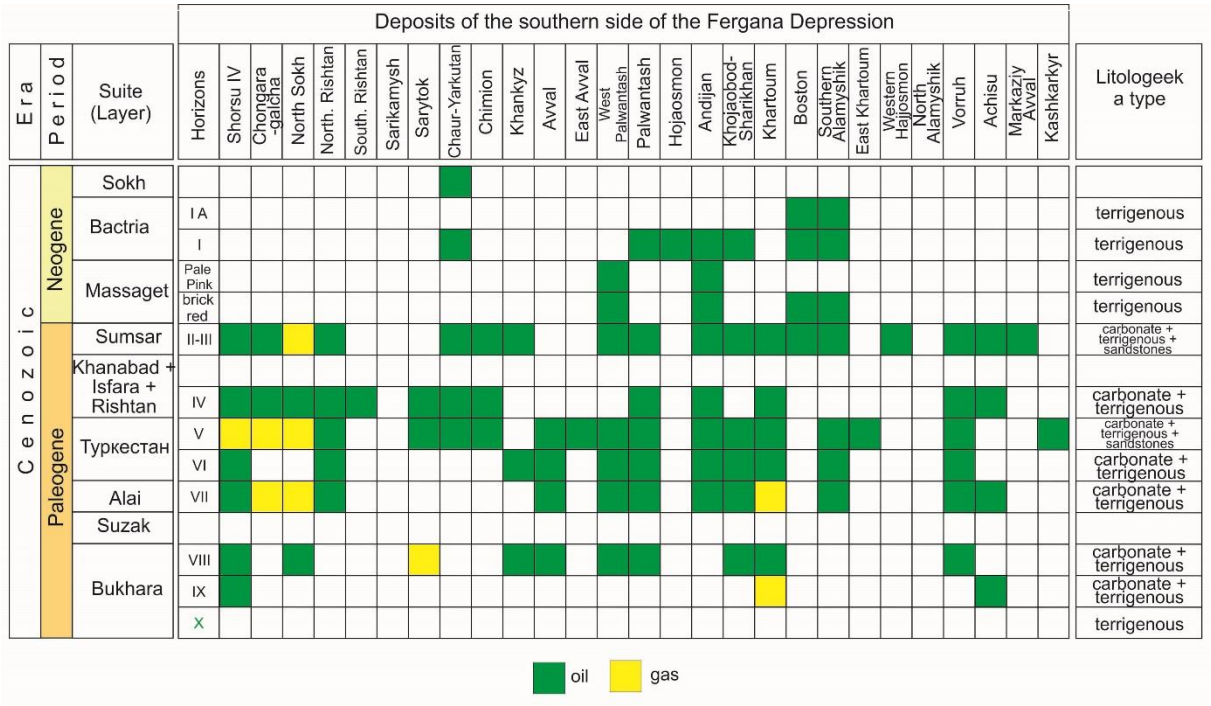

Fig. 3. Distribution of oil and gas fields in the Cenozoic sediments of the southern flank of the Fergana depression.

In the Fergana depression, oil and gas content is possessed by Neogene and Paleogene deposits, to which most of the known oil and gas fields are confined, such as, for example, Alamyshik, Palvantash, Andijan, Boston, Khartum, etc. (Fig. 3).

It can be seen from the diagram in Fig. 3 that the deposits are confined to the Bactrian and Massaget formations of the Neogene, the Sumsar, Turkestan, Alaysk and Bukhara horizons of the Paleogene. Deposits of hydrocarbon accumulations are observed in traps such as arches of anticlines, tectonically and lithologically screened types. On the basis of a statistical analysis of the distribution of deposits by types of structural elements, we found (see below) that the main structural elements, to which the largest number of oil and gas deposits are confined, are monoclines (22%), stepped zones (31%), an edge slope (10%), fault zones (16), the rest fall on the share of anticlinal zones, individual uplifts, flexures, and protrusions.

To accomplish the assigned tasks, we used two sets of multispectral satellite images of the American satellite Lanndsat-8, which were seamlessly combined with each other. In addition, digital models of topographic heights (DEM) and SRTM (with phase accuracy of 90 m), obtained by vectorization of topographic databases, were used (Fig. 4).

With the help of these satellite images, taking into account the geomorphological features of the study area, the structural forms of the relief in the form of uplifts and depressions were established.

At the first stage, with each set of satellite images, a series of operations were carried out using the ENVI computer program. In this case, the radiometric correction of space images was carried out using the ENVI 5.01 program. As a result of radiometric correction due to cleaning from various defects caused by the relief and atmosphere, elimination of variations in light indicators, the quality of satellite images was improved and their geoinformation value was increased [19].

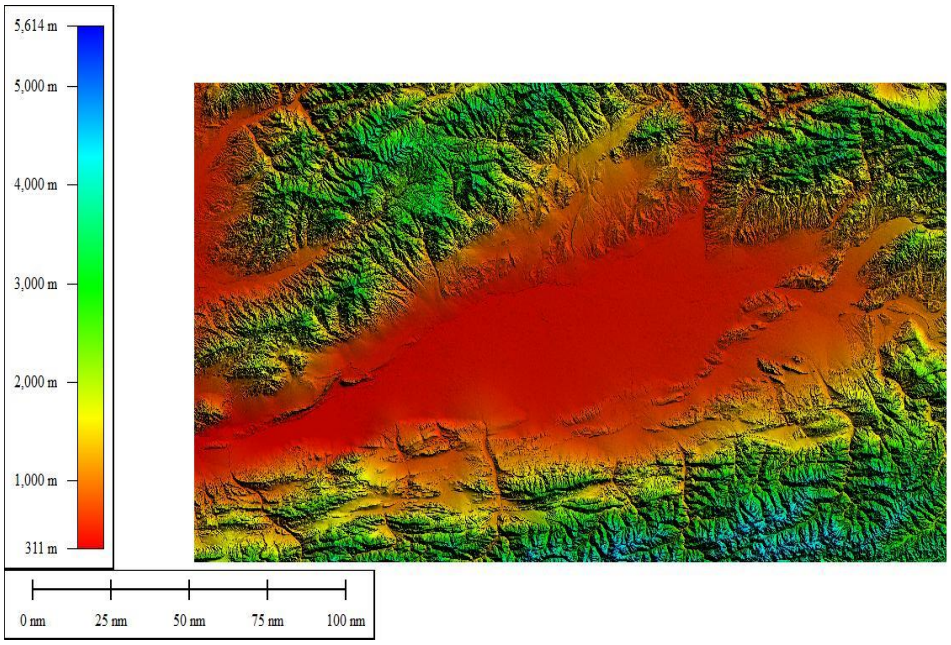

Fig. 4. Radar satellite image (DEM) of the Fergana Depression

At the next stage, atmospheric correction of satellite images was performed. As a result, by eliminating absorption and loss of rays, an increase in the energy brightness of each pixel of a multispectral satellite image was achieved [3,20]. It should be noted that along with the systematic processing of satellite images, along with an increase in the image quality and an increase in information content, it became possible to identify the geological-structural and structural-geomorphological elements of the region.

At the stage of visual interpretation, based on the choice of optimal options for the analysis of spectral channels of satellite images, they were presented in the form of RGB

compositions. Adhering to the requirements for the choice of channels for analysis, on the basis of direct comparison of geoinformation data with the data reflected on the geological map, signs of the structural and geomorphological features of the territory were identified (Fig. 5).

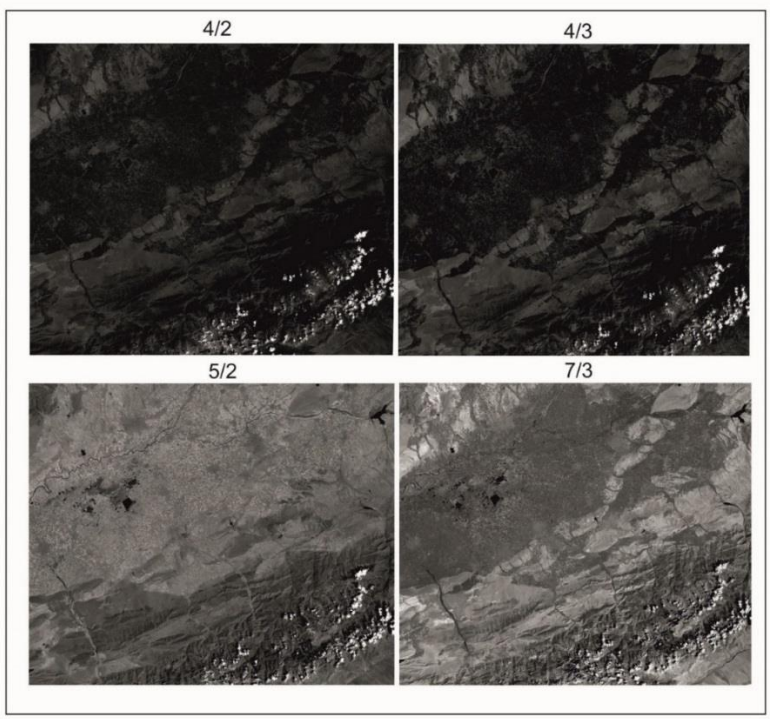

Fig. 5. Overlay of various satellite imagery channels (in the southern part of the Fergana depression)

In addition, relying on the generalized characteristic diagnostic features of space images to identify geological-structural zones (in particular, for the oil and gas region of South Fergana), reference objects were selected. Based on the use of 11-channel satellite images, matching the sequence of the RGB channel system and choosing the most optimal option for the degree of phototones of the space image (from black to color), decoding was carried out on a scale of 1:200 000 and a cosmophotogeological map was compiled. A fragment of this map along the southern side of the Ferghana Basin is shown in Figure 6.

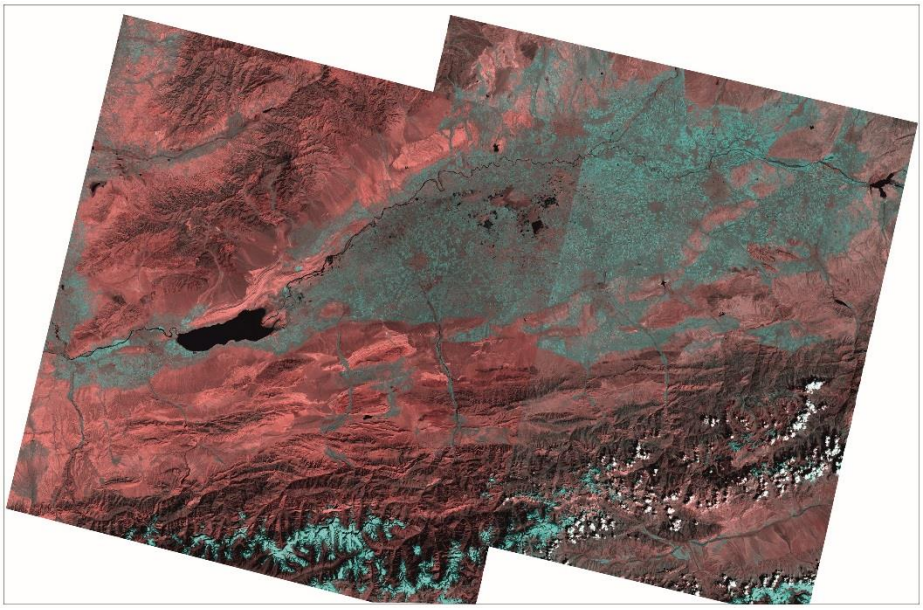

Fig. 6. Space imagery of Landsat 8 of the Fergana depression (RGB 7/5/5).

RESULTS AND DISCUSSION. The Fergana depression is intra-orogenic and is surrounded by mountain rises. Due to the fact that the largest number of oil and gas fields was found in the southern, near-edge part of the depression, we will concentrate the description and analysis of the results obtained in this part of the territory, calling it South Fergana for short.

In the southern part, South Fergana is limited by the uplifts of the Turkestan-Alay fold system, which includes - mountain uplifts: Takhtabuz - in the southwest, Katrantau - in the central part, Karachatyr - in the southeast; individual depressions that limit them. The fact that the geologic structures are arranged in a specific order helps to characterize the geologic signatures of the interpretation. These factors serve to further increase the possibility of space photo-geological analysis of the region in the process of practical use of space images. On the basis of a comprehensive interpretation of the images, the zones of lineatents, faults, structural-material complexes and structural-geomorphological elements were identified. As an example, Figure 6 shows the results of decoding for the southern part of the territory - South Fergana. In the eastern part of South Fergana, by the nature of the manifestation of the phototone, light gray zones are distinguished, corresponding to areas of monoclines. Here, on the structural-tectonic map, it corresponds to the Andijan monocline.

Such zones stretch along the southern flank of the depression, where the near-side slope is clearly distinguished. Due to the similar morphology, we have combined them with one designation with a monocline. The areas adjacent to them are characterized by gray and dark gray tones. In the eastern part of the territory, they correspond to the Karasu, Aim and Kugart trough zones. Anticlinal zones are distinguished to the south of them. These marked areas differ in the density of the brightness levels of satellite images, probably due to the manifestation of various tectonic deformations. In which areas in the middle and southwestern part of the territory, stepped zones are distinguished in the form of areas that are darker in the photon. Almost all of the noted types of structural and geomorphological elements are controlled by faults.

The figure shows discontinuities and lineaments of different ranks, which are reflected in the relief in the form of extended narrow stripes, with characteristic breaks and displacements of relief elements. The map shows structural-material complexes, represented by outcrops of Paleozoic formations of the folded basement, Paleogene, Neogene and, in some places, Quaternary molasses that compose monoclines. The outcrops of the Paleozoic folded basement in the middle part of South Fergana in the thermal channels of space images are separated by large blocks (Thermal) with light gray, gray and RGB (red, green, blue) 7/5/5 channel decoding marks (Fig. 6, Fig. 7).

When comparing the interpretation results (Fig. 7) with topographic and geological maps at a scale of 1: 200,000, these uplifts are characterized not only by the density of the phototone, but also by relatively wider forms expressed in the relief. They are composed mainly of metamorphic and volcanic rocks. It should be noted that the Paleogene and Neogene sediments of the Akbel uplift are characterized by linearly elongated trajectories of gray photons along the boundaries of strongly distorted zones, and the Paleozoic and Mesozoic rocks are marked by pronounced complex forms.

On satellite images, the zones of local uplifts and depressions have dark gray, gray, white-gray colors of photon density. A large part of the territory is manifested mainly in light gray tones, which correspond to alluvial and proluvial deposits.

In addition, in the central part, mainly in the Kokand Basin and its lateral slopes, Quaternary deposits are marked in gray to dark gray. These deposits are also well manifested by the brightness level in the 7/3/4 RGB systems. They are represented mainly by loess, sand, sandy loam and various alluvial deposits.

The above deciphering signs are directly or indirectly related to the petrophysical and geochemical properties of rocks and the results of the manifestation of exogenous geological processes. This circumstance allows, upon detailed examination, to select areas with different properties that can be used for search purposes.

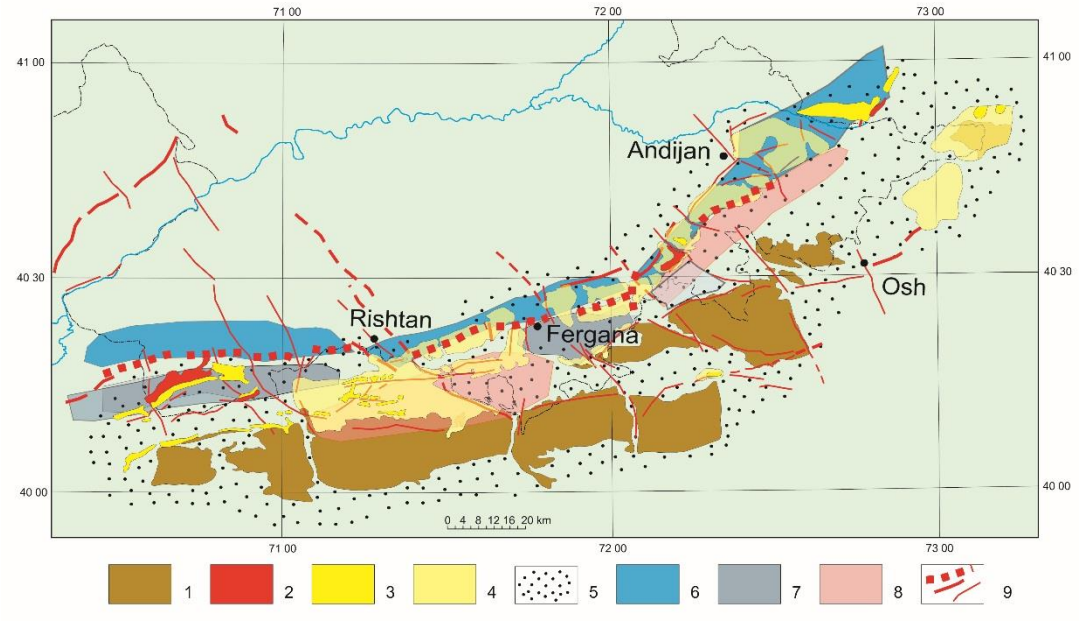

Fig. 7. Schematic cosmogeological map of South Fergana

Legend: Structural-material complexes: 1 - fragments of the Paleozoic folded basement, 2 - Paleogene, 3 - Neogene, 4 - Quaternary molasses, 5 - alluvial-proluvial deposits. Structural and geomorphological elements: 6 - monoclines, side slope, 7 - stepped zones, 8 - anticlinal zones, 9 - faults and lineaments of different ranks.

Deciphering of the southwestern part of the South Fergana depression corresponding to the slopes of the left tributary of the Sokh River, the eastern part of the Tuzluk monocline was also carried out on the basis of sequential selection of features on a variety of different satellite image channels. Geological elements were identified, such as the Kanibadam-Rishtan stepped zone, the Isfara-Lyakan monocline, etc. There are difficulties in recognizing the Paleogene, Neogene and Quaternary stratigraphic complexes. This is due to the fact that the features of limestones, dolomites, and conglomerate deposits do not differ greatly from each other. For a more detailed study of these deposits in the southwestern part of South Fergana, it is necessary to use other types of satellite images (Aster, Qwikbird).

In order to identify the oil and gas control role of the selected elements, a special analysis of the distribution of the number of hydrocarbon fields in the Fergana depression by the types of identified tectonic elements was carried out. Figure 8 shows a histogram of this distribution. The largest number of hydrocarbon deposits appeared to be confined to stepped zones, monoclyrals and fault zones.

The results obtained show that the structural elements that control the oil and gas content of the Fergana Basin are stepped zones, monoclines, near-river slope and fault zones. The use of satellite images to identify these elements allows you to quickly, without extra cost, identify the most promising areas for priority prospecting and exploration work.

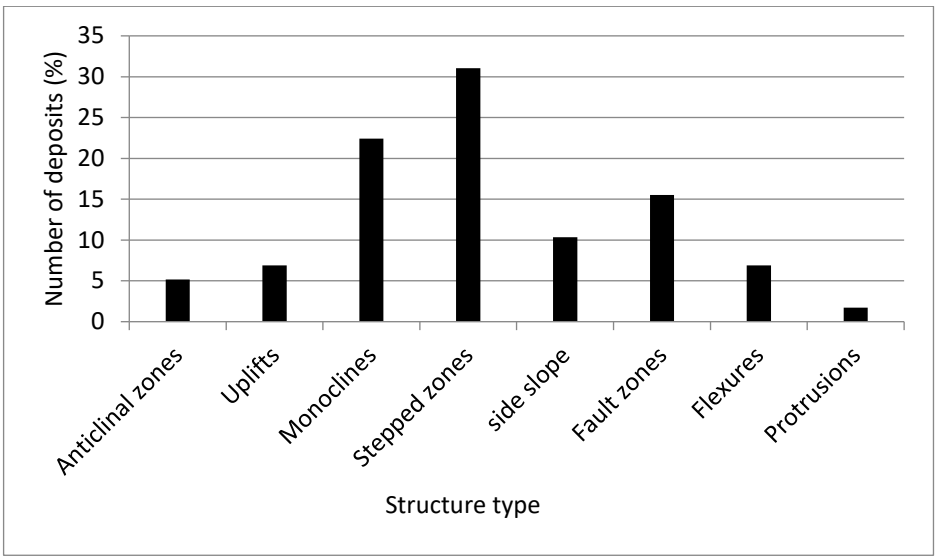

Fig. 8. Distribution of the number of hydrocarbon deposits by types of tectonic elements of the Fergana depression.

CONCLUSION. The development of space systems for remote sensing of the Earth and the use of space images make it possible to successfully carry out cosmo-geological mapping of large territories. In combination with the use of GIS technologies, this allows to significantly reduce the time and material costs for performing geological survey work prior to detailed search and exploration projects. The studies carried out made it possible to obtain new data on the structural and geormophological features of the Fergana depression, their reflection on satellite images.

Signs of their mapping were revealed based on the use of multispectral satellite images of Landsat 8, which are expressed in changes in brightness intensity with a transition from high-contrast photons to less dense phototones. They reflect well the areas of abrupt change in the shape of the relief, making it possible to identify structural and morphological elements that are directly related to the latest tectonic movements. The optimal combination of RGB channels for the conditions of the Fergana depression has been established, which is important for the further use of remote sensing data in solving practical problems. As a result of deciphering along the Fergana depression, such structural forms as monoclines, stepped zones, fault zones, and various geoblocks were identified. which play a structure-controlling role of oil and gas content. The position of the South Fergana fault zone has been clarified, which is not continuous, but has an en-echelon strike, in places complicated by transverse ruptures.

Structural-geomorphological and structural-geological maps have been compiled, which can be used as a scientific and geological basis for solving geological problems. Difficulties in recognizing the Paleogene, Neogene and Quaternary stratigraphic complexes have been identified, and appropriate recommendations have been made for the use of other types of space images (for example, Aster, Qwikbird).

Reference

1. Asadov A.R., Tulyaganova N.Sh. Using Hough Transformation for Detection of Linear Geological Structures in Satellite Images // International Journal of Advanced Research in Science, Engineering and Technology Vol. 6, Issue 12, December 2019.

2. Togaev, I., Umurzakov, R., Nurkhodjaev, A., Romanov, S., Akmalov, SExperience of cosmogeological research on the basis of GIS-technologies (in case of South Nuratau) //

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85094128070&doi=10.1088%2f1757-899X%2f918%2f1%2f012053&partn. DOI: 10.1088/1757-899X/918/1/012053.

3. Nurkhodzhaev A.K. Current state and prospects for the development of remote sensing of the Earth in the field of geological exploration production of the Republic of Uzbekistan. Geology and mineral resources. -2017. - No. 1. - P. 78 - 83. (04.00.00; No. 2). (in russian)

4. Nurkhodzhaev A.K., Togaev I.S., Shamsiev R.Z. Distance basis of the Republic of Uzbekistan: creation, requirement and prospects of its use in planning regional geological research. Geology and mineral resources. - 2017. - No. 4. - S. 3 - 6. (04.00.00; No. 2).). (in russian)

5. A.K. Nurhodjaev. Remote methods for solving the applied problems of geology in the light of modern requirements. International Journal of Geology. Earth and Environment Science. - India. 2018. - vol 8.N1. - P.1- 4. (04.00.00; №7).

6. Nesmeyanov S.A. A quantitative assessment of the latest movements and neostructural zoning of the mountainous region (on the example of Western Fergana and its mountain frame). M .: Nedra. 1971.-144 p. (in russian)

7. Nesmeyanov S.A. Orotectonic method // Moscow, 2017.-376 p. (in russian)

8. Borisov O.M., Morozova L.I., Magzumova D.A. and others. The structure of the earth's punishment in Central Asia from space data. - T .: Fan. 1985.177 p. (in russian).

9. Glukh A.K., Eisfeld O.A. Revealing potential ore fields and forecasting mineral types of structural-material complexes using modern technologies. Geology and mineral resources. - 2014.- No. 5. P.14-17. (in russian).

10. Sitdikov BB Neotectonics of the Western Tien Shan // Tashkent: Fan, 1985, -144 p. (in russian).

11. Umurzakov R.A., Rabbimkulov S.A. Oil va gaz tўplamlari қidiruv methodlarini takomillashtirishda kosmic tasvirlardan foydalanish imkoniyatlari // ToshDTU Khabarlari 2016. No. 4. P.195-200. (in uzbek)

12. Abidov A.A., Umurzakov R.A., Abidov Kh.A., Yuldashev G.Yu., Rakhmatov U.N., Rabbimkulov S.A. Unconventional methods of prospecting for hydrocarbon deposits in the light of the mixed genetic concept of the origin of oil and gas. Monograph. Tashkent: "Fan va texnologiya", 2017. –112 p. (in russian).

13. Brogaard, S., and S. Prieler, 1998. Land cover in the Horqin Grasslands, North China. Detecting Changes Between 1975 and 1990 by Means of Remote Sensing, International Institute for Applied System Analysis, Austria, URL: http://www.iiasa.ac.at/Publications/Documents/IR-98-044.pdf (12. 2006).

14. Agres N.P. Forecasting oil and gas prospecting objects by remote sensing methods // Neftegazovaya Geologiya. Theory and practice 2015. №1. DOI: https://doi.org/10.17353/2070-5379/4_2015.

15. Aksenov AA et al. Remote research during oil and gas prospecting operations // M .: Nauka, 1988. P. 224. (in russian).

16. Sukphornsawan, N., Suwanprasit, C., Wongpornchai, P. The extraction of lineaments from satellite images in Phayao-fault zone // https://www.scopus.com/inward/record.uri?eid=2-s2.0-85090040481&doi=10.1088%2f1755-1315%2f538%2f1%2f012010&partner. DOI: 10.1088/1755-1315/538/1/012010. (in russian).

17. Wu, C., Li, X., Chen, W., Li, X. A Review of Geological Applications of High-Spatial-Resolution Remote Sensing Data // https://www.scopus.com/inward/record.uri?eid=2-

s2.0-85072115124&doi=10.1142%2fS0218126620300068&partnerID=40&md5. DOI: 10.1142/S0218126620300068.

18. Abdullaev G.S., Dolgopolov F.G. Geodynamics and oil and gas content of the lithosphere in Uzbekistan. Tashkent: UzNIO NGP, 2016.-362 p. (in russian).

19. Software complex ENVI: textbook. allowance [Electronic resource]. M.: Sovzond Company, 2007. URL: www.sovzond.ru. (in russian).

20. ERDAS IMAGINE: practical. Tour Guides / Leica Geosystems Geospatial Imaging, LLC. Nocross (Georgia), 2005.