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PREDICTION OF LOCAL OIL AND GAS PERSPECTIVE STRUCTURES ACCORDING TO THE DATA OF GEOPHYSICAL STUDIES AND REMOTE SENSING WITHIN SOUTHWESTERN GISSAR

***Goipov Akram Bayramovich**
Faculty of Geology and Geographic Information Systems, National University of Uzbekistan, Tashkent, Uzbekistan
**Author for Correspondence*

ABSTRACT
The article presents the results of the integrated interpretation of geophysical and satellite information in the infrared range. The deep heat flows and their relationship with the oil and gas potential of the South-West of the Gissar region were analyzed. A 1: 200000 scale geoisotherm map was compiled for various depths. A method for determining the temperature of the Earth's surface using the infrared range of Landsat and ASTER satellite images is given. As a result of processing the infrared ranges, new predicted oil and gas promising areas were identified at the local level.

Keywords: *Night Thermal Survey, Geoisotherms, Fluid, Anticlinal Structures, Thrusts, Lineaments, Faults, Heat Flow, Land Surface Temperature.*

INTRODUCTION
Interest in geothermal research is due to the generally accepted temperature of the subsoil as the most important factor in oil and gas formation, migration and transformations of underground fluids, as one of the important indicators of the distribution of natural and artificial thermal properties of rocks by area and depth (Shestov *et al.*, 2015).
To assess the prospects for the petroleum potential of local structures, geothermal maps are constructed. When using infrared shooting in the range of 10-14 microns, the energy flow is recorded, which characterizes the own thermal radiation of objects on the earth's surface. Modern space thermal imaging systems record discrete thermal images (Gorny and Stepanov, 2001; Schovengerdt, 2015). The brightness values that pixels of thermal space images take are brightness. At the same time, the objects of the earth's surface may have the same temperature, but different intensity of thermal radiation. The ability of objects to emit energy at different wavelengths is called emissivity (Schovengerdt, 2015).
Geothermal studies at the regional stage of exploration are carried out in order to study current temperatures and paleo-temperatures in different types of sedimentary basins and their influence on the generation of hydrocarbons (HC) of different phase states. In detailed studies, thermal anomalies are revealed, often coinciding with local structures with which hydrocarbon accumulations are associated. Geothermal studies for prospecting criteria and relationships with petroleum potential are reflected in numerous publications and scientific papers: "Criteria for predicting petroleum potential" (Nesterov, 1969), "Geothermal studies of oil and gas fields" (Mehdiyev *et al.*, 1971), "Geothermal factors of petroleum potential" (Burtsev, 2006), "Geothermal criteria for prediction of petroleum potential" (Kislukhin, *et al.*, 2012).
Geothermal exploration in combination with other surface and underground geophysical methods is carried out at oil and gas fields.
Geomorphologically, the southwestern spurs of the Gissar Range represent a complex mountain structure, which is due to the intensive mountain-building activity that lasted here for a long period up to the Alpine time. As a result, high elevated mountain ranges exceeding 4000 m above sea level were formed. In addition to the fact that the mountains are heavily cut, they do not have the same strike in different parts of the area; which significantly complicates the implementation of geological and geophysical works. It was necessary to map promising geostructures and to identify additional informative signs of oil

and gas presence in this region, by analogy with the territories where hydrocarbon deposits are already open. The solution of such a task was possible only by creating an integrated methodology for the interpretation of satellite images and the interpretation of geological and geophysical materials.

MATERIALS AND METHODS

B.Tal-Virsky in his reporting on the topic "Study of the thermal regime of the oil and gas regions of Uzbekistan in comparison with the geological structure, seismicity and geophysical fields" of 1976 maps of average vertical temperature gradients, maps of thermoiso-gypsum, maps of geoisotherms and thermal maps flows. The above maps were compiled at a scale of 1: 1 000 000 for the oil and gas regions of Uzbekistan (Tal-Virsky, 1976).

Further A.N. Krot, N.Rakhimov, (Tal-Virsky, 1976; Zuev *et al.*, 1985), F.K.Batsova, A.M. Akramhodjaev, V.N. Pashkovsky, H.Ya.Nabihonov, A.V. Kirshin, A.A.Abidov, A.A.Polikarpov (Polikarpov, 2006), G.S.Abdullaev, F.G. Dolgopolov and others continued research in this direction. Subsequently, it was noted that all known fields are characterized by increased thermal values in the localization areas, but to date there are no medium-scale maps showing thermal values for the South-West Gissar territories.

In the course of scientific research, the logging thermograms were interpreted within 10 areas where hydrocarbon deposits were discovered. As a result, thermoisogypsum maps and geoisotherm maps were compiled.

At the same time, 9 logging thermograms for wells located within the Surkhandarya oil and gas region, which borders on the south-western spurs of Gissar in the east and 5 logging thermograms, were used for wells located within the Bukhara-Khiva oil and gas region. In mapping geoisotherms as well as in the distribution, study and analysis, we used the latest data on wells drilled within oil and gas fields and exploration structures (table 1).

As a result of the research, geoisotherm maps of 1: 200,000 scale were compiled using data from deep wells located in 30 areas (6 of them according to BB Tal-Virsky) for depths of -500, -1000-, 1500, -2000.2500, -3000m. Figure 1 shows the map of geoisotherms for a depth of -500m.

In the upper horizons of the sedimentary cover, the deep heat flux is distorted by a variety of factors. Among them are geotectonic, structural, hydrogeological, sedimentation, denudation, geomorphological and thermophysical factors. These factors were also taken into account when creating geoisotherm maps.

Many studies have been devoted to the study of the geothermal field of the South-Western spurs of Gissar and adjacent territories (Tal-Virsky, 1976; Polikarpov, 2006; Goipov and Nurkhodzhaev, 2018).

The geothermal field of the south-western spurs of Gissar is characterized by high gradients 3.14-3.73 degrees / 100m. The shape of thermograms is weakly convex. An exception is the thermogram for the Akbash well, the mean gradient values in which range from 2.0-2.75 to 3 hail / 100m (Tal-Virsky, 1976).

The change in temperature along the vertical was determined by the lithologic and facial features of the sediments composing the cover, the petrographic composition of the basement, and the deep heat flux.

In the Baysun depression, the geoisothermal lines coincide with the topography of the area and tectonic elements. That is, it is an oval-elongated shape, directed in the northeast direction. The highest temperatures for this area are registered in the Bayangor area at a depth of -500 m. And make up 59.6 °C. This indicator at a depth of -1500 m is 72 °C, and at a depth of -2500 m, it is 90.5 °C. The territory within the Gadzhaksky gas and oil field is also considered a high-temperature area. Analysis of this table shows that if at a depth of -500 m. The temperature is 51.4C, then this indicator at a depth of -2000 m increases to 71 °C, at a depth of -3000 m to 99 °C and at a depth of -3490 m to 130 °C. This proves that near the oil horizons the temperature rises sharply. Geoisoterms that run from the Baysun Basin to the southwestern spurs of the Gissar Range vary in relief in the north-west direction. The main groups of well-known oil and gas fields border on high rates of geoisotherms.

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Table 1: Average values for different isothermal surfaces of the South-Western spurs of Gissar and adjacent territories (New data 1973-2015 by Goipov A.B.).

№	Square	№ of wells.	Date of measurement	Marks of an isothermal surface in m.							Temperature at elevations in degrees T ^{0}C						
				-100	:-500	:-1000	:-1500	:-2000	:-2500	:-3000	: +40^0	: +55^0	: +60^0	: +75^0	: +80^0	: +90^0	:+100^0
1	Zilina	1	31.10.1978г.	25	40.6	52	65.2	79.5	95.8	110.6	-482	-1097	-1296	-1814	-2013	-2356	-2647
2	Guzar	1	04.09.1982г.	22.5	28	49.5	62.8	81.5	96	102	-828	-1297	-1428	-1840	-1966	-2290	-2910
3	Buzahur	1	06.05.1982г.	36.3	43.5	51	61.2	80	102.7	117.8	-196	-1200	-1432	-1897	-2001	-2221	-2440
4	Zhairan	1	28.09.2015г.	32	39.5	47.4					-530	-1355					
5	Garmistan	19		49	52.3	58.1	64.7	71.3	79.2	87	0 <	-798	-1149	-2250	-2543	-3224	-3434
6	Belisainak	1	14.04.1970г.	23	34.8	49.5	68	87	104.5		-1016	-1101	1113	-1726	-1852	-2063	-2319
7	Kyzylbairak	2	04.02.1974г.	29.15	41.8	54.5	69.15				-442	-1015	-1170	-1780			
8	Bobosurhon	1	01.06.1979г.	22.5	28	38	56.8	73.6			-1060	-1440	-1582	-2044			
9	Jarkuduk	1	17.12.1981г.	22	39.6	57.8	73.4	89.3			-510	-943	-1068	-1192	-1648	-2038	
10	Kashkuduk	5	21.02.1986г.	24.9	36.7	50	64.2	74.4			-623	-1178	-1336	-2050	-2330		
11	Karail	1	13.09.1986г.	29.1	39.4	46.2	53.5				-643	-1660					
12	Beshbulak	1	01.06.1990г.	42.6	50.9	62.1	72.4	83	91.7	92.6	-66	-680	-908	-1618	-1865	-2377	
13	Tandyrcha	2	01.07.1993г.	28.3	32	41					-980						
14	Chalka	1	14.03.1997г.	24.6	39.3	55	66.25	74.4			-510	-1000	-1260	-2050			
15	Togam	1	03.11.2008г.	28.25	38.9	50.3	64.8	75			-463	-1150	-1350	-2000	-2190		
16	Bayangara	5	15.12.1973г.	47.4	59.6	65	72	82	90.5		-27	-440	-761	-1700	-1809	-2496	
17	Lyailyakan	2	08.04.1976г.						77.8	87					-2620	-3126	
18	Derbent	2	02.04.1984г.			53.4	54.4	69				-1519	-1711	-2211			
19	Beshkyz	1	07.01.1988г.	36.5	41.9	52.9	64.2	75.4	86.5	98	-328	-1097	-1310	-1984	-2213	2662	3052
20	Karabag	2	23.07.2000г.	16	18.8	34	49.6	61			-1212	-1760	-1950				
21	Hajaipack	1	29.11.2004г.					66	77.56					-2385			
22	Beshyrkak	1	02.11.2005г.	40.1	44.8	52.25	58.3				-100	-1200					
23	Gajak	46	23.07.2009г.	49.2	51.4	57.8	64	71	81.6	99	0 <	-750	-1160	-2360	-2484	-2674	-3100
24	Kagnysay	3		29	32.6	42	51.5	65	81.5	98.8	-889	-1629	-1809	-2319	-2459	-2744	-3038

Lateral temperature changes depend on many factors creating a complex field, among which discontinuous structures are essential for the region under consideration: fracture zones, thrusts. For example, a low temperature of +40 °C at a cut of -500m in Dasmanaga Square is explained by thrust, and high temperatures of 52–56.6 °C in Koshtar Square are explained by a powerful fault zone that cuts the structure in the northeast direction (Tal-Virsky, 1976). Within the south-western spurs of Gissar, the highest temperatures of 65.8 °C at the section - 500 m - are observed on the Mobik structure, which can be explained by the presence of a large fault on the fold wing (Tal-Virsky, 1976).
An analysis of geoisothermal charts that were compiled for various depths from -500 m to -3000 m with an interval of 500 m showed that high-temperature points are closely related to oil and gas deposits.
From a theoretical point of view, the temperature rises in the oil horizons and decreases in the gas horizons. We do not want to refute this idea, but in the intervals of oil and gas contacts, due to physicochemical reactions, heat is released with certain temperatures and it is this heat that has a direct connection between the occurrence of oil and gas deposits or their existence.

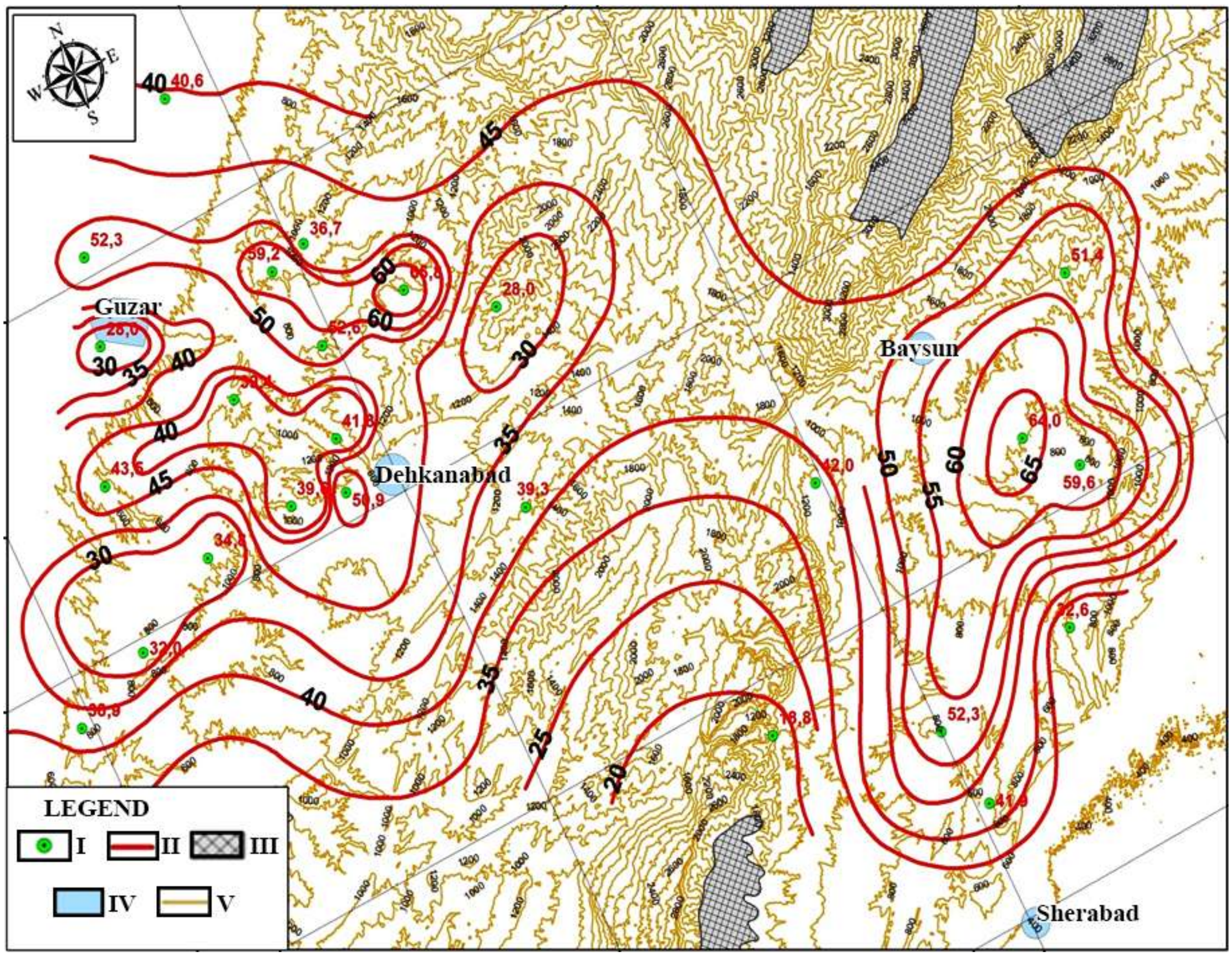

Fig.1 Geoisotherm map at -500 m southwestern spurs of the Gissar Range.
Legend: I - wells and their temperatures in the depths of -500 meters, II - geoisoterm after 500 meters, III – outcrops of the Paleozoic basement, IV – towns and cities, V - horizontals after 200 meters.

When building a geoisothermal map that was compiled for a depth of -500 m, data from 18 wells were used for 14 areas of the South-West Gissar oil and gas region. The distribution of their temperature values are given in Table 1. According to this table, it can be noted that if the highest temperature in the well of

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Mobiksky area is 65.8 °C, then the same indicator within the Bobosurkhan area amounts to 28 °C. That is, the temperature difference is 22.9 °C. Within the SESG, the average temperature of all the analyzed wells of the considered areas in which thermo-logging studies were conducted at a depth of -500 m is 46.6 °C. On constructed geoisothermal maps, temperature values change every 5 °C and their anomalous direction shows that changes in the directions of geoisothermal lines coincide to some extent with the level of the relief and the forms of their geological outcrops. Especially, geoisothermal contour lines coincide with the boundaries of the Paleozoic outcrops.
In this paper, in order to obtain additional and reliable data, a comprehensive interpretation of the results of processing materials from geophysical surveys and materials of remote sensing of the Earth is carried out. When creating the model, we used the results of magnetic prospecting at a scale of 1:25 000, (Kotlyarevsky and Kremnev, 1971; Kaplunov and Orlovsky, 1976, 1979). "Interpretation of data of high-precision gravity survey for the study of complex structures" (Dyrda *et al.*, 2008).

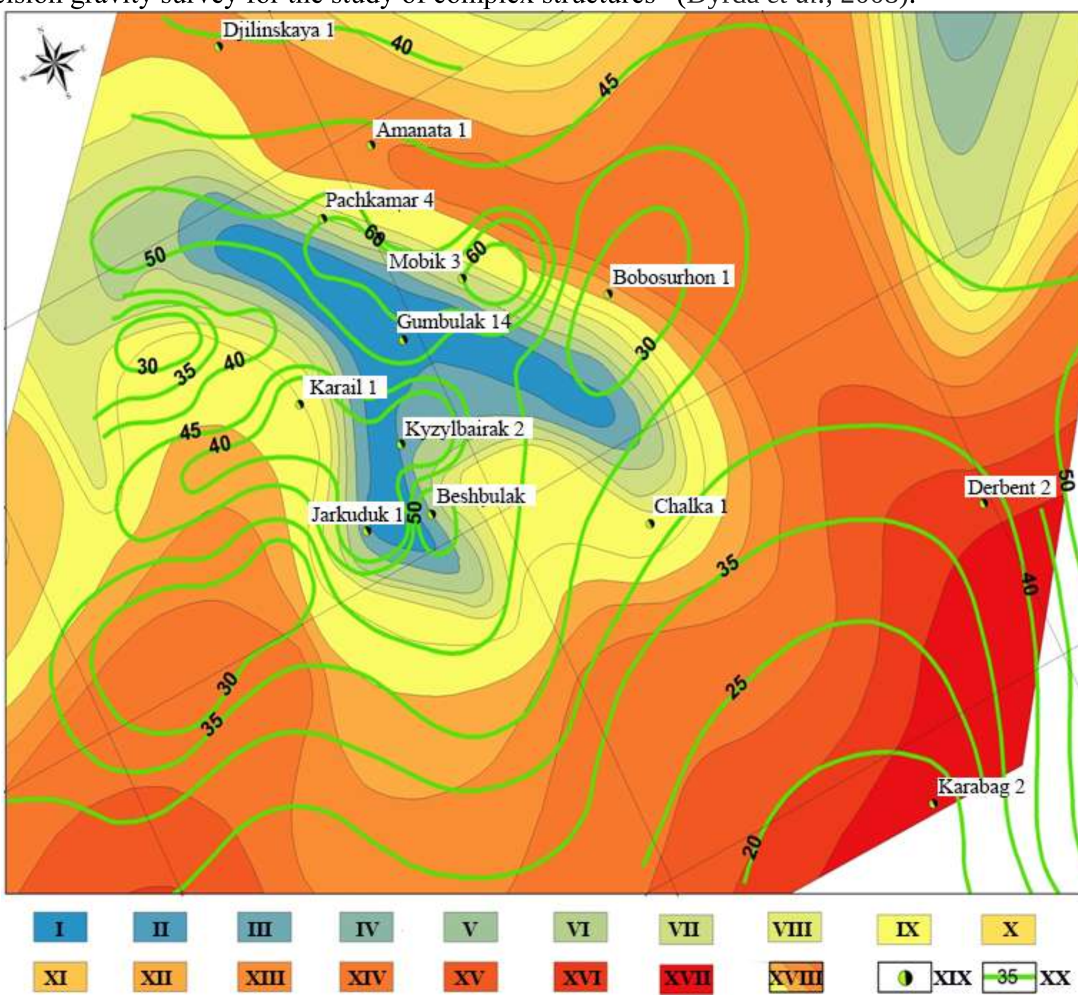

Fig.2.
Comparison of geoisotherms with a map of the total longitudinal conductivity (Seff) of the sedimentary cover of the southwestern spurs of the Gissar Range and adjacent territories (according to R.M. Gatina, 1986).

Legend: the values of conductivity I- <300, II- 300-400, III- 300-500, IV- 400-500, V- 500-600, VI- 600-700, VII- 700-800, VIII- 800- 900, IX- 900-1000, X- 1000-1100, XI- 1100-1200, XII- 1300-1400, XIII-1400-1500, XIV- 1500-2000, XV- 2000-2500, XVI- 2500-3000, XVII-> 3000, XVIII- isolines of conductivity in siemens, XIX-wells. XX- geoisoterms.

As the main feature, according to the geoelectric property of the region of the southwestern spurs of the Gissar and the Bukhara-Khiva region, it was concluded that the geoelectric section of the upper crust is relatively low (without the Meso-Cenozoic cover). According to Russian scientists (Bembel, et al., 2003), this kind of geoelectrical properties of the section, i.e. funnel-shaped permeable zones are associated with favorable conditions for the migration of hydrocarbons (geosolitons), as well as the participation of convective flows in the formation of oil and gas.
Comparing the constructed geoisotherms with the map of the total longitudinal conductivity (Seff) of the sedimentary cover of the southwestern spurs of the Gissar ridge and adjacent territories, it was found that the anomalous zones of changes in the total longitudinal conductivity coincide with the geoisoterms and the main groups of deposits located in this zone.

The method of obtaining the temperature of the infrared range space image.
A technique for analyzing and interpreting images of the earth's surface in the visible and near-infrared spectral ranges is displayed in numerous publications and scientific papers: (Becker, 1990; Watson, 1992; Gillespie, 1992; Wan, 1997; Belov, 2005; Gonzalez, 2006). The development of algorithms for extracting temperature values from thermal images is the subject of many studies (Sobrino, et al., 2004; Yang et al., 2004; Jimenez-Munoz, et al., 2009; Tan et al., 2009; Li et al., 2013). This question has been of interest to specialists in the field of remote sensing of the Earth for several decades. Currently, this area of application of thermal space images is the most common (Voogt et al., 2004; Weng 2009), although the result very much depends on the algorithm used, the source data, in particular, their completeness.
To obtain data on Land surface temperature (LST), Landsat-8 satellite data was used. The Landsat-8 space system is primarily due to the presence of two infrared (heat) channels (with a resolution of 100m), which operate in the wavelength range from 10.60 to 11.19 micrometers, respectively. It should be noted that the TIRS sensor (thermal infrared channel) mounted on Landsat-8 allows you to capture the sensitivity (difference) of temperatures with an accuracy of 0.5 degrees Kelvin, which allows you to map the temperature of the relief surface.
To obtain the absolute values of the temperature, the temperature LST carried out two mathematical operations with the pixel brightness values:
1. Recalculation of brightness values into the values of radiation coming to the TIRS sensor, this operation is performed using the formula:

$$L_{\boldsymbol{\lambda}} = \frac{\mathrm{L_{max}} - \mathrm{L_{min}}}{\mathrm{Q_{calmax}} - \mathrm{Q_{calmin}}} (\mathrm{Q_{cal}} - \mathrm{Q_{calmin}}) + \mathrm{L_{min}} \qquad (1)$$

where, L_λ is the amount of incoming radiation to the sensor; Lmin, Lmax is the amount of incoming radiation; Q_calmin - the minimum calibrated value; Q_calmax - the maximum calibrated value; The values of the above parameters are obtained from the metadata table that comes with the image scene.
The conversion of radiation values into temperature is carried out according to the formula:

$$T = \frac{K_2}{\ln[(K_1/L_{\boldsymbol{\lambda}}) + 1]} \qquad (2)$$

where, T is the absolute temperature in Kelvin; K1 - calibration constant 1; K2 - calibration constant 2; Lλ - radiation on the sensor. Further, the temperature was recalculated from Kelvin to Celsius degrees (C = K – 273.15).
The calculations were implemented in the ENVI 4.8 software using the Radiometric Calibration module or ArcGis using the Arc toolbox, and a map of the surface temperature to the South-West spurs of the Gissar Range was obtained (Figure 3). It is also possible to use the software product ERDAS IMAGINE 2014, in the Model Maker module (Avdan and Jovanovska, 2016). Determined that the Landsat and Aster infrared channels are close to ground-based measurements (Boori, 2010).

The Terra satellite system with an ASTER opto-electronic sensor is used for a wide range of applied and research tasks due to the unique characteristics of this device: it allows you to take images of the earth's surface with a resolution of 15 m to 90 m in 14 different spectral channels. Infrared channels 10-14 (with a resolution of 90 m) allow temperature mapping with a relative gradient of 0.03 degrees Celsius.
Channels 12, 13, and 14 have the highest atmospheric permeability (Jiménez-Muñoz and Sobrino, 2010). Channel 12 is 9 µm in length, channels 13 and 14 are optimal for extracting the Land surface temperature of the earth (LST), and the single-channel algorithm (SC) applies only to one thermal infrared band (LST). The formula of the algorithm for obtaining LST from the Aster infrared channel is the same as that of Landsat-8 (formula-2). For an Aster satellite image, the values of K_1 and K_2 are shown in Table 2.

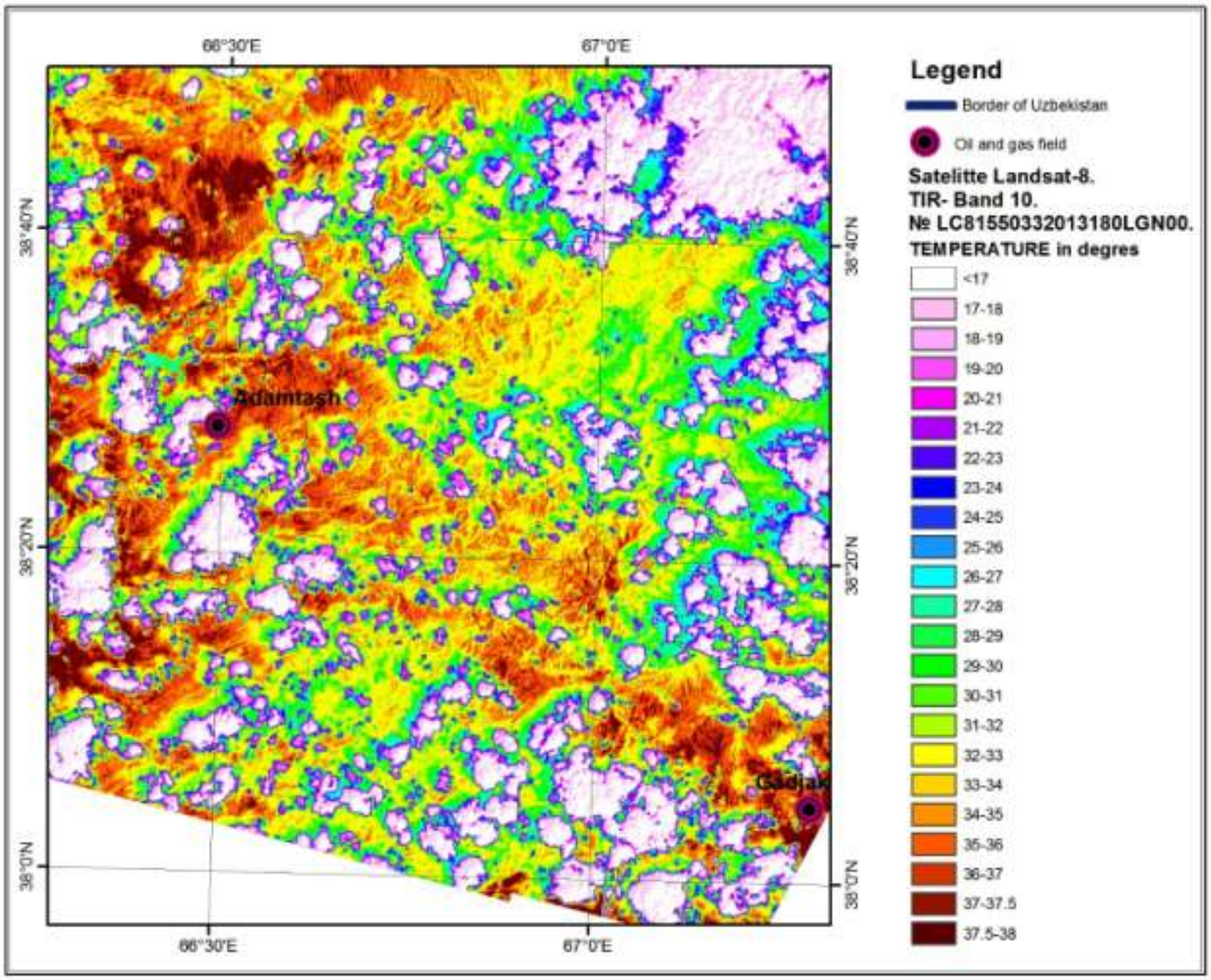

Fig.3. Land surface temperature map (LST) for the study areas, snapshot July 29, 2013

Using the infrared space image, it is difficult to determine the deep heat fluxes of the Earth, there are several factors that affect it, for example: changes in daily temperature, atmosphere, cloudiness, humidity, solar radiation, active and passive sensors, and many others. Despite all these factors, ERS materials in the infrared range can be used in the search and prediction of oil and gas structures, but for this it is necessary to perform a comprehensive interpretation of the data of deep thermal studies in comparison with remote sensing materials.

Figure 4 shows a comparison of the results of processing the materials of the ASTER nighttime thermal satellite images with the known thrust structure displayed on a geological map.

Table 2: Radiation constants used (Jiménez-Muñoz and Sobrino, 2010)

Infrared channels	ASTER wavelength (μm)	K_1 [$W \cdot m^{-2} \cdot sr^{-1} \cdot \mu m^{-1}$]	K_2 [K]
10	8.125 - 8.475	3047.47	1736.18
11	8.475 - 8.825	2480.93	1666.21
12	8.925 - 9.275	1930.80	1584.72
13	10.25 - 10.95	865.65	1349.82
14	10.95 - 11.65	649.60	1274.49

RESULTS AND DISCUSSION

In the zone of large and active faults at night, linear thermal anomalies are distinguished. Based on this fact, the proposed linear zones (shown by a dotted line), which are probably associated with tectonic faults, were identified. The zone of the high-temperature annular anomaly (northeast part of the figure) is also highlighted, it is the assumed local oil and gas perspective structure, which is caused not only by an increase in temperature, but also by the concentration of thrust structures in a given area. The group of thrust structures can also be called a feature of oil and gas perspective structures. Illustrative examples are the Amanat, Pachkamar, Gumbulak and other deposits.

The quantitative forecast was limited to areas that, according to a complex of features, with a high degree of reliability, corresponded to external standards (thermal characteristics of the Earth's surface within oil fields).

The analysis of the obtained map on the processing of the infrared range of a satellite image makes it possible to reveal a decrease in the severity of thermal anomalies within the known fields of the SUSOG and beyond its borders, mainly in the western half. At the same time, there is an increase in the intensity of thermal anomalies associated with some industrial hydrocarbon fields, especially in two well-known oil fields located in areas with elevated thermal anomalies with temperatures of 35-38 °C on the surface.

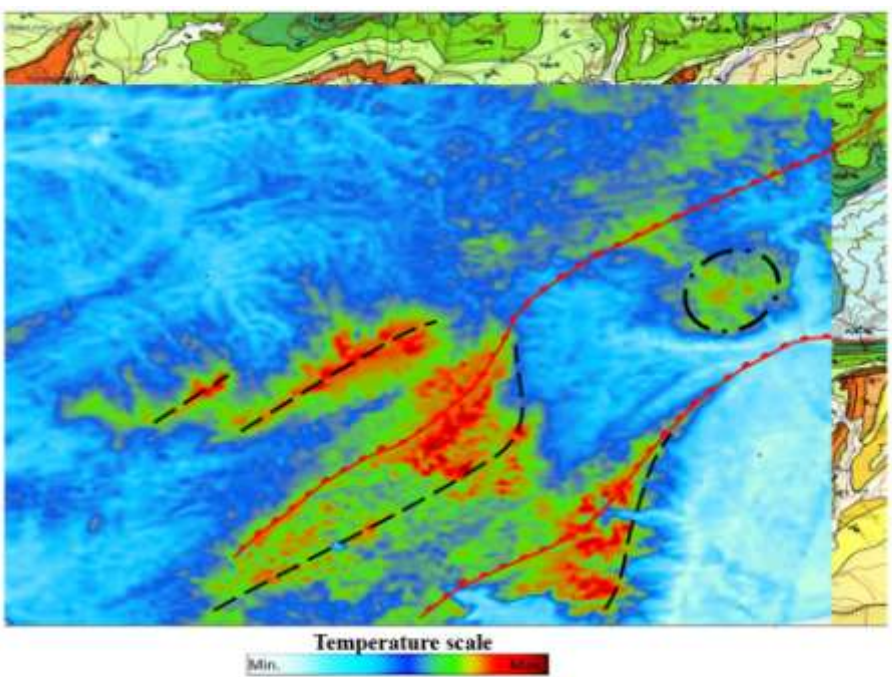

Fig.4. Results of the ASTER night thermal survey.

The results of processing the materials of the ASTER nighttime thermal space images and the infrared ranges of the LANDSAT-8 satellite images show that abnormal changes on the geoisotherm map at depths of -500 m and -1500 m coincide with the processed images. This coincidence, in turn, is the basis for the assumption that the results of interpretation of infrared ranges of satellite images, in addition to the identified oil and gas fields and their infrastructures, can reveal high-temperature anomalous zones. At the same time, we recommend the latter as local oil and gas promising structures for setting up detailed geophysical works.

Based on high-precision gravity survey materials in the eastern part of the South-West Gissar region (Dyrda et al., 2008), identified new 27 groups of gravimetric reservoir-type anomalies (GRTA). All known subsalt, local positive structures, which are deposits of hydrocarbons, are noted in the gravitational field by characteristic reservoir-type anomalies, which are low-amplitude structural maxima complicated by secondary minima. Of these, 5 plots (or object) coincides with our contours. Four objects repeated by processing materials night thermal shooting and three highlighted on structural interpretation of space images. The formation and accumulation of oil and gas deposits in the south-western spurs of the Gissar Range is associated with the geological tectonic features, plicative and disjunctive structures.

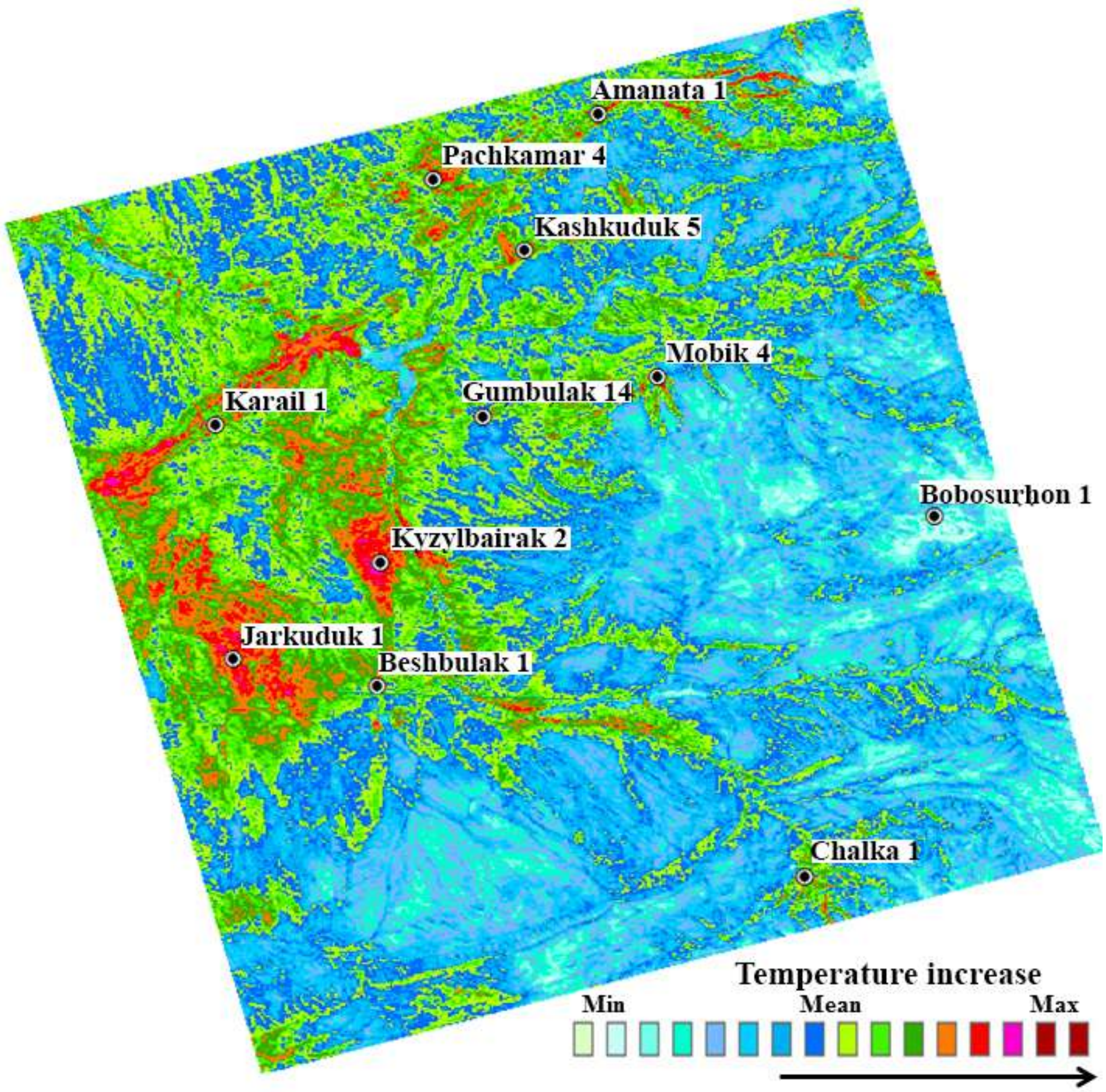

Fig.5. Results of the ASTER night thermal survey.

CONCLUSION

The work performed allows us to purposefully approach the development of the methodology and practice of exploration, forecasting, geological and economic assessment of the area, including the adjacent to developed fields and covered with a platform cover and eolian formations. In addition, the analysis of the deep structure of the buried basement was carried out on the basis of studying complex geophysical data and drilled wells. The work in general terms reflects the first stage of using the capabilities of high-tech technologies, using the territory well studied by traditional methods as an example, and allowed to evaluate the role of individual, including new, methods of remote sensing in geological research in complex works. According to the results of scientific works, 12 predictively promising objects were generally identified. It is recommended that the most recent primary geophysical and geological work on hydrocarbon deposit.

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