# Application of remote sensing in cosmo structures in southeastern Nyurolskaya depression (Tomsk region)

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## Abstract

Tomsk Oblast is on prospect an area for oil and gas exploration. However, it is a "closed area", where most geological structures are unavailable for direct study. The advent of new digital technologies and advanced satellite imagery furthered the possibility of obtaining up-dated information without significant investment and promptly.
Interpretation of satellite imagery was only conducted through survey testing to detect possible depth geological structures, such as zones of discontinuous faults under thick covers of unconsolidated sediments and "cut-through" preexistent tectonic elements.

**Keywords**: satellite imagery, remote sensing and GIS techniques, oil and gas deposits

## Introduction

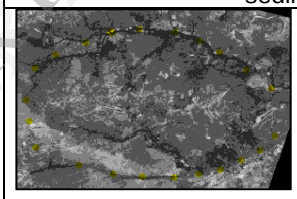
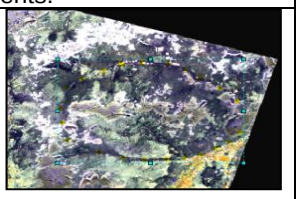
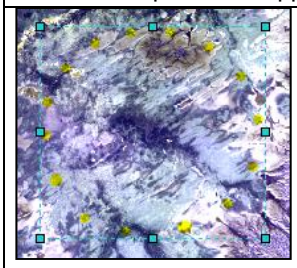
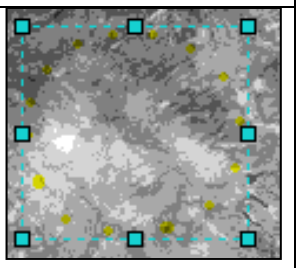
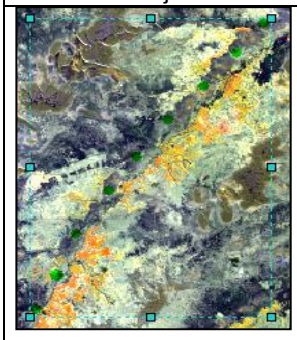
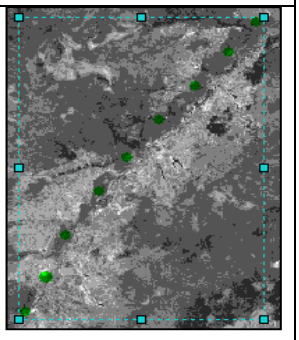
Data for the interpretation of remote sensing materials and geological interpretation were taken from sites: http://glcfapp.glcf.umd.edu:8080/esdi/ and http://gdex.cr.usgs.gov/gdex/ Landsat ETM + imagery and SRTM were used. These spectrum images were created in May 2001, due to the lack of snow cover in the study area during this period. Software programs: ERDAS IMAGINE, ArcMap и CorelDRAW X5 were used to process remote sensing interpretation, analyze geological structures, detect depth structures and buried objects, as well as, evaluate petroleum potential.

## Brief description of landscape components and images of geological objects

The interpretation of satellite data was carried out to investigate the geological allocated territory. In this paper was used the synthesized image with various combinations of channels allowing to recognize slightly abnormal objects of both linear and circular features and ring morphology. The primary combination of channels was 7, 5, 2, which clearly describes the geological structure of the area.

Table 1 presents the interpretation of geologic structure of the studied area.

Tabel 1
Markers of interpreted elements in the geological structures

| Images (texture) | Spectral characteristics and image tone |
|---|---|
| Depression. Concave tectonic, overlapped by sediments. | |
|  |  |
| Dome uplift. Overlapped sediment anticline. | |
|  |  |
| Disjunctive tectonic disturbance. | |
|  |  |

## Interpretation

According to the results of satellite imagery interpretation formal interpretation scheme (Fig. 1) was plotted, showing all visual rings, arcs and linear structures.

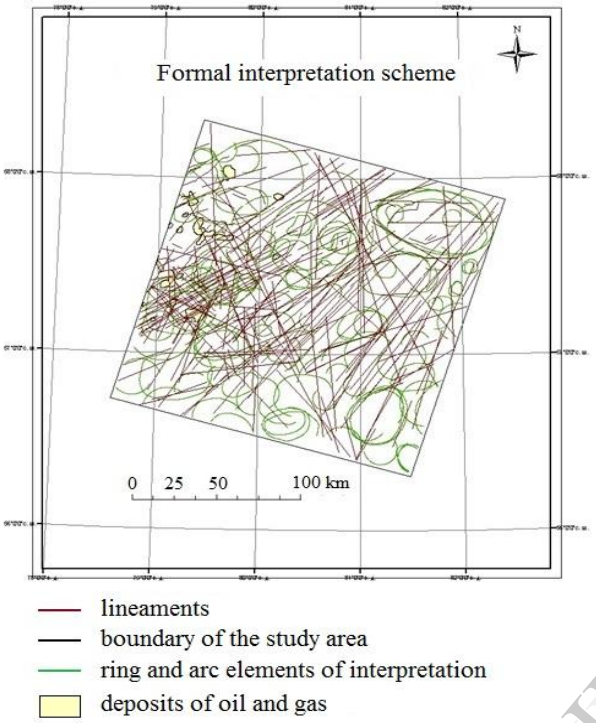



Fig. 1. Formal interpretation scheme

The analysis of above-mentioned scheme shows that the lineaments form tufts and zones in different directions of significant extension and thickness. To verify this hypothesis: these areas are reflections of deep fault tectonics, the layout of hydrocarbon deposits was attached to a card. The location of these objects is controlled by linear and circular structures identified through interpretation.

After analyzing formal interpretation scheme the second scheme reflecting areal tectonic structure: domed uplift, depression and main faulting directions (Fig. 2).

Imposing contours of hydrocarbon deposits, it is obvious that all deposits are confined to domed uplifts (Fig. 3).

Interpretation of ring and arc structures were based on the data obtained by the imposition of formal scheme of interpretation to the images of modern relief and comparing datafrom 80 channel multispectral image with high spatial resolution (Fig. 4, 5).

According to analyzed and compared data with data of areal geological structure area, the following structures were identified: synform - depression and antiform - uplift domed structure and linear zone of heterogeneity - fault tectonics (Fig. 3, 4, 5).

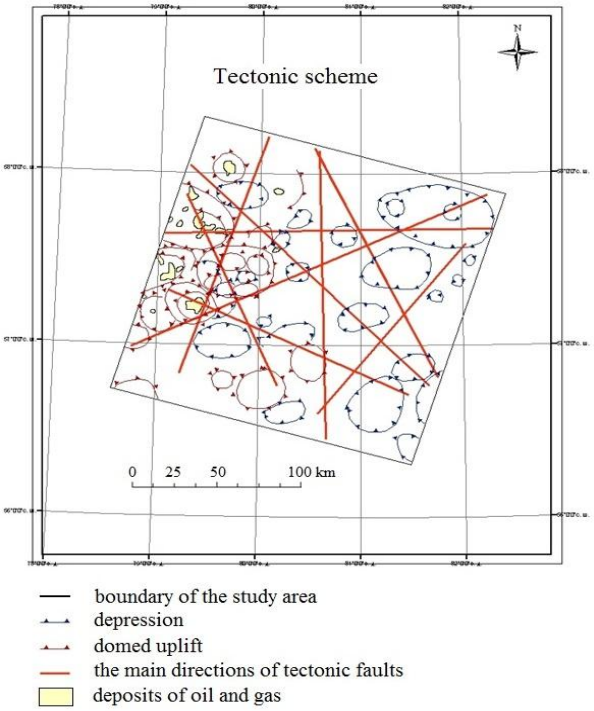



Fig. 2. Tectonic scheme based on the analysis of formal interpretation

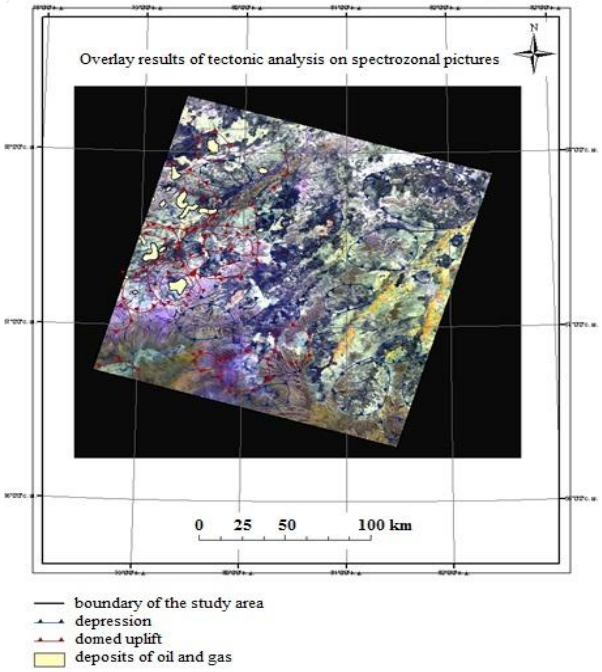



Fig. 3. Overlying ring and arc structures on spectrozonal image

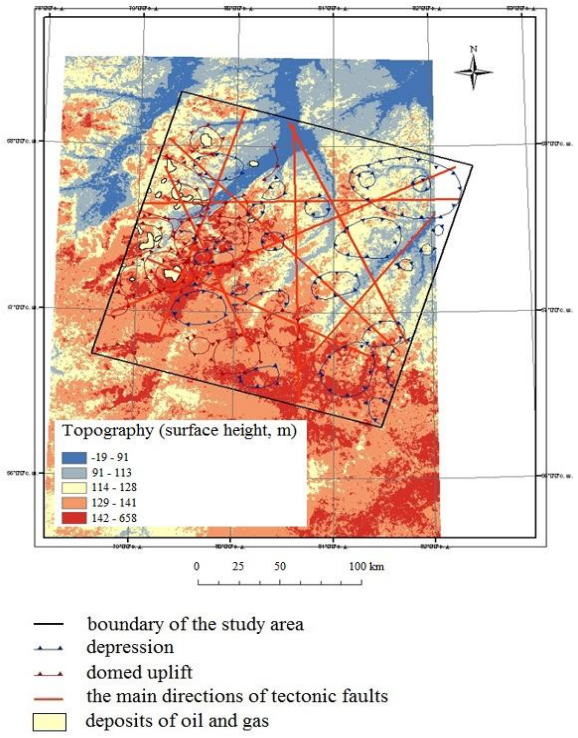



Fig. 4. Correlation of tectonic structures to modern territorial topography

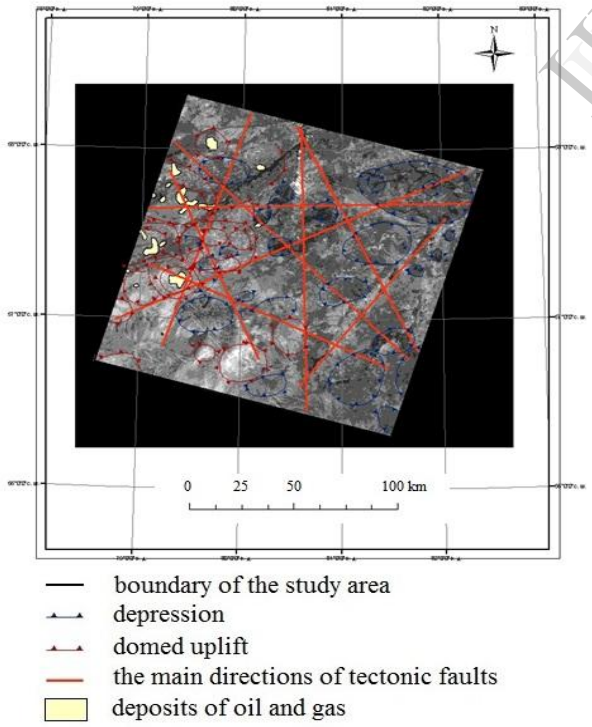



Fig. 5. Comparison of data obtained from analysis of tectonics through spectral image (80 channel)

Fig. 6 shows a simplified scheme of the formation of hydrocarbon deposits in Kazanskoe field based on the visual interpretation of obtained data (Figure 7).

Such an in-depth study of oil field structure in Tomsk Oblast could be possible only as a result of interpretation of geophysical data. Due to advanced computer technology and remote sensing methods geologists have the opportunity to analyze such geological structures based on remote measurements.

The advantage of remote sensing is wide-scale focused study of geological structures within territories of different sizes from the planetary and regional to local level. Based on integrated approach, the data obtained from interpretation can be used to predict the on prospect areas of oil and gas condensate.

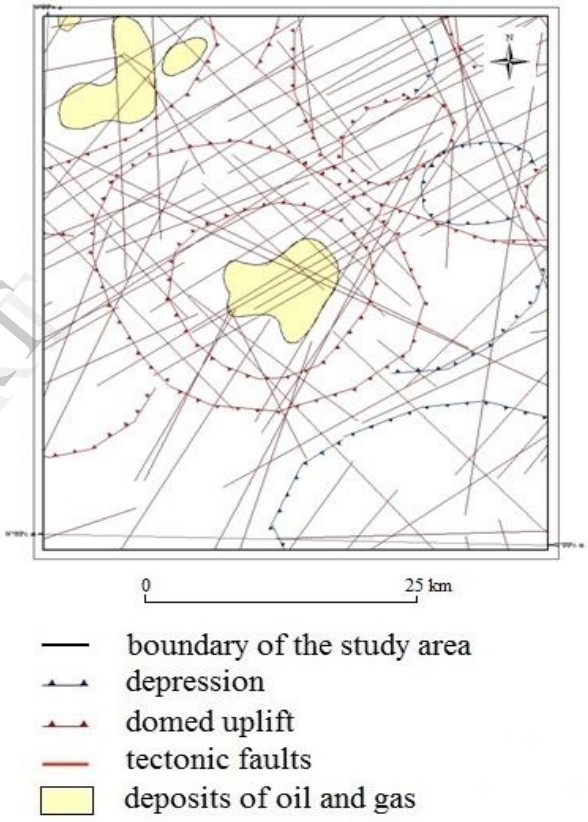



Fig. 6. Map fragment of tectonic faults in Kazanskoe field

## Results

Based on obtained results, the following conclusions were described:

(1) hydrocarbon deposits are confined to domed uplifts as antiform bodies at depth, including smaller tectonic structures (Fig. 6).

(2) areal geology embraces a system of faults and fractures, indicating the possible migration path of hydrocarbons (Fig. 7).

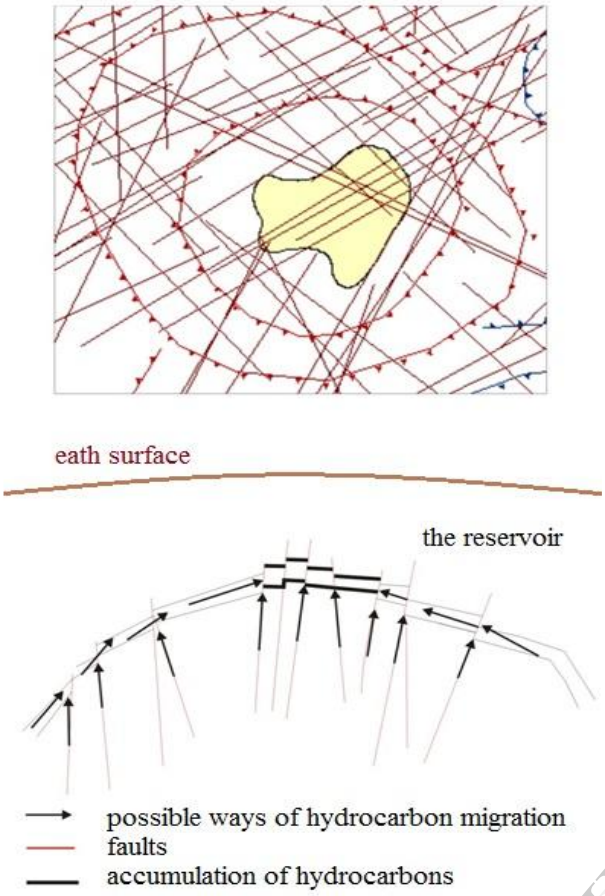



Fig. 7. Simplified scheme of deposit formation

Although the determination of existing deep tectonic structures in oil fields of Tomsk Oblast was based on geophysical survey, nowadays analysis and interpretation of geological data is based on satellite images. Revised geological structure models and deep structure correlation define hydrocarbon deposit formation and on prospect of future deposits.

Division ring and arc structures into positive and negative is due to satellite imagery processed in ArcMap (Landsat ETM + 80 channel), positive structures - lighter shade, negative - darker photo shade (Fig. 5), as well as, correlating relief data to scheme of formal interpretation.

Large domed uplift confined to majority of deposits are deciphered by cosmo pictures as arc and ring structures. When applied to obtained scheme of oil and gas contours, above-mentioned contours were distinctly confined to the central part of the ring and arc structures.

As seen in Fig. 2, these structures are complicated by faulting mainly north-east and north-west strike. In schemes the main directions of tectonic faults in studied area (Fig. 8).

As seen in Fig.4 systems of faults are reflected in the present relief: the river system within the territory is confined to major tectonic faults.

More precise analysis of fault tectonics was based on schemes reflecting density of lineaments with certain azimuth, classification of alleged faults and rose-diagrams.

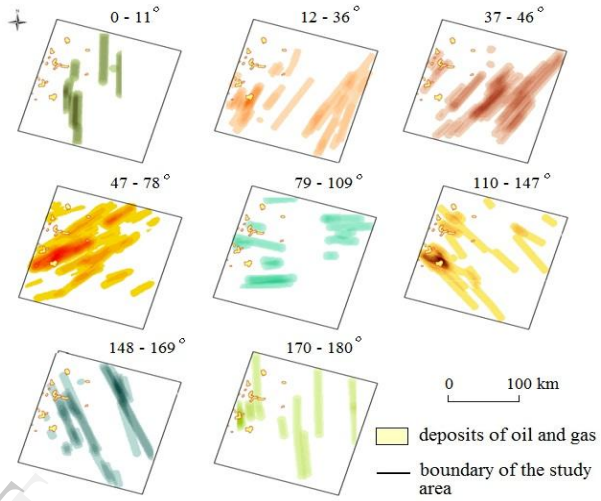



Fig. 8. Scheme showing density of lineaments with 0-180 degrees strike azimuth°

Fig.8 shows density of lineaments (faults). According to these schemes, as well as, the classification scheme of lineaments (Fig. 9), it can be concluded that the oil fields are controlled mainly by two major fault orthogonal systems: north-east and north-west strike.

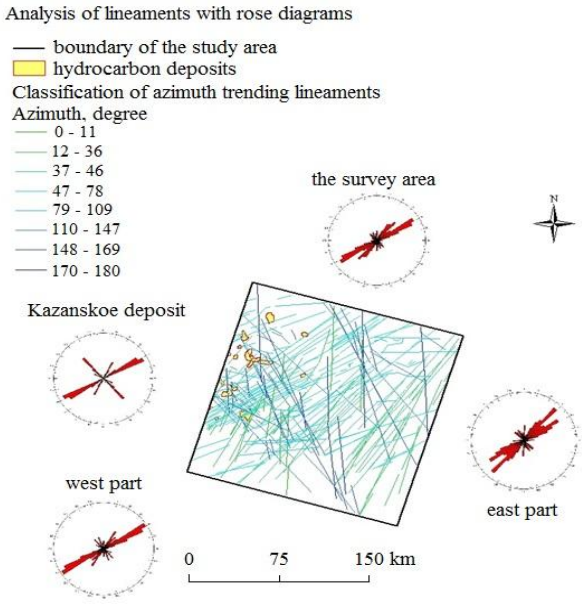



Fig. 9. Classification of azimuth trending lineaments with Rose diagrams

## Conclusion

Thus, the interpretation of remote sensing data and various geological and geophysical survey methods detect preexistent tectonic structures that control oil and gas fields. What is the role of fault tectonics in the formation of oil and gas deposits?
Further, indirect evidence based on interpretation of space data highlighted the significant effect of faulting on the distribution and origin of hydrocarbon deposits.
It has been proved that abnormal flooded areas of the surface coincide with distribution areas of oil and gas fields irrespective of the terrain. This is consistent with the current hypothesis of the "hydrocarbon breath" of the Earth, which is supposed to generate large amounts of methane from the depths to the upper layers of the lithosphere and then convert it into complex hydrocarbons and water. In other words, a portion of the water surface can have hypogene origin migrating through discontinuous conductive structure [5].

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