



THE DEVELOPMENT OF THE IMPLEMENTATION OF SPACE TECHNOLOGIES: A CASE STUDY OF THE FERGANA VALLEY (UZBEKISTAN)

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ABSTRACT

The paper presents an overview of automated methods for interpretation lineament and ring structures from satellite imagery data. The methods are presented to analyze lineament and ring structures in the Fergana Valley (Uzbekistan). As a result of automated processing, it is planned to obtain separate maps of lineament and ring structures, the distribution density of lineaments, spatial orientation of lineament structures, rose-diagrams, etc., which will be entered into the GIS for constructing a thematic map of the distribution of lineament and ring structures in the Fergana Valley.

KEYWORDS: *analysis of lineament and ring structures, automated interpretation method, modern satellite technologies, ASTER, Landsat 8.*

DISCUSSION

Space technologies are the area of concentration of the latest achievements of humanity, the scientific and technological progress, and the solution of global, interstate, state, and regional problems. Space technologies make a significant contribution to the development of science and technology, economics, and informatization of society. The world practice shows, the development of space technologies and the use of remote sensing data, satellite communications, and navigation can significantly increase the efficiency of solving key problems of ensuring national security and socio-economic development of countries and regions.

The attraction of advanced technologies, the development of high tech industries is one of the priority goals for the Republic of Uzbekistan. This is especially true for the creation of new modern industries. In this direction, in recent years, special attention has been paid to the development of its space industry and the attraction of space

technologies. To effectively implement the existing scientific and technical potential for the further sustainable development of the country, including through the use of innovative space technologies in various spheres of the economy, as well as ensuring the security of the Republic of Uzbekistan, the President signed a decree on the establishment of the Agency for Space Research and Technologies under the Cabinet of Ministers of the Republic of Uzbekistan (Agency «Uzbekkosmos»). For the active development of space technologies, Uzbekistan plans to closely cooperate with countries such as India, France, China, Germany, USA, etc. Along with Uzbekkosmos, the country will actively carry out activities in the field of space research and technologies, such as remote sensing, satellite communications, navigation systems that can increase efficiency in areas such as agriculture and water management, ecology, telecommunications, geology, cartography, meteorology, seismology and urban planning [1].



Due to modern satellite imagery and geographic information system, it is possible to interpret and analyze lineament and ring structures. Ring structures on the Earth's surface have been known to geologists for a long time. However, with the advent of space data, the possibilities for their study have expanded. Almost every researcher analyzing a satellite image of a region discovers one or more ring formations, the origin of which in many cases remains unclear. Ring structures are rounded, single, or concentric local formations resulting from internal and external processes [2].

Lineaments are linear and arcuate relief elements associated with deep faults. These linear elements can represent natural morphological fragments or fragments of an anthropogenic nature (roads, watersheds, etc.). Structural heterogeneities of rocks and other features associated with the tectonic activity are the results of morphological lineaments (cliffs, faults, etc.). Lineaments can be expressed as linear depressions, linear breaks in slopes, or ridgelines. Lineaments typically represent fault zone trends or large, systematic junction trends [3]. Lineament analysis (structure, variability) is of great importance for predicting hazardous phenomena and processes, predicting seismic events, determining zones of structural breaks and deep divisibility of the earth's crust, discovering minerals [4].

In many scientific research works, there is a connection between lineament systems and tectonic faults. R. Ramesh Kumar T. (1991) notes that the intersection points of the lineaments are places of increased fracturing of the earth's crust and, as a result, such places are places of development of modern exogenous and endogenous processes [5].

There is a huge variety of methods and algorithms for processing satellite data to carry out semi-automatic and automatic data decryption to extract lineament structures on the Earth's surface. E.A.Ali et al. (2012) extracted lineament structures from the Landsat ETM + 7 to determine the lithological and structural features of the area around Abidia in northern central Sudan. Filtering and Intensity Hue Saturation (IHS) was applied to the image to improve spectral and spatial characteristics. The resulting regional lineaments are used as a basis for creating geological and structural maps through visual and ground processing [6].

F. Al-Nahmi et al., (2016) developed a method for visual extraction and mapping of lineaments from Landsat 8. Each spectral channel of the Landsat 8 satellite is used for specific purposes, for example, band 7 is better suited for allocation of geological deposits, band 5 - to distinguish between soils and rocks and band 3 - to distinguish soil from vegetation. Based on this relationship, they used tools such as Minimum Noise Fraction (MNF) with a 4, 5, 6 bands combination, color composition (RGB) of a

bands combination 7, 5, 3, Principal component analysis (PCA) with a 4 bands combination, 5, 7 and the ratio of the bands is 7/5, 6/4, 4/2. They also applied direction filters. The results of processing with PCA and MNF made it possible to clearly and easily identify lineaments. And the use of RGB results allowed the identification of various geological formations. This approach to processing satellite data made it possible to explain that the structural, geological, and tectonic structure of the study area [7].

Hermi S.O. and others (2017) provides a method for extracting lineament structures from Landsat 7. This method consists of 5 procedures: Principal Component Analysis (PCA), image enhancement using histogram equalization technique, using Sobel filter, histogram segmentation, and binary generation. This method is used to identify the identification of several faults in the study area. Carrying out a statistical and spatial analysis of lineaments, to determine the different morphological state of lineaments. A comparison of the results obtained with ground-based geological maps revealed that the extracted lineament structures from satellite images were identified as faults and most of the lineament structures were associated with tectonic movement [8].

Zlatopolsky (1992) presented a new program for the automated extraction of lineament structures LESSA (Lineament Extraction and Stripe Statistical Analysis). In experimental testing, the results obtained in LESSA reflect the picture of the image and practically does not depend on the applied procedures and their parameters. LESSA can be applied to both optical and radar data, as well as aerial photographs and digital elevation models (DEM). Today, the program has been used for various applied problems in the forecast of minerals, geodynamics, seismology, etc. The results obtained were compared with visual interpretation and geological data [9].

Bouramtane T. et al. (2017) developed an algorithm in MATLAB. The proposed automatic lineament detection approach is based on the Hough transform method. This algorithm identifies linear features in satellite images of optical and / or synthetic aperture radar (SAR) using a set of mathematical calculations. The algorithm was applied to two different types of satellite imagery Landsat 8 and SAR Sentinel - 1A. The results were compared with visual interpretation results based on spatial filtration and tectonic data collected in the field. It was noted that the result of most of the extracted lineaments using the algorithm is similar to the results of spatial filtering. This approach can be used to automatically highlight the geological lineament with acceptable accuracy [10].



The LINE module has been developed in PCI Geomatica software for the automatic extraction of lineament structures. The principle of the module is to extract linear objects from raster images and save the output data in vector format. The LINE algorithm consists of three main processing steps: edge detection, thresholding, and curve extraction [11].

The LEFA (Lineament Extraction and Fracture Analysis) program, performed in the MATLAB, allows lineament analysis based on automatic interpretation of satellite images. The program includes preliminary processing, algorithms for detecting contours, selecting linear elements, accounting for the number of linear elements,

exporting the results obtained in GeoTiff and *shp formats. LEFA has several detection algorithms for edge recognition. A Hough transform is applied to the raster images to identify cracks on the earth's surface. The parameters of the desired curve form a space that is created based on searching for local maxima and filling the so-called accumulator array using the voting procedure [12].

The study area was chosen as the territory of the Fergana Valley (Uzbekistan). The Fergana Valley is the largest intermountain depression in Central Asia. The valley is located in the eastern part of the Republic of Uzbekistan and borders the Republic of Tajikistan and Kyrgyzstan.

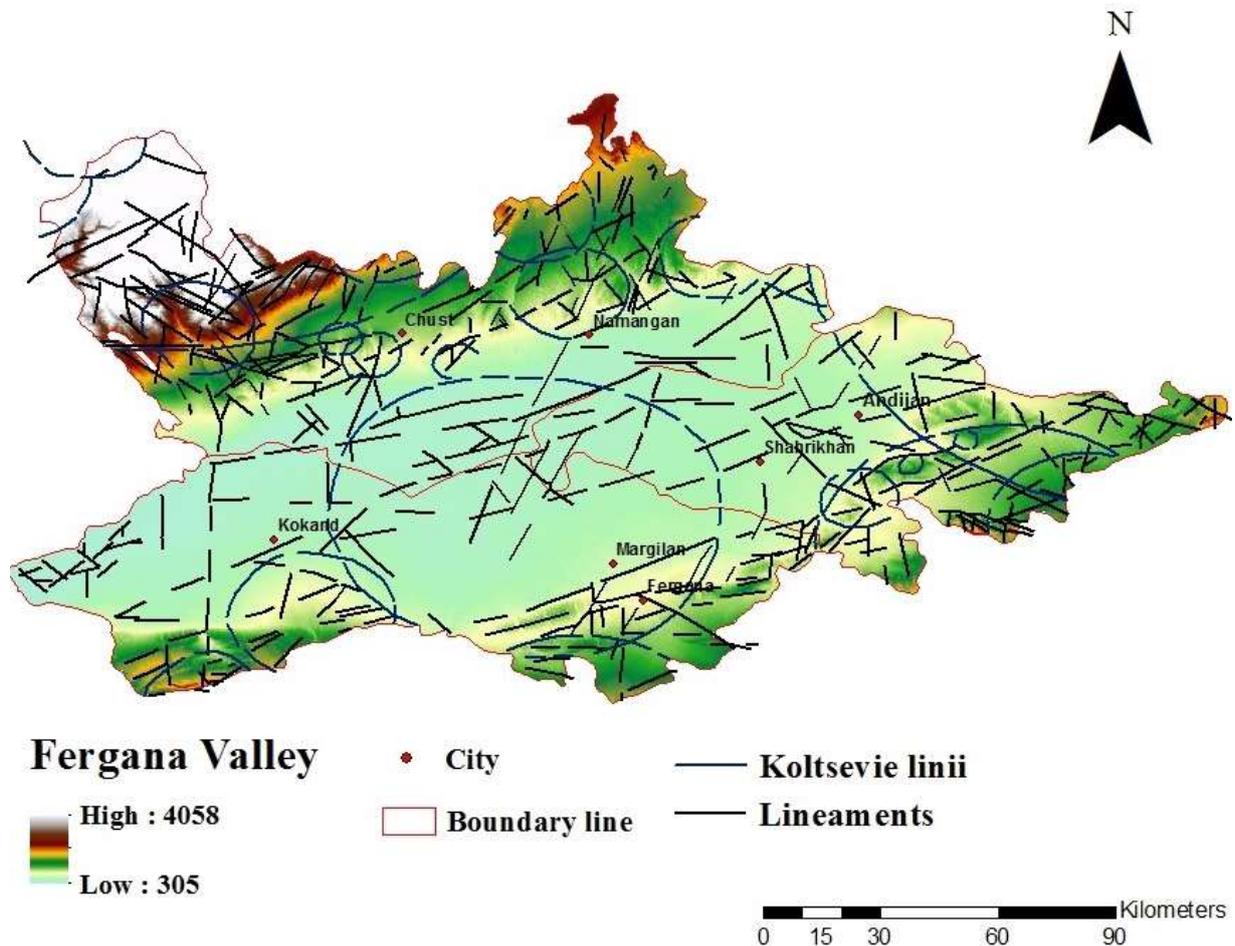


Figure 1. The territory of the Fergana Valley according to the Aster GDEM with geological lineaments and ring structures.

For the analysis of lineament and ring structures, modern satellite data from Landsat-8 and ASTER GDEM will be used. Landsat-8 is an American Earth remote sensing satellite, the eighth in the Landsat program, created jointly by NASA and USGS. The satellite was launched into orbit on February 11, 2013. Landsat-8 surveys in the visible

wavelengths, in the near-infrared and thermal wavelengths, and also surveys in the panchromatic band. The spatial resolution of the images is 30 and 15 meters [13]. The ASTER GDEM product was developed jointly by METI and NASA based on data from the ASTER sensor on the Terra satellite. The sensor has the capability of stereoscopic imaging



along the flight path using two telescopes that take pictures in the nadir and backward in the near-infrared wavelength with a resolution of 15 m. To create the ASTER GDEM digital elevation model (DEM), automatic processing of the entire ASTER data archive, about 1.5 million scenes. In 2011, an improved version of the DEM was created - ASTER GDEM Version 2: new scenes added, bugs fixed [14].

The analysis of space data for the interpretation of lineament and ring structures will be carried out in an automated method using modern software. It is planned to involve software such as ENVI, LEFA, and ArcGIS. As a result of automated processing, it is planned to obtain separate maps of lineament and ring structures, the distribution density of lineaments, spatial orientation of lineament structures, rose-diagrams, etc. All the results obtained will be entered into the GIS to create a thematic map of the distribution of lineament and ring structures in the Fergana Valley.

The use of modern satellite data for the identification and analysis of lineament and ring structures in visual and automated processing greatly facilitates the work of the decoder. Modern satellite data cover a huge territory of the Earth, and also hard-to-reach regions. GIS technologies, along with the use of remote sensing data, allow considering, comparing, analyzing individual maps of the thematic layer, as well as combining all layers into one map, which will lead to a more detailed analysis of the distribution of lineament and ring structures in the Fergana Valley. In conclusion, from the above, it follows that in the theoretical and practical part of the lineament analysis using satellite data, it is currently inactive development. Many scientists assess the relationship between lineaments and their characteristics when studying natural and anthropogenic objects and processes. It should also be noted that some research works are devoted to the determination of the places of deposits of minerals and groundwater, along with the discovery of lineaments of the place of their increased accumulation.

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