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Samariddin Rabbimkulov
Tashkent State Technical University named after Islam Karimov, rabbimkulovsamariddin@gmail.com

Abdulla Almordonov
Tashkent State Technical University named after Islam Karimov

Akmal Asadov
University of Geological Sciences, Tashkent city, Republic of Uzbekistan

Abdimutal Tangirov
Tashkent State Technical University named after Islam Karimov

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IDENTIFICATION OF INTRUSIVE MASSIFS IN THE NURATA MINERALIZED ZONES BASED ON SATELLITE IMAGES

A.R.Asadov[1], A.R.Almordonov[2], S.A.Rabbimkulov[2], A.I.Tangirov[2]
[1]University of Geological Sciences, Tashkent city, Republic of Uzbekistan
[2]Tashkent State Technical University
University St ,2 100095, Tashkent city, Republic of Uzbekistan

Abstract. *The article presents the results of processing space images using PCA, ISODATA, K-Means and similar methods, as well as analysis based on GIS technologies. As a result of automatic and visual interpretation of the obtained images, intrusive complexes, linear and ring structures scattered throughout the Nurata region were identified. In particular, the result obtained by X-ray diffraction analysis proved that the composition of the 2R4G1B and 2R4G3B channels is one of the most effective methods for separating the intrusive massifs distributed in the region. Given that isolated intrusive massifs, linear and ring structures are directly related to gold mining zones in the Nurata region, the results obtained can be assessed as a cosmological criterion.*

Keywords: *satellite image, PCA, principal component analysis, photon, Nurata mineral zones, spectral channel, classification, Isodata, K-means.*

INTRODUCTION. The classical theory and methods of exploration from ancient times were based on the study of rocks in natural conditions. It has been repeatedly noted in the scientific literature that the mineral deposits of the Nurata mountains are associated with intrusive rocks. A number of researchers have carried out observational work to

determine gold production from space data in the structural-formational zones of Northern and Southern Nurata [1-5]. In particular, cosmogeological research in the region of Uzbekistan O.M. Borisov and A.K. Glukh revealed ring structures of different levels in a number of separate areas of the Nurata region [2]. L.I. Ivanov G.A. Aleshina and others.

Special mention should be made of research work on the creation of geological maps based on deciphering materials of satellite images with a scale of M 1:200000 in the region of the Karatau mountains of South Nurata [3]. As a result, faults, linear and ring structures were identified on cosmogeological maps. It should be noted that most of them are not reflected on geological maps of different scales. In addition, it was found that the Nurata mining zones are bordered by intersections of lineaments in different directions.

As a result of special observational work on a scale of 1:200000 and 1:50000 in Nurata and adjacent areas, specialists from the Institute of Mineral Resources and the Earth Remote Sensing Department Sh.E.Ergashev, A.K.Glukh, A.R.Avezov, A.Toychiev, M.Kh.Khodzhibekov, A.K.Nurkhodzhaev, A.R.Asadov, based on space data, developed the scientific foundations of cosmophotogeological mapping [1-2; 4-6].

In addition, geomorphological elements have been identified that reflect modern movements in the relief of this area. The mutual geodynamic conditions of the material composition of rocks and deposits, reflected in different channels of modern satellite images, are described, with the structure divided into photogeoblocks. It should also be noted the scientific research carried out in recent years by A.K. Nurkhodzhaev and I.S. Togaev in this area. At the same time, such tasks are solved as the creation of complexes for structural interpretation by color, structure and spectral clarity of images when various rocks and various tectonic structures are detected on satellite images and the selection of structural elements in open and closed areas by automatic and visual interpretation of images. [4,5].

The study of the features of the geological development of the Nurata mountains has not lost its relevance in our days. This article presents some aspects of the results of cosmogeological studies of the Nurata mountains in the southern part of the Tien Shan Range in Uzbekistan.

MATERIAL AND METHODS. To study the signs of intrusive rocks in the Nurata mineral zones on Landsat 8 space images using modern geographic information systems, the following set of methods was used. Landsat 8 satellite images were processed using ENVI software using basic component analysis (PCA), automatic classification (based on ISODATA and K-Means algorithms), the results of these methods are discussed below. Basic Component Analysis *(PCA)* is a method for analyzing multispectral cross-linked data. Related data shows that as the brightness of pixels in one spectral channel increases, the brightness of other spectral channels also increases. The result obtained by this method showed the features of the geological structure of the Nurata region.

At the same time, rocks of different ages and compositions were separated on satellite images according to the signs of different photographic reflection [7-9]. Based on the combinations of RGB results obtained by the PCA method, deposits of different periods were distributed in the region. However, when expressing the multispectral properties of the Nurata region, a correlation was made between several channels of satellite images.

As a result of the synthesis of the obtained images of the color space, it was found that the boundaries of coeval deposits and zones of intrusive massifs are reflected in the brightness values of several spectral channels (Fig. 1).

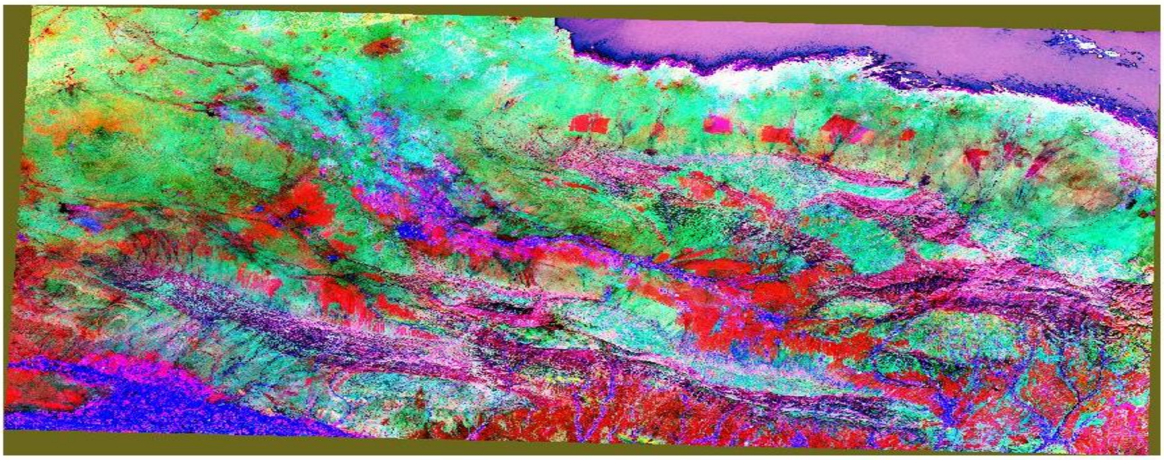

Fig. 1 Satellite image of the Nurata zone processed by the PCA method (RGB-PC5, PC4, PC3**)**

Automated Classification Methods. Classification is a computer interpretation of images or the process of automated division of all image pixels into groups (classes) that correspond to different objects. Automated classification is a process in which the distribution of image pixels occurs automatically, based on the analysis of the statistical distribution of pixel brightness. It should be noted that before the start of classification, it is not known how many and what objects are present in the image, and after the classification, it is necessary to decipher the resulting classes in order to determine which objects they correspond to.

Automated classification method *ISODATA* (Iterative Self-Organizing Data Analysis Technique). ISODATA is a process based on cluster analysis. One class includes pixels whose brightness values are the closest in the space of spectral features.

ISODATA classification steps:

1) Calculation of statistical parameters of the brightness distribution of the entire image in each spectral zone (minimum, maximum, average value, standard deviation);

2) All image pixels are divided into an equal range in the space of spectral features, for each of them the average value is determined;

3) The first iteration of clustering, that is, in the space of spectral features for each pixel, the spectral distance to the average values is calculated, and each pixel is assigned to a specific cluster. One cluster includes those pixels, between which there is less distance in the space of spectral features;

4) Calculation of real average values for the received classes;

5) The next iteration with new values of the averages, and refinement of the class boundaries, while the number of classes may change.

The process continues until the maximum (preset) number of iterations is reached or the maximum percentage of pixels that have not changed their class during the last iteration is reached (this parameter is also set in advance). The resulting image, classified based on the ISODATA algorithm, reflects the mineralization characteristics of the Nurata region (Fig. 2). When determining the material composition of the intrusive massifs belonging to the northern and southern Nurata area, the pixels with the closest brightness values in the range of spectral properties of the same class were used. Method for automated classification of K-Means. It differs from the ISODATA method in that it requires initially setting a certain number of average values to form the initial classes, therefore, this method is used when the objects in the image are quite well distinguished.

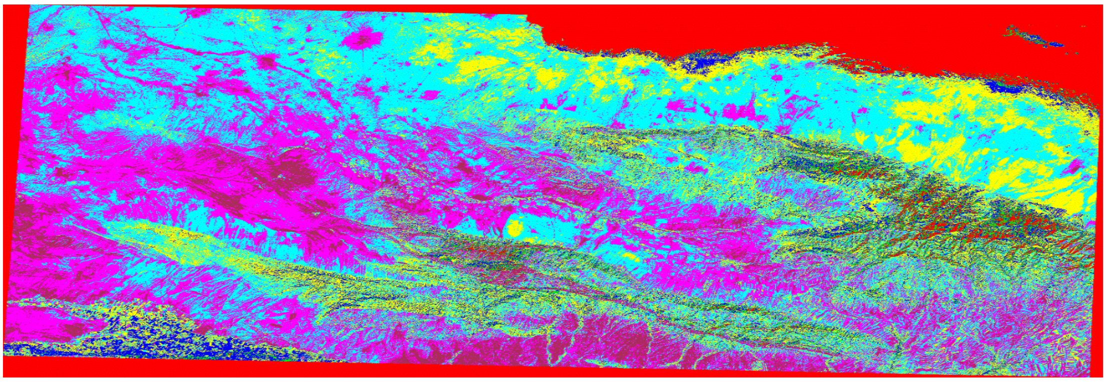

Fig. 2 Result of automatic classification by ISODATA method

After classifying the satellite image of the Nurata region, it was divided into different color classes after several iterations of the image. According to the results of the analysis, this method quite clearly distinguishes objects in the image (Fig. 3).

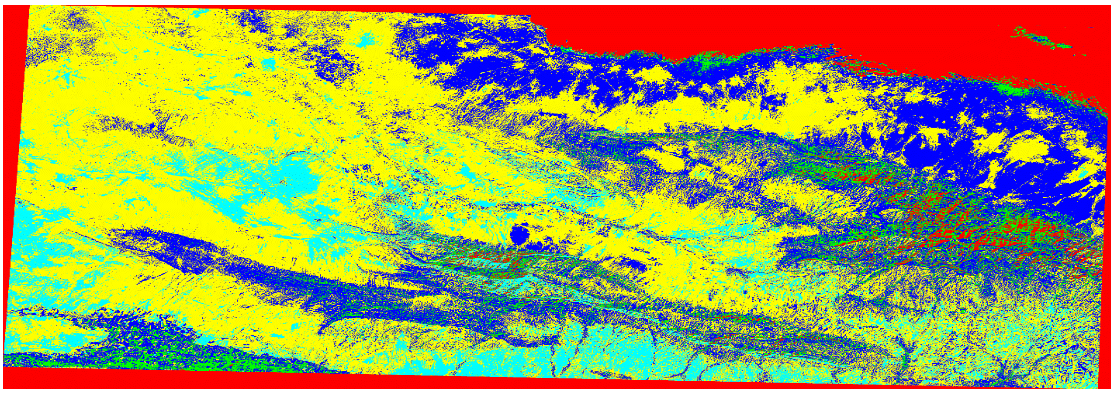

Fig. 3 Result of automatic classification by K-means method

The above algorithms tested by us are implemented in the ENVI software package, designed for the analysis of multispectral and hyperspectral images. The use of the IDL (Interactive Data Language) programming language, on which the ENVI software package is implemented, makes it possible to process large data sets, such as satellite images.

RESULTS AND DISCUSSION. Let us dwell on some aspects of the study of the morphological formation of the intrusive massifs of the Nurata mountains. The Temirkabuk intrusion is located in the northwestern part of the northern Nurata mountains. In the western part of this intrusion, granadioritic and granitic intrusive rocks are formed. The intrusion belongs to the upper carboniferous with granadiorite, adamellitic and granitic rocks in the north and granadiorite, adamellitic-granite and gabbro-diorite rocks in the west. Madavat intrusive complexes also consist mainly of granadioritic and granitic rocks.

The age of the isolated complex belongs to the carboniferous age. In the PCA combination 2R3G7B of these two intrusive complexes, the northwestern parts of the Temirkabuk intrusion are depicted in very light green, the central and southern parts in purple, and the eastern part in green. In the western part of Northern Nurata there is the Madavat intrusion. At the same time, on different channels of satellite imagery, the southwestern and adjacent areas of the intrusive massif were reflected in blue photons by the PCA method. The northeastern areas were bright red.

In addition, the Ustuk intrusive complex in the central part of Northern Nurata is also composed of granites and granidiorites. Here, these rocks are associated with a high-carbon age. However, in the central part of the intrusion there are granites, mainly related to the permian period. At the same time, these complexes are well represented on satellite images; the southeastern flanks of the Ustuk intrusion are colored light green and purple, and the northeastern flanks are purple-red (Fig. 4).

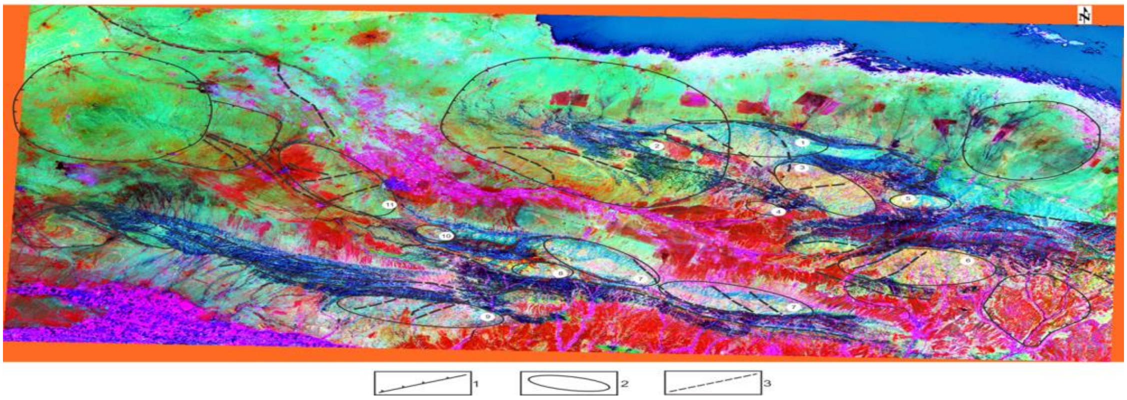

Fig. 4 Map-scheme of representation of zones of civilization of the Nurata region on satellite images

Legendss: 1-ring structures; 2-intrusive arrays; 3 cracks.

Also, granites and granodiorites belonging to the Sentob intrusive are expressed in brightness in different channels of the classification result obtained by the ISODATA algorithm. At the same time, in the northeastern part of the Koshrabat intrusion, dacite-diorite intrusive rocks were well manifested in light phylolitic photon shades. In general, the location of some intrusive bodies is distinguished by its protruding shape and spectral brightness in satellite images. Such bodies have a classic appearance in the northern and southern parts of the Nurata mountains. Manifestations of the Akchop and Sentob intrusions in the North Nurata mountains are interpreted with high accuracy on large-scale satellite images. In the Akchop intrusion, granites (C_3) are composed of leucocratic granites (C_3) in the body. Since granites are composed of large granular crystals, their spectral brightness was more pronounced than that of other rocks.

In the 2R4G1B combination of the resulting Aktau intrusion PCA image, the northwestern portions are colored purple and reddish, while the southern and northeastern portions are shown as purplish light yellow photon markers. The Nurata intrusion and the Yangaklik intrusion are purple-light green, in combination 2R4G1B the northwestern part is dark red, the northern and southwestern parts are blue-yellow, the Karatov intrusion is light yellow.

CONCLUSION. Processing of space images by PCA, ISODATA, K-Means and similar methods and analysis based on GIS technologies gives a reliable result when identifying intrusive massifs in the Nurata ore zones. When identifying several intrusive massive zones and boundaries in the North and South Nurata region, the photon in combinations 2R4G1B and 2R4G3B is characterized by a clear separation of bluish-yellow and light purple hues. It has also been established that existing sections correspond to different levels of lineaments, ring structures and soil cracks in the selected zones. These criteria can be assessed as a new approach to identifying and mapping gold mining zones in the Northern and Southern Nurata region.

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