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LINEAMENT ANALYSIS OF FREE SPACE IMAGES IN LEFA SOFTWARE

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LEFA software product and its capabilities to identify lineament structures in free Landsat-8 space images are described in the article. The results obtained by the LEFA software are compared with the results of other authors.

Nowadays, remote sensing is the most important tool for research in various Earth sciences, including geodynamics. Only remote sensing can provide continuous spatial data of an areal nature. Resources with free access to data (USGS, remotepixel.ca, scihub.copernicus.eu et al. [5,7,9]) allow us to obtain information about the earth's surface in any territory in different epochs. Methods of processing remote sensing materials used in geodynamics can be divided into two groups:

– estimation of vertical displacements of the Earth's surface by interferometric processing of a pair of radar images (the most known project that provides freely distributed radar images is Sentinel-1, which consists of two satellites: Sentinel-1 A and Sentinel-1 B);

– identification of active structural elements in images in the visible and infrared bands.

Active structures identified in space images can have a linear stretch (lineaments), or be expressed in the form of ring structures. These structures can be distinguished in space images both by visual decoding and by using various automated algorithms. LEFA (Lineament Extractor and Fracture Analysis) developed by Sergey Shevyrev at the Far Eastern Federal University (Vladivostok, Russia) is one of the software products that makes an automated lineament analysis. The interface is shown in the figure 1. The product is developed on the MATLAB platform. It allows a user to perform such things as image binarization (edge detection), line detection by the Hough transform, combining lines into linear structures (faults), calculating the fractal dimension of fault systems, creating rose diagrams of the line distribution in length and direction; export the lines into a shapefile.

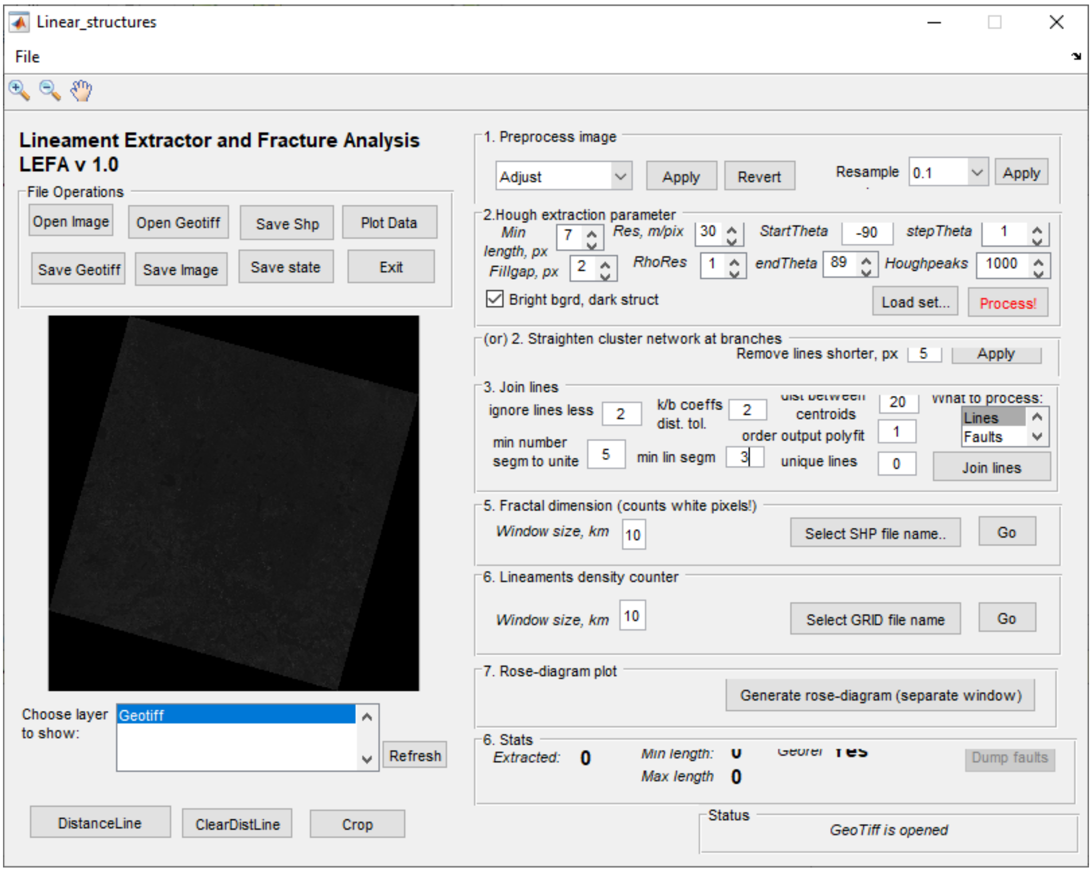

Figure 1. – Main window of the LEFA software

As the input data, the program can use grayscale images in the form of a digital elevation model (DEM), and in the form of a single-band space image. It was experimentally proven that the program was effective when processing the SRTM DEM and Landsat-8 satellite images (obtained from remotepixel.ca).

Landsat-8 data has a resolution of 15 meters in the panchromatic mode, 30 meters in the visible mode, near and short-wave infrared range, and 100 meters in the thermal infrared range. The sensing period is 16 days.

Among the possible alternatives, we can consider the images of the Sentinel-2 satellite, which have a spatial resolution in the visible range of 10 meters, 20 meters in the short-wave infrared range, as well as meteorological satellite data (TERRA (MODIS), SUOMI-NPP) with low resolution and large spatial coverage.

As the author of the program recommends, we used the 7th band of the Landsat-8 image (short-wave infrared range, with a wavelength of 2.1-2.3 microns) on the territory of the northern part of the Vitebsk region, including the Polotsk district, on various dates (table 1). Preference was given to spring and autumn images with poorly developed or withering vegetation.

Table 1. – Landsat-8 images, selected for study

Date	Cloud cover	Brief description of the conditions
11.04.2015	0,21	There is no snow cover, poorly developed vegetation
28.03.2016	1,32	There is no snow cover, poorly developed vegetation, water basins are covered with ice, light clouds are in the northeastern part.
23.09.2017	0,02	There is no snow cover, well-developed vegetation
12.10.2018	0,00	There is no snow cover, withering vegetation
06.04.2019	0,04	There is no snow cover, poorly developed vegetation

Each of the images is preprocessed according to the Canny algorithm [3,4]. A number of authors consider this algorithm to be optimal [2,8]. Then, we perform the Hough transformation, leaving default parameters (figure 2).

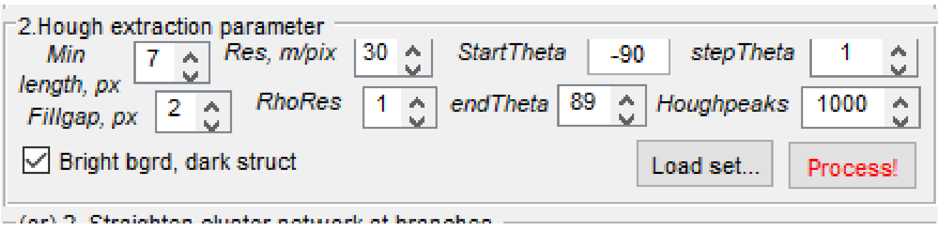

Figure 2. – Hough algorithm parameters

After finding the lines, the program joins the collinear lines into faults. We join lines (figure 3). The final fault will include at least 5 lines, with the minimum length of the fault being 2 km.

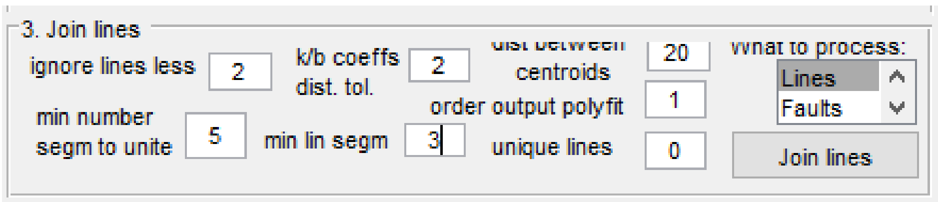

Figure 3. – Lines join parameters

We displayed the resulting faults for each epoch in the GIS-project in QGIS (figure 4, 5). As expected, the pattern of the fault network differs for different images due to different vegetation conditions, cloud cover conditions, and light conditions. However, comparing the images for different epochs, we can see that our study confirms the existence of a large latitudinal strike fault to the north of Polotsk, as well as a number of north-west – south-east strike faults. It should be noted that a number of identified structures correspond to linear objects of clearly anthropogenic origin – roads, forest clearings, etc. Such lines will not be taken into account when interpreting the result.

Figure 4. – Fault network obtained from the image on date 12.10.2018

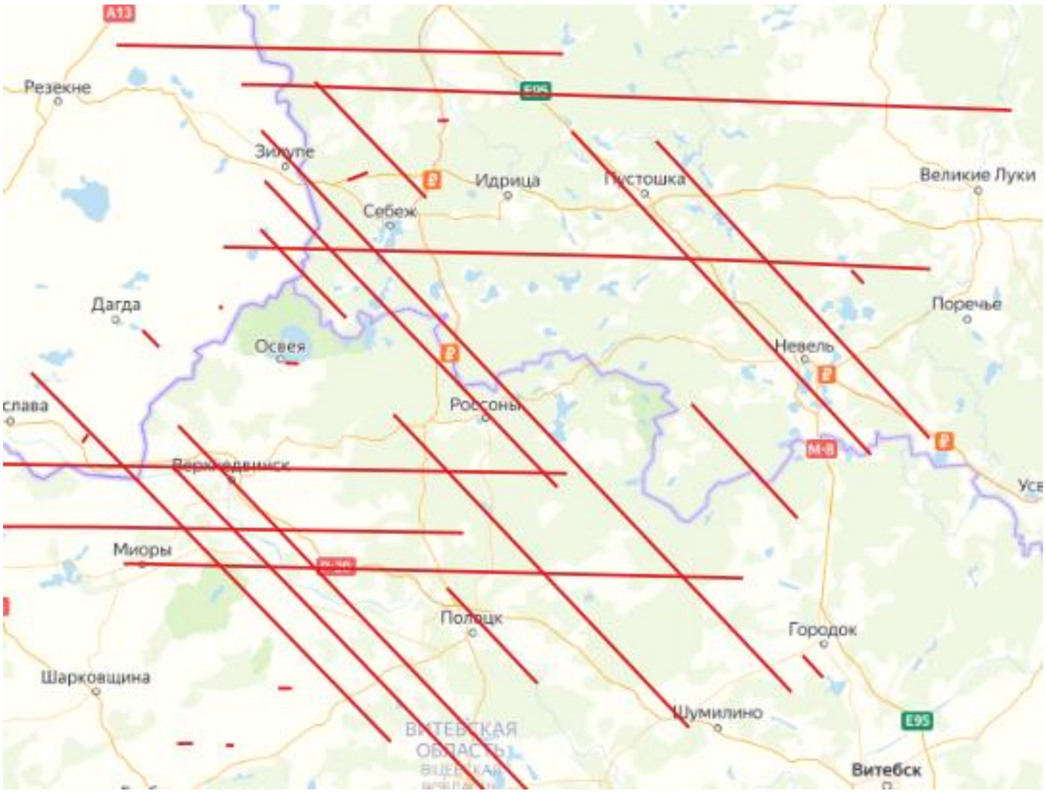

Figure 5. – Fault network obtained from the image on date 06.04.2019

We compared the resulting pattern of the fault network with the one presented on the cosmotectonic map by Garetsky, Karataev, etc. (figure 6). We can note that the directions of the main linear structures obtained by us in this region coincide to the data according to the cosmotectonic map. It can be concluded that the LEFA software product is informative for the study of the fault network based on images from the Landsat-8 satellite. Further study requires to identify algorithm parameters, as well as to develop the possibility of processing survey data from thermal, magnetic, gravimetric and other sensors.

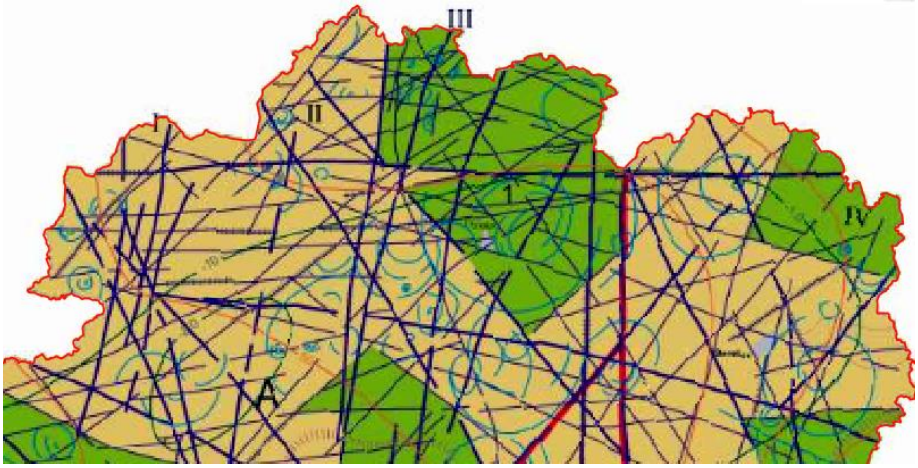

Figure 6. – A fragment of the cosmotectonic map [1]

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