Application of Remote Sensing Technologies for the Environmental Impact Analysis in Kumtor Gold Mining Company

Zheentaev, E.
The University of West Hungary and National Academy of Sciences of the Kyrgyz Republic
N.Isanov Kyrgyz State University of Construction, Transport and Architecture, Kyrgyzstan
E-mail: erik_jeentaev@yahoo.com

Abstract
Nowadays the Environment Protection having high impact on world's environment, but necessary initiation on the environment issues remain unfulfilled. This research will introduce the environmental impact analysis in Kumtor gold mining by using remote sensing technologies, (VHR WorldView-2 and QuickBird satellite images with possibility stereoscopic, multispectral and panchromatic archive data). These satellite images courtesy of the DigitalGlobe Foundation for this thesis work. After completion of this research will get the results for following: a growth monitoring waste - dumps, horizontal-vertical displacements, determining the area of waste - dumps, measuring the volume of waste - dumps, and one of the main environmental problems associated the storage of huge amount of waste-dumps on the glacier and condition assessment of glaciers and their disappearance.

1. Introduction

Kumtor gold mine is located on the northwestern slope of the ridge Ak-Shyirak (Tien Shan), 60 km from the border with China. The Kumtor gold mine is located at an altitude of 4,400 meters, while gold process leads to the formation of large quantities of waste - dumps, which are in the form of a mixture containing cyanide, and heavy metals, which is stored in special containers (used in the development of about 10 tons of sodium cyanide per year). Developed open pit mine and partly within the territory, which previously had covered with glaciers. Disposal of waste - dumps produced in the upper part of the glacier, as it is assumed that the subzero temperature will contribute to fixing liquid waste - dumps and prevent their spread over a significant area. In the territory of mining located five glaciers, one of them, the (Lysyi glacier) covers the upper part of the mine, (Aitmatov et al., 2012).

The western slope artificial mountain formed by glacier Davydov, under this glacier is flowing river Chon-Sary-Tor, and especially during heavy rains, the clean water converted and flows in it dark gray. It may happen overlap the river Chon-Sary-Tor, the accumulation of water in the dam and its breakthrough, which will present the danger of below located buildings. Further, these harmful elements can freely enter the river Naryn, river system network (Syr-Darya, this is one of the main, largest and longest river in the Kyrgyzstan). The adopted version of storage the waste-dumps on the glaciers has brought not only environmental damage but also an economic problem. Currently, regular and secure gold mining at Kumtor seriously complicates the following geotechnical problems:

- At present, the glaciers which located in the activity area of the mine "Kumtor", not fully carried out the state monitoring of the condition of the glaciers;
- Mass gravitational collapse of high and steep slopes in the northeastern part (stockwork zone) Central open pit mine;
- Deformation and movement of the northwestern side of the Central open pit mine;
- Slip into Central initial waste-dumps and glacier Davydov in the southeastern part open pit mine, in the so-called "zone of strong movements or deformations";
- The progress of the glaciers-rock mass dumps down the river valley. Chon Sarytor the real threat destruction of production facilities and mine infrastructure, (Japarov et al., 2012)

This research deals with the analysis and modeling for the condition of waste-dumps using remote sensing technologies at the Kumtor gold mine of Issyk-Kul region in Kyrgyzstan. Common uses of Elevation Models include:

- Creation an Ortho from existing RPC model

- Hyperspherical Color Space (HCS) Pan Sharpening
- Discriminant Function Change Detection
- Supervised Classification
- Calibrate images with RPCs
- Rendering of 3D visualizations as DTM (DEM) extraction and modeling mass movement

Remote sensing will provide objective and reliable information that could be useful for solving the above problems. Data obtained remote sensing provide comprehensive geographic (spatial) information about the condition of the study area on the previous, present and even future. Furthermore, this method requires less time and money compared to conventional works.

2. Gravity Displacement Dumps on Kumtor

As of mid-2013 at the Kumtor mine, was developed and moved over 1.0 billion tons of waste - dumps, as well as more than 100 million m3 of glaciers. Historically, that due to limited suitable place near Central open pit mine, his waste-dumps formed by glaciers Lysyi, Davydov and Sary-Tor (Figure 1). In addition, the vast majority of overburden and glaciers placed on the glacier Davydov. According to "Kumtor Operating Company" for the period from 1995 to 2012 yy, the volume of waste - dumps, stacked in this glacier basin, exceeded 278 million m3 or 775 million tons. Major landslide waste-dumps conducted mostly on sloping surfaces moving glacier moraine at a depth of 1.0-1.5 m below the surface slopes. At the Kumtor mine since the beginning of operations in 1995 in the sharing storage in waste - dumps and glaciers, with overburden removed and within the contours of quarries. The main feature of the structure is freezing dumps detrital-blocky structure of the stone material, with glaciers. By all indications, the movement of waste-dumps, first recorded in 2010, carried out in the form of block displacements of all three stages in which the landslide moves in front of him, moraine valley glacier Davydov and forms a clear head shaft (Figure 2). The latter is a turf surface and moraine valley floor, crumpled into folds, as the thalweg of the valley, and on its starboard side, (Kuzmichonok, 2012).

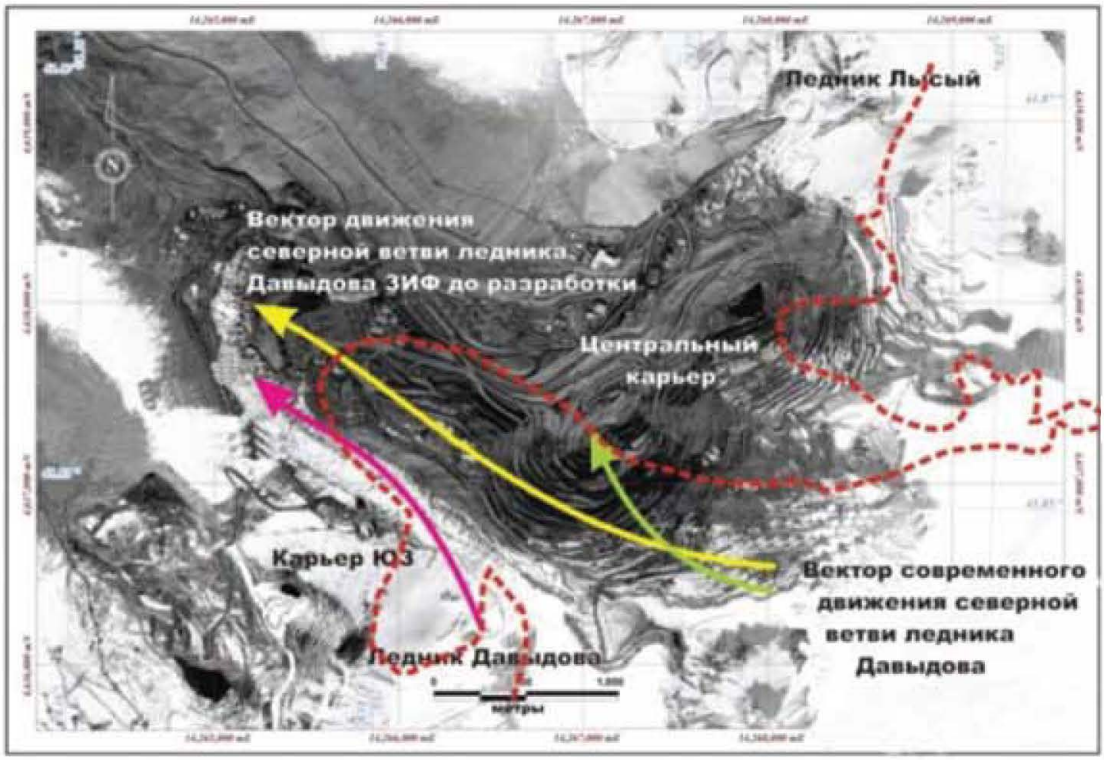


Figure 1: Quarries and waste-dumps on glaciers Lysyi, Davydov and Chon –Sary-Tor: the red dotted line marked contours of glaciers before the start of field development mining, (Robert, 2011)

Figure 2: View frontal part of landslide dump in May 2013 that destroyed the administration building and technical service building of the mine

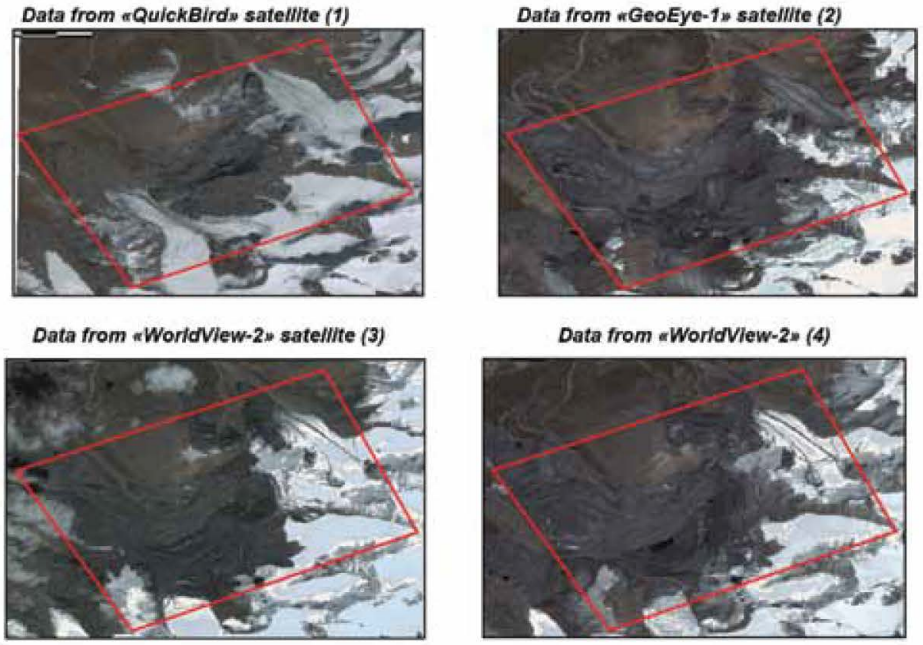


Figure 3: Specifications of satellite imagery

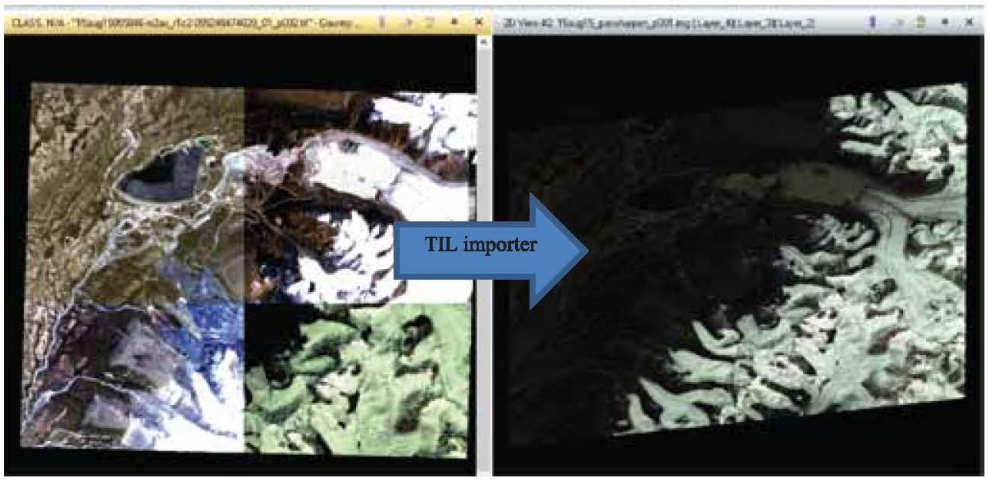


Figure 4: Importing Tiled Imagery

Table 1: Description of satellite images

ID image	Date	The angle of deviation from the nadir, deg	Cloud cover, %	Max GSD, m
(1)- 10100100024C3900	19.09.2003	12.27°	0%	0.78
(2)-105041000075AE00	29.07.2012	10.72°	0%	1,65
(3)- 10300100244B7100	18.08.2013	8.71°	2%	0.59
(4)- 10300100466BEA00	15.08.2015	3.78°	0%	0.57

3. Remote Sensing Data

The main parameter for assessment the environment to use application of remote sensing technologies, which in turn is also the most important. For assess the condition of the waste-dumps is a major factor preference should be very high-resolution images (spatial resolution - less than 1 m). Satellite imagery from WorldView-2 and QuickBird data with spectral channels suitable for use in a variety of subject area - such as the definition of the topography. By product type of imaging for mapping, identifying areas of dangerous exogenous processes for monitoring the growth of the dumps, vertical-horizontal displacements - the stereoscopic images in the centimeter range, followed by interferometric processing and infrared channels in 8 spectral bands (Figure 3).

4. Import Digitalglobe Tiled Data (.Til) to Erdas Imagine

The ERDAS has added support in IMAGINE 2014 for the DigitalGlobe .TIL format. The DigitalGlobe often delivers images cut into smaller tiles that do not overlap. Often times, image files can be extremely large size.

To better handle these large files in third party software, and have the option to tile the imagery. An ancillary .TIL text file provides a list of these tiles and their relationships. To use these files in georeferencing workflows, they must be assembled back into a single original image. Below shown importing all the tiles into a single file with georeferencing. The georeferencing information (RPC) is still preserved (Figure 4).

5. Creation an Ortho From Existing RPC Model

In the Resample dialog, note that the Current Geo Model is RFunctions, meaning the import process preserved the RPC information and created an ortho. Rational Polynomial Coefficients (RPCs) are simpler empirical mathematical models relating image space (line and column position) to latitude, longitude, and surface elevation (Figure 5). Note the Elevation Source is set to Elevation Library by default. The Elevation Library Manager provides a method to collect and manage your elevation source files, including Digital Elevation Model data (DEM), as well as Digital Terrain Elevation Data (DTED).

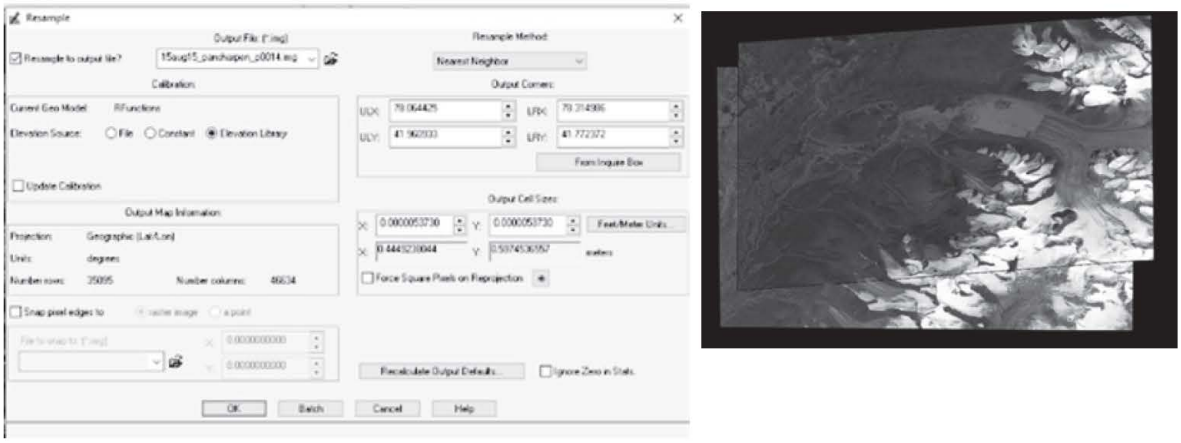


Figure 5: Ortho resampling process and results

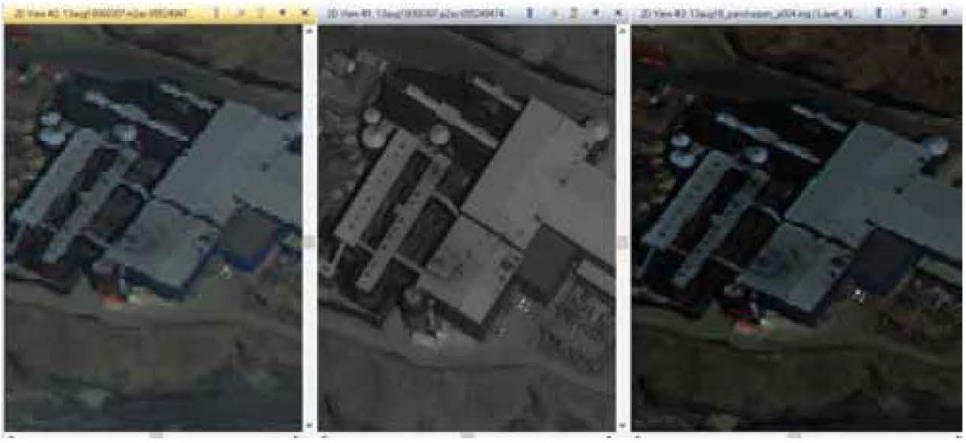
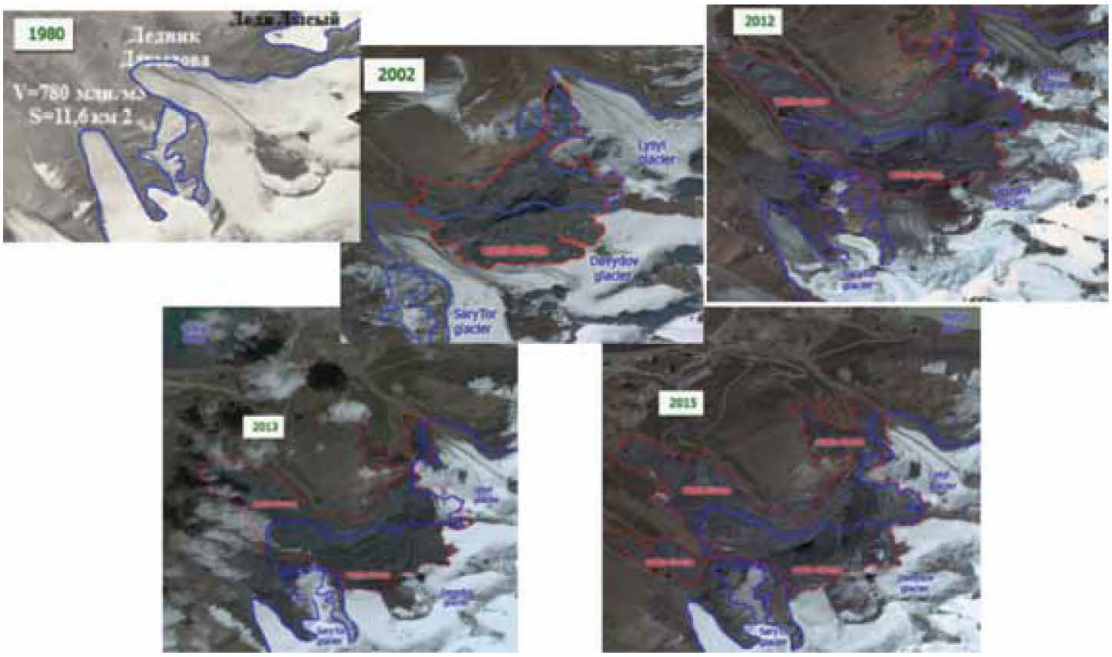


Figure 6: Example of Multispectral, Panchromatic, and HCS Pansharpened Image



Figures 7: The blue lines are contours of glacier, red lines are territory of dumps in Kumtor gold mining

6. Hyperspherical Color Space (HCS) Pan Sharpening

The Pan-sharpening is a technique that merges high-resolution panchromatic data with medium-resolution multispectral data to create a multispectral image with higher-resolution features. Hyperspherical Color Space Pan Sharpening was designed specifically with WorldView-2 in mind and is a new feature in IMAGINE 2014. However, HCS works with any multispectral data containing three bands or more (Figure 6).

7. Periodical Variations of Glaciers in Kumtor Gold Mining

Figure 7 show area of glaciers and Kumtor mining waste-dumps have changed.

7.1 Supervised Classification

WorldView-2 is the first commercial high-resolution satellite to provide eight spectral sensors in the visible to near-infrared range. Each sensor is narrowly focused on a particular range of the electromagnetic spectrum that is sensitive to a particular feature on the ground, or a property of the atmosphere. Together they are designed to improve the segmentation and classification of land and aquatic features beyond any other space-based remote sensing platform. The Figure 8 illustrates the bands of DigitalGlobe's satellite constellation and where they fall in the visible spectrum (Units are in nanometers). It's important to note that the additional bands provide more coverage over the spectrum thus providing more information.

The feature classification using WorldView-2 imagery using ERDAS IMAGINE, the method used here is a Supervised Classification. Supervised classification is much more accurate for mapping classes, but depends heavily on the cognition and skills of the image specialist (Figure 9). The strategy is simple: the specialist must recognize conventional classes (real and familiar) or meaningful (but somewhat artificial) classes in a scene from prior knowledge, such as personal experience with what's present in the scene, or more generally, the region it's located in, by experience with thematic maps, or by on-site visits. This familiarity allows the individual(s) making the classification to choose and set up discrete classes (thus supervising the selection) and then, assign them category names.

7.2 Discriminant Function change Detection

The vast archive of satellite imagery (well over a billion square kilometers) is perfectly suited as a historical account of change on the earth. ERDAS IMAGINE software employs algorithms to extract information from satellite imagery in an automated fashion. For the IMAGINE 2014 release, ERDAS, Inc. has developed a new algorithm for change detection between two co-registered images acquired at different dates.

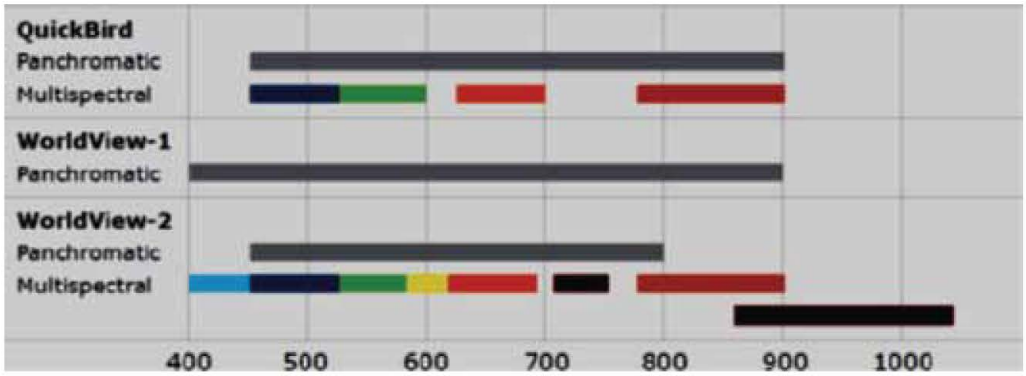


Figure 8: Bands of DigitalGlobe's satellite

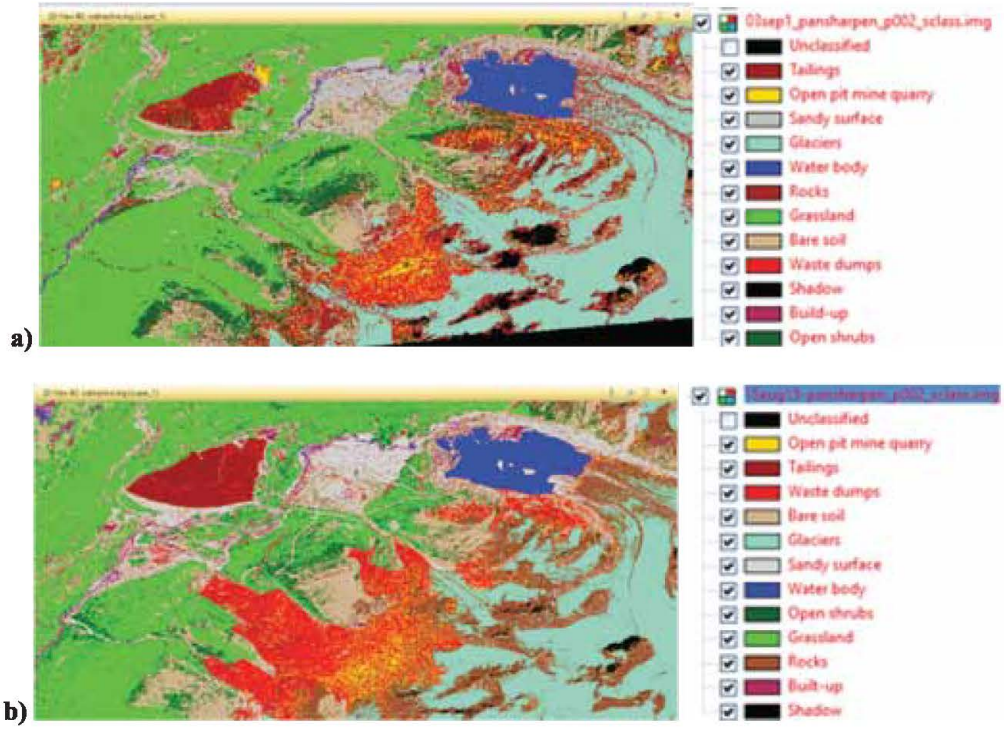


Figure 9: Supervised classification

This algorithm, named Discriminant Function Change (DFC) (Figure 10), characterizes the natural distribution of spectral clusters in one image's data space and then uses a discriminant function to measure probability of change of the pixels in the other image. WorldView-2 is well suited for this application because of its ability to collect more of the visible spectrum with its 8 band technology.

8. Digital Elevation Model (DEM)

A digital elevation model (DEM) is a 3-D representation of the terrain's surface, created from elevation data. There are two types of digital elevation models, digital terrain model (DTM) and digital surface model (DSM). DEMs are an integral part of any Geospatial Analysis. They are required both for the description of the three dimensional surface and to orthorectify imagery used in mapping applications or for modeling purposes. There is a variety of DEM source data available, the suitability of which depends on the project specifications. DEMs can be produced by automatic DEM extraction from stereoscopic satellite images collected by DigitalGlobe's WorldView-1 and WorldView-2 satellites.

8.1 Creating an LPS Block File

Here using WorldView-2 stereo we have the option to use RPCs provided with the imagery. In this Figure 11, shown use the supplied RPCs delivered with a Stereo product.

In th e point mesearument tool we can get tie points by automaticaly and manualy. Tie point procces shown below (Figure 12)

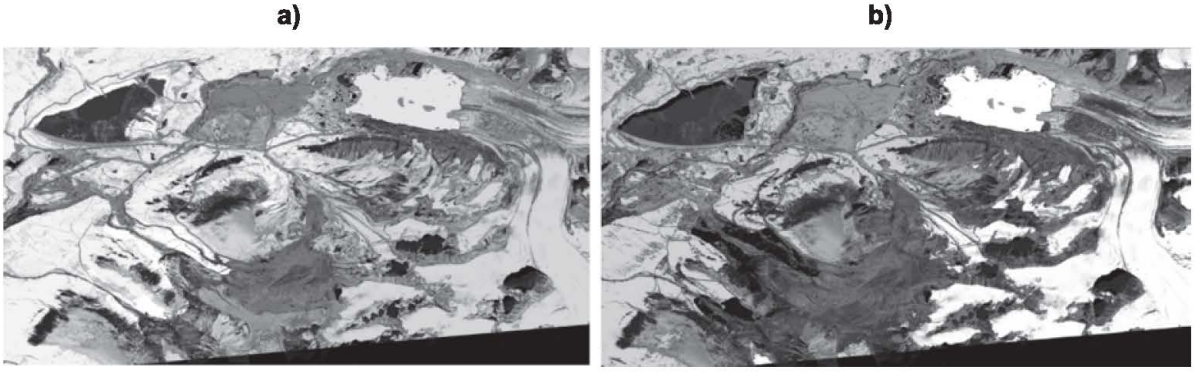


Figure 10: Discriminant function change detection image, (a-2003y., b-2015y.)

Figure 11: WorldView RPC frame editor window

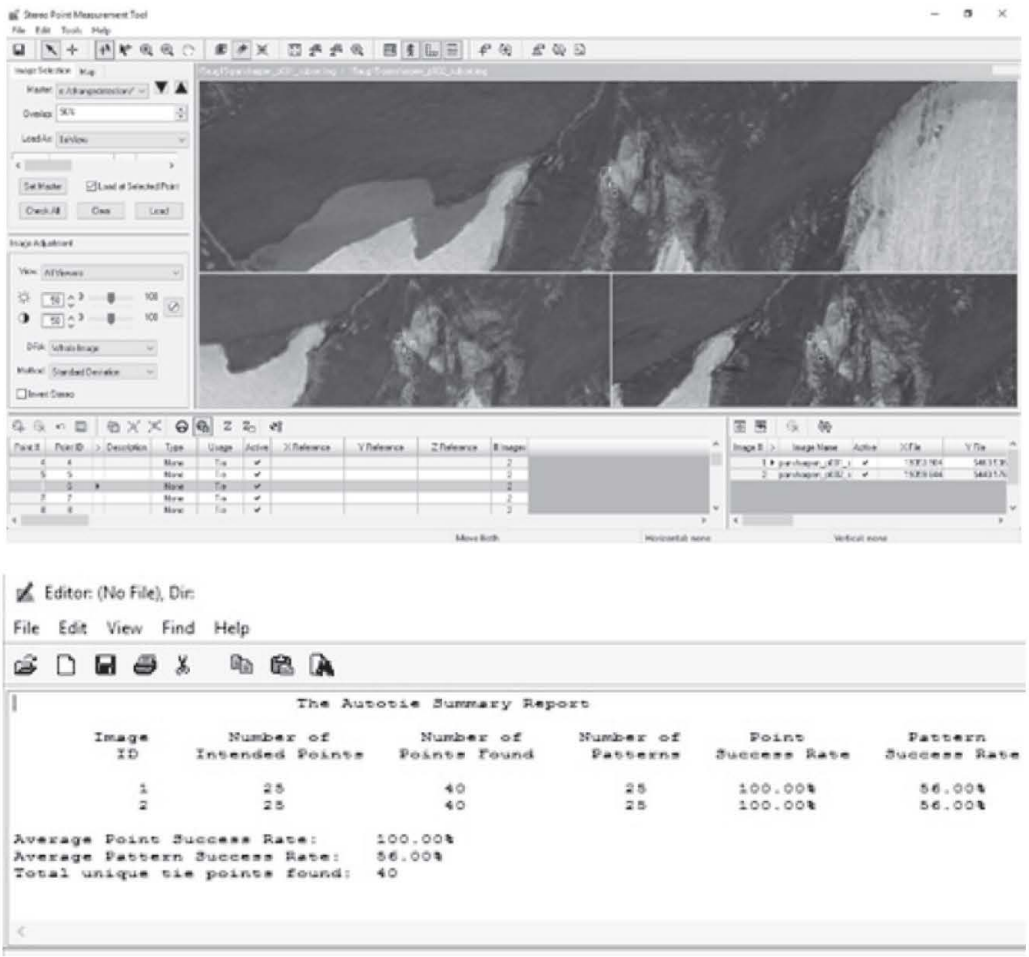


Figure 12: Tie point process

8.2 Monitoring of Displacements and Deformations of the Earth's Surface

For the purpose of early warning systems detection of changes on the analysis and modeling for the condition dumps, focusing on the challenges of its detection and modeling using the method of interferometric processing of satellite stereo images. The proposed technology for monitoring the Earth's surface displacements can reduce the risk of emergencies and reduce their possible effects due to timely detection of displacements and deformations of the earth's surface. Determine the dynamics of motion dumps and movement of rock-glaciers dumps under extreme conditions (earthquakes, abnormal precipitation or a combination thereof) may take the form of a catastrophic nature in rapid displacement of enormous masses of glaciers-rock material.

9. Expected Results

The proposed research expected to determine the condition dumps in the study area using remote sensing. In this regard, the assessment and analysis of the study area, to develop mining plans in the quarries should be based on the management of known and unknown risks, which may take place - i.e. decision making should be based on risk factors. Risk management - an area where the "Kumtor gold mining Company" improvements are needed, which, when properly implemented can have a positive impact for future planning was carried out on the basis of a thorough assessment and modeling, taking into account the potential risks and costs of their administration. The results can help government organizations, environment agencies, and appraisal costs. In addition, the results of modelling may help to control the level of condition dumps in the region and to create Early Warning Systems.

10. Conclusion

Disallow storage of waste-dumps on glaciers. Given the experience of development, should create a comprehensive Scientific and Technical Center to monitor the geological, hydrogeological, climatic, atmospheric phenomena in the mountainous area of the concession of mineral deposits. Development of

recommendations on environmental, climate and technological safety in the mining industries, in collaboration with research institutions and experts and to develop a unified technical project of the subsequent combination rework (surface and underground) and mining in the area of environmental management in accordance with the legislative, regulatory acts of the Kyrgyz Republic. Selecting the location of dumps should be carried out with considering the terrain, seismic, tectonic, geotechnical, hydrogeological, climatic, etc. conditions in the region. Position of dumps should not hinder the development of mining operations at the quarry (section). The territory forming the dumps must be protected against flooding groundwater and floodwaters. Selection of sites for placement of dumps should be preceded by geotechnical and hydrogeological investigations, with considering terrain model of remote sensing.

References

Aitmatov, I. T., Aleshin, Y. G. and Torgoev, I. A., 2012, Risk Assessment and Forecast of Glacial Processes on a High Kumtor (Kyrgyzstan). Problems of Natural Hazards and Reduce Risks: International Scientific and Practical Conference "GEORISK-2012": Vol. 2. Moscow: People's Friendship University. 72-77.

Japarov, S., Kutmanova D., Osmonbetova D. K., Hazbulatova L. M., 2012, The Temporary Parliamentary Commission on Verification and Compliance with the study of CJSC "Kumtor Operating Company". "Standards and Requirements for the Rational use of Natural Resources, Environmental Protection, Safety of Production Processes and Social Protection of the Population in the Area of Impact of Gold Mine, as well as able to exercise state control" Kyrgyz government, Bishkek, Kyrgyzstan, 2011;

Kuzmichonok, V. E., 2012, Dumps rock glacier Davydova (hr. Akshyirak, Tien Shan) / Glaciers and Snow, 2012, № 1 (117). - P.95-104;

Robert E. Moran, 2011, PhD Kumtor Gold Facilities, Kyrgyzstan: Comments on Water, Environmental and Related Issues: September 2011, Michael-Moran Assoc., LLC Water Quality/Hydrogeology/Geochemistry Golden, Colorado, U.S.A. https://ru.scribd.com/document/150430320/Digitalglobe-Rpc-in-Erdas-Imagine