Lithostratigraphy by High spectral images in The North Mahallat, Iran

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Abstract: Today, using satellite data (satellite image) in geological research has various applications. One of these applications is the use of satellite images and digital data in Lithology studies and in particular, in the exploration or stratigraphy of lithologic units. This research tries to compare the lithologic characteristics of rocks in northern Mahallat and southeastern Arak and determine the lithologic units and their extension by satellite images, with a set of data from field measurements and using the remote sensing method and by analyzing the satellite digital data of ASTER with different resolution, which includes spectral data of rocks type, and in this study, it is compared the sequence of lithologic units in different parts based on stratigraphic column obtained. In this regard, a case study has been done on lithologic units belonging to the Cretaceous in northern Mahallat and southeastern Arak. For this purpose, after sampling the rocks and performing the chemical analysis on them, maps drawn by controlled and uncontrolled classification processes was changed to congruent maps and comparable to maps drawn by Geological Survey using the Reclassify process, that according to comparisons performed, more than 81% of the map planned conform to the fact of petrology and geology of the area.

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Introduction

Reflection rays which are a type of electromagnetic waves can have a variety of sources such as solar radiation, heat rays of objects or even, artificial beams. Rays reflected from land objects are recorded and stored visible and processable by the particular sensors (Ambers, 2001). The superior advantage of satellite data than other information sources is their repetitive covering from certain areas with specified intervals (Lucieer et al., 2004 and Abdullah. , et al 2009).

The most appropriate thermal properties of minerals have been detected in the range of wavelengths14-8 μm (Lillesand and Kiefer, 1994).

Due to this feature of remote sensing data, it cab be probably identified and detected the many features of the minerals, materials and sediments through the application of thermal remote sensing (Kruse and Dietz, 1991, Chen. , et al 2010 and Villa. , et al 2011).

On the other hand, in recent decades, the mapping of magnetic anomalies by the airplanes that fly at low altitude has been widely used in exploration (Pena and Abdelsalam, 2006). Even, it can be obtained the details of geology in the aerial magnetic surveys.

Methods

It has been collected the all geological data, reports and map of Salafchegan with scale $\frac{1}{100000}$ and topographic maps and aerial photographs of the area to review the geology of the area. Then, the lithological units in the area were reviewed according to the interpretation of aerial photographs and field works, and the sections having errors, were corrected with regard to field studies.

Applied satellite images are related to the sensor ASTER (Advanced Spaceborn Thermal Emission and Reflection). The system is a part of the NASA program to evaluate the spectra emitted from the earth called EOS, Earth Observation System which was begun in 1999 AD (Pena and Abdelsalam, 2006). Spectral Resolution is equivalent to 15 which compared with other conventional sensors, this rate is an acceptable rate and it is able to display a significant range of information (MacLeod, NS, 1991).

The output format of this system is composed of two file. A file with met suffix that is from a text type and includes Metadata, and another file with hdf suffix which contains information on bands (Sherrod and Smith, 2000). The Metadata file is usually selected to open this type of the file.

The format includes 15 bands produced by three sensors SWIR, VNIR, TIR. This data has a different pixel size i.e. 15, 30 and 90 meters.

Due to the high capabilities of sensor ASTER, many geological researches are currently performed by data from the sensor. Present paper also tries to identify the Lithology of northern Mahallat and compare it with existing geological maps using the various data and based on controlled and uncontrolled classification and by High spectral images.

3. Studied Area

Since satellite images have high volume levels that often cover much greater level than our desired level, saving and analyzing the whole picture require to high time and computer power in addition to large space. Thus, in most projects, only certain area is defined and processed. In this paper, it has been selected the area of Markazi Province in Iran in the range of 50 degrees and 50 minutes to 50 degrees and 15 minutes longitude, 34 degrees to 34 degrees and 10 minutes latitude to prepare lithologic map(Figure 1). From the viewpoint of geology, studied area locates in Central Iran zone (Emami, 1991).

The area located in northwestern Mahallat, consists Jurassic shale, sandstone and conglomerate, and Cretaceous limestone and shale (Figure 2).

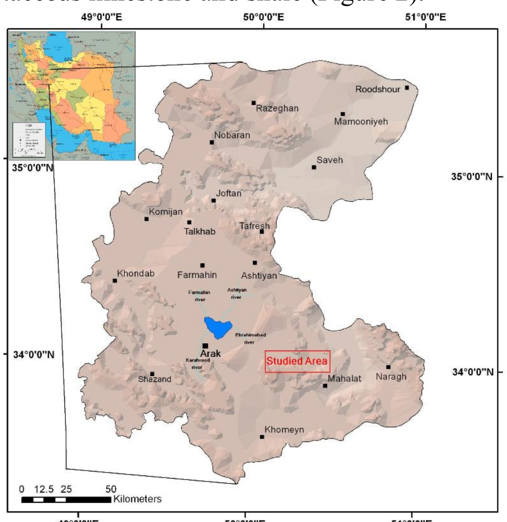


Fig.1. studied area location

Initial Data Preparation

At this stage, the primary format of ASTER data is converted into a basic processing format as pcx or ers**.** This conversion must be done in such a way that none of the parts become lost.

It can be classified 15 bands in the Dataset in the three groups VISNIR, SWIR, and TIR by doing the process.

Ratio between the Bands

Proper ratio between the bands can reveal some of the minerals. For example, the ratio between the two bands 13 to 14 in logarithmic form can reveal carbonated rocks**.**

Extraction of Test Field Limits

It is determined the coordinates of Test points in this stage. Based on existing documents, these points are as follows.

Similarly, the ratio of bands 10 to 13 indicates the amount of silicate in the rocks.

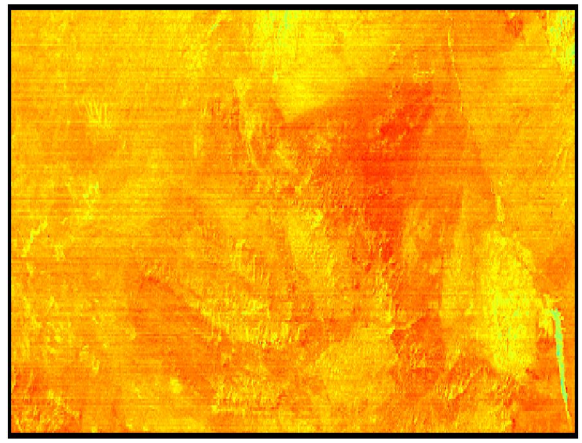
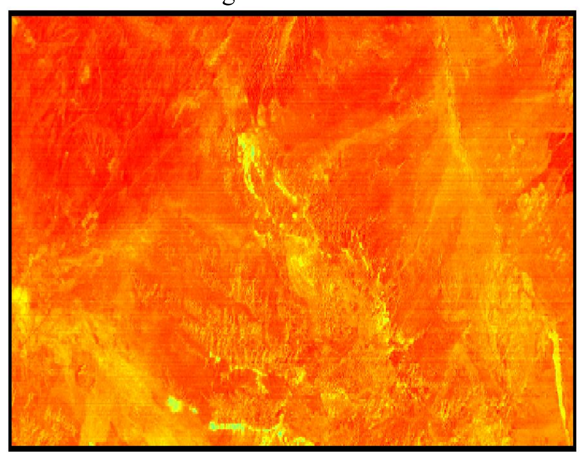
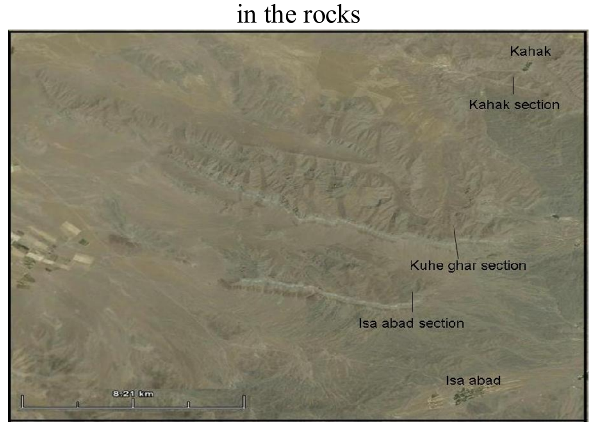


Fig. 2. The ratio of bands 13 to 14 expressing the amount of carbonate. High purity of red color shows higher carbonate.



50 5 E $34^{0}12^{/}$ N

Fig. 3. Pure red color represents the amount of silicate in the rocks



50 5 E $34^{0}1^{/}$ N

Fig. 4. The Position of three studied areas with blue dots in the bottom of the image.

Considering these points, the coordinate in Geodetic system and UTM system are as follows:

Table.1. Geographical coordinates of the studied areas

UTM Latitude	UTM Longitude	Geodetic Latitude	Geodetic Longitude	Area
3770656	427105	34-4-26	50-12-35	Isaabad
3774871	428380	34-6-44	50-13-24	Kuhe Ghar
3769182	449983	34-3-43	50-27-28	Kkorhe

Based on existing data obtained from chemical analysis of lithologic units in marked points, the ingredients of these parts are as follows:

Table.2. Results of chemical analysis of lithologic units in Isaabad area

Unit name	%Al	%Fe	%Si	%K	%Ti	%Ca	%Mg	%Mn
33	1.100	1.200	2.370	2.100	0.060	90.240	0.100	0.040
31	1.330	3.412	6.740	1.538	0.290	87.930	0.000	0.123
28	0.900	0.749	2.700	1.500	0.039	95.500	0.193	0.040
27	1.100	3.741	4.800	2.200	0.305	87.200	0.328	0.123
25	1.156	3.030	5.816	1.994	0.206	86.479	0.455	0.122
22	1.900	5.203	16.374	2.300	0.503	67.258	0.662	0.141
21	0.440	1.100	3.855	0.777	0.172	92.100	0.419	0.050
20	1.101	6.282	5.140	2.087	0.261	83.050	0.167	0.130
19	0.495	0.748	2.534	0.955	0.156	93.960	0.380	0.050
17	0.358	0.929	1.349	0.510	0.122	96.322	0.205	0.054
16	0.798	3.054	3.051	0.661	0.149	91.162	0.382	0.080
15	0.417	5.460	2.244	1.500	0.110	89.970	0.540	0.142
14	3.062	4.279	50.000	3.069	0.704	35.010	3.145	0.211

Table.3.Results of chemical analysis of lithologic units in Kuhe Ghar area

Unit name	%Al	%Fe	%Si	%K	%Ti	%Ca	%Mg	%Mn
29	0.250	0.650	0.297	0.000	0.010	98.200	0.200	0.034
24	0.230	0.215	0.310	0.000	0.020	98.500	0.300	0.041
23	0.330	1.200	1.100	0.030	0.060	96.300	0.230	0.090
21	0.240	1.620	1.310	0.320	0.040	95.100	0.280	0.100
18	0.270	1.150	1.050	0.020	0.030	96.700	0.290	0.033
16	0.040	0.817	0.025	0.000	0.000	98.900	0.340	0.017
15	1.910	7.379	7.120	1.900	0.500	80.100	0.550	0.229
14	1.300	3.743	5.100	0.150	0.125	93.200	0.325	0.092
13	1.200	3.238	4.670	0.970	0.356	88.500	0.390	0.091
12	0.360	2.880	1.380	0.020	0.060	94.400	0.321	0.114
11	0.750	2.860	3.280	0.475	0.210	91.800	0.317	0.070
10	0.590	2.840	2.370	0.416	0.136	92.660	0.276	0.200
9	0.310	1.910	1.700	0.010	0.100	94.100	0.110	0.200

Table.4.Results of chemical analysis of lithologic units in Kahak area

Unit name	%Al	%Fe	%Si	%K	%Ti	%Ca	%Mg	%Mn
13	0.490	1.700	2.600	0.600	0.100	96.200	0.900	0.070
12	0.700	4.100	3.133	0.000	0.138	89.200	0.200	0.150
10	0.700	16.000	7.317	0.700	0.278	65.600	4.600	0.270
9	0.500	1.800	2.400	0.170	0.129	94.400	0.870	0.070
8	0.600	4.040	3.400	0.370	0.161	90.600	0.180	0.160
7	0.400	0.900	1.000	0.000	0.121	97.000	0.810	0.070
6	0.600	6.800	4.700	1.110	0.439	80.400	2.100	0.182
5	0.440	1.500	2.700	0.144	0.080	94.700	0.190	0.080
4	1.700	5.900	22.900	1.350	1.030	64.960	4.100	0.200

1. Spectral Reflectance of the Study Areas

At this stage, it will be surveyed the spectral reflectance of the points specified above.

1.1Isaabad Area

The area placed within the limits of the coordinate specified in the previous table is located in 5 km northern Isaabad village and includes three reflective areas within the visible spectrum. The first area is seen in dark color in the visible spectrum from bands 1-3. The second and third areas are seen in dark brown and light brown colors in the same range respectively.

These three areas include lithologic units formed from shale, sandstone and Conglomerate, and finally, shale -limestone units set.

Fig. 5. Isaabad Area

Reflective curve of Isaabad area in 15 bands of the sensor is as follows:

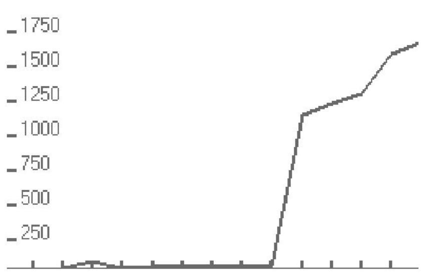


Fig.6. Reflective curve of number one area in Isaabad (Bands horizontal chart represents bands 1 to 15from left to right and vertical chart shows the number of reflection rate)

Reflective curve of number two area in 15 bands of the sensor is as follows:

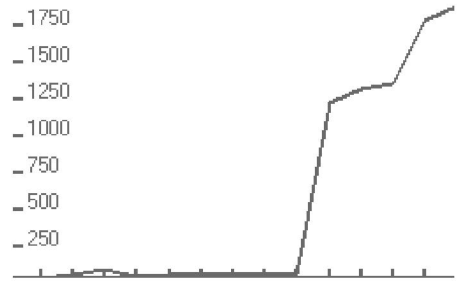


Fig. 7. Reflective curve of number two area in Isaabad (Bands horizontal chart represents bands 1 to 15 from left to right and vertical chart shows the number of reflection rate)

As it is clear in the charts, the rate of reflection in number two area of Isaabad is generally higher than the number one area. Reflective curve of number three area in 15 bands of the sensor is as follows:

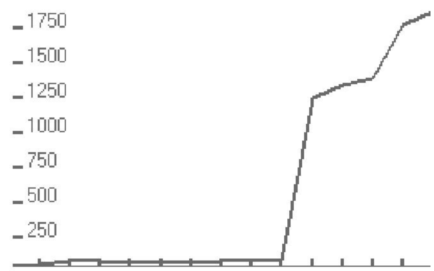


Fig. 8. Reflective curve of number three area in Isaabad (Bands horizontal chart represents bands 1 to 15 from left to right and vertical chart shows the number of reflection rate)

1.2Kuhe Ghar Area

The area is located in the limits of the coordinate specified in the previous table and it has been considered three reflective areas within the visible spectrum. The first area is an area seen in dark color in the visible spectrum from bands 1-3. The number two and three areas are seen in light brown and dark blue colors in the same spectrum respectively. From the viewpoint of rocks type, the areas are just like Isaabad area.

Fig. 9. Kuhe Ghar Area

Reflective curve of number one area in 15 bands of the sensor is as follows:

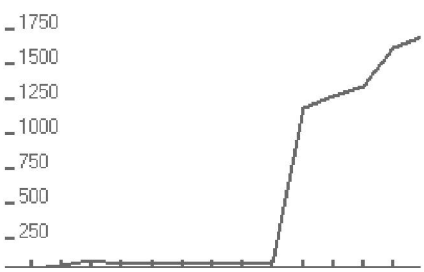


Fig. 10. Reflective curve of number one area in Kuhe Ghar (Bands horizontal chart represents bands 1 to 15 from left to right and vertical chart shows the number of reflection rate)

Reflective curve of number two area in 15 bands of the sensor is as follows:

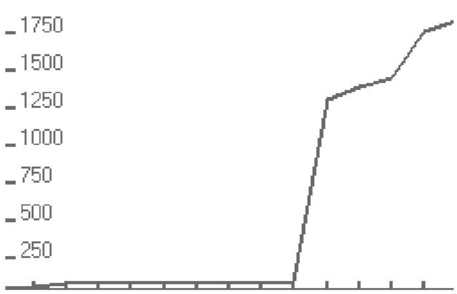


Fig. 11. Reflective curve of number two area in Kuhe Ghar (Bands horizontal chart represents bands 1 to 15 from left to right and vertical chart shows the number of reflection rate)

As it is clear in the charts, the rate of reflection in number two area of Kuhe Ghar area is generally higher than the number one area. Reflective curve of number three area in 15 bands of the sensor is as follows:

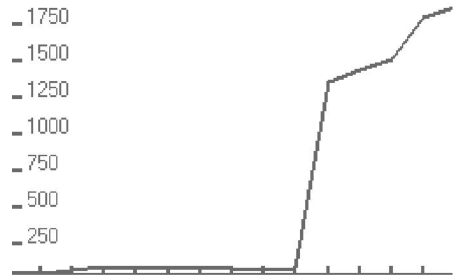


Fig. 12. Reflective curve of number three area in Kuhe Ghar (Bands horizontal chart represents bands 1 to 15 from left to right and vertical chart shows the number of reflection rate)

As it is obvious in the above chart, the total amount of reflection in these two areas is higher than two previous areas.

1.3 Kahak Area

The area placed within the limits of the coordinate specified in the previous table is located in 1 km western Kahak village and includes three reflective areas within the visible spectrum. The number one area is area seen in dark color in the visible spectrum from bands 1-3. The second and third areas are seen in dark brown and light brown colors in the same range respectively, that the area is similar to Isaabad area with a view to Lithology.

These three areas include lithologic units formed from shale, sandstone and Conglomerate, and finally, shale -limestone units set.

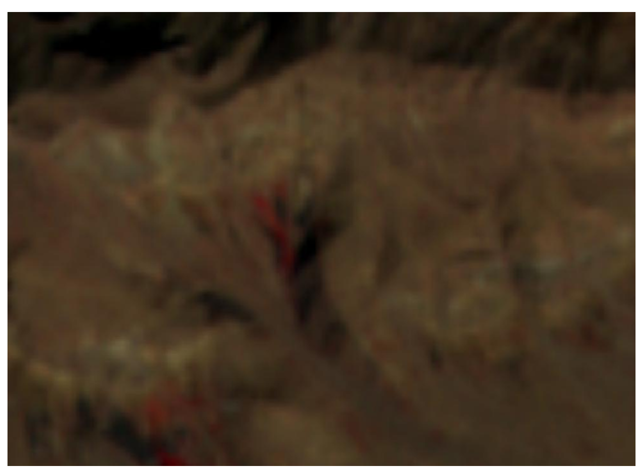


Fig. 13. Kahak Area

Reflective curve of number one area in 15 bands of the sensor is as follows:

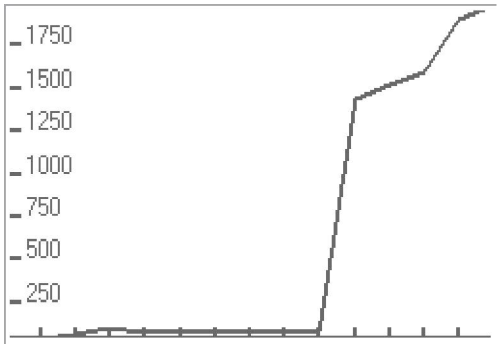


Fig.14. Reflective curve of number one area in Kahak (Bands horizontal chart represents bands 1 to 15 from left to right and vertical chart shows the number of reflection rate)

As it is clear in the charts, the rate of reflection in number two area of Kahak is generally higher than the number one area. Reflective curve of number three area in 15 bands of the sensor is as follows:

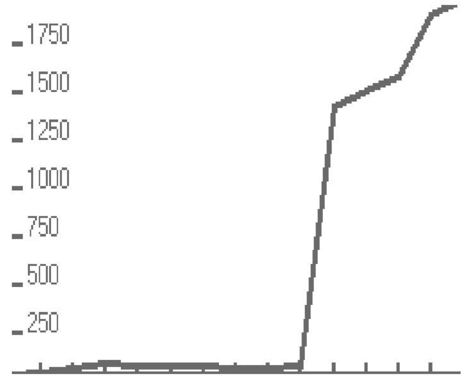


Fig. 15. Reflective curve of number three area in Kahak (Bands horizontal chart represents bands 1 to 15 from left to right and vertical chart shows the number of reflection rate)

As it is clear in the above table and chart, the total rate of reflection in these two areas is higher than two previous areas.

Supervised Image Preparation

After performing the controlled and uncontrolled classification process, the obtained results should be conformed to existing structures in the area. To do so, the maps with scale 1:100000 designed by Geological Survey of Iran are examined as the only reliable reference (Figure 16).

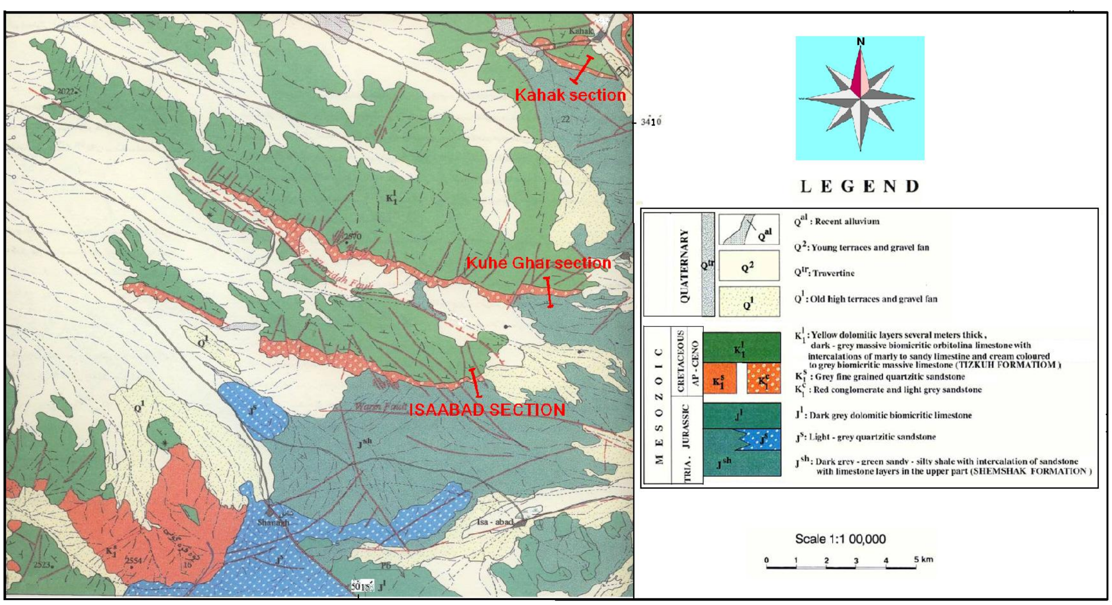


Fig.16.Geological map of north Mahallat (scale 1/100.000)

For this purpose, in first, the maps designed by the controlled and uncontrolled classification process are converted to congruent maps and comparable with maps drawn by Geological Survey using the Reclassify process.
Then, the map of Geological Survey must been also digitalized and converted from vector format to similar raster format. In this regard, the field comprising the type of host rock was used as a converter factor

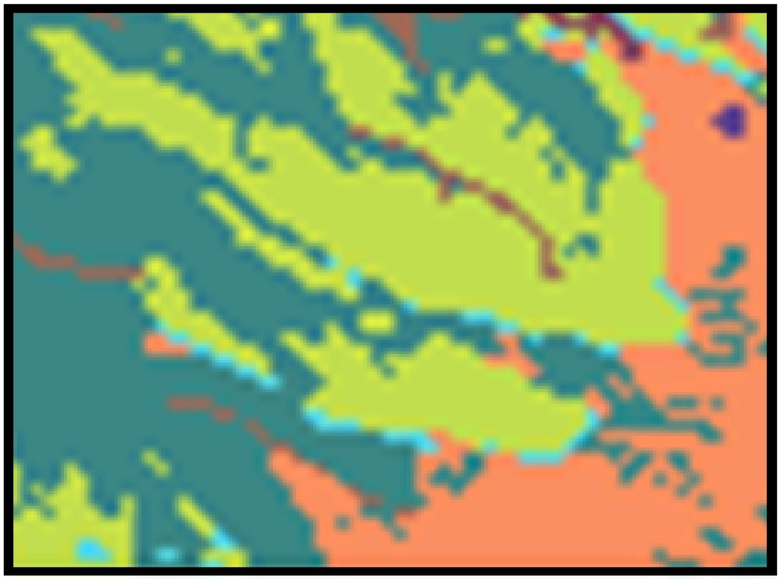


Fig.17. The map converted by Geological Survey

Then, it can be automatically compare these two together.

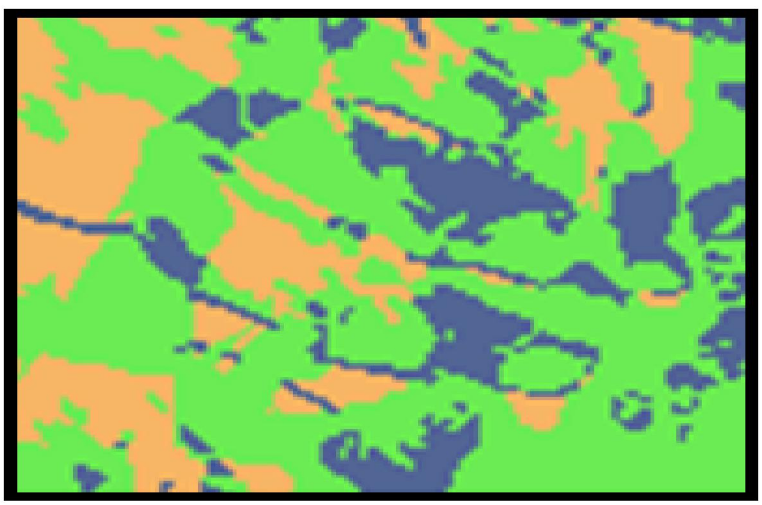


Fig. 18.Comparison of controlled classification image and geological maps converted

Results

Based on the lithological map prepared, the areas seen in dark blue color are accordance with geological map to 95 percent**.** The area with light green color is conformed to geological maps to 65 percent of covered area, while the orange areas conform to geological maps to only 50 percent.

Also, there is essentially no similarity between the areas with purple color and the geological maps.

Table. 5. The degree of conformity between the controlled images and the geological maps

Row	Area	percent of the total	area (ha)
1	The Areas with %95 conformity	23.66	168,790.5
2	The Areas with %65 conformity	57.37	394,955.5
3	The Areas with %50 conformity	20.95	149 448
4	The Areas without similarity	2.35	16.75

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