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Lineaments frequencies from Landsat ETM + of the Middle Atlas Plateaus (Morocco)

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Abstract: A lineament analysis of Middle Atlas Plateaus was carried out by interpretation of ETM+ images acquired by Landsat 7 satellite. The features of geological interest detected during the interpretation process were digitized using a raster-based GIS software. Synthesis map of lineaments was produced from combining four methods; filtering techniques, color compositions, ratios bands and principal components analysis (PCA). In the study area, knowledge of structural lineaments is very interesting to identify areas suitable for circulation of groundwater. A spatial statistic analysis of the lineaments was performed to detect their frequency and main direction, helped then to identify interesting technical for extraction lineaments.

Key words: Geological Cartography · Lineaments · Remote Sensing · GIS · Landsat ETM+ · Middle Atlas Plateaus (Morocco)

INTRODUCTION

Analysis of multispectral Landsat 7 ETM+ provides a valuable aid to geological mapping.

Remote sensing images collected from satellites to multi-spectral radiometer, particularly Landsat images revealed through the synoptic vision they restore the existence and importance as digital linear geological discontinuities in the landscape, the linears"" anglophones, francophones and lineaments alignments [1].

These lineaments are associated with structural elements such as faults, fractures, folds axes and lithological contacts. They result in topographic depressions, the drainage and vegetation anomalies [2] et [3]. However and in almost all cases, the extracted lineaments satellite image characterize these structures at a very high level [1].

The main objective of this study is to identify interesting technical for extraction lineaments and to apply remote sensing in the plateau region by Atlas and assess its contribution to the results of previous studies of conventional mapping.

Geology and Geographic Situation: The study area located between the coordinates 33°30 and 34° latitude north, 4°30 and 5° longitude south. It's the North-Est extension of the Middle Atlas Plateaus, consists mainly of dolomitic limestone's of the Lower Jurassic (Lower and medium Lias), which overcome the series consisting of Triassic red shale and basalt [4], [5], [6]; [7]. It is characterized by a tabular structure, more faulted and folded as a monotone relief. It's a large karst plateaus variously staged, overlooking the plain of Sais, at altitudes above 1000 m. It's crossed by the Fault NE-SW of Tizi n'Tratten and separates, South East of Middle Atlas Pleated, by North Middle Atlasic Fault (ANMA). The limit North and Northwest is determined by the tertiary and quaternary overburden of the Rif south corridor (Figure 1)

- Precambrian and Paleozoic Bedrock
- Triassic and Liassic
- Toarcian-Bajocian-Bathonian and Jurassic
- Cretaceous and Paleogene
- Neogene Molasse
- Main Rides

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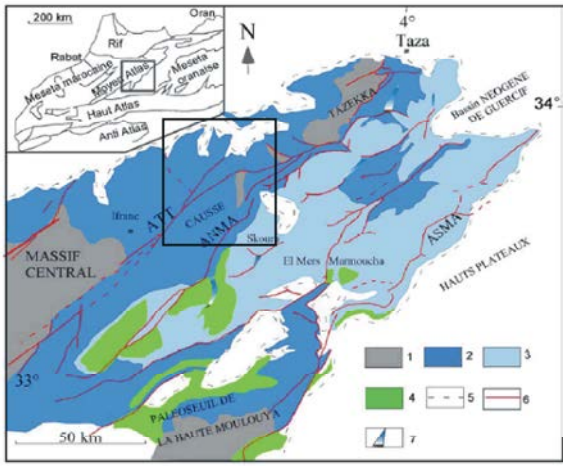

Fig. 1: Simplified geological map of the Middle Atlas (FEDAN and al., 1989 modified), and location of the study area (in part).

- Dyke
- ATT: Tizi N'Tretten accident (Fault).
- ANMA: Accident North Middle Atlas Mountains.
- ASMA: Accident South Middle Atlasic.

MATERIALS AND METHODS

A geological map of Sefrou and geological map of El Hajeb on 1:100000 scale and Landsat 7 ETM+ image of 200 path 037 row projected in zone 30 (Projection UTM) taken on Saturday 15 March 2008, which is composed of six bands multi-spectacles (ETM1, ETM2, ETM3, ETM4 and ETM5 ETM7) at 30 m resolution, panchromatic band at 15 m and thermal band at 120 m resolution.

This images used for the study were cropped to the ??study area, geo-referenced in the Lambert conformal conic projection system of North Morocco, then we proceed to the location and manual extraction of lineaments from techniques (image enhancement in color compositions, principal component analysis, band ratios and directional filter of Sobel). The last step is to overlay the support of GIS, the four lineament maps obtained in four methods to create a synthesis map of lineaments.

Results and Interpretation: The manual extraction of lineaments was used to identify all structures and linear areas on Landsat ETM + images from different treatments performed, the expression of ridge lines, boundaries between geological formations, shear corridors and valleys.

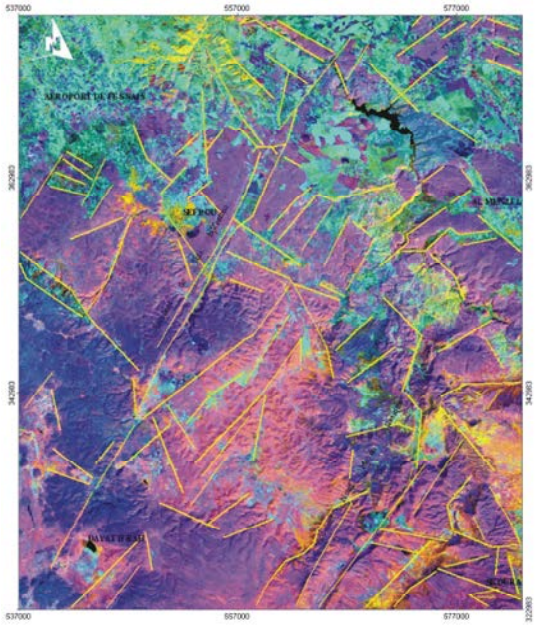

Fig. 2: Lineaments extracted by PCA

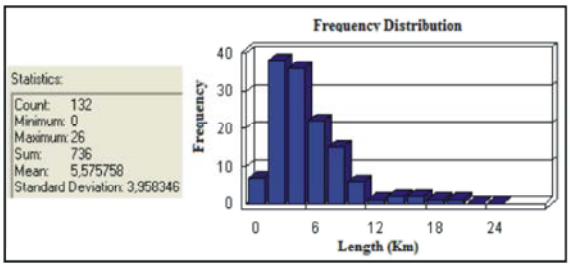

Fig. 3: Frequency and statistics of lineaments by PCA

The extract of all discontinuities on all images used (except the roads, tracks, layer boundaries, etc.). Helped to create the lineaments map of the detailed study area (Figure 13). These lineaments were compared and validated using geological maps.

Principal Composition Analysis: The principal component analysis (PCA) is an effective technical to accentuate a multispectral image for late geological interpretation [8]. It reduces the information contained in several bands, sometimes highly correlated (hence redundant information) into a smaller number of components. These generally represent 97% of the total variance of the original data set [9]. This analysis allows, among others, to create color composition of the first three components are an excellent product for visual interpretation, thus increasing the contrast between various objects on the ground.

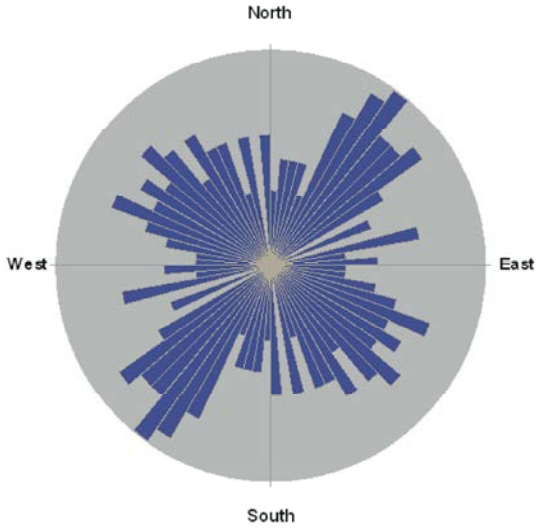

Fig. 4: Rose of PCA lineaments.

Fig. 5: Lineaments extracted from color compostion 432.

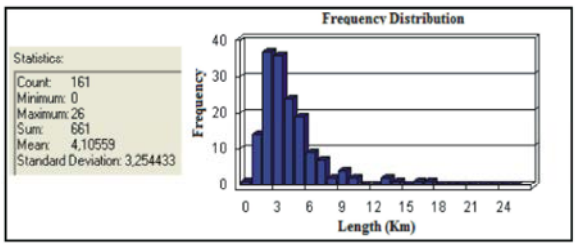

Fig. 6: Frequency and statistics of lineaments by color composite

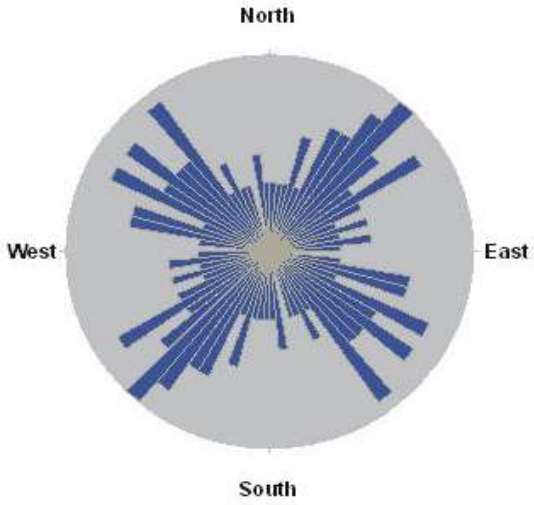

Fig. 7: Rose of lineaments by color composition

Lineaments extracted of the RGB color composite image obtained by PCA treatment of six channels of Landsat ETM+ (bands 1, 2, 3, 4, 5 and 7) (Figure 2). The frequency distribution of fracture lengths shows that the 129 lineaments are in order of 733 km with an average of 5.68 km (Figure 3). The rose of lineaments (Figure 4), indicate two mean directions NE-SW and NW-SE.

Color Composition Bands: The color composition is a combination of spectral bands based on the mean of allocation bands image display three levels based on three primary colors: red, green and blue. Six bands featured in our Landsat ETM + 2008, only bands 4, 3 and 2 were assigned to the channels Red, Green and Blue giving a false color standard. This combination highlighted the edges of geological formations, vegetation, drainage and areas of geological anomalies.

From the visual interpretation of the image (RGB) color compositions 432, 160 lineaments were extracted (Figure 5), the frequency distribution of these lineaments is shown in Figure 6, where the maximum length is 661 km with an average of 4.13 km. The length maximum of one lineament reaches 40 km a little more than that identified by PCA (35 km).

The rose of lineaments extracted from color composition image (Figure 7), also indicate the two mean directions NE-SW and NW-SE.

Ratios bands Analysis: This application based on the reflectance notion, is the ratio between the amount of radiation reflected by a material and the amount of energy

Fig. 8: Extracted lineaments ratios 5/7, 2/3 and 4/5.

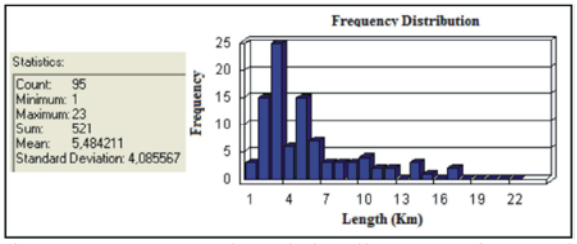

Fig. 9: Frequency and statistics lineament from ratios analysis

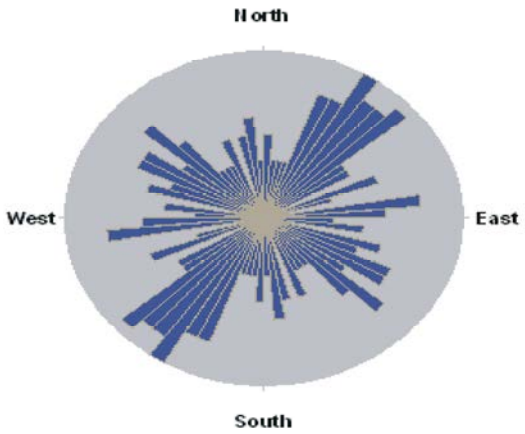

Fig. 10: Rose of linemant of ratios bands

received or incident on an object. In practice, three band ratios are used to obtain an image in RGB. In this study the color composition neo-channels is regenerated from the following ratios: 5/7, 2/3 and 4/5.

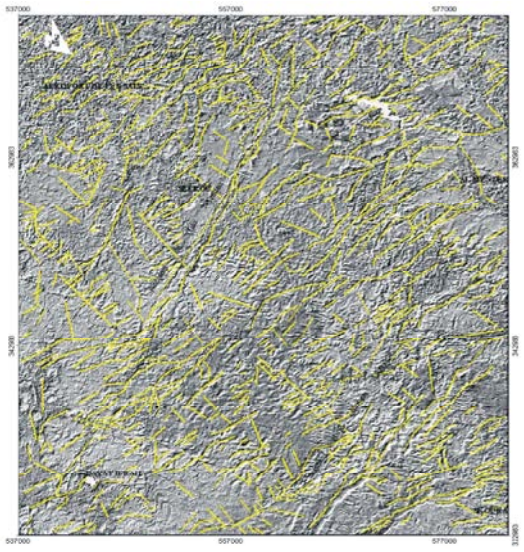

Fig. 11: Lineaments extracted by Sobel filter NW, SW and South directions.

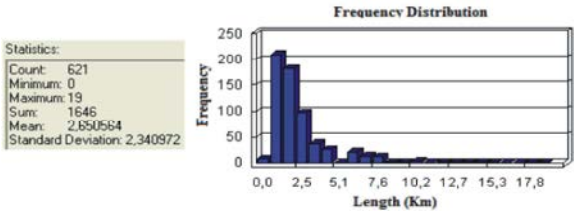

Fig. 12: Frequency and statistics lineaments by Sobel filter.

5/7: Discrimination rocks rich in Al-OH. These minerals can be good indicators of the presence of water along fractures [10].

2/3: Good discrimination of vegetation density, the band 4/5 shows the disturbed areas in dark or black tone [11].

The results of the lineaments distribution in the study area and their frequencies are shown respectively in Figures 8 and 9. The number of lineaments is 44, the maximum length of about 17 km with a total of 265 km, very less than the number generated from the treatment by PCA or analysis ??color composition 432.

The lineaments rose (Figure 10), identify importance direction NE-SW then NW-SE. Les directions N-S et E-W sont faiblement représentées.

Analysis by Directional Filters: The directional filters improve the perception of lineaments causing an optical effect of shade worn on the image as if it were illuminated

Table 1: Sobel filter Applied in the study area ??

North-West					South-West					South				
3	2	2	1	0	0	-1	-2	-2	-3	-1	-2	-3	-2	-1
2	4	3	0	-1	1	0	-3	-4	-2	-1	-3	-4	-3	-2
2	3	0	-3	-2	2	3	0	-3	-2	0	0	0	0	0
1	0	-3	-4	-2	2	4	3	0	-1	1	3	4	3	2
0	-1	-2	-2	-3	3	2	2	1	0	1	2	3	2	1

Table 2: Comparison of the synthesis map with the used methods

	CPA	Color composition	Ratios	Sobel filter	Synthesis map
Frequency	132	161	95	621	822
Total length (km)	736	661	521	1646	2675
Max length (km)	26	26	23	19	26
Moy length (km)	5.57	4.10	5.48	2.65	3.25

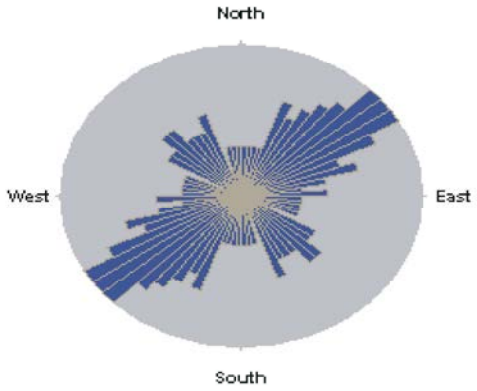

Fig. 12: Rose of lineaments by Sobel filter.

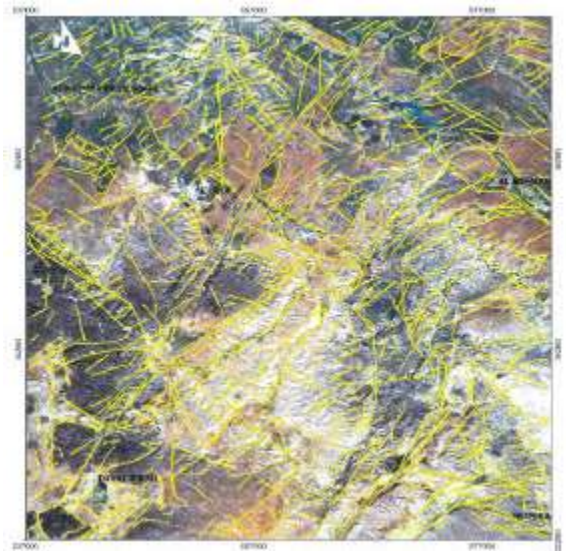

Fig. 13: Synthesis map of lineaments.

by light grazing [12]. In addition, this type of filter can enhance lineaments that are not favoured by the illumination source [13].

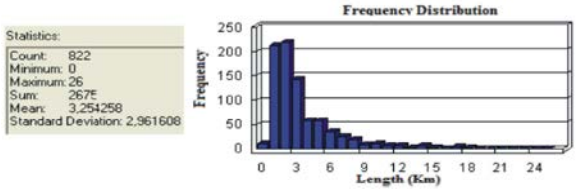

Fig. 14: Frequency and statistics of lineaments synthesis map.

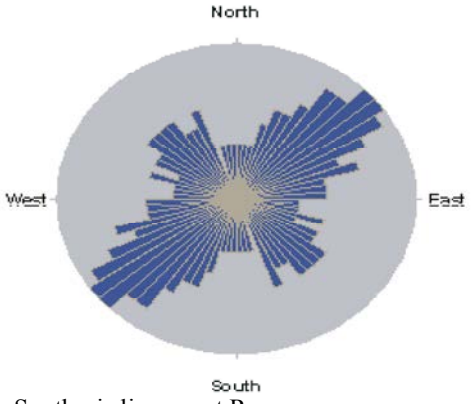

Fig. 15: Synthesis lineament Rose

In our study, we have used in the 5 * 5 window, the image of band 4 (NIR) allows to see the important structural details [14], [15].

The directional gradient of Sobel filter is applied to the Landsat 7 ETM + mage in the following directions Northwest, Southwest and South. The Table 1 below shows the direction of filters for the three main directions of our region:

The application of the Sobel filter on the ETM + image, is more individualized minor lineaments, which gives a total length of 1646 Km lineaments twice higher compared to other methods mentioned above (Fig. 10 and 11). The maximum length of a lineament is about 19km.

Clearly shown by accidents interpretation of the four techniques are those management major north-east to south-west at the Tizi N'Tretten Causse Middle Atlas Mountains and the Northern Middle Atlas Mountains in contact Middle Atlas Plateaus (ANMA).

The rose of lineaments (Figure.12), shows clearly the importance of faults NE-SW better then NW-SE.

There for, the manual extraction of lineaments was done by GIS processes, which allows us then by striking repetition of lines and technical layering and data combination, regenerating a synthesis map of lineaments of the study area and their frequencies, statistics and rose of directions (Figure 13, 14, 15). A comparative summary of the parameters of the four methods of treatment and the final map is given in Table 2.

The total length of lineaments respectively calculated by different methods and at the synthesis map is 3564 km and 2675 km, which means that 889 km of double lineaments was eliminated, indicating then increase the reliability of the digitizing and probality of existence of geological anomalies.

Lineaments extracted by sobel filter represents about 47% of the map synthesis, which decreases to 20% by PCA, 18% by color composition and 15% by analyzing ratios bands. The maximum length of a lineament shown on the synthesis map is 26 Km, of gievn in color composition analysis bands 432. The 0 value indicated in the statistics is given arbitrarily the lineaments having a length less than 1 km.

Lineament density displayed on the synthesis map is very diverse from an area to another, beter than indicated applied the four methods. It's more pronounced in major faults around general direction NE-SW indicated mainly at the Tizi N'Tretten fault and North Middle Atlas Fault. The direction of second family showed is NW-SE.

The rose analysis indicate scattered values ??back to less dense frequencies of lineaments extracted by PCA, color composition and ratios study, then the rose derived from the Sobel filter processing that shows clearly the frequency of important lineaments longer grouped primary in the NE-SW directions and secondary NW-SW. This shows the importance of directional filters in the extraction of lineaments which adds other complementary methods for better realization of a synthesis map of lineaments.

CONCLUSION

The synthesis map of lineaments represent all unique segments resulting from the superposition of the information contained in the four analyzed images. It has a total 822 lineaments, a total length is 2675 km and reveals two important families of orientation of lineaments are: primary NE-SW and NW-SE secondary.

The contribution of aerospace imagery by traitement of Landsat 7 ETM+ image in this part of the Middle Atlas Plateaus, becomes in the sense that it has helped to confirm and complete information and data of structural region. The four methods based on visual interpretation of geometrically corrected images, enhanced (ACP, color composition, ratio of bands and directional filters), to contribute to the realization of a synthesis map at the region. These application have identified the major lineaments of the study area, the orientations are similar to faults identified at the geological map and through previous studies.

The visual extraction of lineaments by this or that technical undergoes changes as variations in topography, vegetation cover, water content or lithology. This creates discontinuities in the path of lineaments. Therefore, in this type of environment, other tools of geosciences, especially field observations remain relevant approaches to combine with the numerical analysis.

The use of Landsat for mapping lineaments proves to be a tool very rich on geological information, both in research of mines as in research favourable sites for groundwater flow.

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