Study of meteorite impact craters using Landsat TM-5 in Bukit Bunuh, Lenggong, Perak

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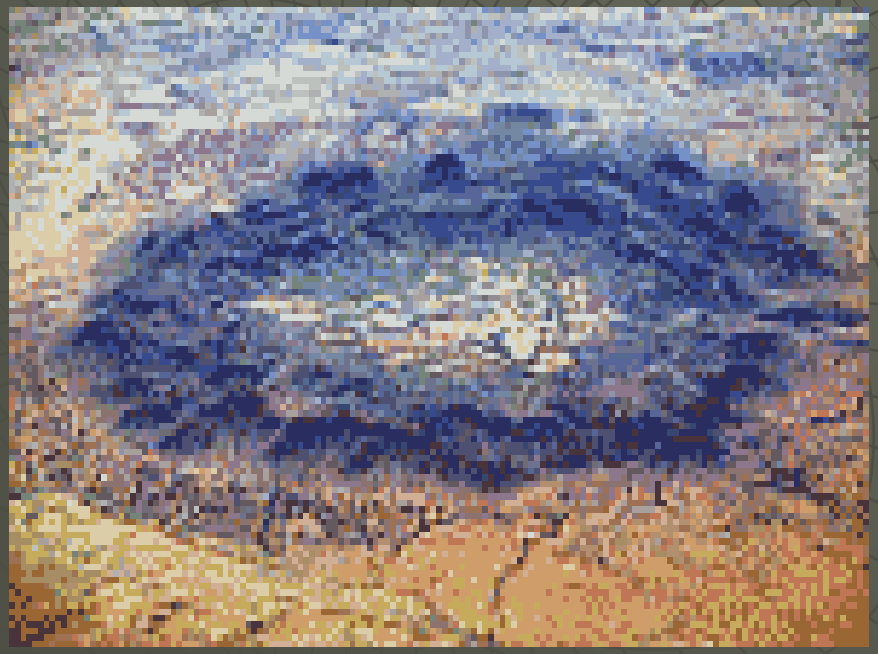
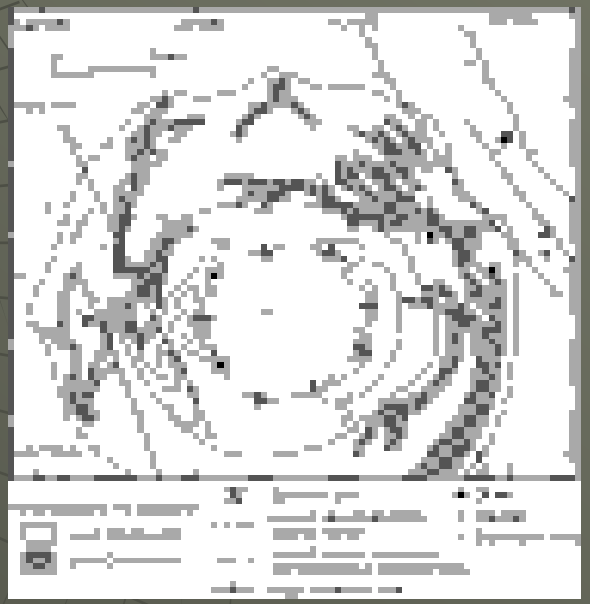
Outline of presentation

- Introduction
- Objective
- Material and method
- Results & Discussion
- Conclusion

INTRODUCTION

- The geological or geomorphological features which are capable of producing circular forms are quite numerous . They are the manifestations of phenomena induced by external factors such as impact craters, karstic subsidences, or by internal factors such as volcanoes , intrusions etc.





- Such features are revealed by the morphology, drainage pattern, vegetation, water content of the soil and spectral differences. Remote sensing is presently the most universal tool for the exploration of circular features. But the origin of the structures identified in space images can be quite varied and their identification in covered regions is sometimes disputable due to subjectivity of interpretation

- Remote Sensing datasets such as RADAR, thermal imagery etc., or to follow the more complex approach of identifying circular forms based on shadowing of the TM data could be useful.

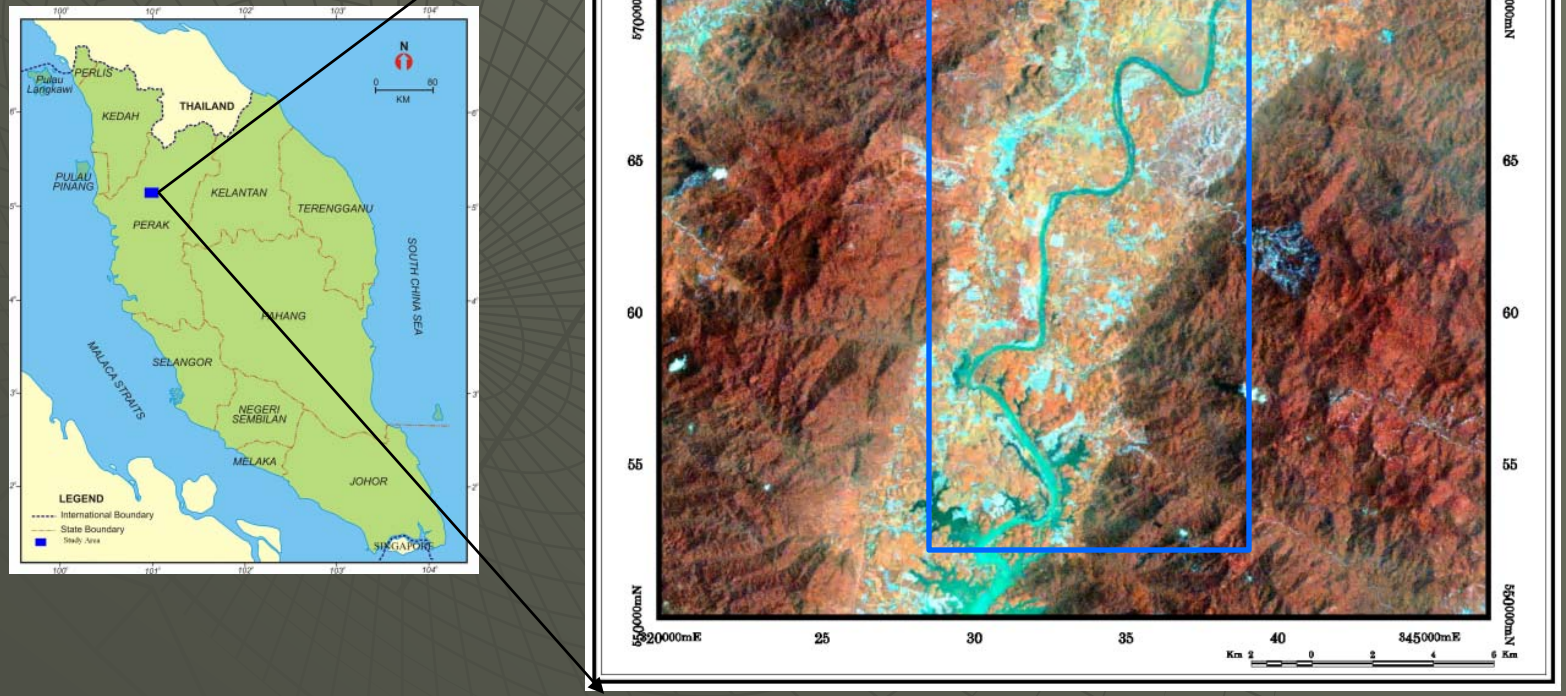
- In the images; Lineaments usually appear as lines or linear formations whose pixels are either lighter or darker (or have a different color) than the background pixels. According to the definitions of the structural features in remote sensing, the circular features mostly resemble positive features (topographical features). It is clearly to highlight that, there is good relationship between the circular features and topographic relief pattern distribution (Anwar et al. 2010).

- This study attempts to use remote sensing technique in identifying geological structures derived from digitally enhanced imageries in Bukit Bunuh area in Lenggong, Perak.

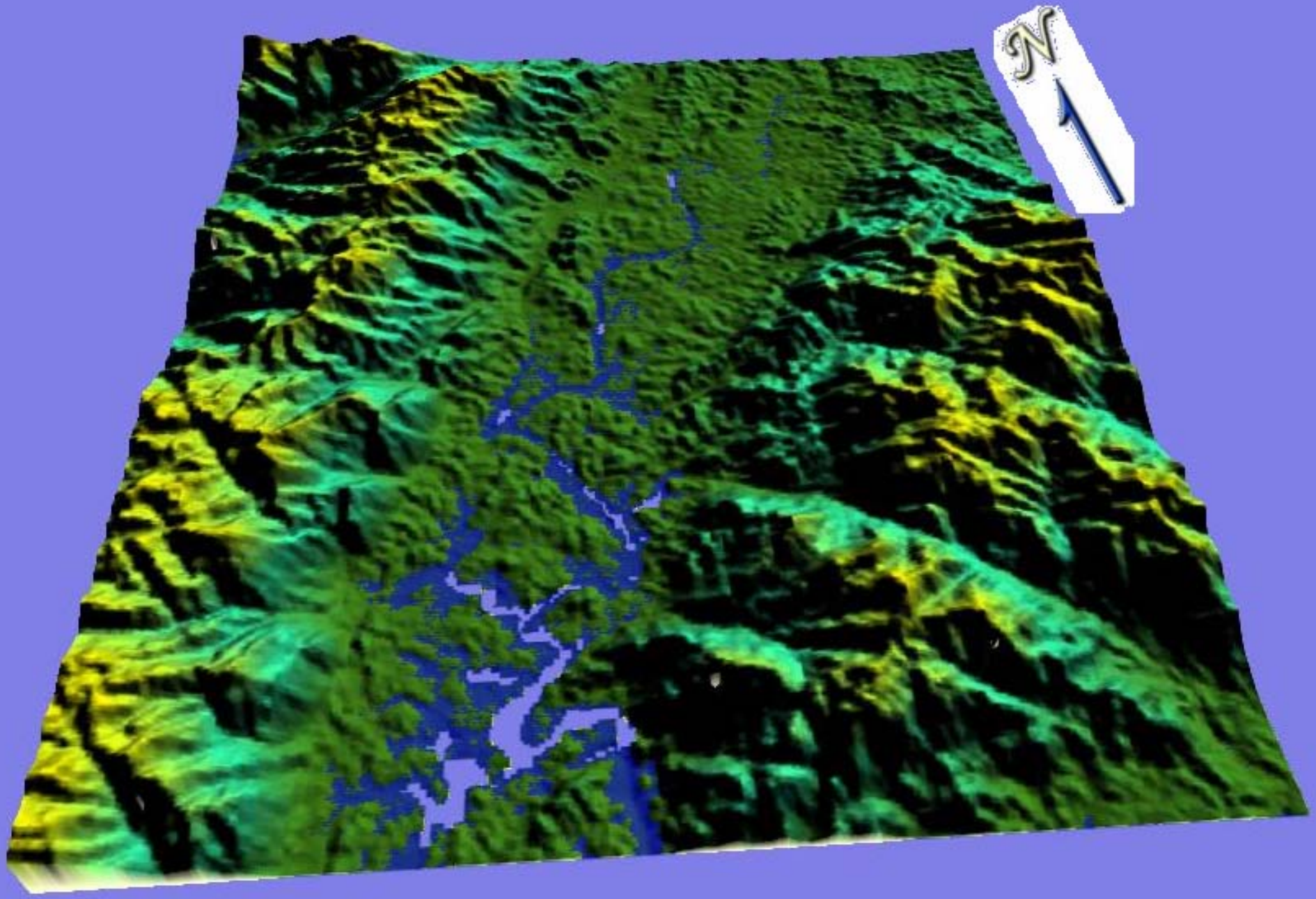
- The study area- Bukit Bunuh is located in Malaysia’s most famous prehistoric valley - Lenggong Valley in the upper part of Perak which revealed evidence of a meteorite impact.

STUDY AREA

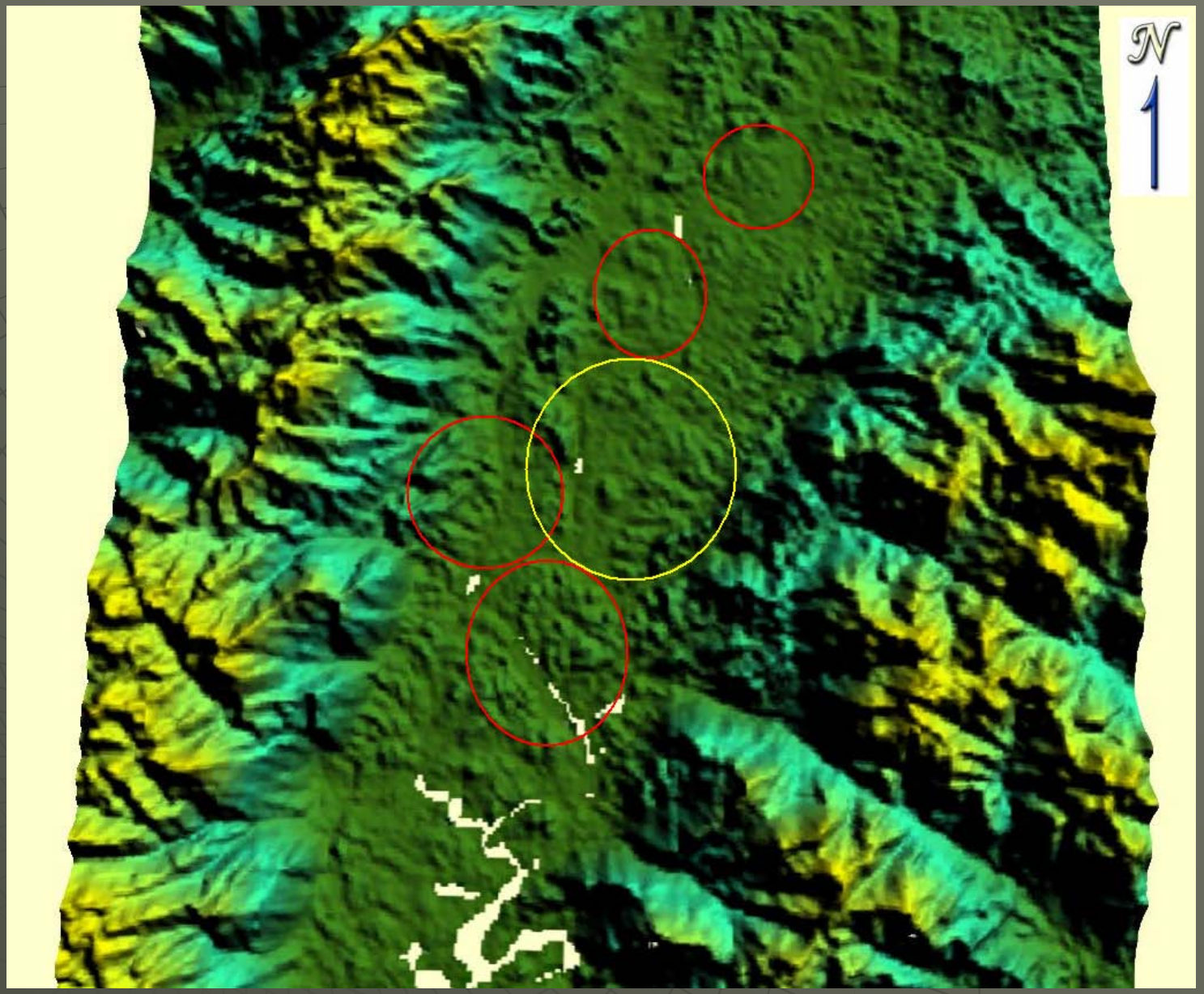
The study area is situated in the northern part of Perak state, Malaysia which is bounded by latitudes 550000 N to 575000 N and longitude 320000 E to 348000 E. It covers an area of approximately 635 sq. km.The study area has different types of rocks; the most common rocks in the area are granites and meta- sediments rocks (GSM 1985).



Location of the study area



DEM of lenggong valley showing Sg Perak river and the topographic relief



Five circular features observed from the DEM of the study area

OBJECTIVE

1- To detect and discriminate circular features by using the shaded relief images created from band 4 of Landsat TM-5.

2- To correlate the circular features with meteorite impact structures in the investigated area.

MATERIAL AND METHODS

Landsat TM-5, Band 4, shaded relief images, geological structural map, Computer and ILWIS , ERDAS, PCI Geomatica, and RoboRealm1.8.16.0 softwares .

MATERIAL & METHOD

LANDSAT-TM satellite data have been used in this study .

1. The first step was to select the band that should be used for circular extraction.
2. Visual inspection of the individual bands was carried out, based on the ability to identify features, and band 4 was selected. This was mainly because, at higher elevations, the mountains are densely vegetated, and for all the bands, except band 4, reflectance values are low.
3. This band also has relatively been unaffected by atmospheric attenuation.
4. Band 4 has been enhanced with median filter to remove the noises from this band, and then Histogram equalization is applied to obtain high quality image visualization .

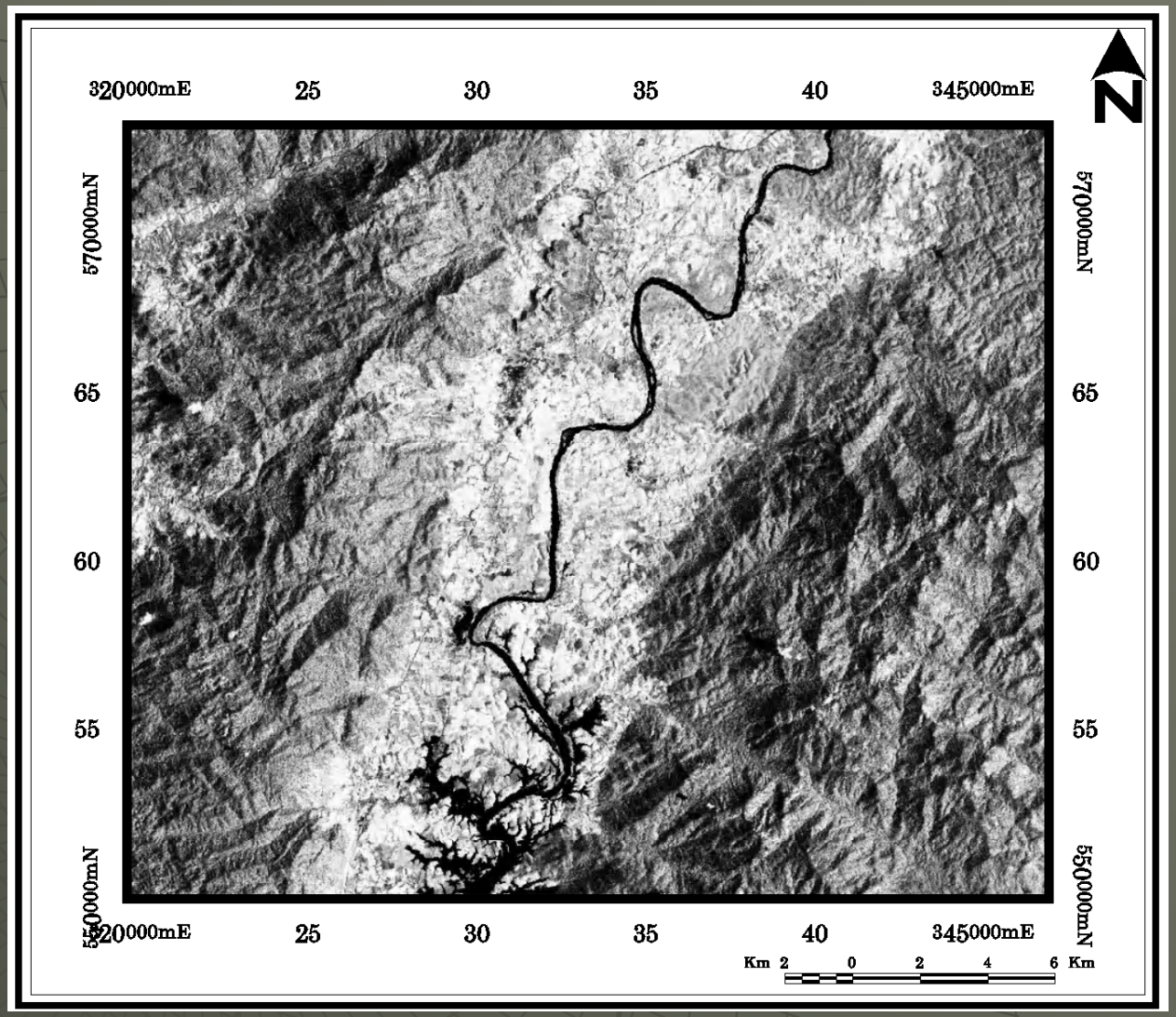
Table1: show variance covariance matrix of seven bands of TM-5

MatrixVarCov(new) - ILWIS

File Edit View Help

Mean per band:
130.31 127.27 123.85 132.06 126.11 136.03 123.54
Std. per band:
31.00 37.28 37.62 50.77 49.80 17.60 42.84

	new_1	new_2	new_3	new_4	new_5	new_6	new_7
new_1	960.74	1086.55	1076.79	735.34	1246.95	365.31	1104.12
new_2	1086.55	1389.76	1351.41	971.66	1637.95	399.50	1446.54
new_3	1076.79	1351.41	1415.39	728.39	1595.95	387.99	1472.93
new_4	735.34	971.66	728.39	2577.67	1699.57	336.83	1065.64
new_5	1246.95	1637.95	1595.95	1699.57	2479.90	474.93	2045.06



Band – 4 of Landsat ,TM – 5 enhanced by histogram equalization

1. In order to identify circular topographic features from band 4 of TM-5, eight shaded relief images were generated:

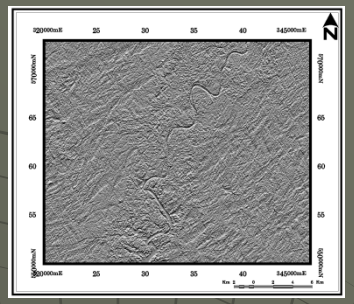
- The first step is the production of eight separate shaded relief images with light sources coming from eight different directions.

- The first shaded relief image created had a solar azimuth (sun angle) of 0°, and a solar elevation of 30°. An ambient light setting of 0.20 was used, which produces a good contrast.

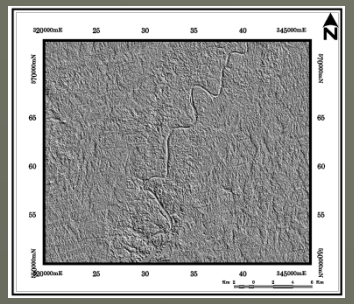
- The other seven shaded relief images were created with seven contrasting illumination directions 45°, 90°,135°, 180°, 225°, 270° ,and 315° . Erdas software have been used to create eight shaded relief images from band 4 of TM -5

2. The second step is to combine four shaded relief image to produce one shaded relief image, for this purpose, the combinations of the four shaded relief maps are computed by using GIS overlay technique, where the first four shaded relief images are overlaid to produce:
3. a) one image with multi - illumination directions (0°,45°,90°,and135°) and
4. b) the second overlay is to produce one image with multi - illumination directions (180°, 225°, 270°, and 315°) .

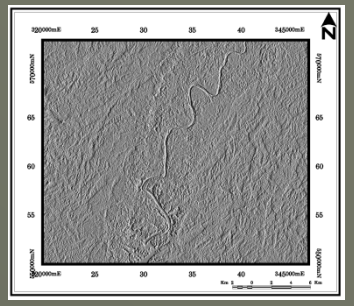
Image enhancement techniques such as Histogram Equalize and Salt-Pepper were applied into these images.



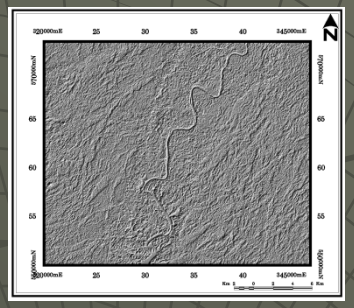
Sun angle 0°



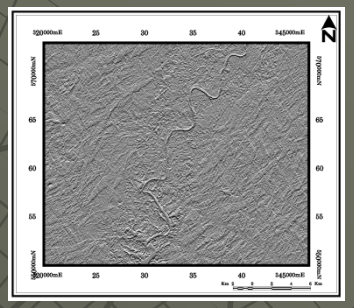
Sun angle 45°



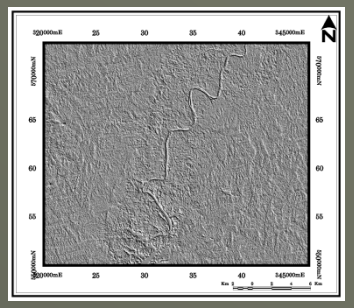
Sun angle 90°



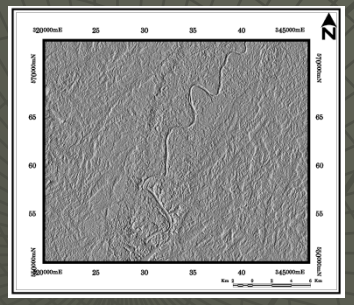
Sun angle 135°



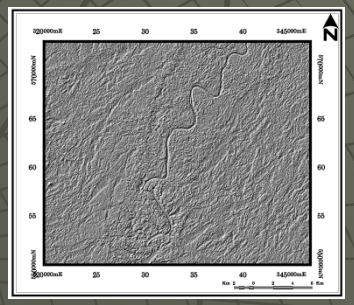
Sun angle 180°



Sun angle 225°

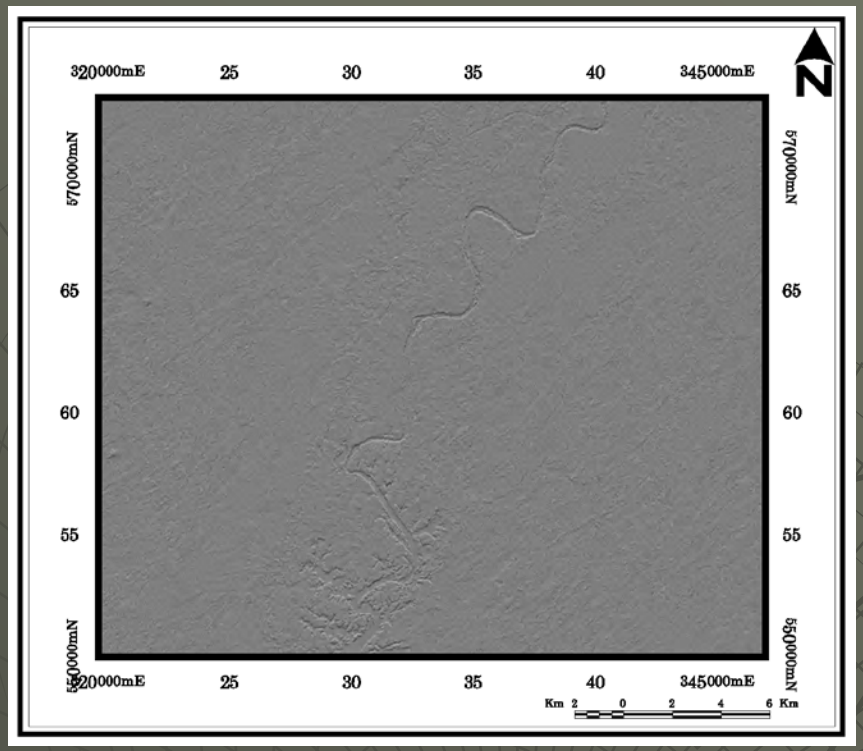


Sun angle 270°

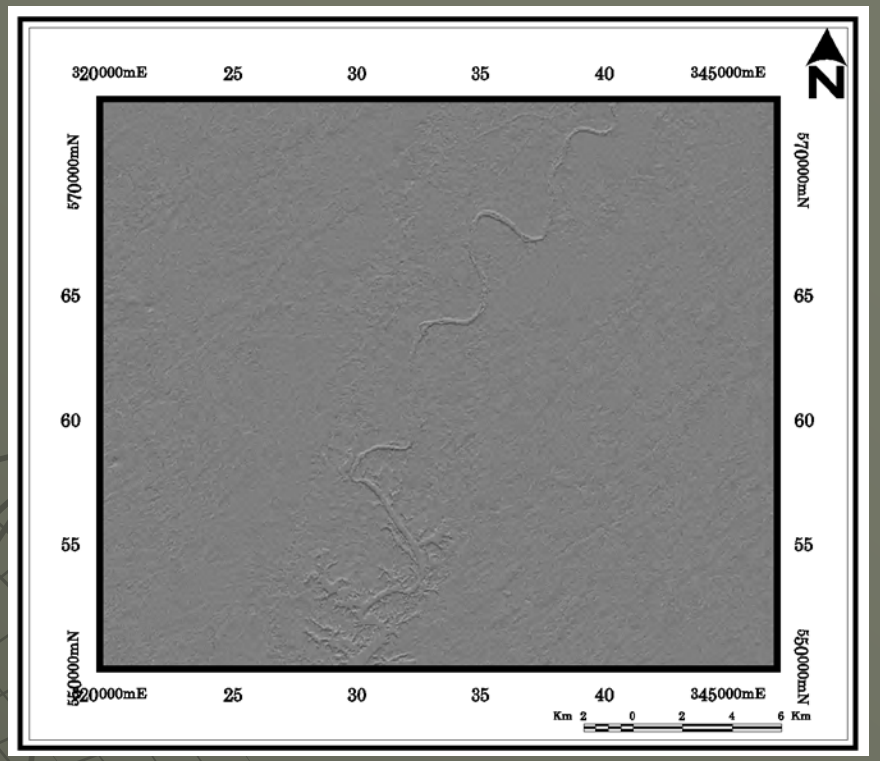


Sun angle 315°

Eight shaded relief images derived from band 4 of Landsat TM-5 with illumination directions(sun azimuth), 0°, 45°, 90°, 135°, 180°,225°, 270° ,and 315°, a solar elevation of 30° and an ambient light setting of 0.20.



A: First four shaded relief images combination



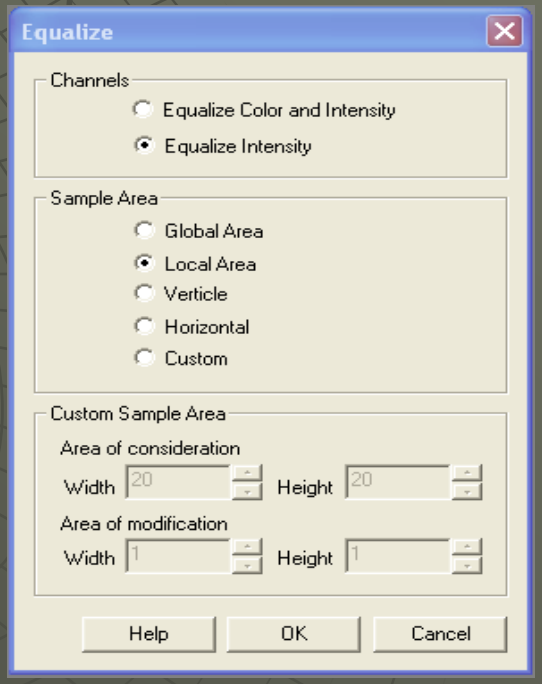
B: Second four shaded relief images combination

Two shaded relief images created by combining different shaded relief images. A: Combining four shaded relief images with sun angle of 0°,45°,90° and 135°.And B: Combining four shaded relief images with sun angle of 180°,225°,270° and 315°.

Histogram Equalize enhancement technique was applied to enhanced both images by using **Equalize module**.

The Equalize module equalizes an image's contrast based on various sample sizes. The module attempts to equalize the number of pixels in a given color (grey color) and will tend to flatten and raise an images histogram. The equalization module can operate on just the pixel intensities. **Equalize Intensity** and **Local Area** parameters have been selected within this module.

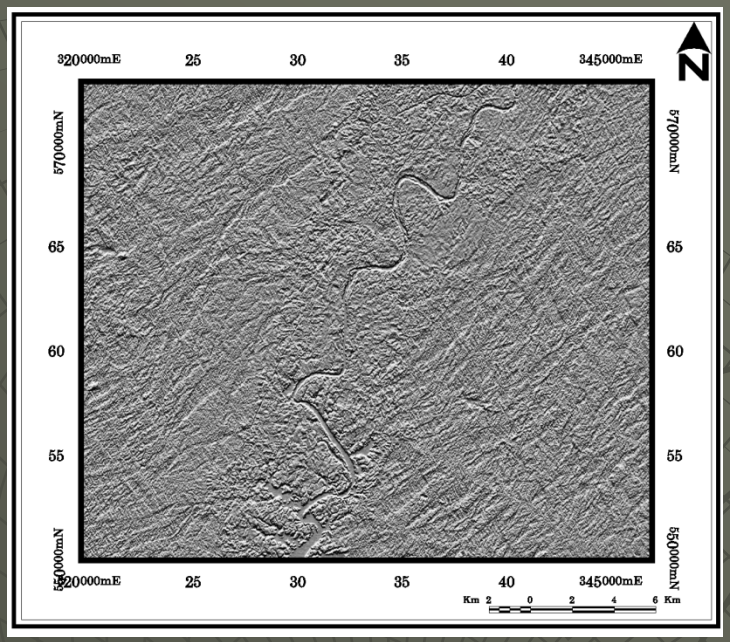
Equalize module



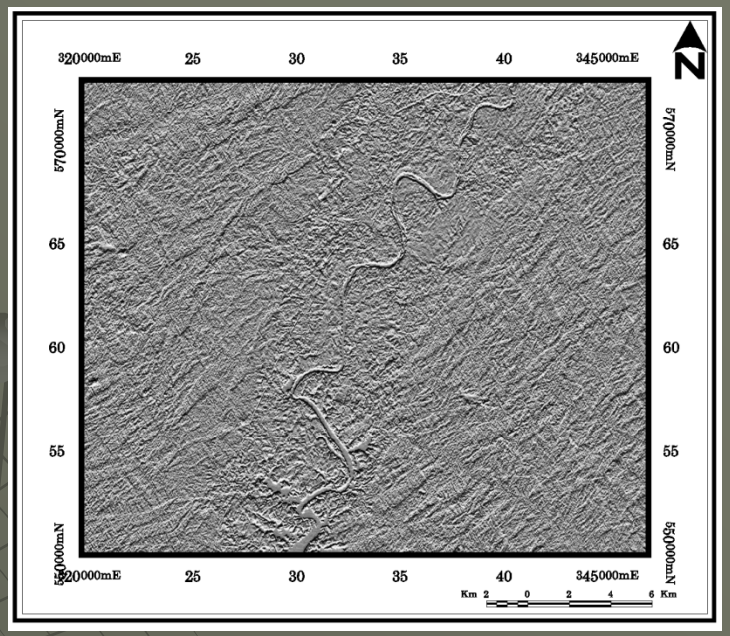
After applying Histogram Equalize technique, the second applied technique was Salt-Pepper enhancement technique. The Salt and Pepper filter will remove “hotspots” in the image. Hotspots are defined as those pixels whose intensity values are abnormally higher (salt) or lower (pepper) than the immediate surrounding. The filter will determine what the average intensity is around a particular pixel and then based on a similarity set the pixel to that average value if the pixels value is above that similarity threshold.

The two images have been enhanced by applying different values of Salt - Pepper filter parameters and the suitable value of Speck Size and Sensitivity parameters of the Salt - Pepper filter model are 4 and 50, respectively

Salt-Pepper module



A

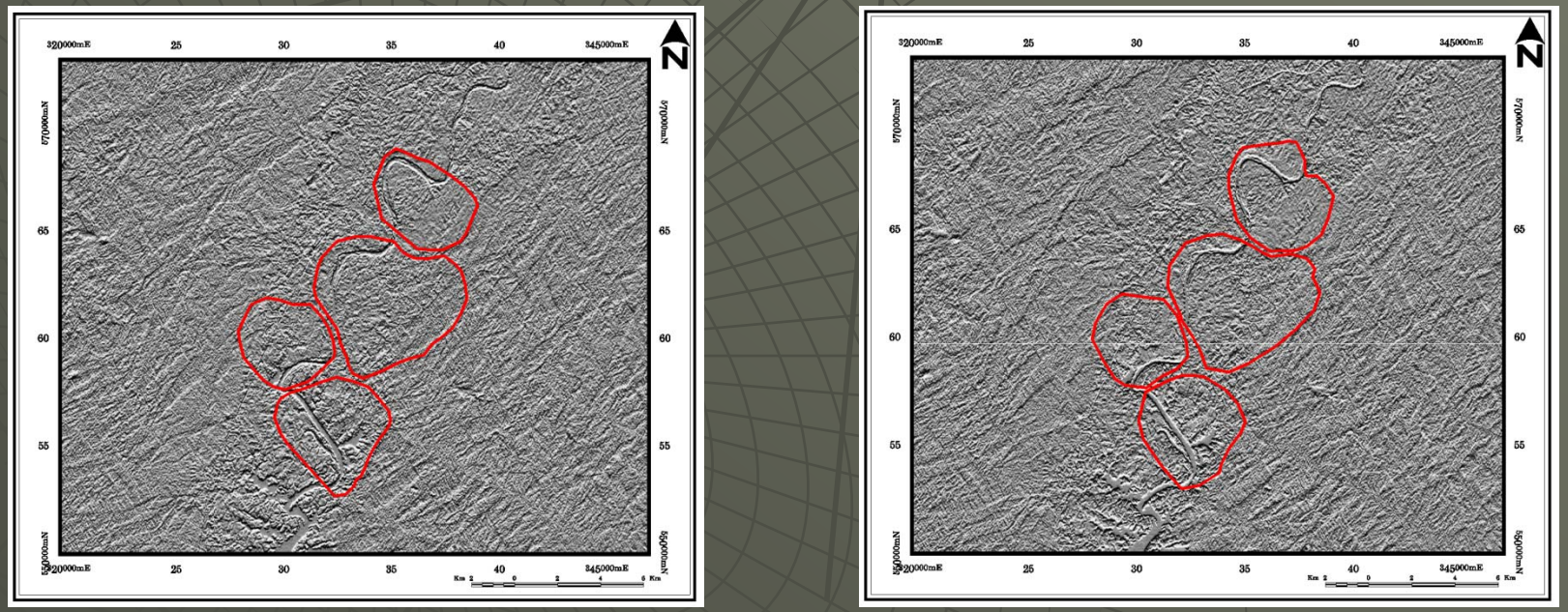


B

Two enhanced shaded relief images after applying Histogram Equalize and Salt - Pepper Models. A: Combining four shaded relief images with sun angle of 0°,45°,90° and 135°.And B: Combining four shaded relief images with sun angle of 180°,225°,270° and 315°.

RESULTS AND DISCUSSION

Four circular features were mapped from both enhanced images. The biggest one was located in the central part of the study area with estimated diameter of 5767 m. Two small circular features were mapped in the southwest area of the biggest circle with average diameters of between 3900m to 4150m. The fourth circular feature was mapped north of the biggest circle with 4495 m in diameter. These circular features could be reflected the impact meteorites.



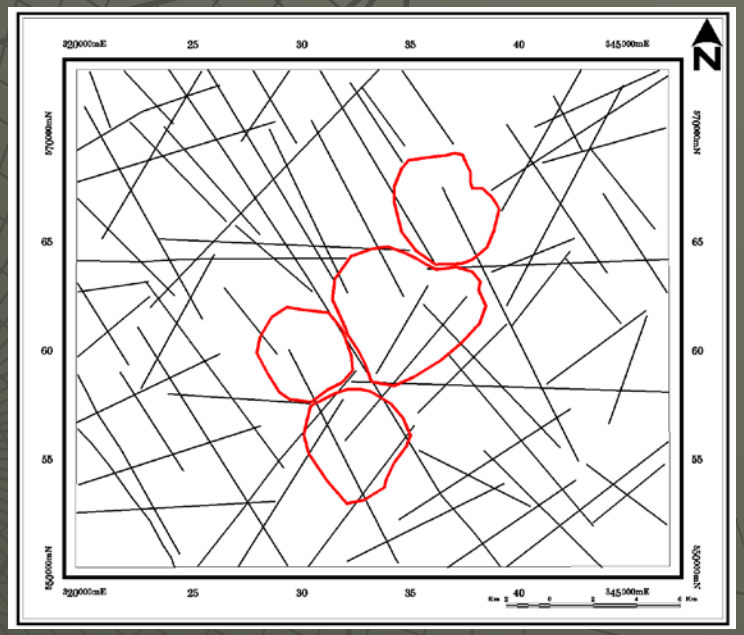
A B

Circular features extracted from first and second images of four shaded relief images combinations. A: Four shaded relief images with sun angle of 0°,45°,90° and 135° combination .And B: Four shaded relief images with sun angle of 180°,225°,270° and 315° combination.

SUMMARY OF RESULTS

1. Circular or near-circular features which were mapped from both images show similarity with not much differences in their general shapes of the circles in both circular features maps.
2. Based on the pattern of the circular features including the shape, linking characteristics, spatial relationships, and visual interpretation of circular features maps with topographic and drainage pattern maps, the extracted circles of the two shaded relief images mostly resemble positive features in the area.
3. The most important feature in the area is the presence of topographic relief pattern. There is good relationship between the circular and near-circular features and distribution of the topographic relief pattern of the study area.

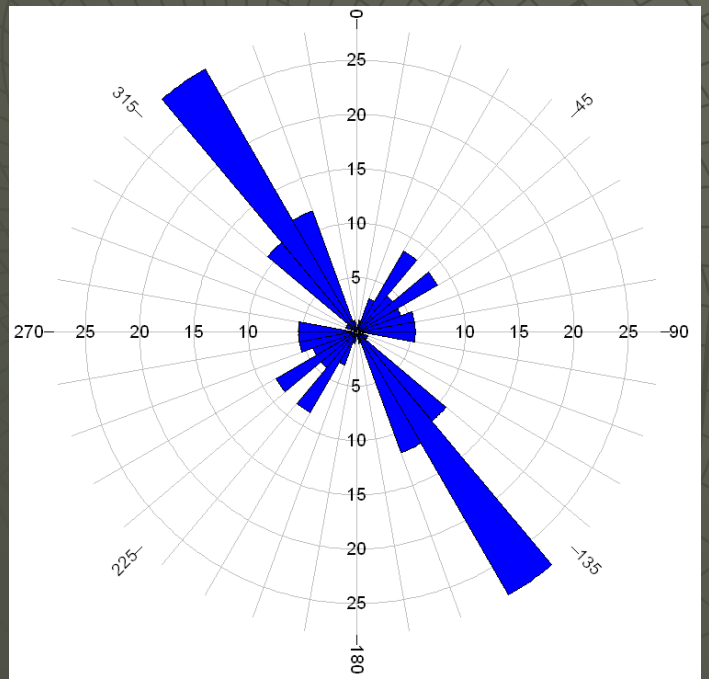
4. A total of **72 faults** (lineaments) are manually identified using the images after different shaded relief images combinations. The total length of all lineaments is approximately **555.3** km.



Lineaments (faults) map extracted from first and second images of shaded relief images combinations.

5. The circular features appears to have been affected by the numerous fault systems in the area. Some of these circles were cut and separated by these faults. The fault and fractures also increases the surface area of circular features that can be eroded, and hence enhances the rate of erosion.

6. The main lineaments directions in the area were dominated by three major trends that are NNW-SSE(40º) and the other minor trends are NE-SW(30º-50º) and E-W(40º).



Rose diagram of lineament map

CONCLUSION

- Results of the study show that Landsat TM-5 with 30m resolution can be a potential tool for circular features study and analysis especially in the tropical area.
- The image enhancement technique is one of the useful technique to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for image processing techniques, one of those enhancements is Equalize and Salt-Pepper modules for enhancing the edges in an image.
- The results of circular or near-circular features extracted from satellite images should be confirmed by other method of investigations such as drilling or geophysical techniques (e.g. gravity or magnetic methods).

Thank you