

Digital processing of LANDSAT TM data for geological applications: an example from the Langkawi Islands

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Satellite data such as LANDSAT MSS, LANDSAT TM, SPOT and RADAR are commonly used in helping geological mapping and interpretation in areas with less or no vegetation, soil and surface material cover. However, in tropical area like Malaysia with a combination of dense vegetation and thick soil cover, the value and potential of using satellite data is greatly reduced, therefore the use of such data in geological mapping and interpretation is said generally to be very difficult to produce useable result. Notwithstanding, the vegetation anomalies and the geomorphologic appearance which are usually related to the rock types, quite frequently could be seen or detected in satellite images and therefore could be used to delineate certain lithologic units. With this regard, this study is carried out in order to see whether the LANDSAT TM image characteristics of the Langkawi Islands could be used to recognise, differentiate and correlate with rock types in the area. The island was selected because it has been mapped in detail geologically.

The Langkawi Islands consist of four rock formations. The oldest, known as Machinchang Formation, consists of mainly quartzite and subordinate flagstone. This formation is conformably overlain by the Setul Formation which is composed of mainly limestone with minor sandstone and shale. The Singa Formation which consists of mainly mudstone and shale with minor sandstone unconformably overlies the Machinchang and Setul Formations. The youngest rock formation is known as Chuping Formation, consists of limestone (dolomitic), conformably overlies the Singa Formation. In addition to these formations, granite and alluvium are also widespread in the islands.

The satellite data was digitally processed with the objective of producing more interpretable images. The processing techniques involved include geometric correction, atmospheric correction, contrast enhancement, colour display in colour composite, principle component analysis (PCA), ratioing and filtering. The characteristics of every image produced were carefully observed and inspected directly from the computer monitor to obtain any relationship with the lithology of the area. As a result, a few processed images show distinct and good image characteristics which could be used to compare and relate with the lithologic units of the area. In order to test the capability of the satellite image in exhibiting the geological information of the area, the image characteristics of these digitally processed LANDSAT TM images were compared to the published geological map.

It was found that the best amongst the image product in exhibiting the good correlation with the geological information of the Langkawi Islands is provided by the band ratio colour composite combination of bands TM2/1-7/1-4/2, followed by the principle component colour composite PC432 and band colour composite TM452 displayed in red, green and blue respectively. Geological lineaments are best displayed on black and white image in TM band 4. The best non-directional filter in displaying lineaments for the area is filter with convolution matrix :

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

whereas for directional filters, the best convolution matrix for each particular direction are as follow:

-1	-1	-1	-1	0	1	-1	-1	0	0	-1	-1
0	0	0	-1	0	1	-1	0	1	1	0	-1
1	1	1	-1	0	1	0	1	1	1	1	0
east-west			north-south			northeast-southwest			northwest-southeast		

The result from this study show that it is clear the characteristics of remote sensing data, in this case the LANDSAT TM images, are well correlated with most geological information in the study area, and therefore have a great potential to be used in general geological mapping in tropical zone like Malaysia particularly the area which is largely still covered by natural vegetation and less disturbed by the development.