UNIVERSITI PUTRA MALAYSIA

LINEAMENT MAPPING IN MALAYSIAN TROPICAL FOREST ENVIRONMENT UTILIZING LANDSAT IMAGERY

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The remote sensing application of multispectral data analysis has been proven as a useful tool in geological exploration especially in lineament identification and mapping. This study demonstrates the use of multispectral Landsat TM and ETM+ satellite data obtained in different two acquisition dates in year 1990 and 2002 for lineament interpretation in a Malaysian tropical forest environment. The Digital Elevation Model (DEM) was also been utilized to improve the interpretation process. Utilizing the rose diagram analysis and histogram superimposition, it was found that most of the major orientations from field station were successfully matched with the orientations from extracted lineaments obtained from the imageries. The lineaments also found to be structurally controlled by the river segments. Thus river segments may be used as a basis in the early stage of interpretation where the knowledge of general lineament trend is necessary. The results from the study showed that remote

sensing technique through the manual extraction is capable of extracting lineament trends in tropical forest which inaccessible by conventional survey technique. The undertaken steps may be utilized as an ideal framework of lineaments extraction utilizing the Landsat imagery in tropical forest environment such as Malaysia.

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Oleh

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Aplikasi sistem penderian jauh bagi analisis data multispectral telah terbukti berguna didalam ekplorasi geological terutamanya didalam pengenalpastian dan pemetaan lineament. Di dalam kajian ini telah menunjukkan kegunaan imej multispectral satelit iaitu Landsat TM dan ETM+ yang diperolehi pada tarikh yang berbeza meliputi tahun 1990 dan 2002 bagi tujuan interpretasi lineament bagi persekitaran tropika Malaysia. Digital Elevation Model (DEM) juga digunakan untuk meningkatkan lagi kualiti interpretasi. Dengan menggunakan analisis rose diagram dan histogram superimposition, didapati bahawa sebahagian besar orientasi utama yang diperolehi dari station kajian boleh didapati pada orientasi lineament yang diperolehi daripada imej satelit. Lineament juga didapati dipengaruhi dengan struktur segmen sungai. Dengan itu, segmen sungai boleh digunakan sebagai rujukan pada peringkat awal interpretasi dimana ia memberi gambaran awal lineament amat diperlukan. Hasil kajian ini menunjukkan bahawa teknik penderian jauh secara manual boleh mengekstrak lineament daripada hutan tropika yang sukar dilakukan dengan menggunakan teknik pengukuran conventional. Langkah-langkah yang telah dijalankan didalam kajian ini boleh dijadikan sebagai rangkakerja yang sesuai bagi mengakstrak lineament dengan menggunakan imej Landsat bagi kawasan hutan tropika seperti Malaysia.

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LIST OF ABBREVIATIONS

FCC	False Color Composite
PCA	Principle Component Analysis
GIS	Geographical Information System
TIN	Triangulated Irregular Networks
DEM	Digital Elevation Model
SI	Superimposition
GPS	Global Positioning System
TM	Thematic Mapper
ETM+	Enhanced Thematic Mapper Plus
GCP	Ground Control Points
FM	Field Measurement
LN	Number of Lineamant
LL	Length of Lineamant
RN	Number of River Segment
RL	Length of River Segment
LLan	Lineament from Landsat
RS	River Segment

CHAPTER 1

INTRODUCTION

1.1 Introduction

Lineament first defined by Hobbs (1904) as a significant line of landscape which reveals the unseen structure of the rock basement. In geomorphological sense, lineament is defined as a mappable, linear feature of a surface whose parts are aligned in a rectilinear or slightly curvilinear relationship and which differ from the pattern of adjacent features and presumably reflects some sub-surface phenomenon (O'Leary et al., 1976). Gupta (1991) had chosen this definition due to it most practical definition in the perspective of remote sensing image interpretation.

Lineaments are assumed to be evidence of fracturing and may indicate zones of increase porosity, fault traps, drape folds and uplifted blocks in the sense of remote sensing (Prost, 1994). Fractures are commonly caused by stress exceeding the rock strength and cause lost consistency in rock structure. O'Learly et al. (1976), Davis (1984) and Clark and Wilson (1994) stressed that these structural weakness originated mostly around physical discontinuities which reforming of faults, fractures, joint sets and dykes. Structural discontinuities in rocks most often result in linear or curvilinear morphological features along the intersection of fracture plane and land surface (Masoud and Koike, 2006). For areas especially in hard-rock are generally related with conductive of fracture zones (Hung et al., 2005). Hung et al. (2005) suggested that fractured rocks could be analyzed by revision the lineaments with the help of lineament indices.

Recently, the use of satellite images for geological mapping and exploring resources is becoming increasingly important (Nalbant and Alptekin, 1995). As early as 1974, Rowan (1974) has undertaken the geological studies utilizing the multispectral satellite imagery of ERTS. Gradually the conventional structural geological studies especially in detecting geological lineament utilizing aerial photo is being complemented, and replaced with the multispectral airborne or satellite imagery (Siegel and Abrams, 1976; Drury, 1986; Smithurst et al., 1987; Juhari and Ibrahim, 1997; Arlegui and Soriano, 1998; Kumanan, 2001; Madani, 2001; Hung et al., 2005; Ricchetti and Palombella, 2005). Boyer and McQueen (1964) found that the lineament may be emphasized by the vegetation and topography in the imagery inforn of linear features which has successfully evidenced the reflection of rock fractures.

The conventional geological mapping of structures like faults, folds and lineaments for structural analysis have provided useful information on structure and stress distribution in small area (Bucher, 1920, Friedman, 1961). Basically, the conventional lineament extraction techniques were regularly based on the visual interpretation on the aerial photographs or paper-based satellite image mosaics

(Masoud and Koike, 2006). This technique was performed utilizing the hand tracing on the overlaid transparent paper by delineating the interpreted lineaments on the aerial photo or the mosaics imageries. However, for regional mapping projects, these techniques are time-consuming, tedious, subjective, and irreproducible (Masoud and Koike, 2006).

Satellite images are among continuous sources of data for mapping lineaments which normally reflect to surfaces of discontinuity in the rock (Mostafa and Bishta, 2005). Thus, the advantages of wide ground coverage and the relative high resolution with respect to scale presented by the satellite images enables regional and local lineament analysis to be analyses in a more accurate way (Suzen and Toprak, 1998). The imagery also may be improved through the image enhancement techniques, where the feature sharpness and contrast increase the effectiveness of the interpretation process in geological applications (Basappa and Gaikwad, 1985; Krishnamurthy, 1997). The geological mapping prepared from the imagery is more cost effective and this mapping may be better rather than utilizing ground observations alone (Krishnamurthy, 1997; Gupta, 2003; Saraf et al., 2004). Therefore, the lack of detecting the continuity of topographic features related to geological structure in field mapping (Drury, 1986) may be compliment with the satellite imagery. Nevertheless, the remote sensing interpretation data must be supported by field measurement data which may be accurately localized and characterized the study area (Gupta, 2003, Peña and Abdelsalam, 2006). Besides, visual interpretation from imagery data is also subsequently compared with results of surface geological mapping (Peña and Abdelsalam, 2006) to verify the geological interpretation accuracy.

The main purpose in this study is to demonstrate the use of multispectral Landsat TM and ETM+ satellite data obtained at different two acquisition dates in year 1990 and 2002 for the lineament interpretation in a Malaysian tropical environment. The high spectral resolution of multispectral Landsat along with image improvement techniques were utilized in this study. The visual interpretation was the main task for identifying the lineaments on the imagery, thus the identified lineaments were delineated manually on the screen. The subjectivity factor which been a crucial issues in lineament identification was also undertaken to enhance the accuracy of extracted lineaments. The obtained final lineament map was than confirmed with the ground verification by comparing with the field measurements and river segments. The verifications were carried out to validate the accuracy of the extracted lineaments and to confirm the influence of river segment to the existing lineaments.

1.2 Problem Statement and Significance of Study

Most of the geological studies in remote sensing applications are more on to the understanding the geological structural interpretation (Arlegui and Soriano, 1998; Pradeep et al., 2000; Hung and Batelaan, 2003; Syed and Saied, 2004; Akman and Tüfekçi, 2004; Mostafa and Bishta, 2004; Richetti and Palombella, 2005; Morelli and Piana, 2006; Yassaghi, 2006). However, only Arlegui and Soriano (1998) discussed the relationship between faults from the outcrop scale to the lineaments on the map. None of these studies undertake any detail comparison of joint and foliation trends from field mapping to the lineament trends detected on the Landsat or any satellite imagery.

Besides, other issue that arises in the lineament mapping procedure is the subjectivity factor (Gupta, 1991; Mabee et al., 1994). This is involved in the identification of the lineament in satellite imagery. From the literature, there was no specific and seldom employed measurement undertaken to minimize the subjectivity factor in lineament extraction (Mabee et al., 1994).

In addition, referring to the fault map obtained from the Mineral and Geoscience Department (JMG) only four major fault lines were discovered in the study area. The fault map was produced manually from the mosaic aerial photos. However, utilizing with better resolutions of spatial and spectral obtained from the satellite imagery such as the Landsat imagery probably may resolve more lineaments in terms of number and length. It is also important to point out herein that the study area is mostly been covered by the thick tropical forest. This also gives a problem to the geologist to identify and verify the fresh outcrop by occupying the geological survey in the field. The survey work is more preferred in providing information on structure distribution in small area. However, for regional mapping projects, this technique is time-consuming, tedious, subjective, and irreproducible (Masoud and Koike, 2006). Thus, it shows that the needs of new improved techniques to enhance the quality and accuracy of the lineaments interpretation especially in the area that mostly covered by tropical forest environment.

This study was undertaken for identifying the lineaments in the thick forest area where the geological features located beneath the vegetation cover which are very difficult to be seen in the satellite imagery. The final lineaments with minimum subjectivity factor were compared with the outcrop field mapping comprise of foliation and joint measurements of the study area. This verification was used to verify the accuracy of the extracted lineaments from the Landsat imagery. Thus, the undertaken study will assist and improve the techniques to identify more lineaments which may cater any inadequate lineaments features from the previous method.