MAPPING ROCK OUTCROPS FROM LANDSAT DIGITAL DATA

A Thesis

Submitted to

The Faculty of Graduate Studies

The University of Manitoba

In partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

by

Pakiraiah Chagarlamudi

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ABSTRACT

Pre-field maps showing the distribution of rock outcrops are an important aid in effective planning and conducting of geological mapping. These maps are, traditionally, prepared from aerial photographs using photogeological methods. An automatic system of producing rock outcrop maps from standardized Landsat digital data has been developed. This system employs a hierarchical classification scheme in identifying rock outcrops and in discriminating among rock types. The system developed in this study has been calibrated and tested in the Coppermine area of the Northwest Territories of Canada.

Rock outcrop and rock type maps of two intensive study areas in the Coppermine area have been produced by the automatic system. Maps have also been prepared for these areas from visual analysis of simulated color infrared images produced by a simple digital enhancement procedure developed in this study. The maps and the digitally enhanced images have been compared with aerial photographs and known geology.

The enhanced images have been found to be superior to aerial photographs in identifying large (about 30 x 30 m) rock outcrops and in discriminating among these outcrops. The accuracy of identifying rock outcrops with the automatic system was better than 90% compared to the visual analysis method, taken as standard, in both the intensive study

areas. The rock type separation accuracies were as high as 86% for dolomites and 57% for basalts with intercalated sandstones, and 77% for sandstones in typical rock outcrop areas of the intensive study areas.

Spectral signatures of nine different cover types were derived from standardized Landsat digital data for establishing threshold values used in discriminating among the cover types. The differences in signatures among rock types were subtle and susceptible to misclassification even with minor contamination due to other rock types or cover types.

The cost of generating rock outcrop maps from Landsat data by the computer method is estimated to be less than 20% of the cost of producing the maps with aerial photographs using conventional methods. A unique benefit of the method is in easily providing mensuration data on cover types identified, which are helpful in planning field mapping programs. Other benefits include the use of digitally enhanced simulated color infrared images as base maps and in field studies, although these benefits are more directly attributable to the Landsat data characteristics than to the automatic method.

It is cautioned that the system developed does not replace conventional geological mapping but rather aids the field geologist in efficiently carrying out the mapping. It is recommended that the system be tested in other areas to

further validate the calibration procedures and accuracies obtained in identifying rock outcrops as well as in discriminating rock types. It should be realized that rock outcrops must be relatively large for recognition by the system as the spatial resolution of the Landsat Multi-Spectral Scanner data used is 50 m x 50 m.

DEDICATION

This thesis is dedicated to my dear wife - Vijaya and to my wonderful children - Raghu, Radhi, and Rekha. The "price" they have paid for it is extravagant and surpassed even my most optimistic estimates.

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1.0 INTRODUCTION

Geological mapping is of fundamental importance in economic and engineering geology, as well as in geological research. The purpose of this study is to develop a system to map rock outcrops from Landsat digital data as an aid in gelogical mapping. To be viable the system must, at least, generate maps comparable to those obtained from conventional sources and be cost effective.

Historically, geological mapping has been done entirely based on field evidence or ground-based methods. However, over the past 40 years or so, aerial photographs have been used to supplement information acquired in the field. This use of aerial photographs through photogeological interpretation has been proven to aid the geologist in field mapping and be cost effective.

Work maps or pre-field maps are prepared using information obtained through photogeological methods. Geologists spend considerable time in preparing the pre-field maps. These maps usually contain locations of rock outcrops and some structural information. The pre-field maps are used in planning the field mapping program and to augument information collected in the field. In planning the mapping program, the maps are used in estimating time requirements in the field, familiarizing the geologist with the area, and also in directing the geologist

to locations of outcrops. The quality and quantity of information present on the maps greatly influences the time required in the field and how effectively this time is utilized.

The availability of aerial photographs is a prerequisite for making the pre-field maps. Aerial photographic coverage exists for almost all regions of Canada, although it may not be current, at the scale required by the agency involved in mapping, and acquired in a season suitable to extract maximum utility. However, photographic coverage does not exist for all regions of the Earth. Flying large areas to acquire aerial photography is costly. Unfortunately, in areas where aerial photography does not exist, geological mapping is generally limited.

Landsat data may now be thought of as an alternative to aerial photographs in preparing the pre-field maps for regional mapping. Landsat satellites have been providing images of almost all regions of the Earth repeatedly since 1972. The data acquired by Landsat satellites have several advantages over aerial photographs. Some of the more salient advantages are that they provide synoptic coverage under essentially the same illumination conditions, are acquired in several spectral regions of the electromagnetic spectrum thereby providing color imagery, and are in digital form allowing data manipulation using computers.