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Unsupervised Classification of Intrusive Igneous Rock Thin Section Images using Edge Detection and Colour Analysis

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***Abstract*—Classification of rocks is one of the fundamental tasks in a geological study. The process requires a human expert to examine sampled thin section images under a microscope. In this study, we propose a method that uses microscope automation, digital image acquisition, edge detection and colour analysis (histogram). We collected 60 digital images from 20 standard thin sections using a digital camera mounted on a conventional microscope. Each image is partitioned into a finite number of cells that form a grid structure. Edge and colour profile of pixels inside each cell determine its classification. The individual cells then determine the thin section image classification via a majority voting scheme. Our method yielded successful results as high as 90% to 100% precision.**

Keywords— Minerals; Classification; Igneous Rocks; Edge Detection; Colour Analysis.

I. INTRODUCTION

Petrographic thin section microscopy study has a long tradition both in applied and academic geosciences. A geoscientist can straightforwardly identify a rock's constituent mineral phases, quantify fabric parameters and infer a rock's genesis using thin sections and a petrographic microscope.

Point counting of petrographic thin sections is the standard method for mineral and rock classification. This process is performed by a petrologist to find out the percentage of each mineral inside the thin image. Since this process is done manually, it is more inclined towards qualitative analysis rather than quantitative, as individual observation may vary and this could possibly lead to misclassification by the observer [1].

In mineralogy, a microscope is commonly used tool for manual mineral classification in thin sections. Experts have problems with automation of mineral classification process using a microscope [2]. Images obtained from rock thin sections exhibit inhomogeneous colours for each mineral type. This is caused by subtle tone changes which are related to inhomogeneous chemical composition and deformation due to stress affecting the rock sample [3].

There are inherent drawbacks of using petrographic microscopy. The process itself is time-consuming and iterative. It requires a human expert with substantial knowledge and experience in combining multiple petrographic and microscopy classification criteria, e.g., texture, colour, cleavage, twinning and tartan pattern, to perform the point counting. Due to this, we argue that an unsupervised classification of the rock thin sections to replace the human operator is therefore necessary.

This paper presents our unsupervised classification method and the classification results using edge and colour as the discriminating features.

II. RELATED WORKS

According to [4], minerals comprising of igneous rocks are grouped either as primary or secondary minerals. Primary minerals are the type of minerals that crystallized directly from magma. According to [5], the composition of magma ranges widely. These compositional variations, together with rock textures, provide the best basis on which to classify igneous rocks and to distinguish them from other rock types

TABLE I.
MINERAL COMPOSITION OF INTRUSIVE IGNEOUS ROCKS, BASED ON THE QAPF DIAGRAM [6].

No	Intrusive igneous rocks	Quartz %	Alkali Feldspar %	Plagioclase Feldspar %	Accessory Mineral %
1	Granite	20-60	35-90	10-65	5-20
2	Adamelite / Quartz monzonite	5-20	35-65	35-65	10-35
3	Tonalite	15-50	10-35	65-90	10-40
4	Diorite	<5	-	70-90	20-50

The 3 principal discriminant features used to classify igneous rocks are modal parameters, grain size characteristics and chemical characteristics. In this study, classification is solely based upon the determination of modal parameters. The Quartz, Alkali feldspar, Plagioclase, Feldspathoid (Foid) (QAPF) diagram is used in classification and nomenclature of coarse-grained crystalline rocks [6]. Percentage distribution of the modal mineral (QAPF) contents is shown in Table 1.

The optical properties of rock-forming minerals serve as the discriminative criteria for the classification of igneous rock thin section images. External knowledge on minerals with crossed

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