A STUDY ON AUTOMATED SEGMENTATION FOR OBJECT-BASED IMAGE ANALYSIS FOR GEOLOGICAL MAPPING IN THE NORTHERN CAPE PROVINCE, SOUTH AFRICA.

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KEY WORDS: Automated image segmentation, geological mapping, accuracy assessment

ABSTRACT

This pilot study assesses the accuracy of the automated image segmentation technique for lithological discrimination. The result of this technique is compared to the existing geological map compiled from manual discrimination of lithological contacts from the Hymap minimum noise fraction bands 459 combination images. The study uses the geologist's visual analysis to examine the accuracy of this technique. The overall results reveal that the automated image segmentation technique managed to discriminate between different lithologies; however there over segmentation in certain lithologies. The study therefore recommends the incorporation of expert knowledge in the automated segmentation classification technique.

Introduction

The creation of geological maps entails examining remotely sensed images and other auxiliary data for assistance in discriminating between different lithologies. For the remotely sensed images, there is always a need to improve the available processing techniques as the computer and technological capabilities improve. This study assesses the capability of the automated image segmentation technique towards lithological discrimination. The results are compared to the geological map composed by an expert (geologist) by manual digitising of different lithologies from hyperspectral Hymap data (Ngcofe *et al.,* 2010).

Automated image segmentation is an image processing technique that automatically groups the image pixels into regions (or segments) based on similarity criteria by applying independent operators (or algorithms) across an image (Taye, 2011; Chen *et al.,* 2008; Orkonselenge, 2004; Neubert *et al.,* 2006). Darwish *et al.,* (2003) assert to this stating that the merging decision is based on local homogeneity criterion describing the similarities between adjacent image objects. The homogeneity criterion is defined by Neubert *et al.,* (2006) and Blaschke (2010) as a combination of colour (spectral value) and shape properties of the observed object.

The study discussed in this paper uses eCognition software developed by Definiens Imaging, a German company for object based image analysis processes. The eCognition software offers the capability of applying different scale parameters and colour and / or shape combinations driven by the user in order to build a hierarchical network of image objects whose results are then used to outline different materials within the image.

The aim of this pilot study is to visually assess the accuracy of automated image segmentation technique in lithological discrimination with the reference geological map compiled by Ngcofe *et al.,* 2010. The study area is located in the south-eastern part of the 1:250 000 scale 2816 (Alexander Bay) geological map sheet in the Northern Cape Province of South Africa. The selection of the study area was driven by the availability of Hymap hyperspectral data through collaboration between the Council for Geoscience (CGS), the Geological Survey of Namibia (GSN) and Hyvista (an Australian based) Company. There is also a completed pilot research in this study area. The completed research entailed the production of a more detailed geological map in the area from Hyperspectral data using the Minimum Noise Fraction technique (Ngcofe *et al.,* 2010). Furthermore, the area has a revised 1: 250 000 geological map sheet (Minnaar *et al.,* 2011) and unpublished 1:50 000 geological maps (produced by the CGS) which provide more in-depth information about different geological lithologies occurring within the study area (Figure 1).

Geological setting

The study area is located in an arid region of the country having rocky outcrops dominating the landscape. The geological setting in the study area is has a sequence of geological events in which the deposition of the Orange River Group (2.0 Ga) was closely followed by the intrusion of the Vioolsdrift Suite (2.0 to 1.73 Ga) with contemporaneous deformation of the Orange River Group. The deformation related to the Namaqua orogeny (1.3 to 1.0 Ga) left its imprints mainly to the east and south of the Alexander Bay map sheet but evidence of its influence on the rocks of the study area exist in weak foliations. A number of pegmatite bodies in the study area are related to the closing stages of this orogeny. Mafic dykes of the Gannakouriep Suite were intruded during the initial rifting stages of the Pan African orogeny (around 600 Ma) and strike mainly north-east. Minor Cenozoic deposits make up the rest of the geology in the study area (Figure 1).

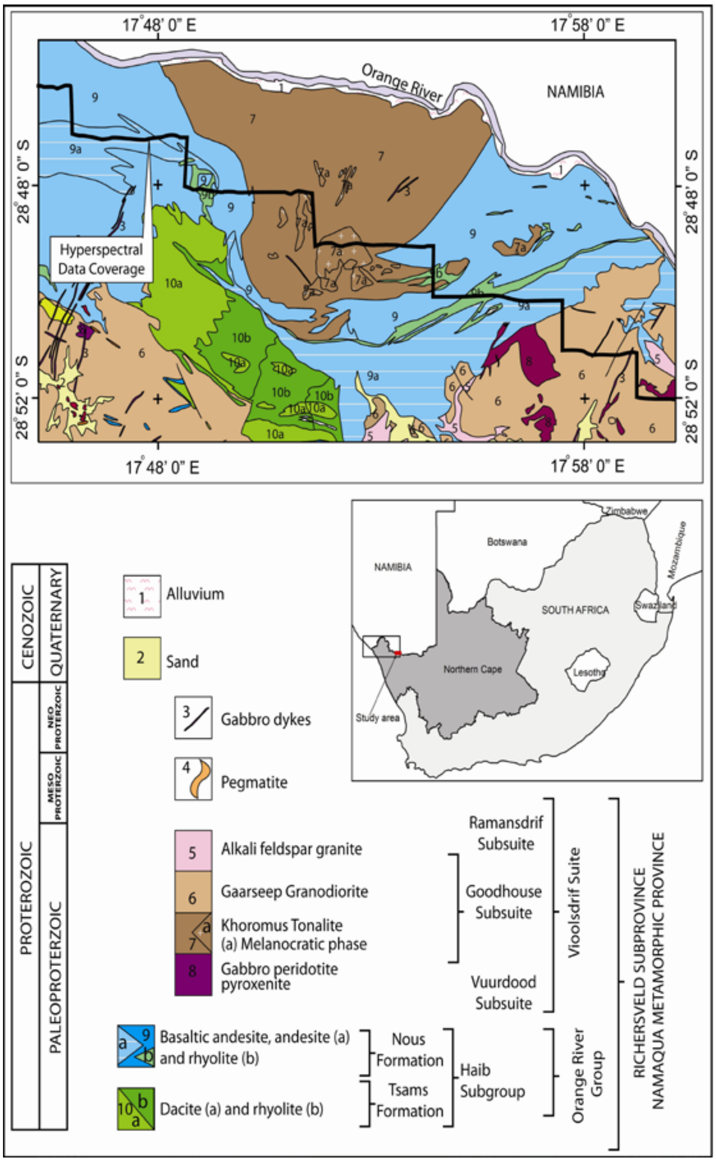

Figure 1: Geological map of the study area captured at 1:50 000 scale with the top of the stepped line highlighting the coverage hyperspectral image area.

Methodology

The methodology for this study is explained through Figure 2.

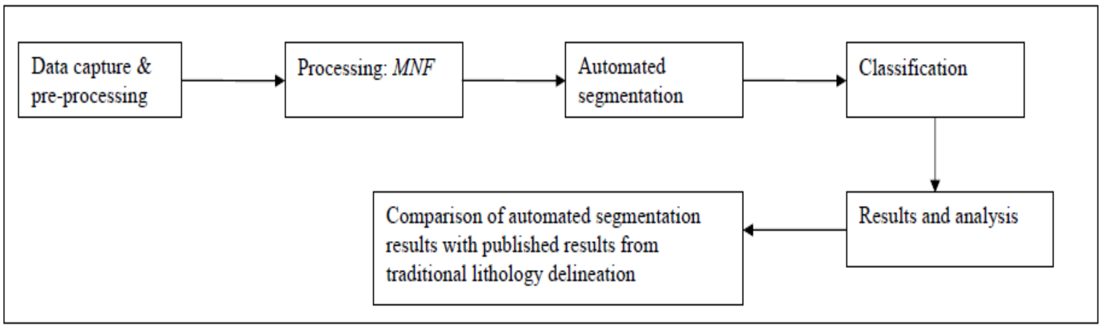

Figure 2: Methodological processes of the study.

As mentioned previously the data used for this study was provided through collaboration between the CGS and the GSN and Hyvista Company. The Hymap data was captured as an extension of a survey carried out north of the Orange River by Hyvista for the GSN. Hymap is an airborne hyperspectral sensor developed by Hyvista. Hymap data has 128 different spectral bands covering the visible near infrared (VNIR) wavelength to short wave infrared (SWIR) wavelength spectral region. The Hymap image has 64 bands from VNIR and 64 from SWIR wavelength spectrum, all with 5m spatial resolution (Cocks *et al.*, 1998; Papp and Cudahy, 2002; Hausknecht, 2005). The data was pre-processed (atmospheric correction and mosaic) by Hyvista.

The Minimum Noise Fraction (MNF) technique was used in this study in order to enhance the extraction of lithological discrimination. The MNF is defined as a technique that reduces inherent dimensionality of image data in order to segregate noise from the data and to create a small number or relevant spectral bands without the loss of essential information (Chen, 2000; Bertels *et al.*, 2005).

As already been mentioned, automated image segmentation was conducted using eCognition software. The software provides a variety of colour and scale parameter values to select from, in order to derive image segments or objects. The colour parameter determines the weighted use of spectral value and / or shape and texture value of an object being studied. The values range from 0.1 to 0.9, with high weighted values providing more emphasis on spectra and less on shape and texture while low values emphasise more on shape and texture and low on spectra. Chitade and Katiya (2010) recommend that high colour value should be used where possible, due to the high discriminative power of spectral information in imagery data. In this study several colour values where chosen systematically (starting from low value 0.1 to high value 0.9) and the results were analysed. A colour value of 0.9 was chosen as the better lithological discriminatory value.

The scale parameter is a tool provided by the software to determine the size of the image segmentation. The selection of a suitable scale parameter value is dependent on subjective trial and error methods. Dragut *et al.*, (2010) and Meinel and Neubert (2004) concur citing the lack of objective methods to chose scale for image segmentation as a huge challenge for this technique as trial and error methods takes time and are expert driven. The bigger the scale the larger the object segments and vice-versa. The scale parameter on eCognition software ranges from 5 to 250. For this study scale parameters were randomly selected starting from 5 to 250. The scale parameter of 250 better discriminated lithologies than other parameters. The final result used in this study was image segments derived from 0.9 colour and 250 scale parameters.

Experimental results and evaluation

The results of the automated classification are compared with the results produced by the expert-driven classification as shown in Figure 3.

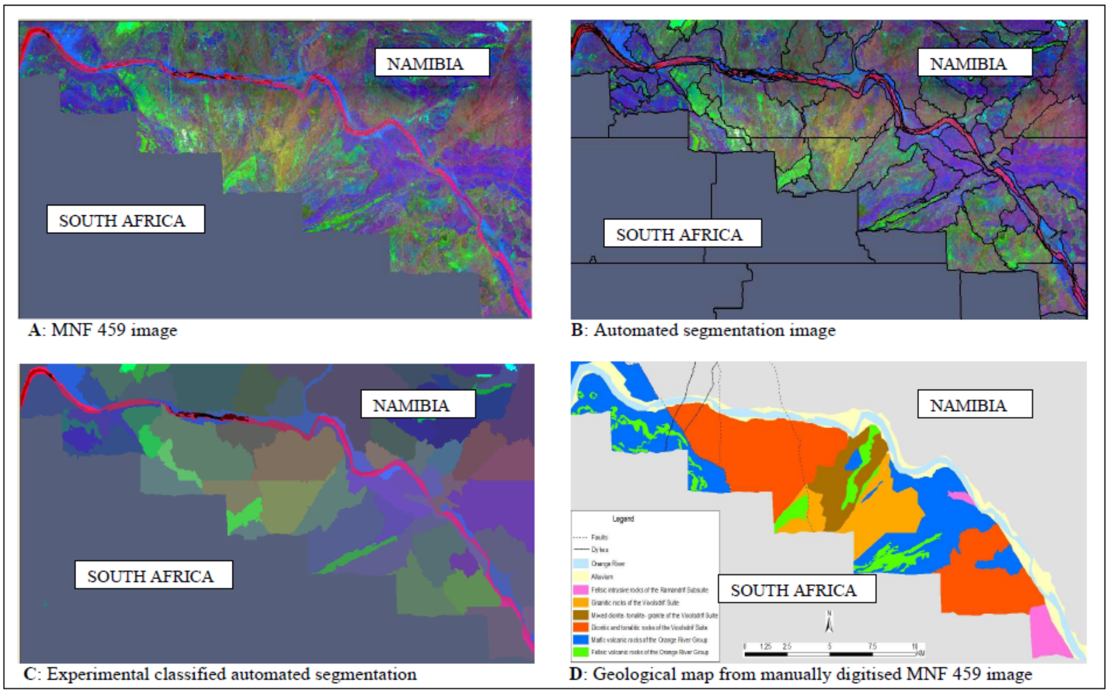

Figure 3: Un-scaled experimental results of image segmentation. The diagram **(A)** shows the MNF459 Hymap image used in the automated segmentation process, with the segmentation results shown by diagram **(B).** The diagram **(C)** shows the results from the classified image obtained from automated segmentation while diagram **(D)** shows the geological map derived by an expert from the manual digitising of a Hymap MNF 459 image.

The visual comparison of the automated image segmentation classification versus the expert-driven classification reveals some differences and similarities between the two classification results (Figure 3). The automated classification succeeds in distinguishing between mafic and felsic rocks (Figure 4). The discrimination of these lithologies however does not follow real geological contacts. They segregate similar rock types as two or more different units or lithologies (e.g. the subdivisions within polygon C and H cut across geological trends shown by two or more different colours in Figure 4). This subdivision is not based on any geological principle. It is also argued that there is over segmentation which resulted in segments (or objects) which are not geological related (polygon D, Figure 4). Despite such challenges, positives results have been also noted for example the correct classification of polygon A, F, G, K & L (Figure 4) when visually compared to reference map (Figure 3D). It is therefore recommended that more expert knowledge is required for correct classification together with more in depth understanding of the automated image segmentation process.

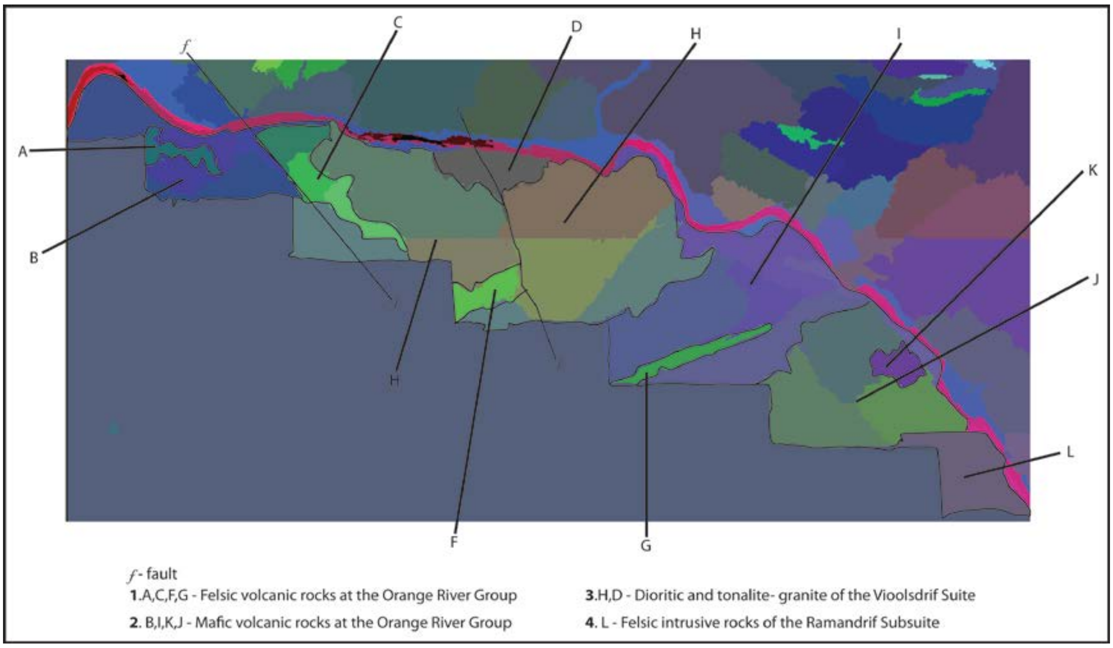

Figure 4: Interpreted automated image segmentation image

Conclusion

In this paper the result of automated image segmentation technique has been compared with the expert classical manual classification method of Hymap data. Using visual assessment, it was concluded that the automated image segmentation technique can contribute towards geological mapping. However, it is recommended that a geological expert still needs to modify the segmentation results as it has limitations towards discriminating certain lithologies. As this study is in the experimental phase, it is apparent that several techniques can be applied to improve the automated classification for geological mapping.

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