Mapping geology of SW Namibia using Landsat-8 band ratio combinations

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INTRODUCTION

Landsat-8 data was used to test the effectiveness of using spectral analysis and remote sensing in the differentiation of lithological units and mapping geology in Namibia. The study area is located in SW Namibia, in an arid region with little vegetation, making it an ideal place for remote sensing analysis. Different color composites and band ratios were compared to find the image providing the most geologic information and highest contrast between units. A false color composite (6,3,2 in red-green-blue) was first created to to show differences in bare earth, and from there, various band ratio combinations were created. Geologic maps were used to verify the results and select the best band combination. The best color composite image was created using band ratios from (7/6, 6/5, 4/2), and allowed identification of lithological units and vegetation. The results show that it is possible to draw accurate lithological conclusions from spectral patterns, and that high quality imagery can be used to update existing geologic maps or used for exploration.

STUDY AREA

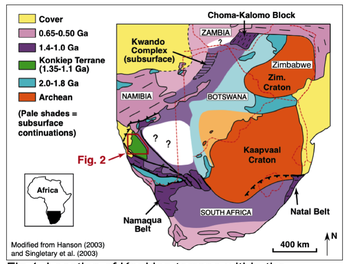


Fig 1. Location of Konkiep terrane within the Precambrian tectonic framework of southern Africa.

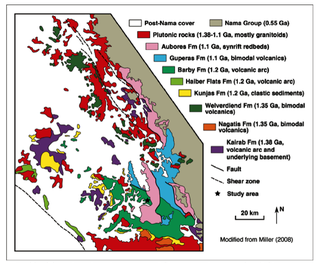


Fig 2. Geological map of the main part of the Konkiep terrane showing location of study area.

Mesoproterozoic arc rocks in SW Namibia occur within the Konkiep terrane (Fig. 1), which is a major tectonic element within the 1.4-1.0 Ga Namaqua-Natal orogenic belt that extends along the southern margin of the Archean Kaapvaal craton and represents one of the main convergent margins active during assembly of the Rodinia supercontinent. The Konkiep terrane contains a series of volcanic and sedimentary units and associated, dominantly granitoid plutonic rocks separated partly by major unconformities (Fig. 2).

The Barby Formation, which is the focus of the present work, contains a composite volcanic arc stratigraphic succession as much as 8 km thick. Our recent mapping in two well-exposed areas (Fig. 2) has revealed that significant parts of the formation consist of Hawaiian, Strombolian and phreatomagmatic pyroclastic deposits that were emplaced close to source vents (fissures or scoria and spatter cones) and are intercalated with fine-grained lacustrine strata, which are ubiquitous throughout the study area. The facies relations are consistent with the interpretation that these rocks accumulated in extensional basins during oblique subduction along the convergent margin. At least in the limited areas we have so far investigated, there is no evidence for high-standing stratovolcanoes.

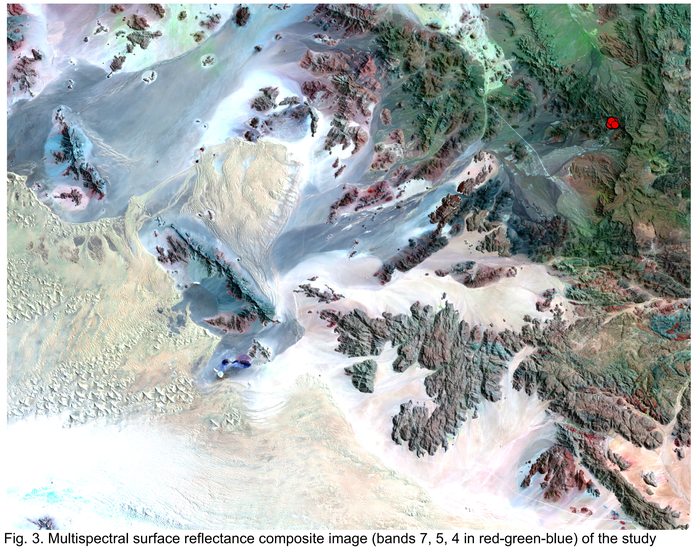


Fig. 3. Multispectral surface reflectance composite image (bands 7, 5, 4 in red-green-blue) of the study area.

Island-arc tholeiitic rocks of the ~1.38 Ga Kairab Formation represent the earliest arc magmatism in the terrane. Following accretion of this arc and its underlying metamorphic basement, renewed magmatism at ~1.35 Ga formed the bimodal (basaltic and rhyolitic) Nagatis and Welverdiend Formations, probably in rift environments. Development of a new continental margin arc is recorded by the ~1.2 Ga calc-alkaline Haiber Flats Formation and the calc-alkaline to shoshonitic Barby Formation, which is located farther inboard. These rocks are unconformably overlain by 1.1 Ga synrift bimodal rocks of the Guperas Formation and slightly younger redbeds of the Aubures Formation (Fig.4).

Band ratios were created by taking the individual Landsat-8 bands and dividing them to create a single band. These bands were then used to create a color composite image, and were then placed in different combinations in the RBG gun. Ratio suggestions were taken from researchers working on using remote sensing for geologic purposes.

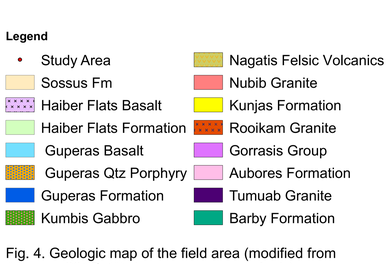


Fig. 4. Geologic map of the field area (modified from Andrews 2017). White areas represent Post-Nama cover.

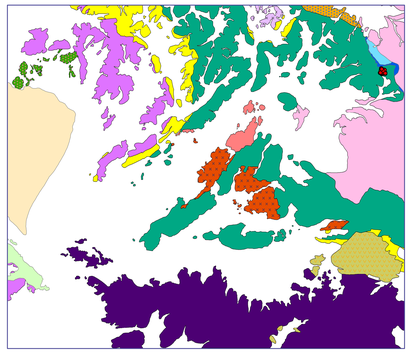
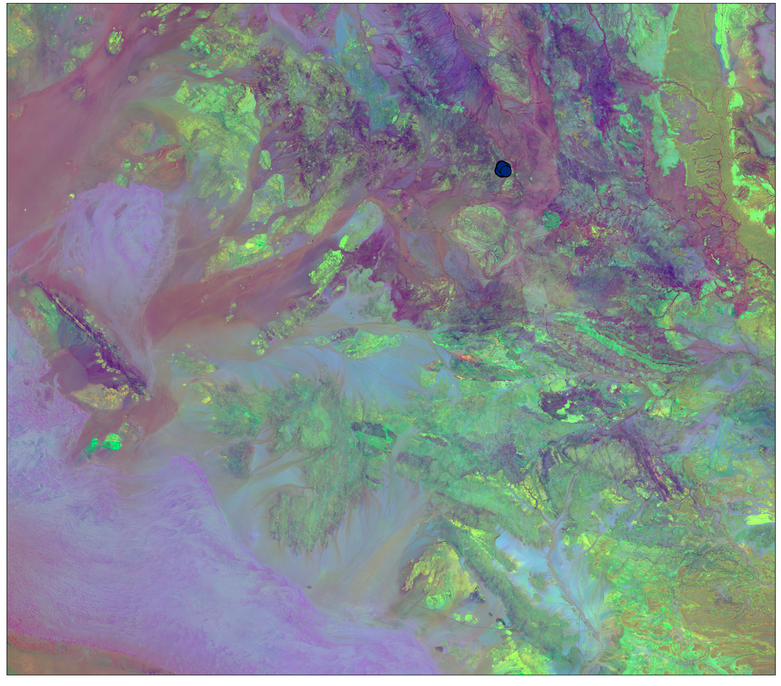


Fig. 5. Band ratios 7/6, 6/5, 4/2 in red-green-blue combined in a composite image. This combination is used to pick up vegetation, lithology, and hydrothermal alteration zones.



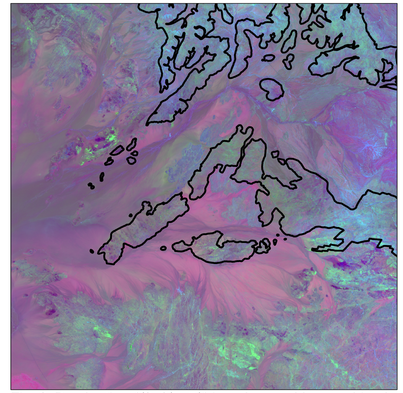


Fig. 6. Band ratios 4/2, 6/7, 5/4 in red-green-blue combined in a composite image. The band ratio 4/2 best picks up ferric iron minerals, and the band ratios 6/7 and 5/4 best picks up clay minerals. The Barby Formation is outlined in black.

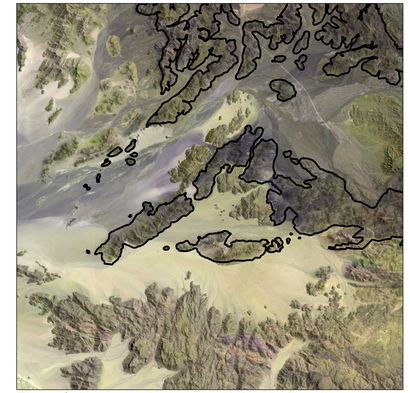


Fig. 7. Color composite image with bands 6, 7, 4 in red-green-blue to produce an image with higher color contrast, allowing for differentiation of units. The Barby Formation, outlined in black, shows up darker then the other formations.

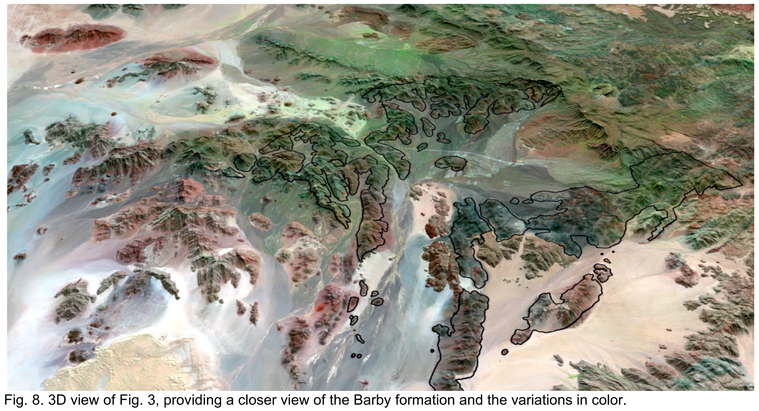


Fig. 8. 3D view of Fig. 3, providing a closer view of the Barby formation and the variations in color.

CONCLUSIONS

Due to the bimodal nature of many of the volcanic rocks in the area, it can be difficult to distinguish lithological units based on the spectral band ratio images alone. The simpler color composite images (Figs. 3, 7, and 8) provide good color contrasts between the units and can be used to validate or expand existing geologic maps. The imagery would be ideal for exploration - Landsat-8 is freely available and high quality. With more detailed understanding of formation compositions, units would be readily distinguishable in spectral imagery, and zones of hydrothermal alteration could be mapped.

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