Satellite Imagery Analysis of the Central Karoo Basin, South Africa: Focus on Hydrocarbon Exploration

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The Karoo Basin is a complex foreland basin situated northward of the Cape Fold Belt. Both tectonic features stretch nearly east-west across the southern tip of South Africa and reflect the north-verging continent-to-continent subduction zone active during Permo-Triassic time. Reactivated compression from the south and west has deformed basin sediments, resulting in a west-northwest to east-west orientation of high-frequency, low-amplitude folding. Fold patterns tend to be tight and parallel and in many cases exhibit isoclinal folding, all suggesting that younger near-surface sediments may not have been fully lithified before folding. Fault zones are observed by linear incised drainage, cross-cutting structural strike but for the most part are subtly expressed and overprinted by surface fold patterns. It is anticipated that basement fault zones have experienced reactivated movement in this dynamic foreland setting, impacting hydrocarbon migration and entrapment. Sorting through and prioritizing structural features becomes the forensic exercise facing hydrocarbon exploration in this location, where limited subsurface and only regional geologic mapping exist.

The focus of satellite imagery evaluation attempts to map and prioritize structures plus recommend areas for further investigation for the 10,500 square kilometer project area. In fulfilling this task, two primary goals are established: 1) utilize fracture analysis to propose deep-seated fault zones and predict apparent offset; this statistical approach will suppress the influence of tight, parallel surface fold patterns obscuring deep structural expression and will offer a tectonic framework; and 2) evaluate and map surface minerals associated with known pyrobitumen locations and other hydrocarbon alteration models. Many investigations cite alteration minerals associated with hydrocarbon occurrence and migration. Visible and shortwave infrared bands from Landsat and ASTER satellite imagery predict the composition of potentially altered locations through spectral modeling and image classification mapping. Structures exhibiting alteration minerals may reflect fluid flow and hence become higher priority areas for field observation.

The combination of statistically-based fracture analysis and alteration mineral modeling from satellite imagery data has essentially taken a poorly understood frontier basin region and systematically identified tectonic domains, primary and secondary fault zones with apparent offset, fold axes, paleotectonic fault zones, potentially altered locations, and initial concepts regarding fluid vectoring. The program has reduced the exploration area down to roughly 10% in a cost effective manner that will be critical for planning seismic and other ground-based surveys.