

Old Rocks, New Eyes: Remote Sensing Refinement of a Complex Mafic Intrusion in the Kruger National Park, South Africa

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The Timbavati Gabbro (TG) is situated in the Kruger National Park (KNP) along the northeastern margin of the Kaapvaal Craton, South Africa. It represents a shallowly inclined, laterally extensive, yet irregular ~1.11Ga mafic intrusion. It is the only intrusion of the Umkondo LIP that is distinctly layered and the LIP's only sill-like body emplaced within the basement, raising important questions regarding its emplacement and evolution. Despite its geological significance, the TG has historically been represented on regional geological maps derived primarily from aerial photogrammetry and limited field observations (e.g., the CGS's 1:250000 sheets).

Mapping mafic layered intrusions in densely vegetated, dangerous, and protected terrains presents significant challenges for conventional geological fieldwork. In the KNP, dense vegetation cover, hazardous wildlife, and restricted access have hindered detailed remapping of the TG. This study evaluates the effectiveness of integrated remote sensing methods for refining the geological extent of the highly irregular and extensive TG.

Three complementary datasets were analysed: high-resolution optical imagery from Google Earth Pro, C-band synthetic aperture radar (SAR) backscatter from Sentinel-1, and multispectral imagery from Sentinel-2. Sentinel-2 imagery provided the most effective lithological discrimination, clearly separating darker gabbroic units from surrounding granitic basement and overlying Karoo strata, whereas Sentinel-1 enhanced detection of structural lineaments beneath moderate vegetation cover. Google Earth Pro imagery supported detailed manual interpretations.

Remote sensing interpretations were compared with field observations, petrography, and whole-rock geochemistry, enabling evaluation of mapping accuracy and dataset performance. This comparison revealed legacy mapping errors, including misidentification of amphibolitised basement, greenstone belts, and dolerite dykes as TG outcrop. The model indicates a shallow, northward-stepping, ENE-dipping sill, with arcuate geometry, variable thickness. This revised model differs substantially from previous interpretations and demonstrates how integrated remote sensing approaches can improve geological mapping accuracy while providing new insight into the emplacement of previously misunderstood rocks.