From Regional Insight to Discovery: Integrated Targeting for Sapphire Mineralization in Southeastern Madagascar

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Sapphire deposits in southeastern Madagascar remain underexplored despite the region's known gem potential and favorable geological setting. This study applies an integrated exploration workflow—from regional targeting to project-scale delineation—aimed at advancing new discoveries within the Anosy region, across the NANTIN and SIAM licenses (~11,910 ha).

The study area encompasses four distinct geological domains characterized by northward structural trends, predominantly comprising foliated marbles and pyroxenites intruded by granitic bodies, shaped by high-temperature metamorphism and deformation events linked to shear zones hosting sapphire. Zircon U-Pb ages of 523–510 Ma confirms the metamorphic framework conducive to mineralization.

We combined conventional methods—regional geology, known sapphire occurrences, remote sensing (ASTER and Sentinel), and airborne geophysics (magnetometry and radiometry)—with non-conventional approaches. Machine learning techniques, including Fuzzy logic and Self-Organizing Maps (SOM), were applied to generate mineral potential maps. This led to the identification of five new prospective zones. Among them, Ankaramavo, Antirimena, and Satrokala emerged as high-priority targets, while Ankazoavo and Andranondambo were ranked medium-priority.

Ankaramavo was elevated to project-scale focus due to its strong mineralogical and spectral indicators, including calcite-phlogopite associations and AlOH spectral anomalies. Ground-truthing through petrography, mineralogy, and geochemistry (notably enrichments in Al, Si, K, Rb, Y, Nb) supports a robust geological-geochemical model for sapphire mineralization.

These results highlight the effectiveness of integrating remote sensing, geophysics, geochemistry and machine learning for gemstone exploration in complex metamorphic terrains, providing a scalable framework for future discoveries across the Central-East African belt.