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Application of Conventional and Unconventional Exploration Methods for Sapphire Discovery in Southeastern Madagascar: From Regional to Project Scale

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The research area is located in southeastern Madagascar, within the Anosy Region, encompassing the NANTIN and SIAM licenses spanning approximately 11,910 hectares. Geologically, it spans four distinct geological domains characterized by northward structural trends, predominantly comprising foliated marbles and pyroxenites intruded by granitic bodies. Deformation and high-temperature metamorphism have led to the formation of shear zones associated with sapphire mineralization, dated to 523-510 Ma based on zircon dating. This investigation's aim is to employ both conventional and unconventional exploration methods to delineate exploration targets at a regional scale, prioritize them based on exploration significance, and advance them to a project scale to facilitate sapphire discovery.

Conventional exploration techniques, including regional geology and the assessment of sapphire mineralization occurrences, along with Remote Sensing using ASTER and SENTINEL satellite image analysis, mapping of spectral signatures associated to sapphire mineralization, and geophysical analysis employing magnetometry and radiometry, were conducted at a regional scale. These methodologies were integrated to generate mineral prediction maps using unconventional exploration techniques such as supervised (Fuzzy) and unsupervised (SOM) classifications. This comprehensive approach resulted in the identification and categorization of five new sapphire exploration zones, with Ankaramavo, Antirimena, and Satrokala designated as high-priority areas, and Ankazoavo and Andranondambo as medium-priority zones.

The prioritization of new sapphire exploration targets has emphasized the development of the Ankaramavo objective as a top-tier priority for project-scale exploration. Through geological mapping, petrographic and mineralogical characterization, and spectral signatures analysis, discernible mineralogical-spectral trends (calcite, phlogopite, enclaves, AlOH and AlOH/water indexes) indicative of sapphire presence have been identified. These findings, augmented by geochemical analyses defining the geochemical signature associated with such deposits (Al, Si, K, Rb, Y, Nb), have laid the groundwork for the establishment of a geological-geochemical model facilitating the discovery of mineralized sapphire deposits.