MASTER OF SCIENCE
MINERAL EXPLORATION

PETROLOGICAL AND GEOCHEMICAL STUDIES OF TANEKA TERRANE FROM COPARGO AREA, NORTHWESTERN BENIN REPUBLIC.

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MINERAL EXPLORATION

The Taneka Terrane in Northwestern Benin, is part of the Pan-African Dahomeyide Belt, exhibiting geological complexity with the potential for gold mineralization. This study examines the petrological and geochemical characteristics of the region, focusing on lithological units, structural geology, and geochemical properties. Field mapping encompassed the identification and documentation of various rock formations and structural features, resulting in the collecting of 31 rock and quartz vein samples, including gold concentrates from nearby river beds. Laboratory analyses included petrographic study of thin sections of twenty-two (22) samples and geochemical assay via inductively coupled plasma mass spectrometry (ICP-MS) and atomic emission spectrometry (ICP-AES). This process aims to characterize the mineralogical and chemical composition of lithological units. Gold grains from Tanekas were studied under a microscope. Petrographic analysis identified key lithological units such as granite-gneiss, quartzite, schist, and amphibolite, each exhibiting distinct mineralogical compositions. Structural investigations revealed three main deformational events (D1, D2, D3) influencing the region, characterized by foliations, faults, joints, and quartz veins aligned predominantly in NW-SE, NE-SW, E-W, and N-S directions, indicative of the Pan-African orogeny. Geochemical analysis classified the granite gneisses as calc-alkaline and peraluminous, formed in syn-collisional to volcanic arc settings. In contrast, the gneisses belong to the high-K calc-alkaline and shoshonite series, formed in within-plate settings. Both rock types exhibit fractionated REE patterns with LREE enrichment, negative Eu anomalies, and elevated Rb, Ba, and Pb in granite gneisses. The quartzites range from quartz arenite to sublitharenite, derived from recycled sedimentary rocks in a passive margin setting. The schists, classified as quartz schists, show compositions ranging from shale to wacke with sedimentary rock sources. Gold concentrations were found to be highest in quartzite (2 ppb), followed by amphibolite (1.9 ppb) and granite gneiss (1.6 ppb), with associated elevated levels of Cu (63.9 ppm), Pb (50.3 ppm), Zn (370 ppm), and As (10 ppm), suggesting potential areas for further gold exploration. Gold grains from the Singrer and Sensitru rivers showed varied morphologies, suggesting multiple sources of gold mineralization. This indicates that both local and transported origins of the gold were found in the region.

Key Words: Taneka Terrane, Gold concentration, Dahomeyide belt, Pan-African Orogeny

GEOLOGICAL MAPPING FOR GOLD EXPLORATION IN BUTIHINDA-MUYINGA AREA, NORTHEASTERN BURUNDI USING GIS AND REMOTE SENSING

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MINERAL EXPLORATION GEOSCIENCE

Gold mineralization in Burundi is primarily associated with the geological formations in the region, particularly in the northern and eastern areas of the country. Previous studies indicate two types of primary gold mineralization: sulfide vein assemblages with gold related to the post-Kibaran, G4-granite magmatism (900–1000 Ma) and Pan-African ferruginous breccia zones with gold dated around 640 Ma. Gold mineralization in Burundi occurs not only in the form of native gold; but also, in the invisible form in solid solutions containing arsenic in iron sulfide, such as pyrite and arsenopyrite, from which it is released during supergene weathering processes and remobilized in the oxides and hydroxides of iron. Gold mineralization in the region of Butihinda-Muyinga is linked to iron oxides formed from the oxidation of sulfide minerals. Geological mapping of gold deposits in Butihinda-Muyinga was remotely sensed via Landsat-8 imagery to support initial gold exploration activities. Different image processing techniques were compared: Red Green Blue (RGB) combination, band ratios, and principal component analysis (PCA) to identify geological features indicative of gold mineralization. Gold mineralization in this area is associated with iron oxides. So, the focus was to identify these minerals via Remote Sensing and GIS software. Selective PCA proved most effective for mapping pixels containing spectral signatures of hydroxyl and iron oxide minerals. The processed imagery successfully distinguished urban areas, iron and hydroxyl-rich zones, and clay-rich areas. The dominant NNE-SSW structural trends identified in the imagery were considered highly promising for gold mineralization and were validated through field observations, which revealed a strong correlation between the remote sensed data and field geological mapping.

Key Words: GIS and remote sensing (RS), Landsat-8, gold mineralization, principal component analysis (PCA), band ratio.

RARE METALS MINERALISATION POTENTIAL OF PEGMATITE AROUND ELEWURE –ISEYIN AREA, SOUTHWESTERN NIGERIA

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The resurgence of the global demand for rare metals, which are essential in the energy transition, has stimulated renewed interest in exploring pegmatites. This study was carried out to evaluate the mineralisation potential of pegmatite bodies around the Elewure–Iseyin area, southwestern Nigeria. Geological field mapping was conducted in the study area and 43 rock samples were collected. The rocks were subjected to petrographic studies, and fifteen (15) rocks and mineral extract samples were subjected to geochemical analysis via inductively coupled plasma-mass spectrometry and inductively coupled plasma-atomic emission spectrometry. Discrimination plots for mineralisation were thereafter used to characterise the pegmatite and determine its potential mineralisation. Geological mapping revealed that the area is underlain by banded gneiss, amphibolite, syenite, diorite, and pegmatite. Pegmatites occur as NE–SW intrusions in banded gneiss, syenite, and diorite, and are mainly composed of feldspar, quartz, biotite, muscovite, and tourmaline. For the pegmatites, the geochemical analysis results revealed that the concentration of SiO_2, Al_2O_3 Na_2O, K_2O, P_2O_5, and CaO ranged from 69.3–76 wt%, 13.2–17.55 wt%, 0.31–6.26 wt%, 0.7–10.65 wt%, 0.03–0.23 wt%, and 0.04–0.67 wt%, respectively. The concentration of Nb, Ta, Cs, W, Li, Sn, Rb, Hf, and Zr ranged 0.4–196 ppm, 0.1–21.9 ppm, and 0.51–14 ppm, 1.60–9.90 ppm, 10.00–40.00 ppm, and 0.50–96.60 ppm, 69.90–437.00 ppm, 0.13–1.89 ppm, and 2.00–72.00 ppm, respectively. The K/Rb, K/Cs, Zr/Hf and Nb/Ta values ranged from 83.12 –240.16, 7.59 –971.59, 11.40 –38.10, and 4 –14.10, respectively. These values indicate that the pegmatites were not much fractionated and were not enriched in rare metals. Discrimination plots such as Ga vs Ta and Cs+ Rb vs Ta showed low mineralisation in Ta. total rare earth elements (ΣREE) ranged from 6.8–152.98 ppm with a mean value of 50.9 ppm and values were below 8 ppm in mineral extracts. The total light earth elements (ΣLREE) and heavy rare earth elements (ΣHREE) ranged from 1.8 –119.0 ppm and 1.35 –27.07 ppm, respectively. Chondrite–normalised REE patterns revealed LREE enrichment with pronounced negative Eu anomalies and moderate Ce anomalies, which signifies insignificant fractionation or metasomatic processes, and compared with globally REE–enriched pegmatites, they are not mineralised in rare earth elements. This study revealed that the pegmatites around the Elewure–Iseyin area are not mineralised in rare metals and rare earth elements

Key Words: pegmatite, rare metal, mineralization, rare earth element, Elewure-Iseyin area

ASSESSMENT OF RARE-METAL IN PEGMATITE AROUND FAMOLE AREA, PRECAMBRIAN BASEMENT COMPLEX SOUTHWESTERN NIGERIA, USING REMOTE SENSING AND SOIL GEOCHEMISTRY

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MINERAL EXPLORATION

The renewable energy sector vitally depends on lithium because this element enables production of essential lithium-ion batteries used in electric vehicles as well as energy storage systems. The study investigates the lithium potential of pegmatites around Famole area, Precambrian Basement Complex of Southwestern Nigeria using remote sensing data, geological mapping, soil geochemistry, and machine learning analysis. The study aimed at determining the rare metal-bearing status of the pegmatite from the pegmatite-derived soil covers. Remotely sensed imagery from aeromagnetic and radiometric data were used to delineate lithologic boundaries and geological structures. Geological field mapping was carried out on a scale of 1:25,000 to determine the field relationships and the rock types. Soil geochemical sampling was carried out over the imagery-delineated pegmatite body and the host rock. Forty (40) soil samples were collected, air dried and pulverized to <2µm fineness for geochemical analyses, using Instrumental Neutron Activation Analysis (INAA) and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). Data obtained were subjected to descriptive statistics, Correlation Analysis, Principal Component Analysis (PCA) and Random Forest Regression prediction. The remote sensed imagery showed the lithologic boundaries and geological structures of the rock types of the study area. Migmatite, biotite granite gneiss and biotite schist are the principal rock types, while pegmatite dykes and quartz veins are the minor rock types. Geochemical data indicated elevated concentrations of Li, Rb, Cs, Ga, Be, Sn, Nb and Y, Zn, Zr, Hf, Th and U in soils above the pegmatite relative to the soils above the host biotite schist. The correlation analysis showed strong positive correlation between Li and Cs ($R = 0.74$) and Li and Rb ($R = 0.77$). These geochemical patterns indicated the pegmatite is rare-metal bearing. The Random Forest regression model from machine learning indicated lithium concentrations in soils overlying the imagery-delineated pegmatite. This study revealed rare-metal enrichments in soils overlying the imagery- delineated pegmatite and therefore confirm its rare metal-bearing status and established that combining statistical and predictive modelling and machine learning boosts lithium prospecting precision through mineral exploration operations. The model needs more development mainly through integration of detailed geophysical data and implementing additional field tests to achieve better results.

Key Words: Rare-metal Pegmatite, Remote sensing, Soil Geochemistry, Mineral Exploration, Famole, Southwestern Nigeria.

GOLD MINERALIZATION POTENTIAL, PETROGENESIS, AND TECTONIC SETTING OF FELSIC ROCKS AROUND OKEIGBO-EPE, SOUTHWESTERN NIGERIA

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MINERAL EXPLORATION

This work is based on the studies of the petrogenesis, the tectonic setting of rocks and stream sediments around Okeigbo-Epe and its environs for gold mineralization potential in Ondo State, Southwestern Nigeria. The study addresses the limited scientific research on gold occurrences in Okeigbo-Epe and its environs. Landsat-9 OLI 2 digital satellite image data were processed through Principal Component analysis (PCA), False Colour Composite (FCC) for lithological and lineament features mapping. Petrographic studies, geochemical analyses of stream sediments and rock samples were performed using Inductively Coupled Plasma Mass Spectrometry and Instrumental Neutron Activation Analysis (ICPMS-INAA). Key findings include putting into evidence of NE-SW, NNE-SSW, and NW-SE trends of the lineaments indicative of tectonic activities during the Pan-African orogeny. The lithology within the study area includes granite, folliated gneiss and quartzofeldspathic rocks. The samples were highly silicious. Noticeable concentrations of pathfinders like Co (3-23ppm), Cu (9-19ppm), Pb (12-22ppm), and Zn (10-94ppm), were found in the stream sediment samples. Au concentrations were low (<5ppb); nonetheless, the R-mode Factor analyses enable deciphering latent patterns indicating the presence of sulfur-mineral, zircon, and monazite. La (1.6-182ppm) and Ce (5-317ppm) anomalies were found, indicating a promising area for REE exploration. The rocks studied were formed in a syn to post-collisional environment, giving them a volcanic arc granitic imprint. The major rocks, granite and gneiss, are meta-aluminous and cal-alkaline, while quartzofeldspathic rocks are peraluminous. Integrating remote sensing and geochemical data proved effective in characterizing the area's geology, lineament patterns, geochemical signature, and mineralization potential. It is recommended that further geophysical investigations like magnetic and induced polarization could help in delineating hidden structures and subsurface mineralization targets.

PETROLOGY AND RARE METAL-BEARING POTENTIAL OF PEGMATITES FROM ITASA AREA, SOUTHWEST, NIGERIA

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MINERAL EXPLORATION

Pegmatites are significant hosts for gemstones and rare metals, and play critical role in global technological industries. While extensive research has been conducted on rare metal deposits in Nigeria, there is limited information on rare metal and rare earth elements mineralisation within Itasa area, which are known to contain minerals such as spodumene, tourmaline, tantalite, and columbite. This study aims to evaluate the rare metal-bearing potential of pegmatites in Itasa area of southwest Nigeria. Geological mapping of the area was performed to identify the various rock types. Fifteen pegmatite samples were collected for geochemical and mineralogical analysis, whereas ten host rock and ten pegmatite samples were subjected to petrographic analysis. Geological mapping revealed the presence of granite-gneiss, chlorite-schist, hornblende-gneiss, and biotite-granite gneiss in the study area. Petrographic studies indicated that the pegmatites are composed of microcline, plagioclase, quartz, muscovite, spodumene, hornblende, and opaque minerals. This study assessed the rare- metal and rare earth elements potential of the Itasa pegmatites by analysing concentration, distribution patterns, and mineralization potential. The elemental composition was determined via Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Rare-metals such as Ta, Nb, Rb, Cs, and Sn are relatively depleted in the whole-rock units. Elemental ratios such as K/Rb and Ba/Rb also indicate low fractionation indices, reflecting poor fractionation and barren mineralization. Plots of K/Rb vs. Rb, K/Rb vs. Ba, Ta vs. Cs + Rb, Ta vs. K/Cs, Rb vs. Ta, and Ta vs. Ga confirm that the whole-rock samples from this area are localized mineralisation compared to other mineralized Nigerian pegmatites. The fractionation ratio $(La/Yb)_N$ of the pegmatite samples ranged from 0.23 to 170.81, reflecting magmatic differentiation. The total REE content (∑REE) of the samples was 207.95 ppm, with Light REE (∑LREE) at 124.25 ppm and Heavy REE (∑HREE) at 83.70 ppm. The samples showed moderate enrichment in LREE and depletion in HREE. The values of rare metals and rare earth elements enrichment of Itasa pegmatites were significantly lower than those of economically viable pegmatites. Consequently, the pegmatites in the Itasa area are unlikely to be economically exploitable.

Key Words: Rare Earth Elements, Rare Metal, Itasa, Pegmatite, Mineralisation

DOCTOR OF PHILOSOPHY
MINERAL EXPLORATION

GEOLOGICAL ASSESSMENT OF URANIUM OCCURRENCES IN THE EASTERN PART OF REGUIBAT SHIELD, NORTHERN MAURITANIA

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MINERAL EXPLORATION GEOSCIENCE

Mauritania uranium occurrences are mainly hosted in the eastern part of the Reguibat Shield. Despite the number of proven occurrences in Mauritania and the scope of the debate on uranium genesis and the globalization of its discourse, Mauritania's uranium remains poorly understood, indeed studies and academic publications that focused on Mauritanian uranium as a distinct subject is rare. Consequently, several major questions remain unanswered concerning the genesis of the uranium deposits. Hence, the aim of this study was therefore to undertake a detailed geological investigation of the calcrete uranium mineralisation potential of Mauritania to define its genetic model thus allowing for understanding of the evolution of uranium mineralisation. Satellite imageries were acquired, processed and analyzed to aid geological mapping exercise complimented with ground truthing. Hundred drill core samples from two uraniferous areas were collected for mineralogy and geochemical investigation, using optical microscopic, EPMA +EDS, XRD. Whole rock analysis by ICP-MS, ICP-OES, and XRF were undertaken. The results delineated two prospective uraniferous zones in part of Ain Sder and Oued el Foule areas. Lithologic section from the top to the bottom, are siltstone, sandstone, weathered granite, and fresh granite. Two types of uraniferous granites differentiated by colour and structure were distinguished. Coarse-grained porphyritic pink granite with a mylonitic texture and medium-grained grey granite. Mineralogical composition of all these rocks presents association of primary and secondary uranium-bearing minerals. Paragenesis consists of Quartz + K-Feldspar + Plagioclase + Biotite + Apatite + Sphalerite + Zircon + Fluorite + Amphibolite + Calcite + Celestine ± granet ± Barite ± Ilmenite. The pink and grey granites of the study area are geochemically similar and exhibit characteristics of moderately evolved, weakly peraluminous rocks that originated from partial melting of the Early-birimian to Late-birimian granitoids and the volcano-sedimentary groups of Karet and Ghallamane. Both granites display low Chemical Index of Alteration (CIA) and Plagioclase Index of Alteration (PIA) values, indicating low to moderate weathering. Petrographic analysis revealed alteration of plagioclase and biotite to sericite then through carbonisation result in the precipitation of calcite mineral. Weathering process of the granite result in layered gravel cemented by carbonite, association generally called calcrete forming the upper part of the bedrock. High U and V averages in the country rocks permit the incorporation of uranium bearing minerals such as Carnotite and Tyuyamunite. Uranium minerals occur as small grains size (~ 10 microns) filling voids and fractures of the granites. The presence of calcite, celestine, gypsum, and halite associated with uranium minerals are the indictors of formation process within evaporitic context at low-temperature conditions during the Mio-Pliocene. The uranium minerals were found as void filling small grain sizes that originated from granite weathering and consequent uranium enrichment in the area. This knowledge would guide the exploration and eventual extraction processes of the uranium resources.

Key Words: West African Craton, Reguibat shield, weathering processes, Carnotite, Calcretes.

LITHOSTRUCTURAL SETTING AND PETROGENESIS OF MANGANESE MINERALISATION AND ASSOCIATED ROCKS OF TÉRA REGION, LIPTAKO, WEST NIGER

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The Téra manganese mineralisation is the most significant manganese deposit discovered in Niger to date. This mineralisation is part of the manganese deposits of the West African Craton, located in the Paleoproterozoic (Birimian) greenstone belts, which provide an attractive target for exploration and eventual exploitation. Manganese is a transition metal with a multifaceted array of industrial uses, including in alloys, and the manufacturing of batteries, glass, porcelain, paint, and fertilizers. Although several studies have investigated the various manganese deposits from the West African Craton, very few have focused on the Téra manganese deposit. Therefore, the genesis of the Téra manganese deposit remains unknown. This study aims to determine the detailed characteristics of the Téra manganese mineralisation and associated rocks, to highlight the provenances of the rocks, and the processes of manganese enrichment. The methodology employed involves field investigation (sampling and mapping), followed by petrographic analysis via microscopic observation of fifty-two (52) thin sections and fifteen (15) polished sections. Additionally, geochemical analyses were conducted using ICP-MS (32 samples) and XRD (17 samples) methods. The study area comprises metasedimentary rocks, including grossular, almandine-bearing amphibolites, staurolite-kyanite-cordierite-bearing mica schists, almandine-bearing quartzites, and spessartite-almandine-bearing gondites, to which the manganese mineralisation is associated. The XRD analysis revealed that spessartite is the primary manganese mineral in the fresh gondite, which is replaced by manganese oxides such as pyrolusite, cryptomelane and lithyophorite in the manganese ores. Three phases of deformation (D1, D2 and D3) are distinguished in the study area. Phase D1 is tangential to transcurrent ductile deformation and comprises three episodes: D1a, D1b and D1c. D1a is characterised by thrust contacts associated with S1 schistosity/foliation (NE-SW), which is compatible with NW-SE shortening. D1b is marked by thrust sheets and S2 schistosity/foliation (NW-SE), compatible with NE-SW shortening. D1c is highlighted by folded schistosity/foliation with submeridian axes, compatible with E-W compression. These shortening and kinematic features persist until a semiductile rheology (D2), marked by flanking structures associated with fractures. The deformation phase D3 consists of two episodes, D3a and D3b. D3a exhibits a sinistral NW-SE and dextral NE-SW to NEE-SWW shear sense resulting from E-W shortening. In contrast, D3b is characterised by brittle conjugate shear zones with sinistral NNE-SSW and dextral NW-SE senses, which are compatible with N-S shortening. The geochemical classification plot [log (Na_2O/ K_2O) vs. log (SiO_2/Al_2O_3)] of the samples indicates a shale-sand-ferruginous composition of the sediments. The Al_2O_3/TiO_2 ratios, TiO_2 vs. Zr plot and La/Th vs. Hf diagram indicate that the samples were derived from Archean sediments of intermediate igneous origin from an active tectonic setting. The traces and rare earth elements normalised to the primitive mantle and chondrite show patterns similar to the continental crust. The primary origin of Téra manganese mineralisation is of hydrothermal type; the secondary origin is an enrichment by supergene weathering, allowing the manganese enrichment from 19.15% MnO in the fresh gondites to 47.92% in the manganese ores. These knowledges would improve the understanding of the Téra manganese deposit petrogenesis.

Key Words: Manganese deposit, Diagourou-Darbani greenstone belt, Paleoproterozoic, West African Craton.

FIELD OCCURRENCE, PETROLOGY AND GEOCHEMISTRY OF LITHIUM-BEARING PEGMATITES AND ASSOCIATED ROCKS IN BOUGOUNI AREA, SOUTHERN MALI

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MINERAL EXPLORATION GEOSCIENCE

The Bougouni Region, located in southern Mali, is a geologically rich and complex area, home to a diverse array of mineral resources. Among these, the pegmatites are of particular interest due to their unique composition and their potential for hosting a variety of rare metals that are essential in electronics and advanced technologies. However, detailed geological information on the geology, mineralogical and geochemical status of these pegmatites remain largely unknown. This study is therefore aimed at constraining the genesis, tectonic setting and rare metal mineralization of pegmatites and the associated rock units in the Bougouni area. Field traversing of the area was undertaken using a base map of 1:50,000. Fresh outcrop and drill core samples were obtained and prepared into thin sections which were then observed under plain polarized and cross-polarized light. XRD analyses on selected samples for mineralogical identification were undertaken. The chemistry of minerals were determined using the EMPA analytical technique. The major, trace and rare earth elements of selected samples were analysed using ICP-OES and ICP-MS, respectively. The petrographic study reveals that the felsic granitoids including pegmatites are mainly composed of quartz, albite, microcline, orthoclase, micas, spodumene and accessory minerals such as apatite, tourmaline, zircon, garnet, bastnaesite, Columbite group mineral (CGM), pyrite and arsenopyrite, while the least evolved gabbro and diorites were composed of hornblende, plagioclase, edenite, calcium aluminium silicon hydrate, anthophyllite, minor quartz and accessory minerals such as titanite, ilmenite, epidote, beryl, osumilite and opaque minerals. The genesis of the granitoid units is constrained to be associated with the fractional crystallisation of crustal derived magma, as evidenced by their peraluminous (ASI= 1.12 to 2.11.) character and REE fractionation pattern, while the gabbros are derived from fractionated mantle magma. The tectonic settings are believed to be associated with the Eburnean orogeny's second and last deformation phases, with the granitoids and diorites being probably emplaced within the metasediments of the early Proterozoic in a compressive domain during the second and third deformation phases. The pegmatites were intruded in zones of weakness during post-tectonic regime. Lithium shows significant enrichment (ranging from 3400 ppm to >10000 ppm) but with record of low to moderate depletion (19 ppm to 871 ppm) in some samples. The significant enrichment of lithium is controlled by the presence of lithium-bearing minerals such as spodumene, petalite, and lepidolite. Spodumene is the major lithium-bearing mineral while petalite, lepidolite and zinnwaldite are the accessory minerals. Additionally, the white rock of Sinsikourou and Kola exhibits fairly enrichment in rare elements including Cs (11-203ppm); Ta (2-149ppm); Nb (9.4-90.8ppm); Sn (50,8-561ppm) and Be (52-668ppm) but comparatively abundant in Rb and Sr.
The Bougouni Region pegmatites are lithium rich, intruded within the metasediments and granodiorites and have been formed through fractional crystallisation of crustal-derived magma.

Key Words: Spodumene, Lepidolite, Petalite, Proterozoic

PETROGENESIS, TECTONIC SETTING, AND GEOCHRONOLOGY OF THE GOLD-BEARING ROCKS OF NAMPALA AREA, SOUTHERN MALI

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MINERAL EXPLORATION GEOSCIENCE

The Nampala gold deposit occurs within the Paleoproterozoic terranes of southern Mali. Despite its economic potential, current knowledge of the deposit is predominantly derived from mining company reports focused on resource estimation and economic viability. The aim of this study is to determine the petrogenesis, tectonic setting and geochronology of the gold-bearing rocks of Nampala area, southern Mali, which could guide future exploration strategies. Geological mapping of Nampala area was conducted on a scale of 1:5000. A total of 50 rock samples were collected from Diamond Drill Holes. Thirty samples were prepared into polished thin section for morphological studies and mineral identification using the Scanning Electron Microscope and petrography. Major oxides, trace and rare earth elements were determined using Inductively Coupled Plasma-Atomic Emission Spectroscopy and Mass spectroscopy. Polished thin sections of sulphide-bearing quartz and extracted zircons from granodiorite were analysed using Laser Ablation Inductively Coupled Plasma-Mass Spectrometry to determine the chemistry of the sulphides and U-Pb age of the zircons in the granodiorite, respectively. The Lutetium-Hafnium isotopic composition of the same zircons dated for U-Pb analysis were used to determine the magma source. Raman Spectroscopy on graphitic schist determined the degree of metamorphism, while Finnigan Delta XP mass spectrometer was used for oxygen and hydrogen stable isotope determination on 15 auriferous quartz veins, to decipher the source and nature of the ore forming fluid. Geochemical discrimination diagrams were used to interpret the data obtained. The major rock units in the area are metasediments of greywackes, siltstones and graphitic schist, with intrusive granodiorite and lamprophyre. The greywacke and siltstone are immature, with felsic igneous provenance and minor mafic contributions, minimal sediment recycling and deposition in an arc setting compatible with Paleoproterozoic Birimian greenstone terrane. The peak metamorphic temperatures of the graphitic schist ranged from 358.25 to 485.54°C ± 50°C, corresponding to a lower to upper greenschist facies, with an average temperature of 416°C ± 50°C. The lamprophyre is mantle derived, peridotitic and product of partial melting of phlogopite-bearing Lherzolite at 75-80 km depth, while the granodiorites are I-type, peraluminous, high-K calc-alkaline with a crystallization age of 2.1 Ga. The δD values of -48 to 0.3‰ and $\delta^{18}O$ values of 15.23 to 16.57‰ indicated a dominantly metamorphic water origin and subordinate meteoric water input consequent on the elevated δD values. The granodiorite age of 2100 ± 10 Ma, is similar to other Paleoproterozoic granitoids in southern Mali. The $^{176}Hf/^{177}Hf$ ratios of 0.281391–0.281536, εHf(t) values of -1.83 to 3.3, and TDM1 ages of 2.52–2.33 Ga, indicated that the granodiorite evolved from hybrid juvenile mantle and reworked older crustal materials. Pyrite generations: PyI, PyII, are consistent with hydrothermal origin, while PyIII suggests a sedimentary influence, with gold mineralization controlled by arsenic substitution in pyrite as lattice-bound Au+1. High As/Ag (85,777) and Sb/Bi (8.82) ratios confirm a metamorphic hydrothermal origin typical of orogenic gold deposits. The Nampala gold deposit is an orogenic mesothermal gold deposit hosted in greywacke and Eburnean granodiorite. The mineralizing fluid originated from a metamorphic hydrothermal material with a subordinate meteoric water influence.

Keywords: Petrogenesis, U-Pb geochronology, Stable isotopes, orogenic gold deposit, Mali

COMPOSITIONAL, PETROTECTONIC, AND GEODYNAMIC FEATURES OF GREENSTONE-HOSTED BIF-SUPERGENE-HYPOGENE IRON ORE BODIES IN THE MBARGA AREA, SOUTHEASTERN CAMEROON

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PAU-UI-0699 MINERAL EXPLORATION GEOSCIENCE

The Mbarga deposit, located within the Ntem Complex at the northwestern edge of the Congo Craton, contains a hematitic banded iron formation (BIF) resource of ~1.8 Bt at 34.6 wt% Fe and a high-grade hematite resource of ~2.1 Bt at 56.8 wt% Fe. Previous studies largely focused on exploration and regolith geochemistry, leaving uncertainties regarding the origin, timing, and geodynamic setting of the BIFs, and the processes responsible for their enrichment into high-grade ores. This study integrates petrographic, mineralogical, geochemical, Sr–Nd, stable O–H, and zircon U–Pb isotope data to constrain the genesis of the deposit. Fieldwork involved geological mapping through cross-sectional profiling, followed by the collection and analysis of representative bulk rock samples. Mineralogical and textural characteristics were examined using X-ray diffraction (XRD), optical microscopy, and backscattered electron (BSE) imaging. Magnetite compositions were analysed by electron probe microanalysis (EPMA). Whole-rock major and trace element concentrations were determined using X-ray fluorescence (XRF), inductively coupled plasma mass spectrometry (ICP-MS), and inductively coupled plasma atomic emission spectroscopy (ICP-AES). Stable isotope ratios (δ18O and δ2H) were analysed using isotope ratio mass spectrometry (IRMS), while zircon U–Pb ages were obtained via laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Whole-rock Sm–Nd and Rb–Sr isotopic compositions were measured using multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS). The Mbarga deposit comprises BIFs, supergene, and hypogene iron ores hosted within metavolcanic schistose rocks composed of quartz, biotite, plagioclase, K-feldspar, and amphibole. The BIFs show partial to extensive alteration of magnetite to hematite-martite and are of the Algoma-type. The supergene ores are composed of hematite, martite, goethite ± gibbsite ± magnetite ± quartz, while the vein-hosted specularite ores contain specular hematite and quartz. Geochemically, the schists have high SiO2 (52.81–79.14 wt%) and Na2O + K2O (4.24–8.54 wt%) contents, suggesting an andesitic to dacitic protolith, with trace element signatures (high Ba, depleted Nb–Ta) indicating a volcanic arc setting. The BIFs have high Fe2O3 (~54.06 wt%) and SiO2 (~45.40 wt%) with low Al2O3 (~0.14 wt%), TiO2 (~0.1 wt%), and REE–Y contents. Their REE patterns, marked by LREE depletion, positive Eu anomalies (~2), mild Ce depletion (Ce/Ce* 0.67–1.16), and superchondritic Y/Ho ratios (~34), suggest deposition under anoxic to suboxic Archean marine conditions with minor (0.1–1.0%) hydrothermal fluid input. The supergene ores are enriched in Fe2O3 (~95.37 wt%) and depleted in SiO2 (~0.38 wt%) due to weathering, while the specularite ores show Fe2O3 enrichment (~99.42 wt%) and SiO2 depletion (~0.18 wt%), consistent with precipitation from iron-rich, trace-element-deficient hydrothermal fluids. Stable isotope data support a multi-stage fluid evolution, with the BIF formation involving mixed magmatic–metamorphic fluids (δ18O 8.5–10.2 ‰, δ2H -85 to -91 ‰), the supergene ores developing from isotopically light paleo-meteoric fluids (δ18O -2.5 to -0.3 ‰, δ2H -75 to -123 ‰), and the specularite ores precipitating from meteoric-related hydrothermal fluids (δ18O -3.4 to 2.0 ‰, δ2H -70 to -119 ‰). Zircon U–Pb dating of the schists yields an age of 2890 ± 4 Ma, suggesting a Mesoarchean protolith, while an imprecise Rb–Sr age of ~2.65 Ga aligns with known tectonothermal events (~2.75–2.65 Ga) within the Ntem Complex. Initial εNd(2.89) values (+0.8 to +2.0) suggest an unevolved, mantle-like source for the protoliths, while sparse 2951 ± 24 Ma detrital zircons in the BIFs establish a depositional link to the

schists, placing the BIF formation at ~2.95–2.89 Ga. The combined dataset links the Mbarga deposit to late Archean arc magmatism, supporting its formation in a back-arc basin setting.

Key Words: Mineral chemistry, whole-rock geochemistry, Nd-Sr isotopes, Zircon U–Pb isotopes, stable O–H isotopes, Mbarga deposit.