**MINISTRY OF MINING, BLUE ECONOMY AND MARITIME AFFAIRS**

**STATE DEPARTMENT FOR MINING**

# EVALUATION OF MANGANESE OCCURRENCE IN LALI HILLS -TANA RIVER COUNTY, KENYA.

**Prepared by Geological Survey**

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# EXECUTIVE SUMMARY

This report presents an evaluation of the manganese occurrence at Lali Hills in Tana River County, Kenya, undertaken by the Geological Survey under the State Department for Mining. The assessment integrates available geological mapping, historical studies, and recent airborne geophysical data to determine the geological context and potential of the manganese occurrence.

The study area lies within the coastal sedimentary belt of southeastern Kenya, where Permo–Triassic sedimentary formations of the Duruma Group overlie Proterozoic basement rocks of the Mozambique Belt. The principal host rock associated with the manganese occurrence is the Mazeras Sandstone, a coarse-grained and permeable sandstone that is susceptible to weathering and structural fracturing.

Previous geological mapping of the Mid-Galana Area (Degree Sheet 66 NW) and investigations in the Lali Hills–Dakadima area provided the regional geological framework for the area. In addition, the National Airborne Geophysical Survey (NAGS) conducted in 2022 identified geophysical anomalies within the Lali Hills area based on airborne magnetic and radiometric data. These anomalies suggest the presence of structural features and lithological contrasts that influence mineralization.

Field observations and geological interpretation indicate that manganese occurs mainly as oxide nodules and fracture-controlled coatings within brecciated Mazeras Sandstone, particularly along structural zones associated with the Lali Hills fault system. The brecciated sandstones contain angular fragments veined and coated with manganese and iron oxides, suggesting structural control on mineral deposition.

Geophysical interpretation further indicates the presence of linear structural trends interpreted as faults or fracture corridors, which appear to influence the localization of manganese mineralization. The mineralization occurs mainly as nodular accumulations. Presence of structurally controlled manganese mineralization within a favorable sandstone host environment, combined with geophysical anomalies identified from airborne survey data, indicates presence of a potential Manganese deposit.

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# 1 INTRODUCTION

This report presents a focused evaluation of the Manganese (Mn) Prospect at Lali Hills, Tana River County, Kenya. The objective is to highlight the potential of the Manganese occurrence and the respective geological formation hosting manganese. This report also highlights previous works undertaken in or near Lali Hills and the exploration methods employed.

## 1.1 LOCATION

The Lali Hills prospect lies within the coastal sedimentary belt of southeastern Kenya, in Tana River County. The defined prospect area falls within the area defined by coordinates given in Table1-1 below.

*Table 1-1: Coordinates defining the project area (WGS84)*

| *Point* | *Latitude (DMS)* | *Longitude (DMS)* |
|---|---|---|
| 1 | 02° 55′ 00.00″ S | 039° 13′ 30.00″ E |
| 2 | 02° 55′ 00.00″ S | 039° 20′ 30.00″ E |
| 3 | 03° 02′ 44.00″ S | 039° 20′ 30.00″ E |
| 4 | 03° 02′ 44.00″ S | 039° 14′ 15.00″ E |
| 5 | 03° 00′ 44.69″ S | 039° 15′ 30.00″ E |

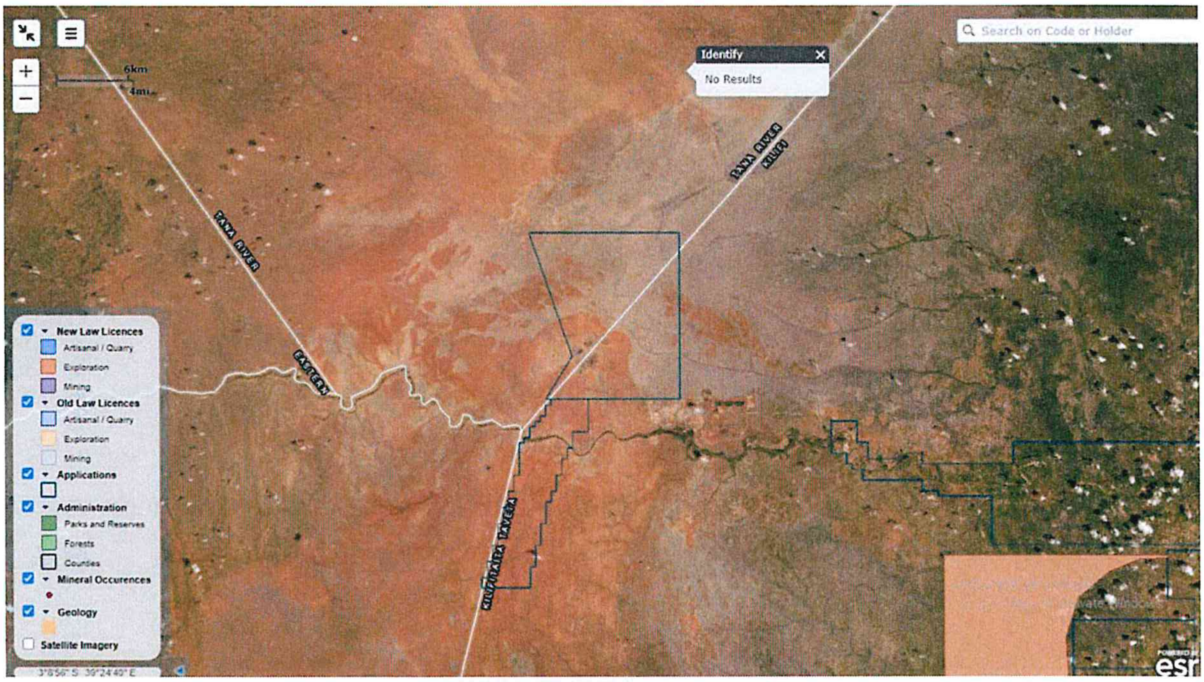


*Figure 1-1: Location of the project Area(Accessed from Kenya Cadastre Map)*

# 2 GEOLOGICAL SETTING

## 2.1 Regional Geological Setting

The geology of the area is documented in the Geology of the Lali Hills–Dakadima Area (Degree Sheet 61 SW Quarter), Geological Survey of Kenya Report No. 76 and in Geology Map of Mid-Galana Area Report No. 46 (Degree Sheet 66 NW Quarter). The area is underlain by Proterozoic basement rocks of the Mozambique Belt, which are overlain by sedimentary formations of the Duruma Group, representing a Karoo-equivalent sedimentary sequence.

The principal lithological unit relevant to the manganese occurrence is the Mazeras Sandstone, described as coarse-grained, arkosic, and locally kaolinitic. The sandstone is permeable and susceptible to weathering processes. Extensive superficial cover and weathering profiles limit continuous exposure of fresh bedrock, making structural interpretation partly inferential.

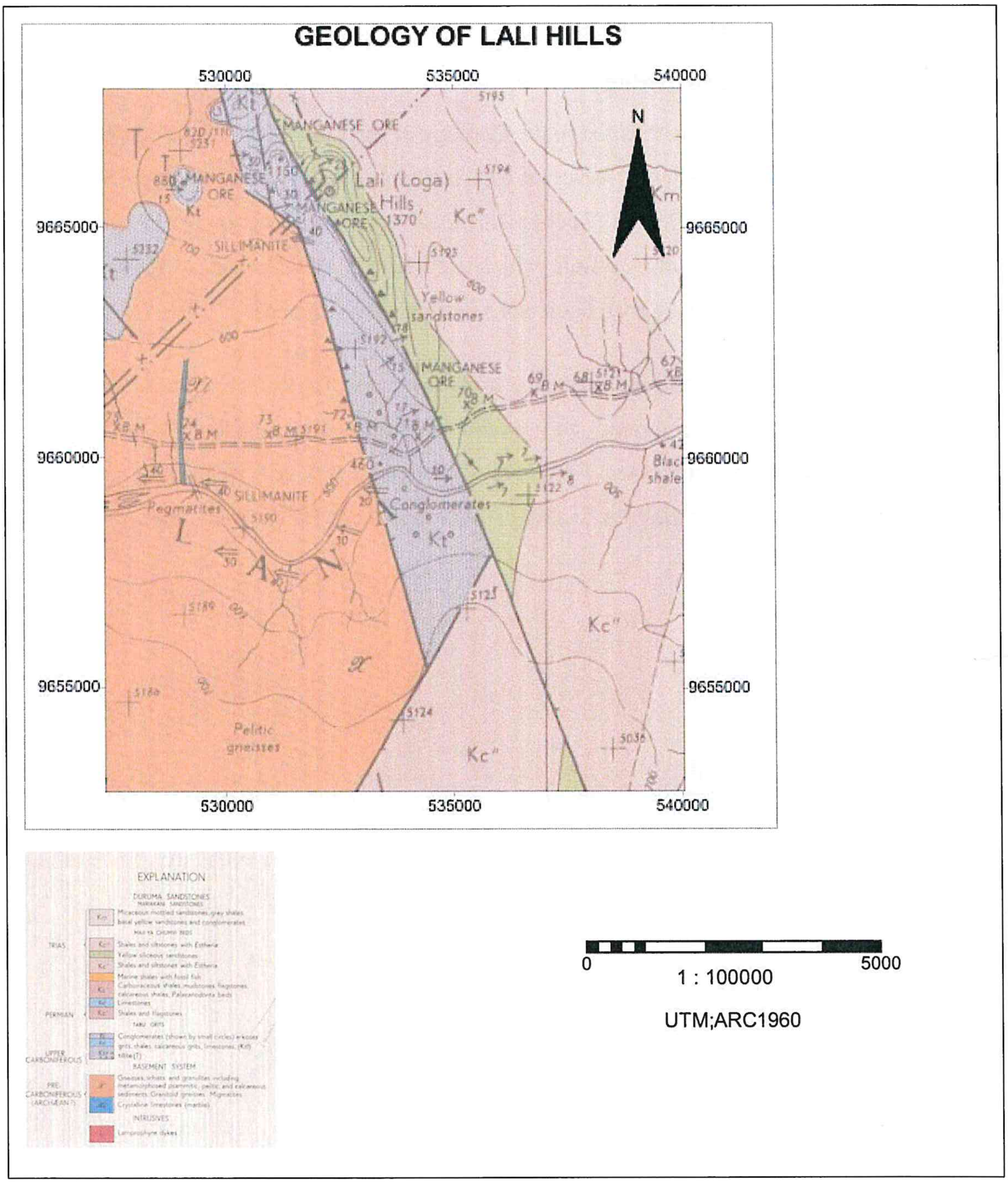


*Figure 2-1: Geological Map of Lali Hills (Modified After Geological Map of Mid Galana Area Report 46)*

# 3 PREVIOUS WORKS

The occurrence of manganese in the Lali Hills area was previously documented during the regional geological mapping of the Mid-Galana area by Sanders (1959). In this work, manganese mineralization was reported within brecciated sandstones of the Duruma Sandstone Formation, particularly within fault zones and shatter belts on the western side of the Lali Hills. The mineralization occurs mainly as pink to maroon manganese "bloom", nodular aggregates, and coatings along fractures and breccia fragments. Identified manganese minerals include pyrolusite, psilomelane and wad (an amorphous mixture of manganese oxides), while associated iron-bearing minerals include specularite, hematite and limonite occurring as cavity fillings and coatings within the brecciated sandstone.

Chemical analysis of a representative iron–manganese mineralized breccia from the Lali Hills area reported **24.40% $SiO_2$, 41.28% $Fe_2O_3$, 0.96% $MnO_2$ and 0.02% CoO** (Sanders, 1959). The results indicate that the breccia is predominantly iron-rich, with ferric oxide forming the largest proportion of the analyzed sample. These early analytical results therefore support the interpretation that the mineralization is structurally controlled and associated with secondary enrichment processes within fractured zones of the Duruma Sandstone.

The geology of the Lali Hills area was first documented through regional geological mapping undertaken by the Geological Survey of Kenya. The area falls within the Mid-Galana Area (Degree Sheet 66 NW – Mid Galana) where the dominant lithology is mapped as Mazeras Sandstone Formation, consisting mainly of quartzitic sandstones forming low ridges and hills across the coastal sedimentary basin (Dodson, 1966). In this mapping, three magnetometer traverses were conducted across the Lali Hills–Dakadima area at approximately one-mile station intervals to aid interpretation of the subsurface geology beneath extensive superficial cover. The results indicate that Basement System rocks exhibit slightly higher magnetic responses compared to the Duruma Sandstones, while superficial deposits display the lowest magnetic intensities. Profile analysis reveals localized magnetic highs between stations 13–16 and 25–29 along the west–east cut-line traverse, interpreted as possible up-faulted blocks of Basement System rocks beneath the sedimentary cover. Along the Kona Lali–Dakadima traverse, a gradual decrease in gamma values northwards suggests progressive deepening of the Duruma Sandstone basin in that direction. In contrast, the Mutha–Mambrui road profile shows minor magnetic variation with a small peak near station 76, possibly associated with a weakly magnetic pegmatite body. Overall, the magnetometer survey proved valuable in delineating subsurface structural features despite the scarcity of rock outcrops in the area (Dodson, 1966).

A comprehensive Airborne Geophysical Survey was undertaken in the area using magnetic and radiometric methods NAGS 2022) The study identified geophysical anomalies within the Lali Hills area. Interpretation of the airborne magnetic and radiometric datasets indicated localized anomalous responses that may reflect lithological variations, structural features, or possible mineralization.

# 4 METHODOLOGY

Previous investigations in the Lali Hills area utilized a combination of airborne geophysical surveys and geological field mapping techniques to characterize the geology of the area and identify areas of potential mineralization. The main methods applied included airborne magnetic surveys, radiometric surveys, geological traverses, geochemical sampling, and the collection of geological structural data.

## 4.1 Airborne Magnetic Method

The National Airborne Geophysical Survey (NAGS) conducted in 2022 applied airborne magnetic methods to measure variations in the Earth's magnetic field caused by differences in the magnetic properties of subsurface rocks. The magnetic data were used to delineate lithological boundaries, identify structural features such as faults and fractures, and detect magnetic anomalies that may indicate zones of mineralization.

## 4.2 Radiometric Method

Radiometric survey methods were also applied as part of the airborne geophysical survey. The radiometric data measured natural gamma radiation emitted from potassium (K), thorium (Th), and uranium (U) present in surface rocks and soils. These measurements assisted in identifying variations in surface geochemistry and lithology, as well as zones of alteration that may be associated with mineralization.

## 4.3 Geological Traverses

Regional geological mapping of the area, documented in the Geology of the Mid-Galana Area (Degree Sheet 66 NW), Geological Survey of Kenya Report No. 46, applied systematic geological traverses. During these traverses, rock types, stratigraphic relationships, and geological boundaries were observed and recorded in the field, enabling the preparation of the geological map of the area.

### 4.4 Geochemical Sampling

Geochemical sampling involved the collection and analysis of rock and soil samples to determine the concentration of various elements. This method assisted in identifying geochemical anomalies that may indicate the presence of mineralization.

### 4.5 Geological Structural Data

Structural geological data were collected through field observations and measurements of features such as joints, fractures, bedding orientations, and faults. These measurements provided information on the structural framework of the area and assisted in interpreting the controls on mineral occurrence.

## 5 RESULTS

The eastern side of the Lali Hills fault zone is characterized by brecciated sandstones that exhibit mineralization by manganese and iron in varying proportions. The fault breccia consists of angular sandstone fragments and blocks, which are locally veined and coated with manganese oxides. This mineralization occurs along fractured and brecciated zones within the host sandstone, indicating a strong structural influence on the distribution of the ore.

The manganese occurrence mapped within the Lali Hills area, as shown on the Geological Map of the Mid Galana Area, appears to be spatially associated with major fault structures. The presence of brecciation, fracturing, and mineral infill suggests that hydrothermal fluids circulated along these structural zones, leading to the deposition of manganese within the fractured sandstone host rocks.

Figure 5-2 illustrates a blown-out section of the standard deviation output grid derived from airborne geophysical data, highlighting a prominent linear structural zone interpreted as a fault or fracture corridor. The manganese mineralization is inferred to follow this structural trend, indicating that the mineralization is structurally controlled.

The deposit is therefore interpreted to occur along fault zones previously mapped through geological investigations and further indicated by airborne geophysical anomalies. However, the ultimate source of manganese within the system remains uncertain and requires further investigation.

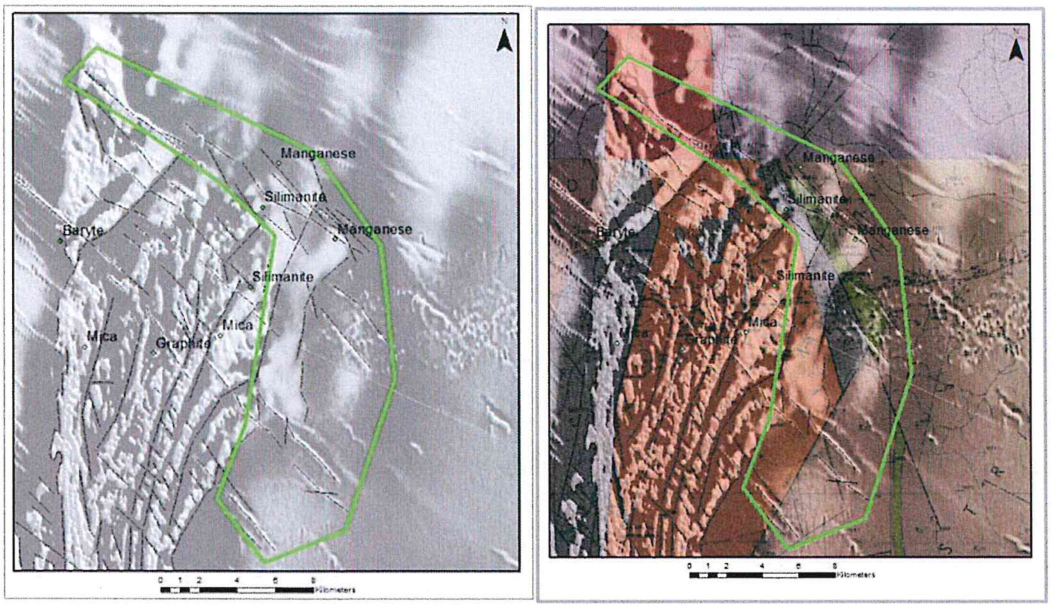


*Figure 5-1: :Blown out section of the Standard deviation output grid indicating linear structural zone Manganese ore is inferred to follow during the genesis (NAGS, 2022)*

# 6 DISCUSSIONS

Manganese at Lali Hills occurs predominantly as Mn-Oxide nodules and fracture-controlled staining within the Mazeras Sandstone. The mineralization is interpreted to be structurally influenced, where joints and minor fractures within the sandstone act as permeability pathways for manganese-bearing fluids. These fluids are believed to have mobilized manganese within the near-surface weathering profile and subsequently precipitated it along fracture planes, forming nodular concentrations and localized staining.

The style of mineralization is therefore consistent with supergene enrichment within the weathering zone (Nicholson, 1992). Field observations indicate that the occurrence is discontinuous and localized, characterized mainly by nodular accumulations rather than stratiform, massive, or laterally continuous manganese bodies.

From a geological perspective, the presence of manganese nodules confirms localized enrichment within a permeable sandstone host. The fracture-controlled model provides a plausible mechanism for concentration. The observed manganese occurrence suggests credible geological potential within a favorable sandstone host environment.

# 7 CONCLUSIONS AND RECOMMENDATION

## 7.1 Conclusion

The manganese occurrence at Lali Hills, Tana River County, is hosted within the Mazeras Sandstone Formation of the Duruma Group, which overlies Proterozoic basement rocks of the Mozambique Belt. The mineralization occurs mainly as manganese oxide nodules and fracture-controlled coatings within brecciated sandstone along structural zones associated with the Lali Hills fault system.

Geological observations and geophysical interpretation indicate that the mineralization is structurally influenced, with fractures and brecciation providing pathways for manganese-bearing fluids. The mode of occurrence is consistent with supergene enrichment processes within the near-surface weathering profile.

The manganese mineralization identified in the area has potential for laterally continuity to warrant a manganese deposits capable of supporting medium to large-scale extraction. Additionally, the presence of structural lineaments identified from airborne geophysical data suggests high chances of zones of mineralization occurring along these structural trends.

## 7.2 Recommendations

Structural controls for manganese mineralization are eminent and should be targeted to determine and extent mineralized zones.

Since the area has high potential for manganese mineralization, detailed geological exploration including ground geophysical survey, trenching followed by targeted drilling, should be enhanced in order to delineate and quantify the resource.

## REFERENCES


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