Mineral Sector Support for Economic Diversification Project (MinDiver) Project Nigeria

ENGAGEMENT OF AN ADVISORY FIRM TO CARRY OUT MINING INVESTMENT FACILITATION ACTIVITIES ON AQUIRED GEOLOGICAL INFORMATION

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REPORT D6

PROJECT FINAL REPORT

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List of Abbreviations

CSV: COMMA SEPARATED VALUES FILES

DEM: DIGITAL ELEVATION MODEL

DST: DELIVERY SUPPORT TEAM

MINDIVER: MINERAL SECTOR SUPPORT FOR ECONOMIC DIVERSIFICATION

MPM: MINERAL PREDICTIVE MAP

MGCP: MULTI-NATIONAL CO-PRODUCTION PROGRAM

NGSA: NIGERIA GEOLOGICAL SERVICE AGENCY

QA/QC: QUALITY ASSURANCE/QUALITY CONTROL

SHP: ESRI SHAPEFILE

1. Introduction

1.1 Project Background

The current project finalizes the Nigeria Mineral Sector Support for Economic Diversification (MinDiver) Project aimed to boost and solidify the Mining Industry in Nigeria. This last part intends to merge the different data streams into one key deliverable containing a simple guide to conducting mining business in the country.

With the aim of diversifying the raw material sector and to reduce the dependency on the oil industry, the government embarked on the objective of securing financing from the World Bank to develop the mining industry. The result was a $120m IDA credit for the implementation of the MinDiver Project. Part of this umbrella project is the current mission under the name "Engagement of an advisory firm to carry out mining investment facilitation activities on acquired geological information". After a competitive bidding process, Beak Consultants GmbH has been engaged to execute this project.

This D4 is a progress report, building on all previous Deliverables, and is named "Report on Investment attraction policies, marketing, and investor identification".

1.2 Project Objective

The main objective of the project is to collect, review and organize all geoscientific data of the country to develop mineral prospectivity maps that allow the selection of targets and the preparation of the respective prospectuses as investor-ready documents. These mineral passports act as tangible material for the engagement of both domestic and foreign investors and other relevant parties, as part of the Ministry's strategy in attracting investment to the country to develop the mining sector and further diversify the economy.

2. Project management

2.1 Project Governance

The project governance has been structured after Figure 1, allowing a clear and clean communication flow between the project's stakeholders. Critical is the Steering Committee leading the project with the responsibility of reviewing the project performance and taking sound decisions The Project is managed by the following team:

- Project Chair: **Engr. Linus Adie**,
- Project Vice Chair: **Mr. Ime Ekrikpo**,
- Project QA/QC: **Engr. Abba Usman/ Eng. Also Abdullahi/ John Eyre**,
- MinDiver M&E: **Dotun Ajibola/Seyi Olawale**,
- Vendor Project Manager: **Emmanuel Etuk**,
- Vendor Technical Lead: **Luis Pizano**,

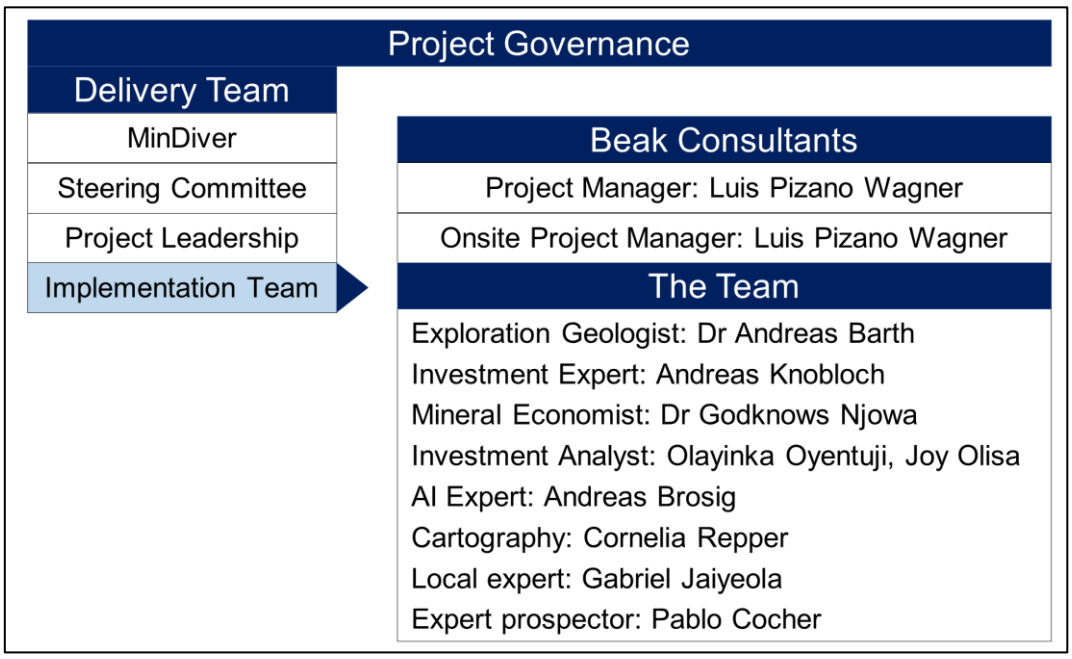


Figure 1: Project Governance details.

2.2 Communication and Collaboration

The communication and collaboration plans define how Beak, NGSA and MMSD should interact and cooperate. To achieve the targets of the project, the meeting Cadence of Table 1 is established to track, discuss and align on deliverables and data.

Table 1: Cadence of the project to guarantee a successful project.

Project Cadence		
Type	Frequency	Participants
Delivery Support Team (DST) Meeting	Monthly	MinDiver, Implementation Team
Internal Progress Meeting	Weekly	Implementation Team

Until this point, thee DST meetings have been held allowing the follow up of critical activities for the functionality of the project and the cooperation between the parties (Annex 1: List of DST Meetings).

2.3 Training (Cooperation Procedures)

The transfer of knowledge to the Ministry and NGSA Staff took place during the days 22-23-24 of April in the ASM Offices. The topics covered from the initial step of data gathering to the identification of targets. With this ground information, the Staff is capable of selecting appropriate prospective areas and conducting either further analysis of preparing the information for marketing purposes. The list of participants is shown in Annex 3: Attendance Lists Training (22-23-24.04.2024). The topics covered were the following figure (compressed into three days):

	17. Apr	18. Apr	19. Apr	20. Apr	21. Apr
Topic	Data Integration	Data Integration	Data Integration/Predictive Mapping	NA	NA
Activity	Review of the MIS functionality Revision of Selected Mineral Occurrences (e.g., Au) Real case of data import: Geochemistry, Xcalibur Geophysics, Official Reports	Derivation of info from original data: e.g., Slope, interpolation Import of new derived data to MIS, link to existing data Compilation and comparison	Develop a strategy and methodology for future activities Selection of relevant commodity Introduction to Metallogenic Models and Machine Learning Prepare additional derived data useful for predictive mapping for selected commodity Create project for advangeo: organization of data	Weekend	Weeknend

22. Apr	23. Apr	24. Apr	25. Apr	26. Apr
Predictive Mapping	Predictive Mapping	Evaluation	Investment and Marketing	Investment and Marketing
Review: Machine Learning and predictive mapping Import of project data to advangeo Running the first calculations	Calculation of models, understanding the results Recalculation and analysis of new possible scenarios Suggest a target area for exploration	Revision on the concepts. Presentation of standarized reports. Questions and doubts solved. Revision on the concepts of the Predictive Mapping topic. Questions and doubts solved.	Effective Communication Data Presentation Familiarization with terminologies Understanding global economic trends	Stakeholder Management Response adaptability and agility Marketing, Consultative Selling, Relationship Summary and questions

Figure 2: Capacity building topics covered during training in Abuja.

2.4 Status of project completion

The status of the activities of the project is shown in Table 2. For a complete version as a Gantt diagram, please refer to Annex 2: The Detailed Workplan. The inception report, Deliverable #2 Deliverable #3, Deliverable #4 and Deliverable #5 have been finalized and delivered. This Report marks the end of the Project.

Table 2: Status of completion of the activities of the project.

Activity	Completion	Remark	Deadline
Deliverable #1: Inception Report	100%	Delivered	NA
Data Compilation	100%	Pending Geochemistry	-
Deliverable #2	100%	Delivered	Month 4
Metallogenic Models	100%	Completed	-
Metallogenic Domains	100%	Completed	-
ANN Predictive Modeling per Commodity	100%	Completed	-
Deliverable #3	100%	Completed	Month 5
Ranking of targets	100%	Completed	-
Draft Investment Facilitation	100%	Completed	-
Template for Prospectuses	100%	Completed	-
Deliverable #4	100%	Completed	Month 6
Report Targets	100%	Completed	-
Report on Investment Facilitation	100%	Completed	-
Report Conferences and events	100%	Completed	-
Report investment identification	100%	Completed	-
Report Mining Facilitation	100%	Completed	-
Final template Prospectuses	100%	Completed	-
Deliverable #5	100%	Completed	Month 7
Deliverable #6	100%	Completed	Month 8

3. Project methodology

3.1 Workflow of the entire project

The **Project consists generally of two branches as shown in Figure 3:**

- The identification, ranking and selection of exploration targets D1 – D3
- The communication with the mining community, distribution of information and attraction of investment to various identified targets D4 – D6.

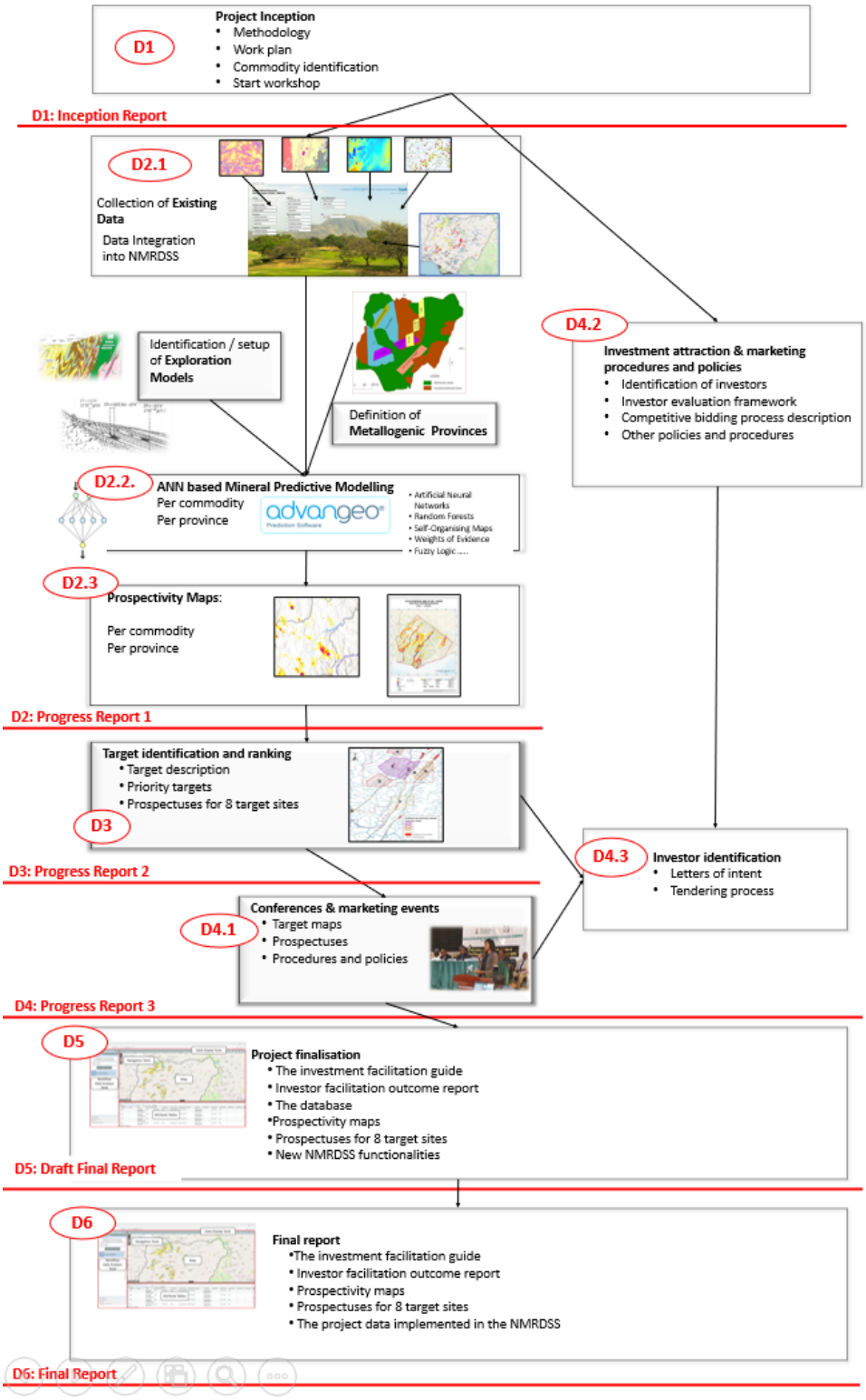


Figure 3: General workflow of the project.

3.2 Part-project: Target Identification and Ranking

The commodities for this project will be identified by comparing the needs of the national/ international markets with the currently in Nigeria known/ prospective commodities (see Section 3.4). This requires working on the existing mineral occurrence database available for the country and the revision on known sources (e.g., published reports) that confirm the identified locations[1].

With the use of Artificial Intelligence (6.1) on these points to identify relevant patterns, it is possible to identify favorable areas in Nigeria for a selected group of commodities and the selection of targets[2]. Finally, a document with a compendium of key details, both in content and context, will be shared with interested parties and investors. This whole process is summarized in Figure 4.

[1] Ground visits to mineral occurrence locations is not possible and out of the scope of this project.

[2] Due to a reduced number of occurrences for some identified commodities, only selected cases will be analysed through AI.

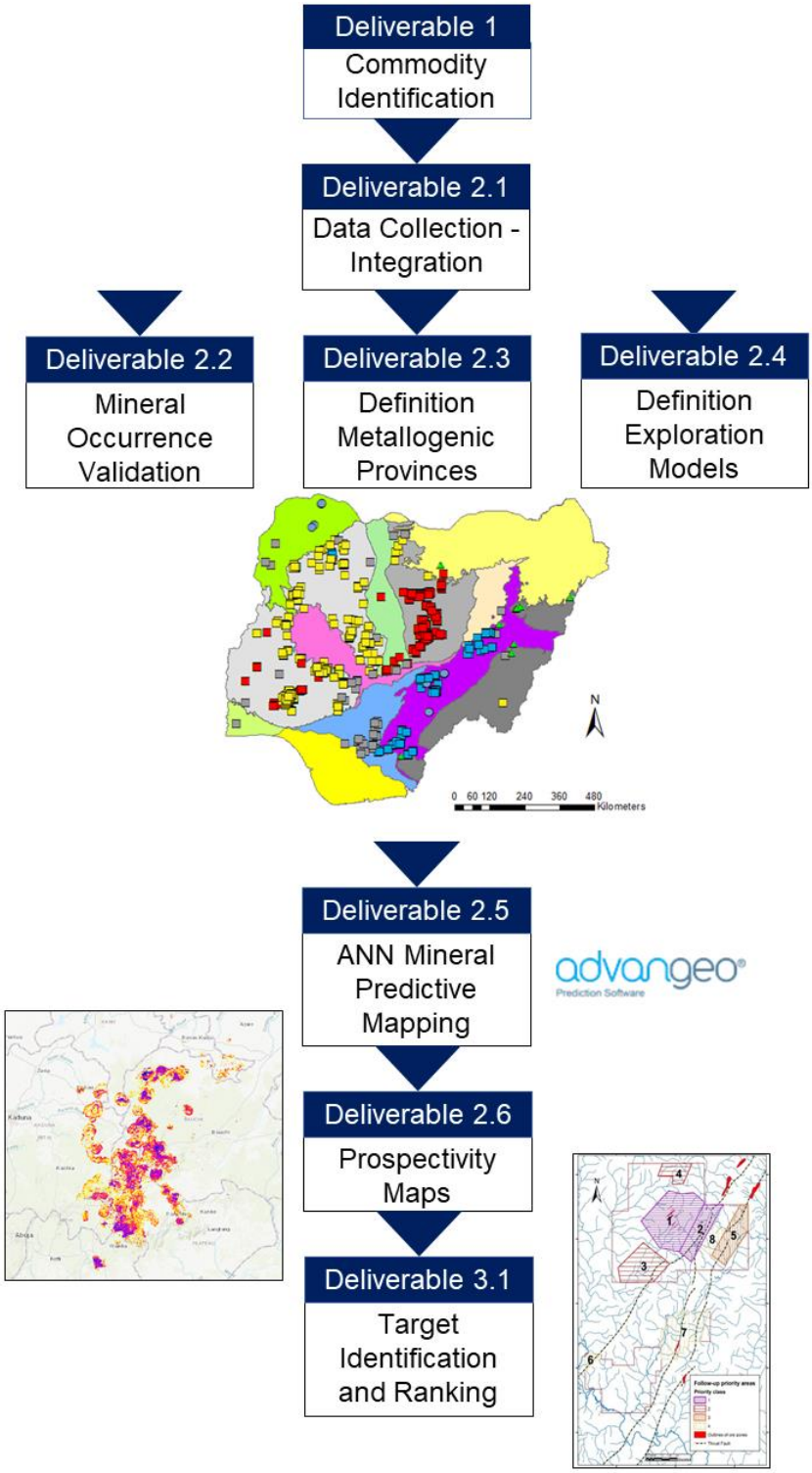


Figure 4: Workflow for mineral target identification and ranking.

3.3 Part-project: Investment Facilitation

The second part of the project focuses on investment facilitation methodologies and investor engagement. One of the main deliverables is an investment facilitation guide, including a description of main drivers of the mining industry of Nigeria, such as infrastructure, quality and quantity of operations, technology being used, among other items. The project finalises with the investor identification, tendering process and framework policies, summarized in Figure 5. Deliverable 4 activity runs parallel to the activities from the previous section (3.2).

Figure 5: Workflow for the investment facilitation plan.

3.4 Identification of the target commodities and of the project area

3.4.1 Target commodities

3.4.1.1 Global Needs

The identification of target commodities in this project is based on the following considerations:

- Review of existing critical raw material lists, e.g. of the EU and the USA,
- Analysis of the expected worldwide demand for commodities in future oriented technologies up to 2040, e.g. the research (Marscheider-Weidemann, et al., 2021),
- Further considerations according to current market developments.

When compared to the world market economies and the current needs, such as for Energy Transition Metals (ETM), most commodities are marked as critical. For instance, the EU has made the list as shown in Table 3 and the U.S. has defined Table 4. No included as critical but with reasonable market value prices and future demand are Gold (Au), tin (Sn), Copper (Cu), U (U), the latter is relevant as energy fuel for the upcoming years.

Table 3: Critical raw materials as identified by the European Commission (Commission, 2023).

2020 Critical Raw Materials					
Antimony	Cobalt (**)	Hafnium	Natural Graphite (**)	**Phosphorous(*)**	Vanadium
Bauxite	Arsenic	Nickel (**)	Feldspar	**Manganese (*)**	Helium
Barite(*)	Coking Coal	Heavy REE	Fluorspar(**)	Scandium	Copper (**)
Beryllium	Natural Rubber	Light REE	**Niobium(*)**	Silicon metal	**Lithium(*)**
Bismuth	Gallium	Indium	PGM (**)	**Tantalum(*)**	Titanium
Borate	Germanium	Magnesium	**Phosphate rock(*)**	**Tungsten(*)**	Strontium

(*) Commodities currently known in Nigeria and discussed in this section marked in bold.
(**) Commodities with potential in Nigeria.

Table 4: Critical raw materials after assessment by the U.S. Department of Energy. Compiled after (U.S. Department of Energy, 2023).

2020 Critical Raw Materials					
Aluminum	Bismuth	Gallium	Iridium	**Niobium(*)**	**Tin(*)**
Antimony	Cesium	Germanium	**Lithium(*)**	REE(**)	Titanium
Arsenic	**Chromium(*)**	Graphite (**)	Magnesium	PGE (**)	Tungsten(**)
Barite(*)	Cobalt	Hafnium	**Manganese(*)**	Rhodium	Vanadium
Beryllium	Fluorspar (**)	Indium	Nickel(**)	**Tantalum(*)**	**Zinc(*)**

(*) Commodities currently known in Nigeria and discussed in this section marked in bold.
(**) Commodities with potential in Nigeria.

3.4.1.2 Main commodities of Nigeria and their regional distribution

According to the current knowledge (this project, (Crowe, Garba, & NGSA, 2023), (Olade M. A., 2020) and general metallogenic considerations in Nigeria the following commodities are known or could be expected in the main geological / tectonic units

- Archean and Paleoproterozoic domains → Au, (Mn, Cr, Ni, PGE?) and Cu, Pb, Zn, Sb, Fluorite
- Pan-African post-tectonic Granites and Pegmatites → Sn, Ta, Nb, Li, gemstones and related hydrothermal-metasomatic formations Au, Cu, Pb, Zn, (U?)
- Jurassic Young Granites → Sn, Nb, W, Mo, Li, (REE?), fluorite, (U?)
- Cretaceous Benue Trough → Pb, Zn, Cu, barite, U
- Anambra Basin → Coal
- East Dahomey Basin → Phosphorite, Bitumen
- Sokoto Basin → Phosphorite, (U if reasonable grades can be identified), (Mn?)

For further consideration in this project, we selected commodities as shown in Table 5.

Table 5: Selected commodities to be worked on within the scope of this project

Commodity Group	Selected Commodities
Ferrous metals	Mn, Ni, Cr
Precious metals	Au, PGE
Base metals	Pb, Zn, Cu
Rare metals	Ta, Nb, Li, Sn, REE
Nuclear fuel	U

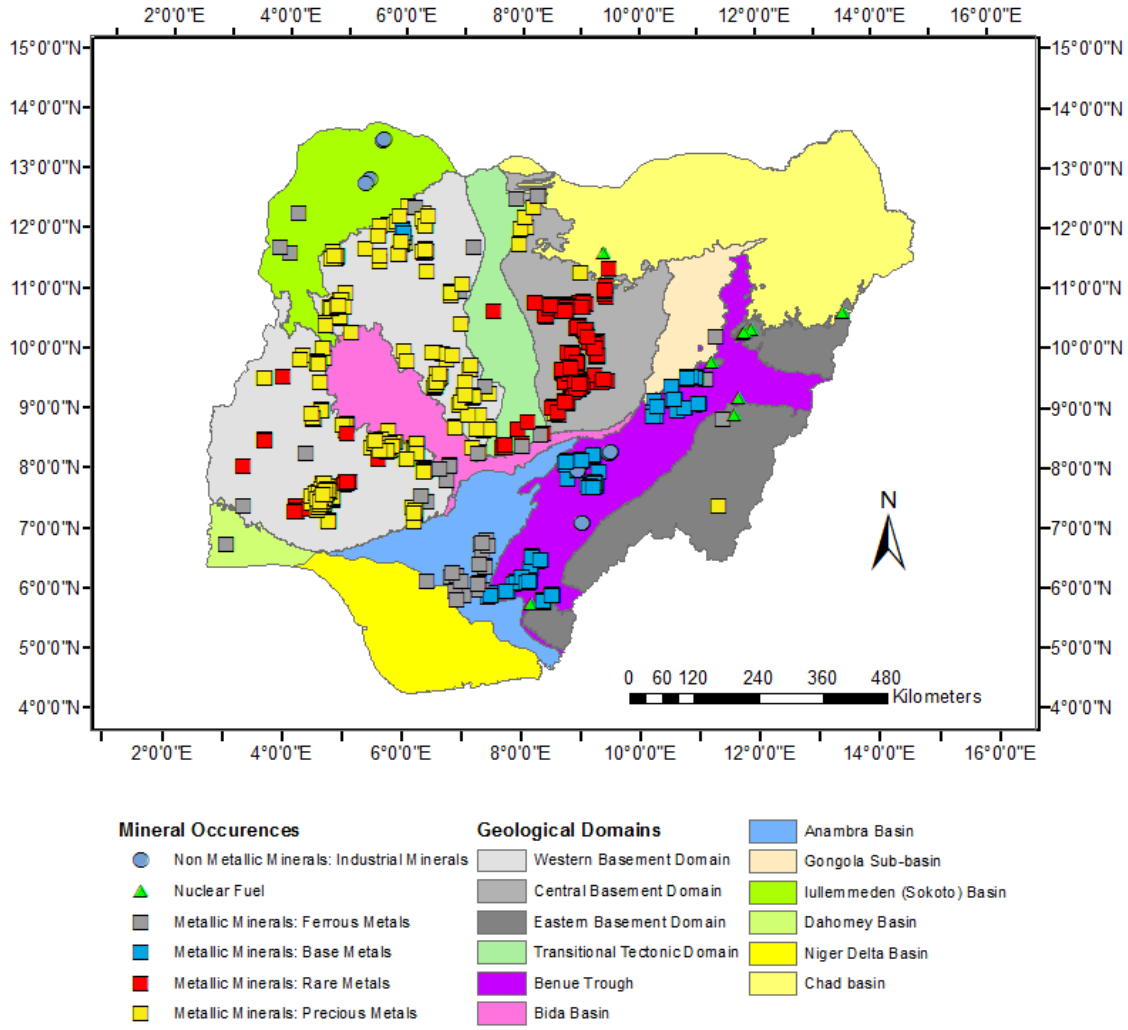


Figure 6: The project areas follow the main geological domains of Nigeria. Modified after (Crowe, Garba, & NGSA, 2023).

The following rationales were applied for commodity selection:

- Mn, Ni, Cr are listed as critical raw materials, but currently not known in Nigeria in industrial grades and quantities, but important geological pre-conditions exist.
- Au is currently the most common mined metallic commodity in Nigeria, and great potential for the future.
- PGE are not known in Nigeria, but might occur in the environment of Cr, Ni mineral occurrences in ultramafic rocks.
- Cu is a very important commodity, but potential for large Cu deposits is not clear.
- Ta, Nb, Sn, Li have a known potential in Nigeria.
- The Jurassic alkaline complexes are known for their Sn and Nb potential (possibly Li). In this geological environment carbonatites (REE mineralisation) may occur as well.
- The Pan-African pegmatites and possibly post-tectonic granites are promising for Ta, Li and Sn.
- U was described in early cretaceous sandstones from the Eastern Benue Trough and recorded from some areas from the eastern basement domain.

3.4.2 Project areas

The project area is based on the current knowledge of the metallogenic provinces and domains where mineral occurrences are documented (Figure 6). This allows the identification of project areas (Figure 7) that encompass the main commodities to be analyzed for target identification (section 0). The identified areas are:

- Western Basement Domain,
- Central Basement Domain,
- Benue Trough, and
- Sokoto Basin.

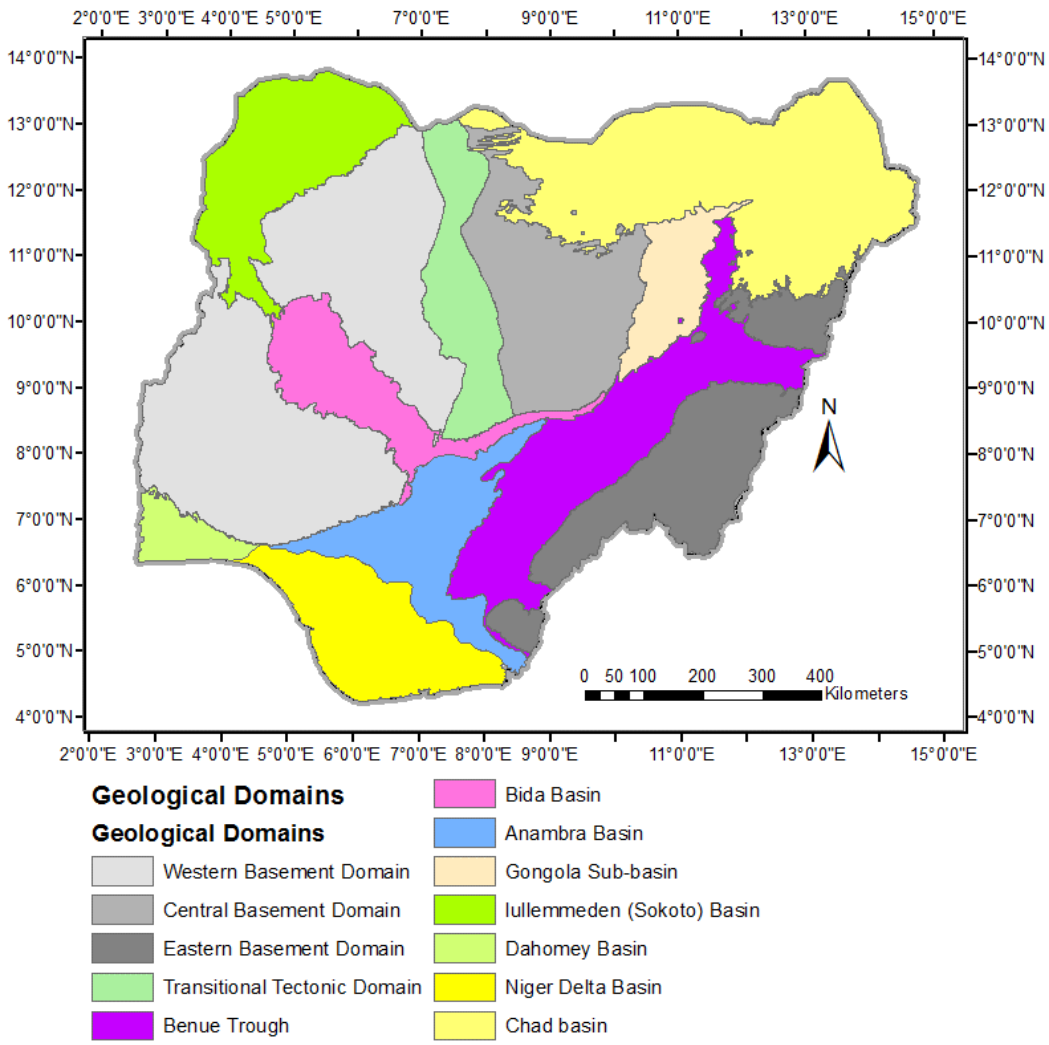


Figure 7: Project areas. Modified after (Crowe, Garba, & NGSA, 2023).

4. Status of geo-scientific and geo-economic knowledge

4.1 Geoscientific maps

The following geological maps were made available to the client:

- 1: 250K maps, mainly from the 80's (Figure 10),
- 1: 2M maps
  - Geological Map (Figure 9)
  - Litho-structural Map (Figure 10)
  - Metallogenic Domain Map (Figure 11)

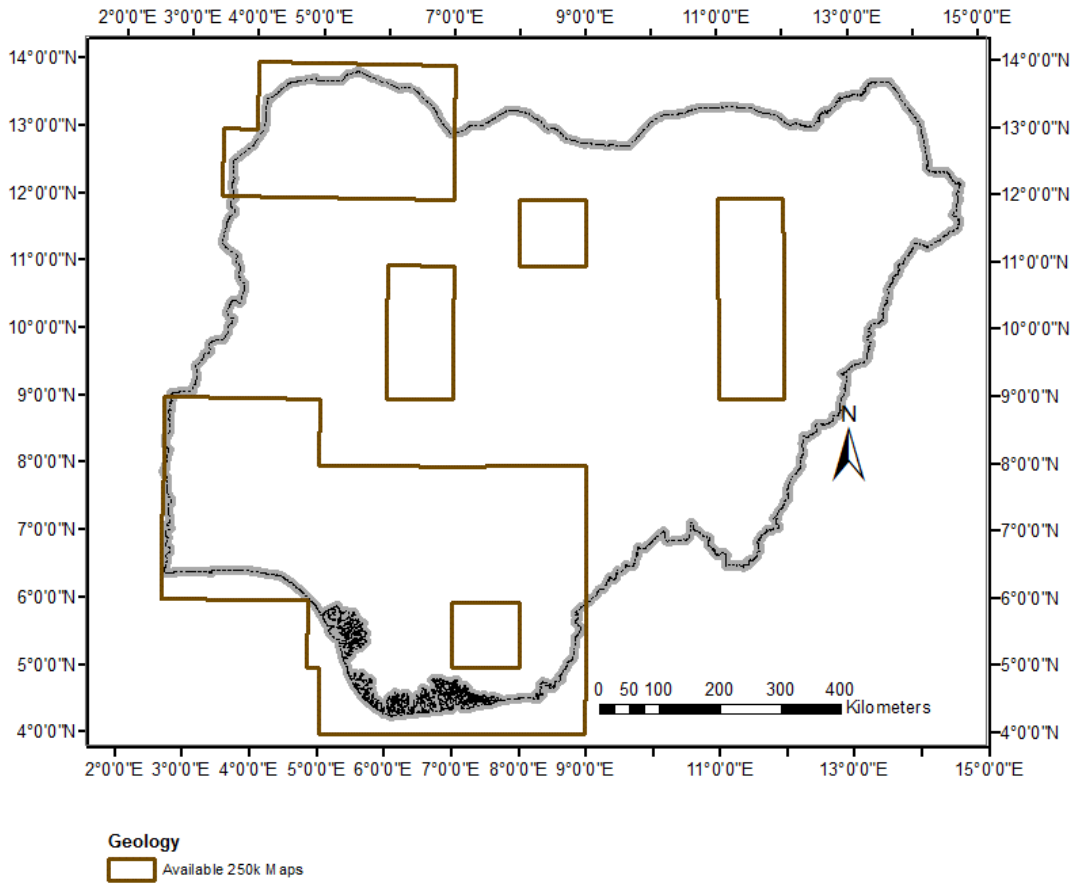


Figure 8: Coverage of available 1:250K Maps.

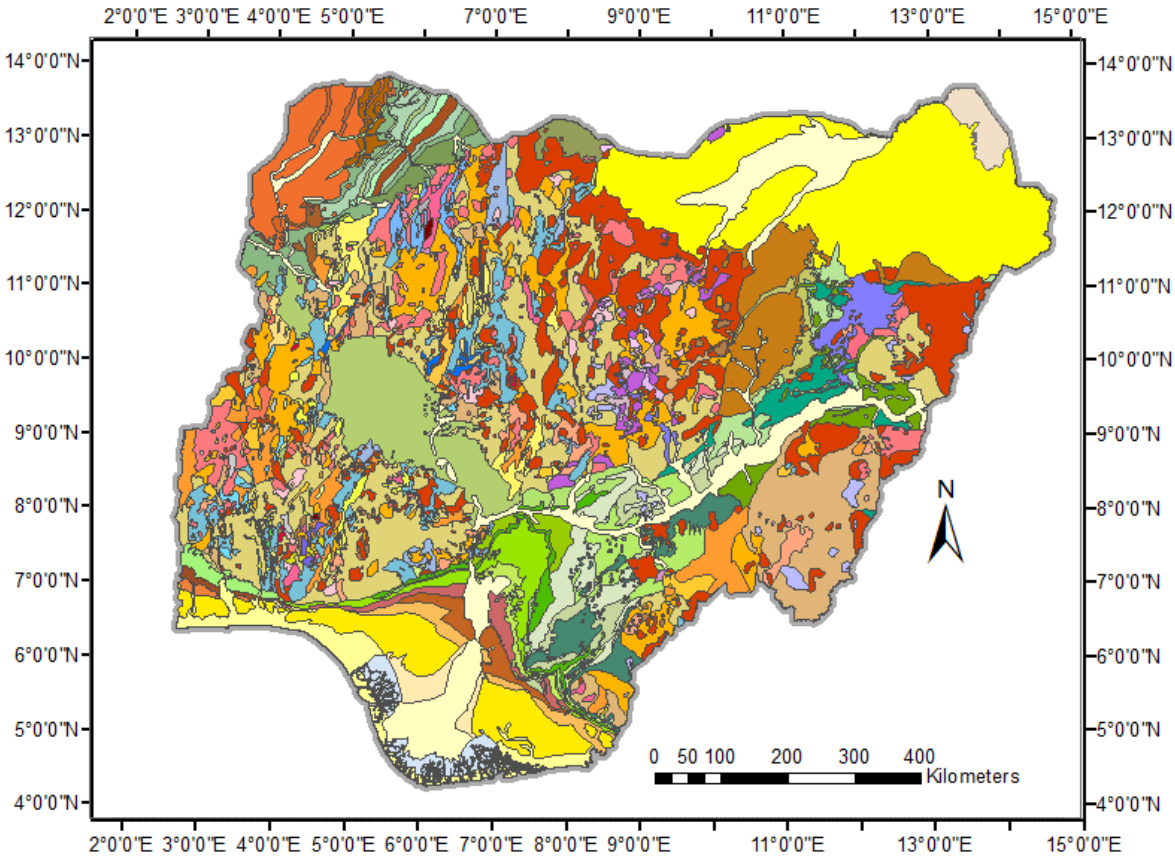


Figure 9: Geological Map of Nigeria. Modified from (NGSA, 2022).

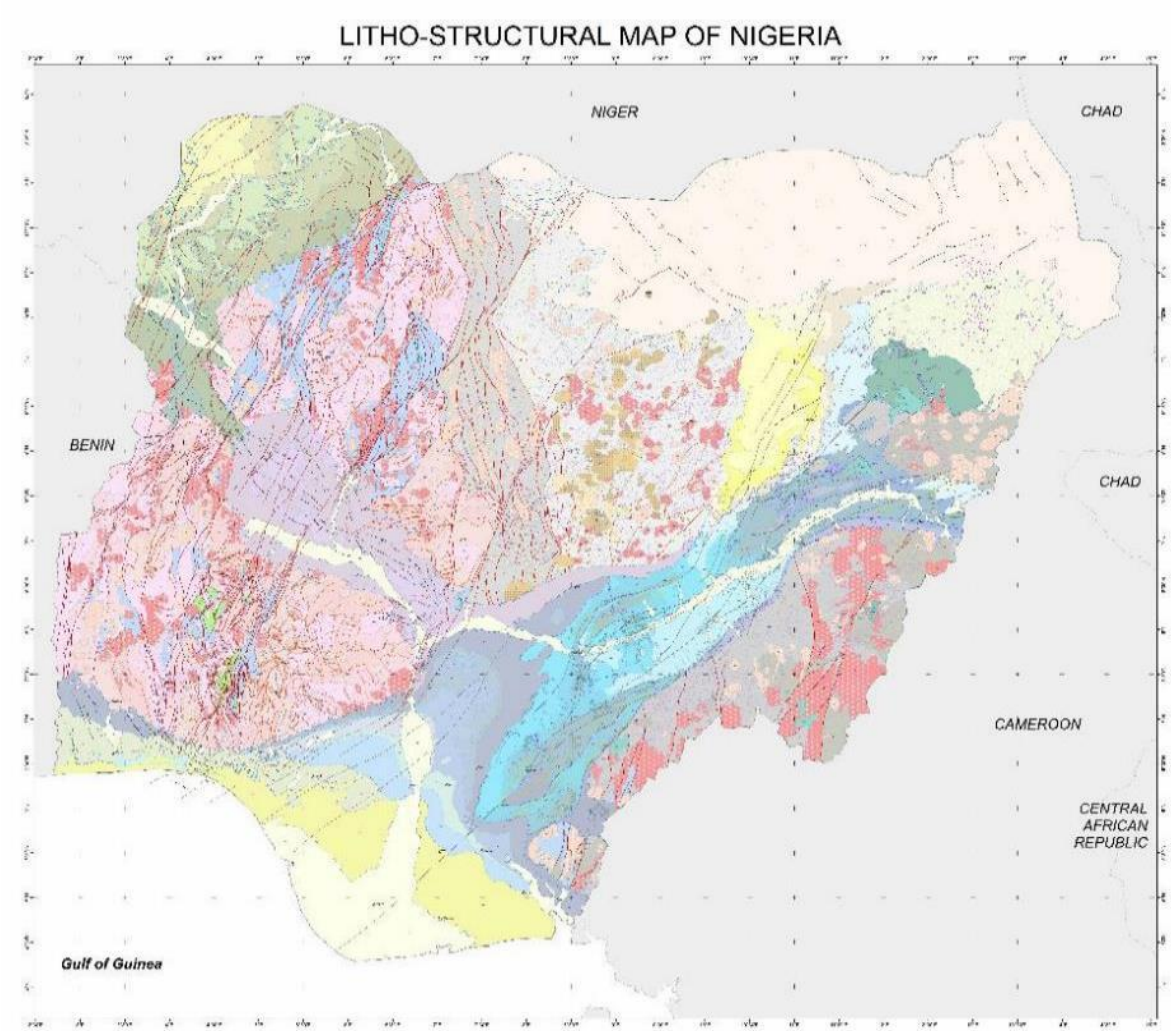


Figure 10: Litho-structural map of Nigeria.

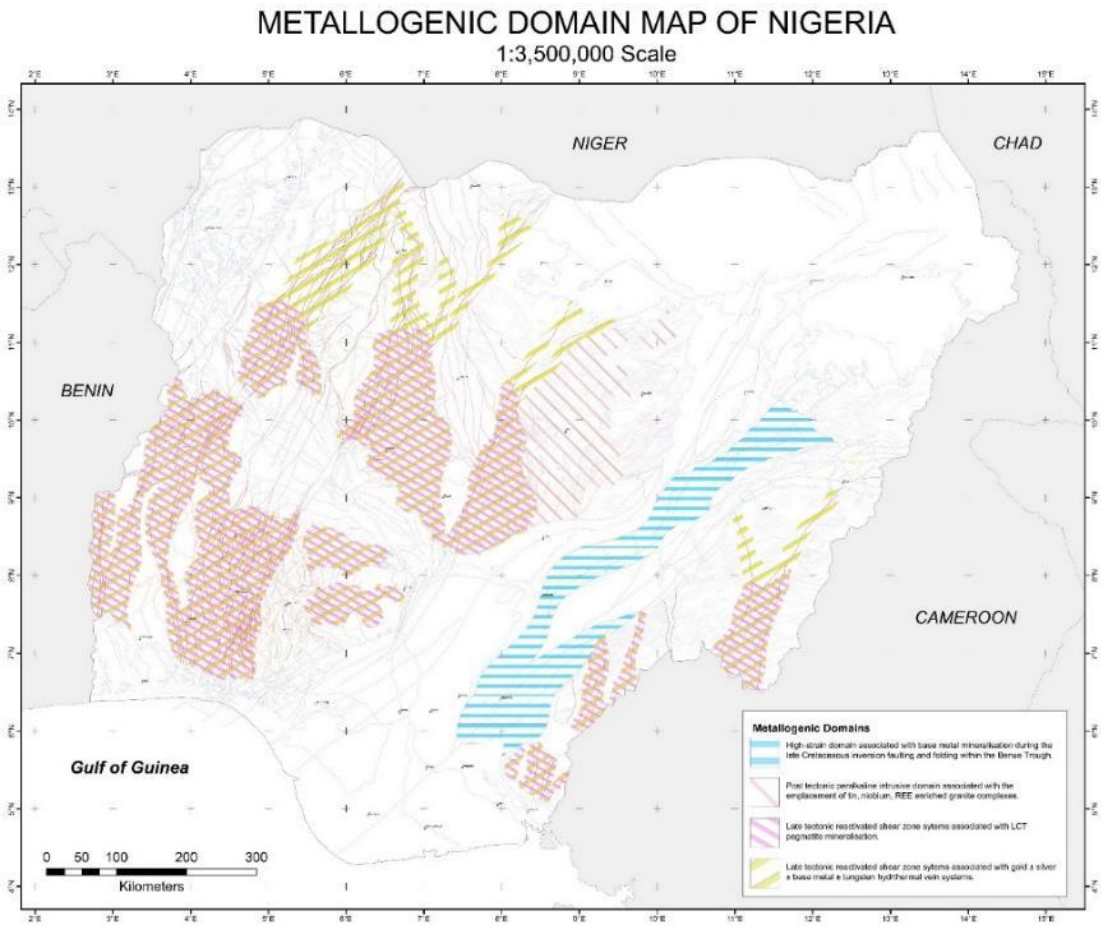


Figure 11: Metallogenic domain map of Nigeria delivered by NGSA as PDF (Crowe, Garba, & NGSA, 2023).

4.2 Geophysical datasets

Nigeria is completely covered with low-resolution airborne geophysical datasets (500m line spacing, 80m angle and spatial resolution of 125m) as follows:

- Aeromagnetic survey.
- Radiometric survey.

Currently, high resolution geophysical surveys (150m line spacing, 50m angle and spatial resolution of 30m) are ongoing as follows (Figure 12):

- Finalized (flown and interpreted) and made available to the Consultant.
- Ongoing (being flown and interpreted) and not delivered to the Consultant.

No current estimated time for delivery has been proposed from Xcalibur on the remaining blocks, therefore it is currently impossible to present a schedule on the implementation of this information.

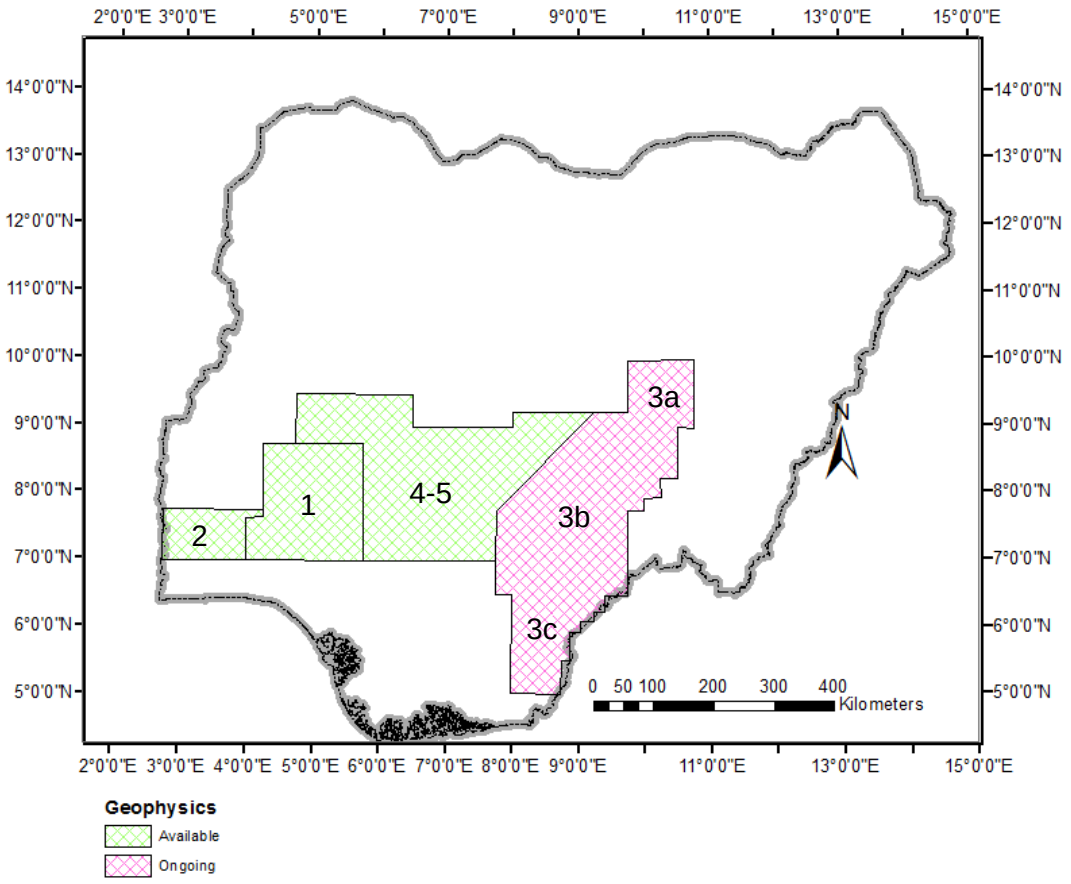


Figure 12: Availability of high-resolution geophysical data.

Gravity data were compiled from a number of published sources (Adejuwon, Selemo, Ibe, Ibeneme, & Akaolisa, 2021) (Adighije, 1976) (Ajakaiye, 1970) (Ajakaiye & Sweeney, 1974) (Ajayi & Ajakaiye, 1986) (Akaoltsa, 1997) (Aku, 1996) (Amosu, 1979) (Anasiudu & F., 1994) (Ayinde, 1988) (Candu, 1984) (Cratchley & Jones, 1965) (Eklne, 2014) (Ekpa, Okeke, Ibuot, Obiora, & Abangwu, 2018) (Ekwue, 1994) (Fairhead & Okereke, 1987) (Fairhead, Okereke, & Nnange, 1991) (Hospers, 1965) (IRD, 2014a) (IRD, 2014b) (IRD, 2014c) (IRD, 2014d) (IRD, 2014e) (IRD, 2014f) (IRD, 2014g) (Ibe, 1982) (Likkason, 1991) (Ndubuisi, 2000) (Obasi, Selemo, & Nomeh, 2018) (Ogbuoji, 1981) (Okiwelu, Okwueze, & Akpabio, 2009) (Oladosu, 1987) (Shemang, 1997) (Udensi, 1984) (Umego, 1990) (Zaiss, 2014) and suitable data were composited into a set of Bouguer anomaly values (reduction density 2670 kg/m³).

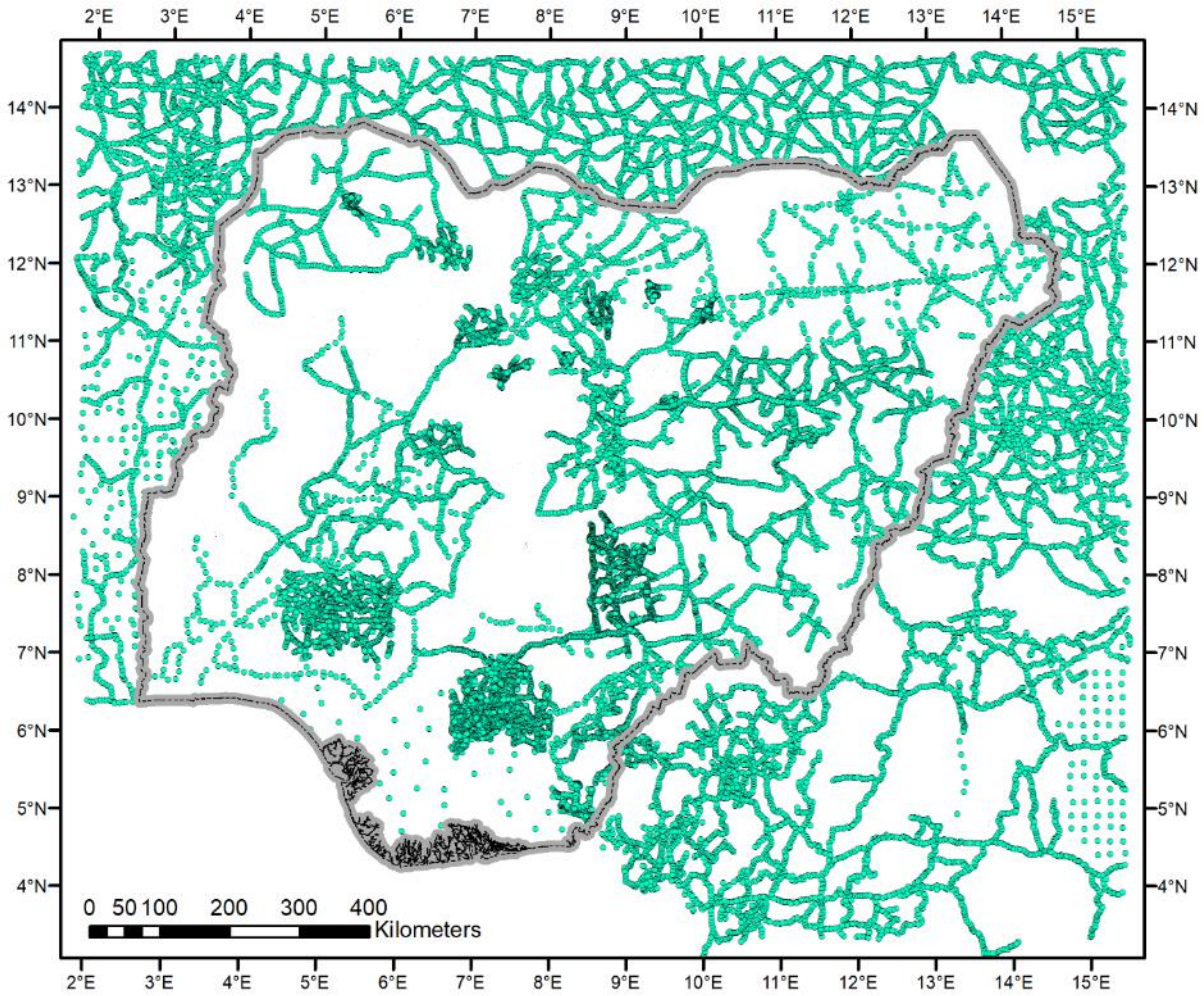


Figure 13: Data coverage of Bouguer anomaly points

4.3 Geochemical datasets

4.3.1 Historical Geochemical Data

The Nigerian Geological Survey made datasets available to the Consultant that cover the areas shown in Figure 14 (soil sampling) and Figure 15 (stream sediment). The dataset covers the following elements:

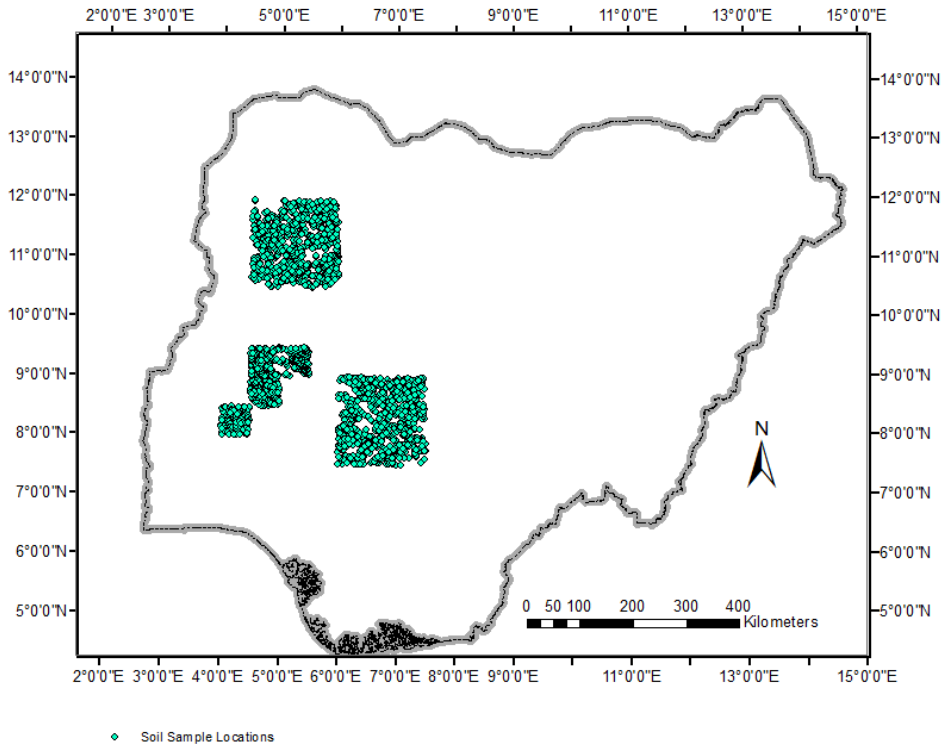


Figure 14: Data coverage of historical geochemical data for soil geochemistry.

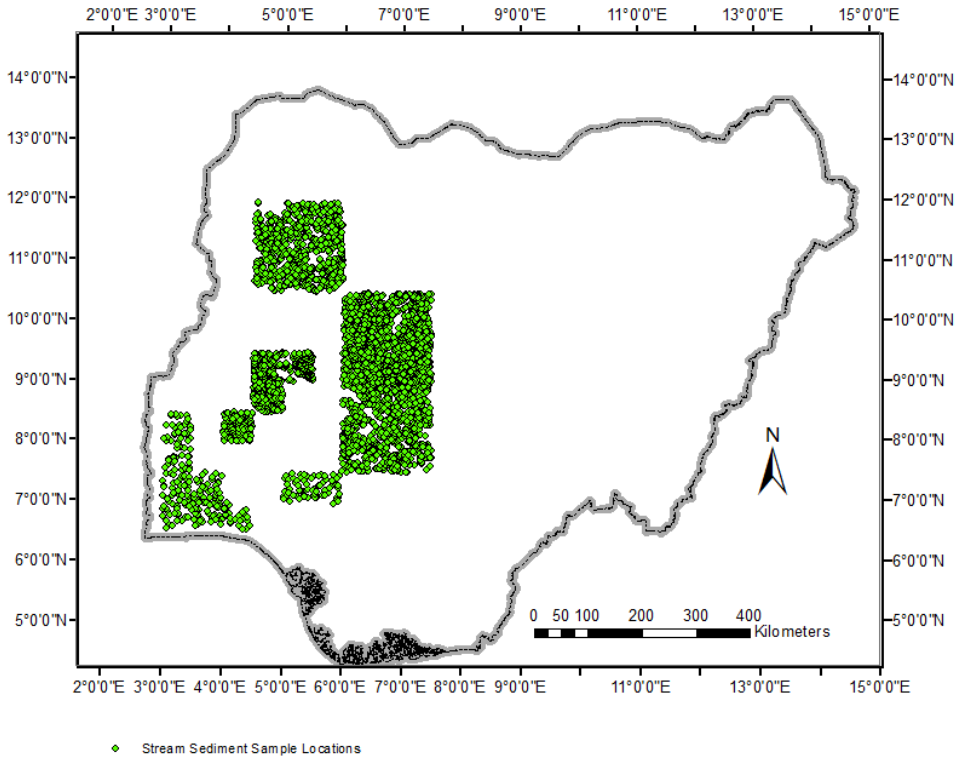


Figure 15: Data coverage of historical geochemical data for stream sediment.

The elements analyzed in this survey are: Mo, Cu, Pb, Zn, Ag, Ni, Co, Mn, Fe, As, U, Au, Th, Sr, Cd, Sb, Bi, V, Ca_, P, La, Cr, Mg, Ba, Ti, Al, Na, K, W, Zr, Ce, Sn, Y, Nb, Ta, Be, Sc, Li, S, Rb, Hf, In, Re, Se, Te, Tl, Hg.

The Consultant identified the following issues:

- No metadata file describing the dataset has been provided.
- Elemental analysis distributions are not homogeneous, covering different patches.
- Detection limits are not specified

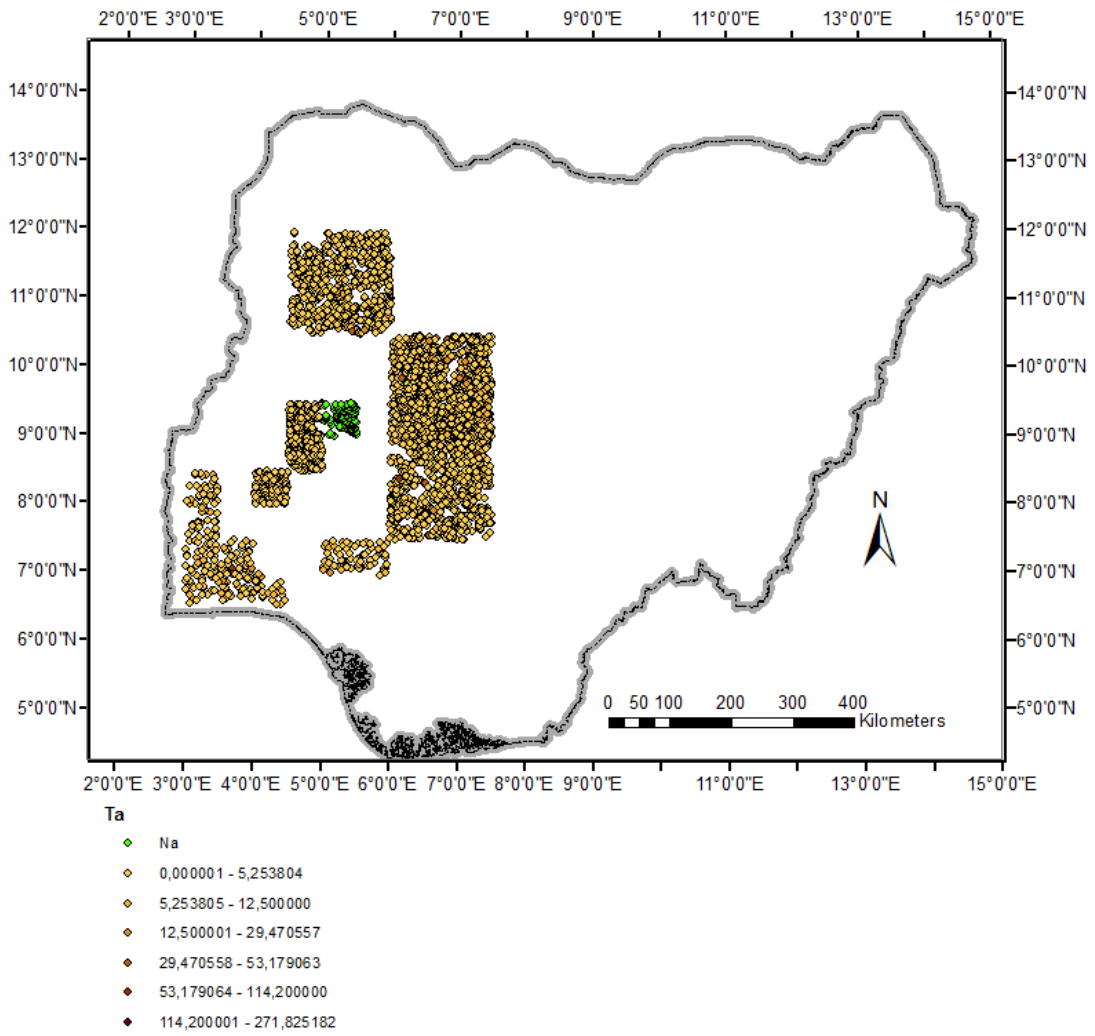


Figure 16: Inhomogeneous elemental Tantalum (Ta) distribution (see green points).

4.3.2 New Geochemical Data

New geochemical data have been made available to the Consultant. The company responsible for the geochemical survey and analysis, Seismic Consult, has indicated the receipt of 3,197 test results, however, just a percentage of them were made available to the consultant (Figure 17). The results will be taken into account only as a means of verifying the selected targets and attaching relevant information in the prospectuses. As of the submission of this Deliverable (#4), it was not possible. The delivered sheets are the following:

- Keffi (#695),
- Akwanga (#696),
- Wamba (#697),
- Soko (#615), and
- Agana (#616).

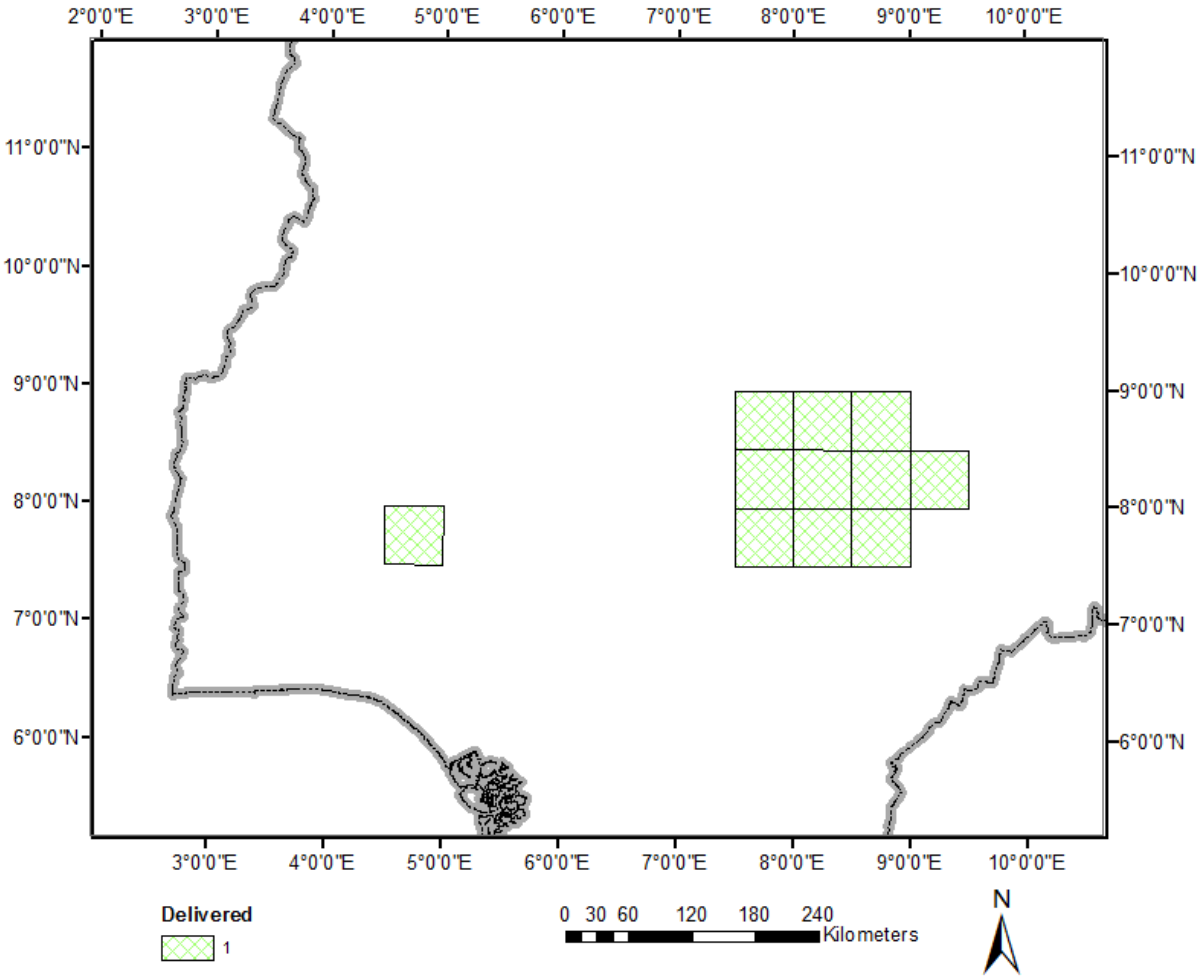


Figure 17: Delivered geochemical sheets for soil and stream sampling.

4.4 Mineral occurrence database (MODB)

The actual MODB contains 4833 records. For the AI based mineral potential mapping, requiring the knowledge of the exact locations of mineral occurrences, the locations of metallic commodities were verified with satellite images, publications and reports. In case of doubt, the respective mineral occurrences were marked as not usable ("advangeo-no") for predictive mapping. The current status of the MODB is shown in table Table 6.

Table 6: Summary of number of metallic commodities marked as "advangeo-yes".

Commodity	Number of entries	Number with "advangeo-yes"
Gold (Au)	1673	1604
Lead (Pb)	425	359
Zinc (Zn)	369	332
Tin (Sn)	557	447
Tantalum (Ta)	316	196
Niobium (Nb)	195	150
Lithium (Li)	150	91
Manganese (Mn)	39	16
Chromium (Cr)	5	4
Uranium (U)	14	9

4.4.1 Verification of the Mineral Occurrence Database

For the verification of the mineral occurrence database the following datasets have been used:

- Public Literature (NIMEP data, peer-reviewed papers, discussions with exploration companies, satellite imagery)
- Unpublished Literature (Reports from MinDiver Projects)

For instance, the NIMEP data was used to identify a pegmatite occurrence in Nassarawa State, as shown in Figure 18. All relevant information, was added to the MIS and linked to the respective deposit entry, thus solidifying the underlying database of the project.

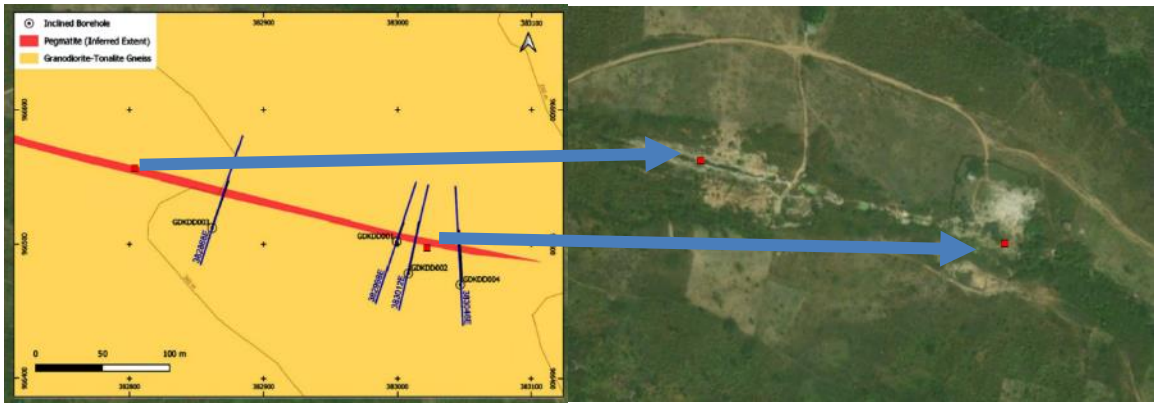


Figure 18: Example of mineral occurrence (pegmatite) location documented in the literature and visually identifiable in satellite imager (Deposit 3423 → Keffi – 4 and 3424 → Keffi – 3).

Although some points are confirmable with this approach, other entries from the original database remain unverifiable. To discern between the verified and not verified mineral occurrence locations, in the database field “work done” the following new entries were generated:

- “advangeo-yes” → locations and commodity verified.
- “advangeo-no” → either location or commodity could not be verified.
- Missing entry → occurrence not verified.

The current status of the database is shown in Table 7. The overview of the location of these occurrences is shown in Figure 19.

Table 7: Summary of number of verified mineral occurrences

Item	Number of entries
Confirmed mineral occurrences (advangeo-yes)	2,544
Not-confirmed mineral occurrences (advangeo no)	412
Not yet verified (no entry)	1,877
Total	4,833

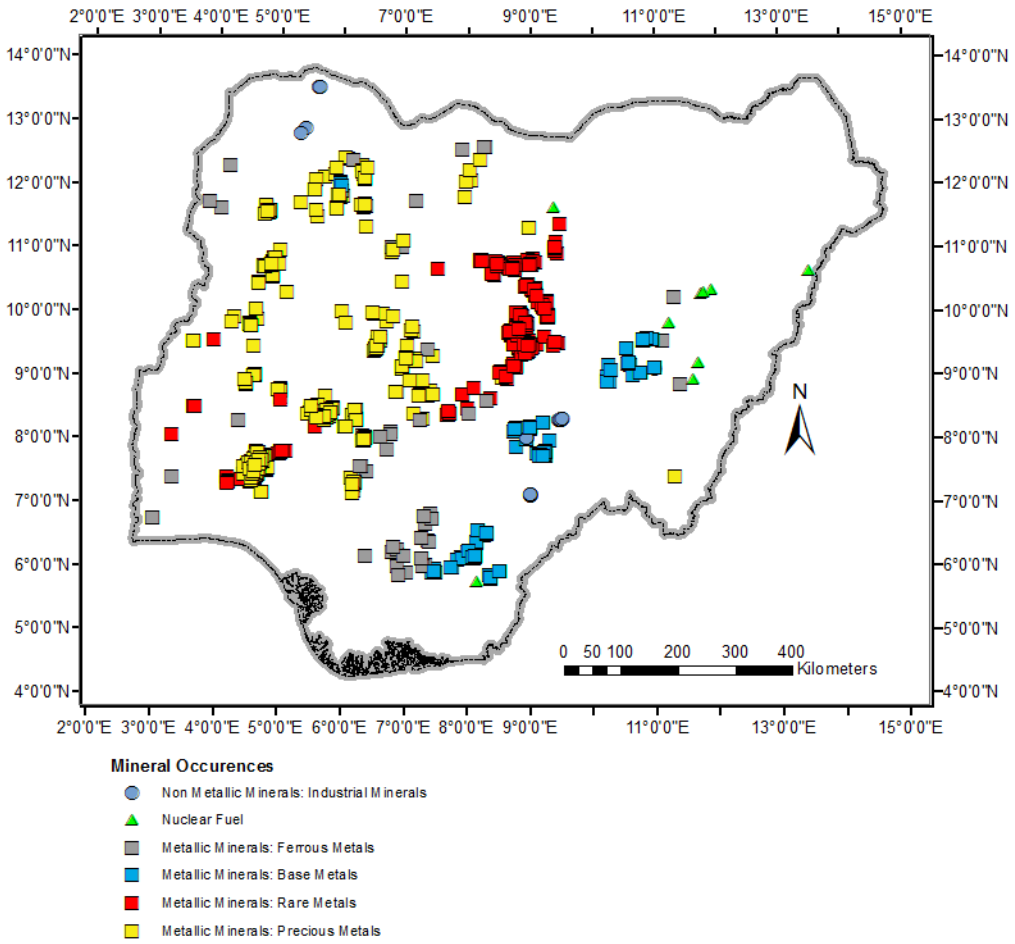


Figure 19: Location of verified mineral occurrences marked as "advangeo-yes"

4.5 Summary of data collection

The summary of available can be seen in Table 8. A visual representation of the data is shown in Figure 20.

Table 8: Summary of available data.

Dataset	Type of Data	Delivered by
Nationwide gridded data: magnetics and radiometric	GRD	MinDiver
Geophysical map Blocks 1, 2, 4, 5: individual results	GRD	Xcalibur
Geological map 1:2M	Raster, SHP	NGSA
1:250K and 1:50K sets	Raster	NGSA
Mineral Occurrence Database	CSV, SHP	NGSA
Selected historical geochemical data	SHP	NGSA
New Geochemical Data (partially)	CSV	MinDiver
MGCP data	Raster, SHP	Woolpert
Litho-structural map 1:2M	Raster, SHP	NGSA
Metallogenic Domain map of Nigeria 1:2M	Raster, PDF	NGSA
Merged geophysical maps of blocks 1, 2, 4, 5	GRD, Raster	Xcalibur
Geophysical interpretation blocks 1, 2, 4, 5	SHP	Xcalibur
Bouguer Gravity Data	SHP	Public

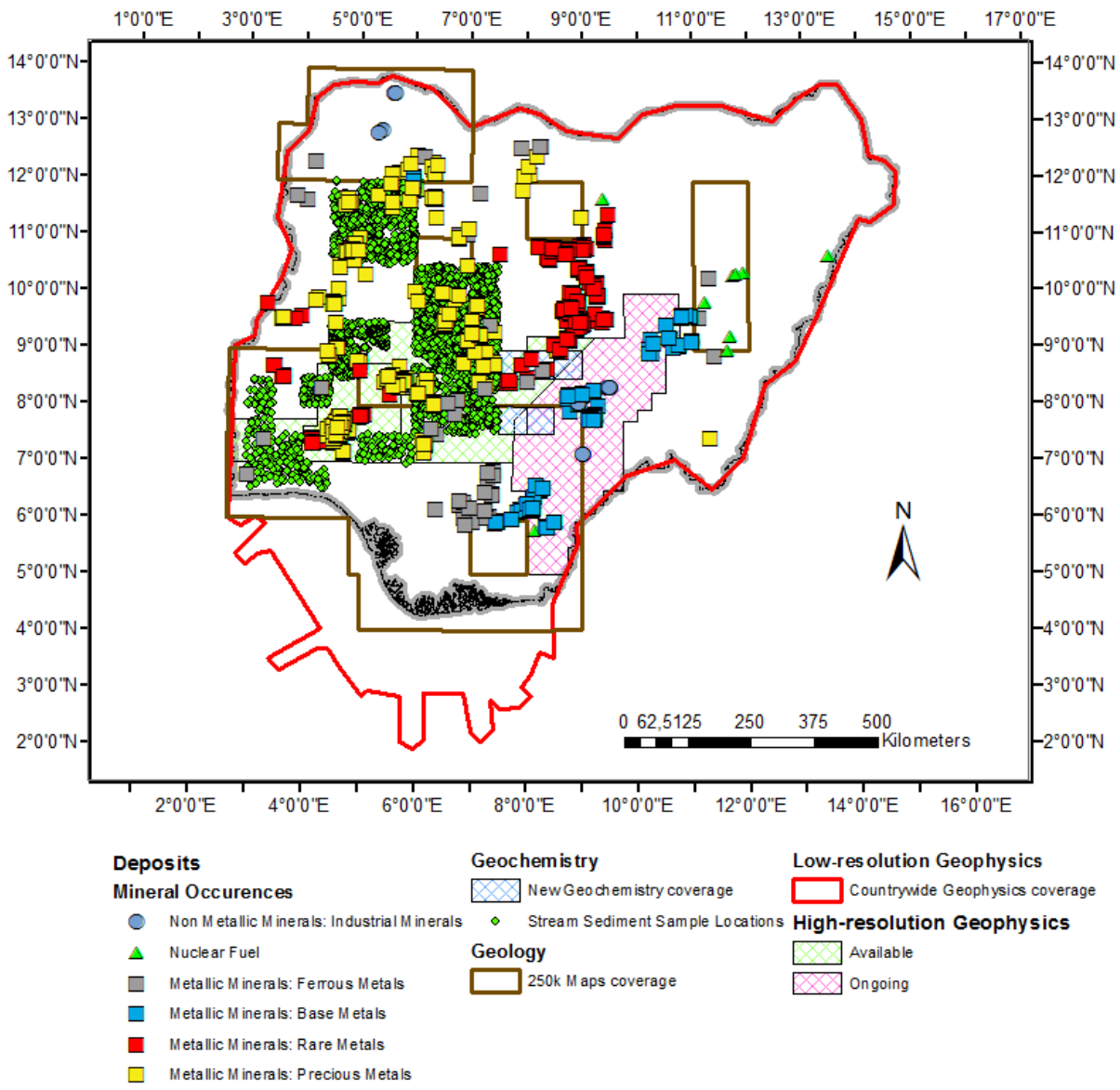


Figure 20: Summary of available data.

5. The resource geology of Nigeria

5.1 Geological review

Nigeria lies in a broad belt of Archean to Paleoproterozoic crust remobilised during the Pan African orogeny between the Western African Craton to the west and the Congo Craton to the southeast. Within this old crust, one large scale suture zone between old terranes and several schist belts representing accreted island-arc complexes is known. Only the easternmost part of the country sits on newly formed Neoproterozoic (Panafrican) crust (de Wit & Linol, 2015) (de Wit, Stankiewicz, & Reeves, 2008). Magmatic activity resumed in the Jurassic along a north-south line extending from the Jos Plateau (Abaa, Kinnaird, Ike, & Turaki, 1984) towards the analogous but older intrusive ring complexes of the Aïr Massif in northern Niger (Moreau, Demaiffe, Bellion, & Boullier, 1994). Beginning in the Barremian, the breakup of Pangea led to the formation of several rifts in western and northern central Africa. In Nigeria, the Benue trough and several branching rifts formed by the reactivation of Panafrican fracture zones by transtensional forces (Benkhelil, Dainelli, Ponsard, Popoff, & Saugy, 1988) (Benkehlil, 1989). In the Cenozoic large scale shallow epeirogenic basins formed in Saharan Africa of which the Chad basin (with its Gongola subbasin) and the Lullemmeden basin extend into northern Nigeria (Schlüter, 2008). In contrast, southern Nigeria is characterized by the very thick sediment accumulations of the Anambra, Niger delta and Danomey basins that formed over the dilated transitional crust on the Atlantic margin (Hospers, 1965) (Uko, Emudianughe, & Tamunobereton-ari, 2013).

Therefore the country can be divided into a number of structural and sedimentary complexes (Crowe, Garba, & NGSA, 2023):

- Basement Complexes: The Western, Central and Eastern complexes and the Transitional Tectonic Zone, largely composed of migmatite-gneiss belts with some intercalated schist belts, intruded by numerous Pan African granites
- Cretaceous Rift basins: The Benue Trough with its several arms and the Bida basin
- Late Cretaceous – Cenozoic Basins: The northern epeirogenic basins (Chad basin, Gongola sub basin, Iullemmeden basin) and the southern continental margin basins (Anambra basin, Niger Delta basin and Dahomey basin)

The metallogenic interpretation of these geological and tectonic complexes is given in chapter 5.3.

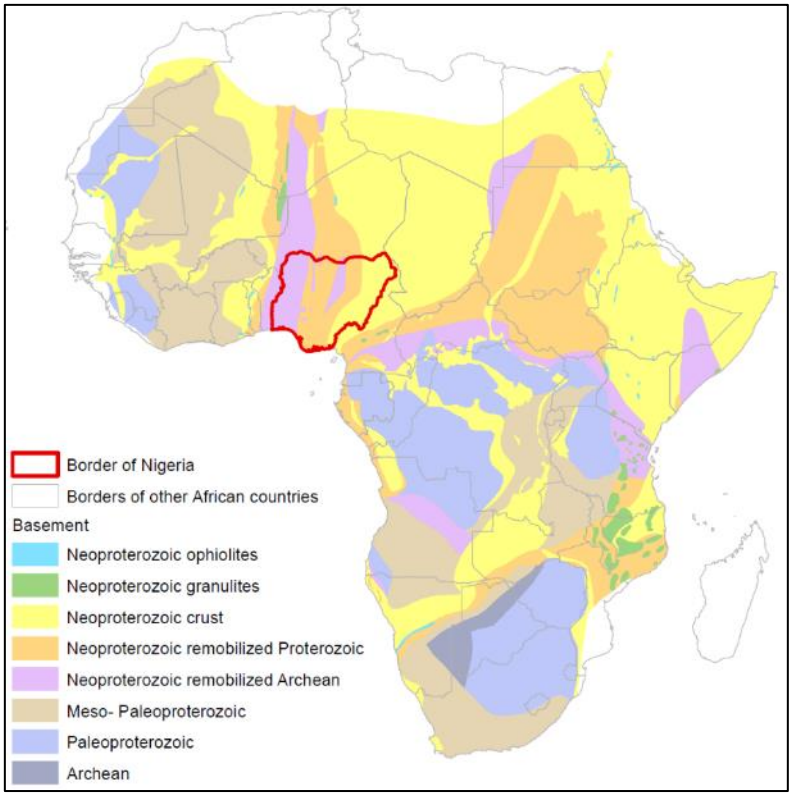


Figure 21: Overview of the African Precambrian basement structure. The Nigerian basement is composed of remobilized Archean and Proterozoic terranes in the west and center of the country and younger Neoproterozoic basement in the east. Modified from (de Wit & Linol, 2015), (de Wit, Stankiewicz, & Reeves, 2008).

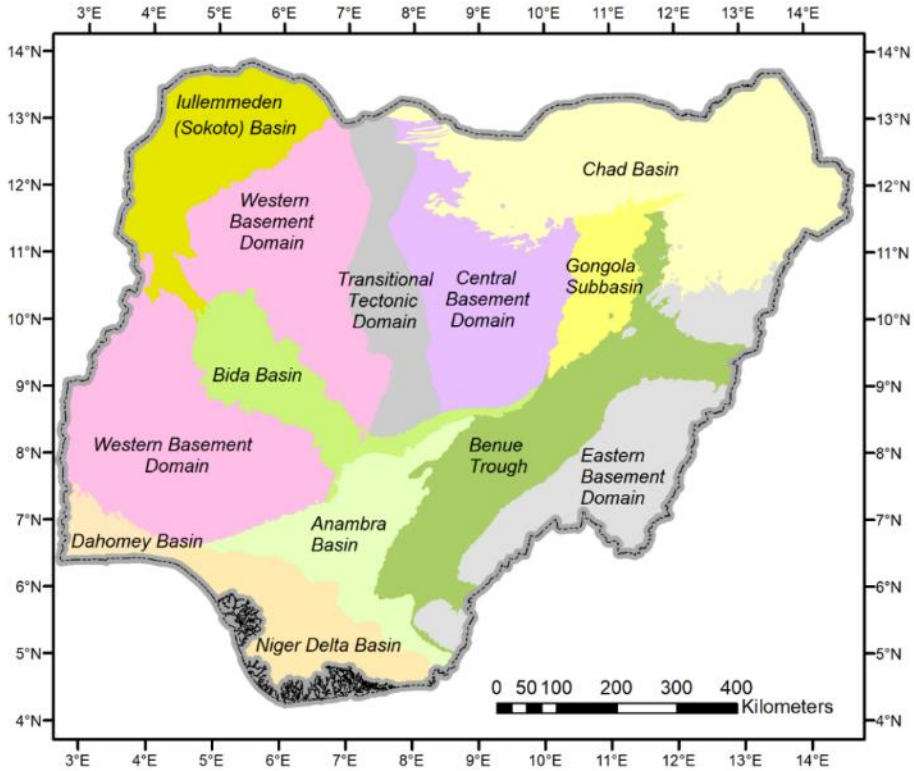


Figure 22: Simplified geological map of Nigeria showing the main structural and sedimentary domains of the country. Modified from (Crowe, Garba, & NGSA, 2023).

5.1.1 Basement Complex

The Nigerian Basement belongs to the Trans-Saharan Belt (Adeoti & Okonkwo, 2017) a collage of gneiss-migmatite terranes with some intercalated mafic ultramafic schist belts that was widely overprinted ant intruded by numerous granitic melts (“Older Granites”) during the Pan African orogeny. Commodities related to the metamorphic lithologies are Au, Fe, Mn, Pb, Cu, Zn, Ni, and Cr. Finally, the Pan-African cycle, responsible for the Older Granites (syn- and post tectonic), hosts Pb-Zn-Cu veins and Sn-Ta-Nb-Sn pegmatites.

The protolith age of the basement and its metamorphic history has been contentious due to the remobilization and overprinting in the Panafric an orogeny. Detrital zircon samples derived from the Western Basement Complex and sampled from the Dahomey basin sediments give a good overview of the age distribution in the basement (Figure 23) (Oyebanjo, Ekosse, & Odiyo, 2021).

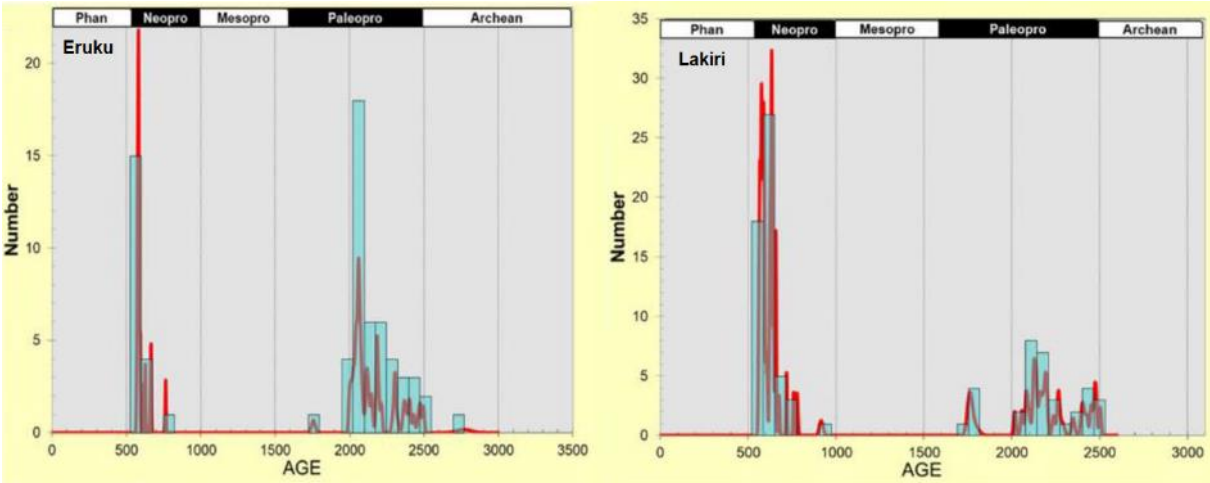


Figure 23: Detrital zircon ages in sediments derived from the Western Basement Complex show the presence of Liberian (~2700 Ma),Eburnean (~2000-2500 Ma) and Mesoproterozoic (~1700 Ma) metamorphic/magmatic rocks in addition to the widespread Neoproterozoic Panafrican suites. Modified from (Oyebanjo, Ekosse, & Odiyo, 2021)

In a review of various radiometric dating methods applied to samples of the Western and Central Basement complexes (Dada, Crust-forming ages and proterozoic crustal evoluton in Nigeria: a reappraisal of current interpretations, 1998) conclude that the major crust-forming event in this region was around the Archean-Paleoproterozoic boundary as opposed to a slightly younger age (Late Paleoproterozoic/ Mesoproterozoic) for the Eastern Basement Complex (Ferré, Déléris, Bouchez, Lar, & Peucat, 1996) (Ukwang, Ekwueme, & Kröner, 2012).

Several Rb-Sr whole rock ages confirm the Paleoproterozoic age of some gneiss-migmatite complexes in the Western Basement Domain: at Okene with an upper limit of 2202 + 31 Ma and a lower limit of 1683 + 56 Ma (Caen-Vachette, 1987), at Ibadan with 2190 _+ 30 Ma (Grant, Rex, Burke, & Freeth, 1969) and at Igbeti with 1904 _+ 18 Ma (Rahaman, Emofurieta, & Caen-Vachette, 1983). At Kankun in the Western basement province a magnetite cumulate at the base of a folded amphibolite shield is also assigned an Eburnean magmatic age, with metamorphosis and folding occurring in the Pan African orogeny (Annor & Mücke, 1991).

The schist belts are composed mafic to ultramafic greenschist to amphibolite facies metamorphic rocks with intercalated peraluminous schists and gneiss (Turner D. C., 1983). Petrographic and geochemical studies of amphibolites from the Iseyin-Oyan and Ilesha schist

belts indicate that the likely protolith was island arc tholeite (Bolarinwa & Adeleye, 2015). However, the findings in the Mokuro mafic-ultramafic complex by (Ige, Okrush, Schüssler, Schmädicke, & Cook, 1998) indicate an affinity for a “rift-related, intracontinental igneous activity”. In the local picture, the later explanation seems more favourable, whereas the first may be consistent on a broader tectonic context, noting that the regional shear zone systems (e.g., Ifewara and Anka) are not related to suture zones but to intra continental rift systems. Based on lithological characteristics a similarity with the greenstone belts of the West African Craton and consequently an Archean age has been proposed (Klemm, Schneider, & Wagner, 1984), but confirmation by radiometric dating is lacking. The few available dates suggest the schist belts underwent metamorphism during the Kibaran Orogeny (1.1-1.3 Ga) (Turner D. C., 1983) (Grant, Hickman, Burkholder, & Powell, 1972); however, these dates are based on Rb-Sr ages from adjacent granit-gneiss samples and, therefore, not representative of the Schist Belts. . Nonetheless, limited zircon (U-Pb) geochronology close to Abuja in the work by (Ekwueme & Kalsbeek, 2014) have shed evidence on an early-Neoproterozoic deposition for these supracrustal sequences with ages related to Pan-African Orogeny. Further investigation is necessary to further constrain concluding ages.

For the Western and Central Basement Complexes a wide range of Panafrican ages from 650 to 450 Ma is given, with some indication that the age of peak metamorphism (amphibolite to granulite facies) increases towards the west (Dada, Tubosun, Lancelot, & Lar, 1993). Pegmatites at Guburunde in the Eastern Basement Complex yield Panafrican ages around 580 Ma, with inherited ages and Hf crustal model ages and Lu-Hf systematics suggesting contribution of older crustal rocks (up to 1.9±0.1 Ga) to the source melt with minor mantle contributions. The voluminous late orogenic magmatism in the Eastern basement complex was likely caused by lithospheric delamination (Bute, Yang, Yang, Kayode, & Lu, 2022). P-T conditions for the peak metamorphism of the Panafrican orogeny are estimated at 600–650 °C and 8 kbar for migmatitic schist; and 600–700 °C and 8–12 kbar for amphibolite, corresponding to upper amphibolite to lower granulite facies (Ephraim, Ekwueme, Moazzen, & Modjarrad, 2008).

Dates for the widespread gold mineralization are scarce, but one case study at the Bakoshi-Kundila gold deposit near Kano (Central Basement Domain) shows remobilization of gold from

the country rock by a granitic intrusion dated at 683 Ma and a second stage of dissemination into the wall rock dated at 606–610 Ma (Elatikpo, Li, Liu, & Zhang, 2022).

5.1.2 Mesozoic Rocks

5.1.2.1 Young Granites

The “Young Granites” are anorogenic intrusions - the result of a mantle plume producing doming of the lithosphere (Wright, 1985). The plutonic to sub volcanic emplacements are normally the only remaining feature of these intrusive-volcanic complexes. The complexes represent isolated and nested calderas that are often eroded down to the intrusive complexes, although in some cases the ring dykes and minor amounts of volcanic rocks are preserved (Figure 24). The intrusives can be divided into three main rock types: peraluminous biotite granites, peralkaline riebeckite-arfvedsonite granites, and metaluminous hornblende-fayalite bearing granites (Abaa, Kinnaird, Ike, & Turaki, 1984).

While not all of the complexes are dated a distinct age gradient from north to south is detectable, where the northern complexes have a Lower Jurassic age (Fagam: 191 Ma, Ningi-Burra: 183 Ma) and the southernmost complexes straddle the Jurassic-Cretaceous boundary (Afu; 141 Ma, Mada: 147 Ma) (Abaa, Kinnaird, Ike, & Turaki, 1984).

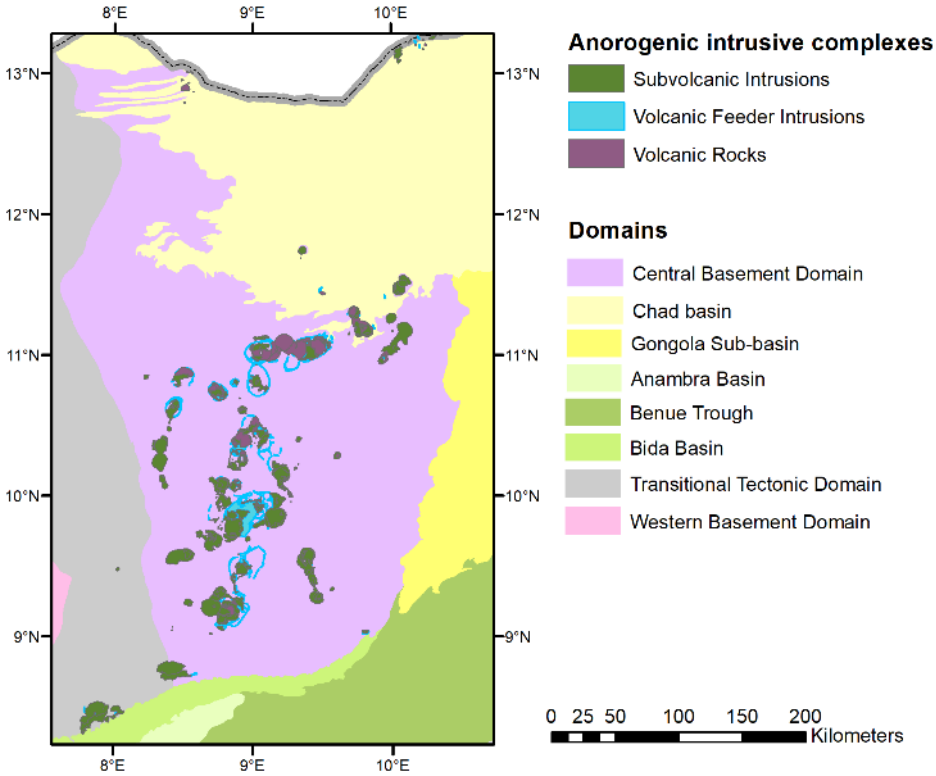


Figure 24: The Jurassic anorogenic intrusive-volcanic complexes in north-central Nigeria. The area of intusive complexes extends to the north below the Chad basin and extends into the Aïr Basement in northern Niger. Modified from (Crowe, Garba, & NGSA, 2023) and (Kinnaird J. A., 1985)

5.1.2.2 Benue Trough

The Benue Trough is a result of a failed rift (aulacogen) linked to the breaking up of the Gondwana continent during the Cretaceous. Thinning of the crust generated subsidence along a graben structure with a width of 130 – 150 km and more than 800 km in length (Ofoegbu, 1985). The main faults are old Pan-African faults zones that were reactivated in the Barremian – Aptian (Maurin & Benkhelil, 1990). Several branches to the west (Bida basin) and to the east (Mamfe embayment, Yola arm) dissect the basement. The trough is filled with mostly siliciclastic sediments ranging in age from the Aptian to the Maastrichtian. Syn-rift magmatism resulted in the emplacement of numerous basaltic sills and some flows within the sediment pile. The tectonic regime was characterized by transtensional forces, resulting in an internal

graben and horst structure with several deep sub-basins (Figure 26). Rapid subsidence of the mostly marine siliciclastic sediments led to the liberation of metalliferous brines that precipitated lead and zinc along with barite within and near the reactivated fault zones (Maurin & Benkhelil, 1990). Two episodes of compressional tectonics deformed the basin: In the southern part (Abaliki anticlinorium) during the Santonian, and in the northern part at the end of the Cretaceous (Benkehlil, 1989) (Figure 25).

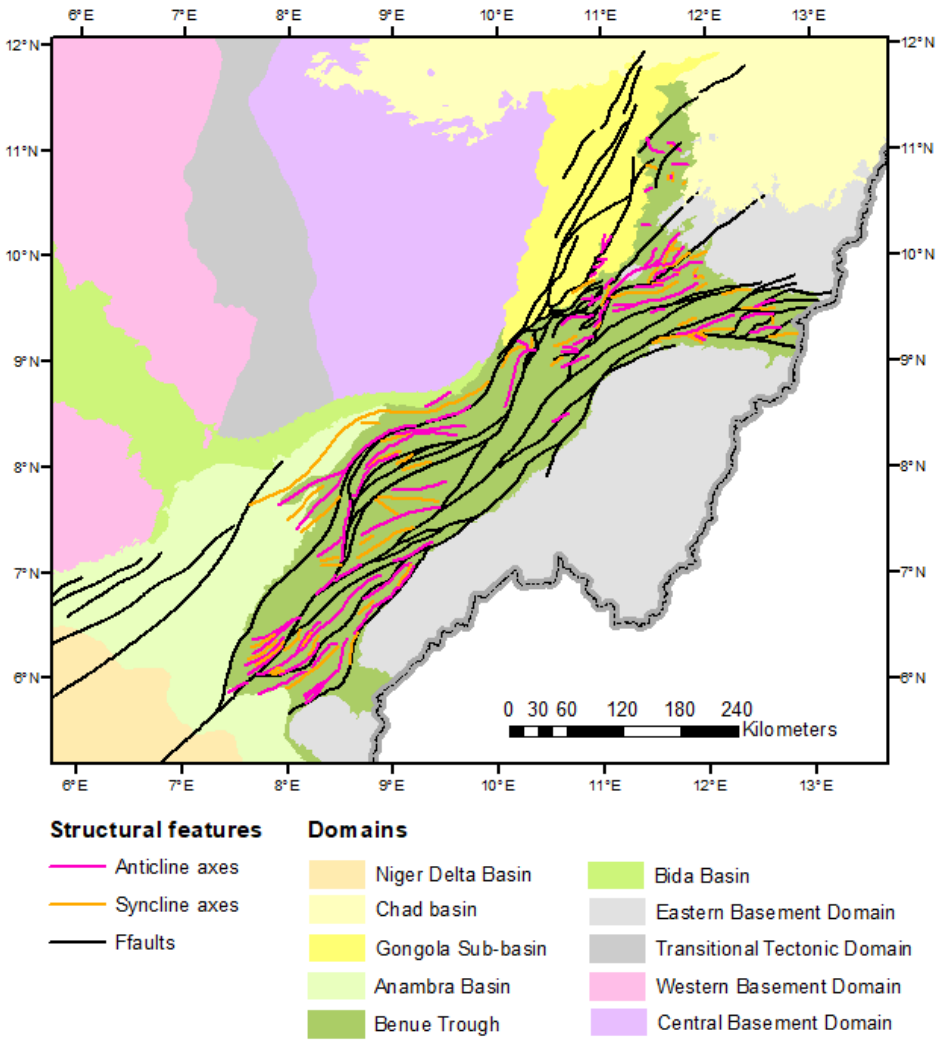


Figure 25: Compilation of structural features in the Benue Trough. Modified from (Crowe, Garba, & NGSA, 2023) and (Benkehlil, 1989)

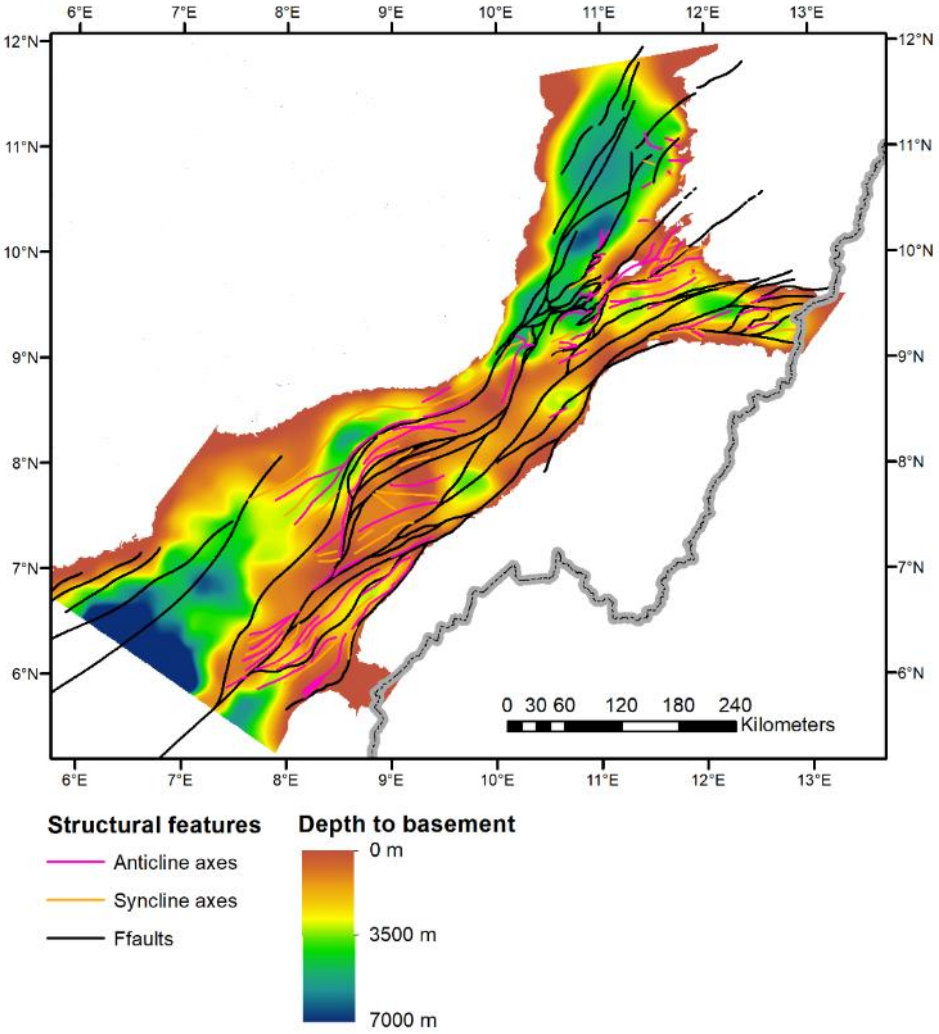


Figure 26: The depth to basement map of the Benue Trough shows the internal basin and swell structure caused by the transtensional forces reactivating old (Panafrican) tectonic zones. The mineralized anticlinal structures are strongly related to basement highs. Data from (Crowe, Garba, & NGSA, 2023) and (Benkehlil, 1989)

5.1.3 Cenozoic Sediments

In the late Cretaceous and throughout the Cenozoic many intracontinental areas of Africa are characterized by large-scale epeirogenic subsidence leading to the formation of large but shallow sedimentary basins. In northern central Africa the largest such basins are the Chad and the Iullemmeden basin, both of which extend into northern Nigeria (Schlüter, 2008). The

older sediments in both basins are of lacustrine, fluvial-lacustrine and deltaic origin, whereas the younger to recent sediments are predominantly aeolian (Adelana, et al., 2008).

The basement areas in central and southern Nigeria are characterized by uplift and denudation. Neogene to Quaternary basaltic flows erupted particularly on the Jos plateau and the Eastern Basement Complex at the southern margin of the Chad basin. The surface of the flows is often altered to laterite (Adelana, et al., 2008), other laterite occurrences are known as isolated plateaus and dissected remnants of old land surfaces, particularly in Kogi and Benue State (Figure 27).

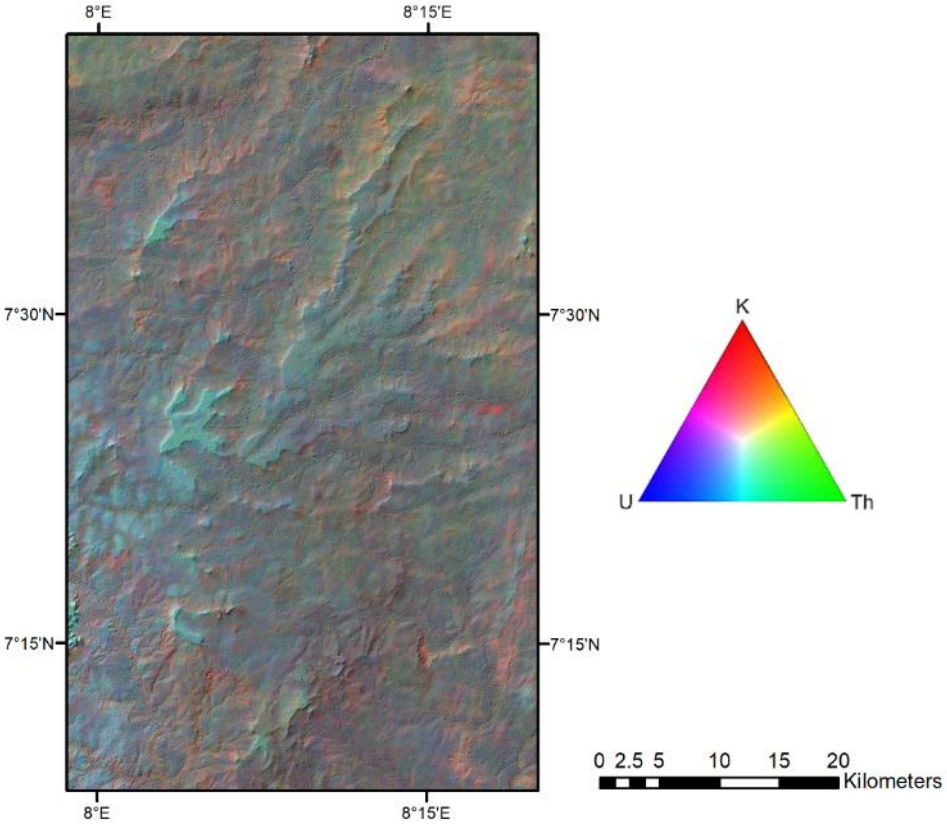


Figure 27: Laterite plateaus in Benue state, to the southwest of Makurdi. In the radiometric ternary colour composite they appear blue-green, indication enrichment of thorium and uranium and depletion of potassium.

Following the opening of the Atlantic Ocean thick sedimentary sequences accumulated at the continental margin over the dilated and subsiding transitional crust. Since the Eocene the Niger delta has progradated 300 – 400 km into the Atlantic Ocean and deposited sediment into an up to 10 km deep basin. The crustal subsidence has led to tectonic deformation of the young sediments with extension and block rotations on listric faults in the basin centre and thrust structures at the delta front (Figure 28). The complex tectonics resulted in the formation of many hydrocarbon traps (Uko, Emudianughe, & Tamunobereton-ari, 2013).

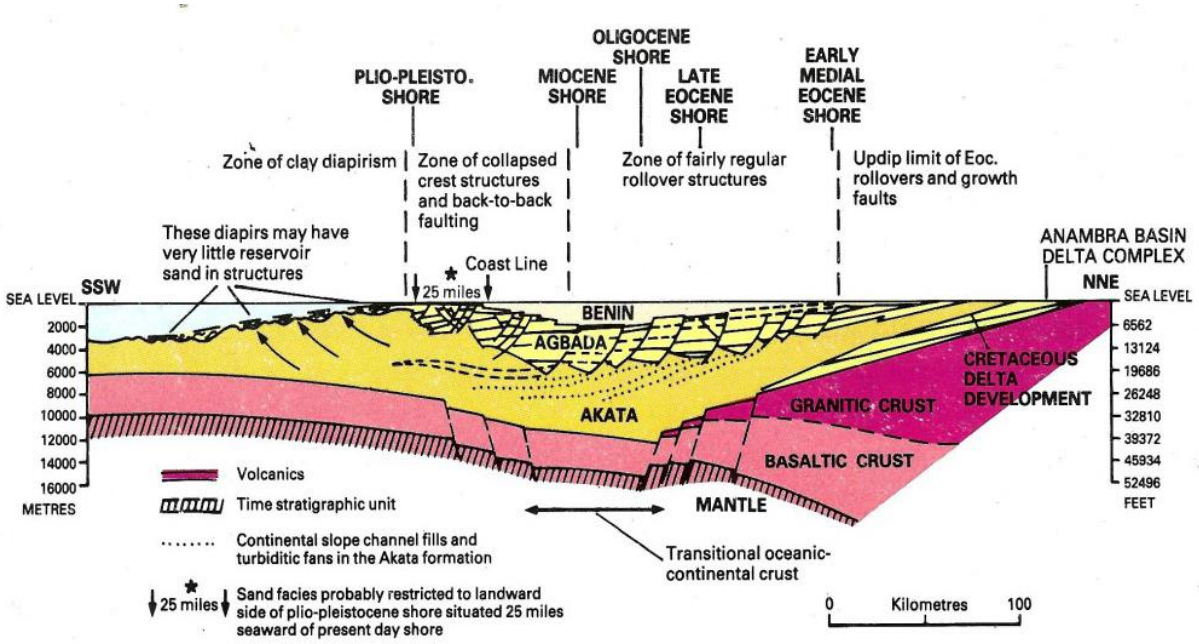


Figure 28: Schematic cross section of the Anambra and Niger delta basins. The subsidence of the dilated transitional crust has accommodated up to 10 kilometres of sediment accumulation. Modified from (Uko, Emudianughe, & Tamunobereton-ari, 2013)

5.2 Single commodities

5.2.1 Gold (Au)

5.2.1.1 Location of occurrences

Currently, the Mineral occurrence database of Nigeria (MODB) contains 1604 gold occurrences (Figure 29). These are mainly located in the Basement Complex and are almost predominantly located within the schist belts.

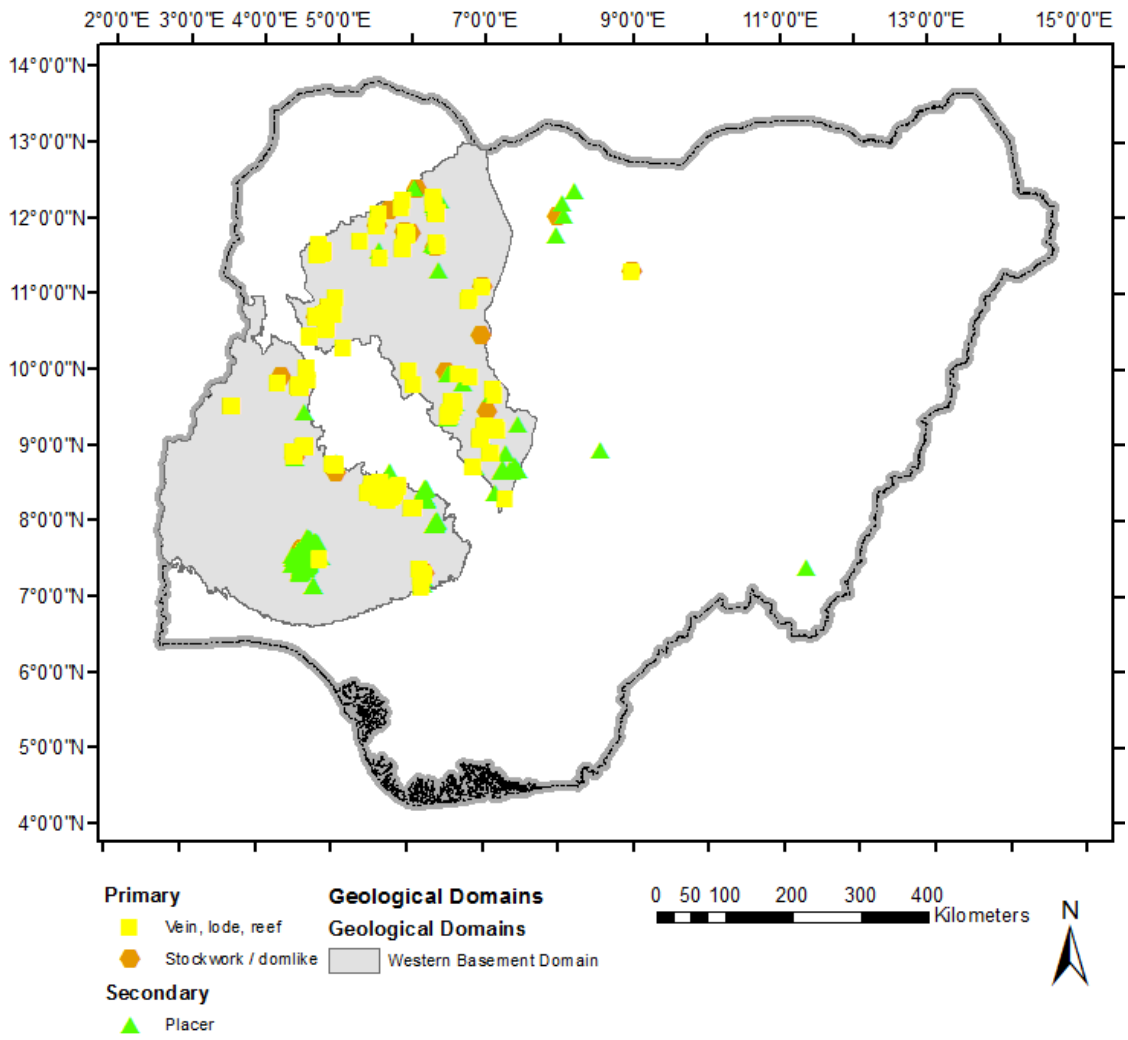


Figure 29: Location of confirmed Gold (Au) occurrences in Nigeria.

5.2.1.2 Shape and interpreted type of occurrences

According to the appearance of the mine sites in airborne photographs and their geological and topographical environment they can be distinguished into the following three types:

- Lenticular shape (1,092 points): open cast mine sites (pits) that follow mainly the recent drainage system, and, to a certain degree, paleo-terraces (Figure 30A). These occurrences are interpreted as placers.
- Vein, load, reef (469 points): mine sites are mainly shafts or linear deep channels following mainly the mineralization. They are interpreted as 'Hydrothermal', and correspond with fault systems/lineaments, ranging from a few tens of metres to a few kilometres (Figure 30B). All points of this classification have structural data (dip and direction). A wide variety of mineralization types are expected within this class, such as quartz veins and sulphide mineralizations, with and without carbonates.
- Stockworks / dome-like (disseminated, veinlets) (45 points): this type of mineralization is interpreted as 'Hydrothermal'. However, the mineralisation is not located in single structures but in zones of various thickness, large extensions and related to intrusives. Despite some visible veins, the irregular pits do not reveal any main direction (Figure 30C).

Figure 30: Gold occurrence points, (A) Occurrence 2751, Name: 'Ife - Ilerin - 138' alluvial type, the mine sites follow the recent river sediments, (B) Occurrence 4586, Name: 'EL-002962 - 13' veins oriented N65/90 for around 900m and (C) Deposit 239, Name: 'Kampani/Rimi 1', irregular cluster of pits, with smaller pits related to veins.

5.2.1.3 Genetic Model

The occurrences are associated with three predominant geological contexts:

- Sediments (Quaternary/Tertiary): alluvial (recent) and paleo-terraces (older) from existing sources, transported by water and concentrated on low-energy areas.
- Schist Belts: are linked with the tectonic events that created the perfect conduit for fluid flow and precipitation, thus are structurally controlled. The locations of gold deposits are not correlated to the type of country/host rock, however linked to pre-existing green-schist belts.
- Old Granites: mineralization occur in and/or around Syn- and Post-tectonic granites possibly related with subsequent shearing after the emplacement of these granites, accompanying the late Pan-African pegmatites (see 5.2.3), or as hydrothermal-metasomatic processes.

5.2.2 Tin (Sn)

5.2.2.1 Location of occurrences

Currently, 451 Sn occurrences across Nigeria were recorded and characterized in the MODB (Figure 31). They are related exclusively to two metallogenic provinces:

- the rare metal-bearing pegmatite belt located in the Basement Complex (southwest area of the country) as a secondary mineral (discussed in 5.2.3), and
- The alkaline ring complexes (known as “Younger Granites” (located mainly in the Central basement domain and to a lesser degree in the South of the transitional tectonic domain This province, extending from northern Niger to south-central Nigeria, covers a total area of 7500 km2 and consists of massifs of over 50 anorogenic ring complexes made up of both volcanic and plutonic rocks formed during the Mesozoic (Kinnaird J. , Hydrothermal alteration and mineralization of the alkaline anorogenic ring complexes of Nigeria, 1985).

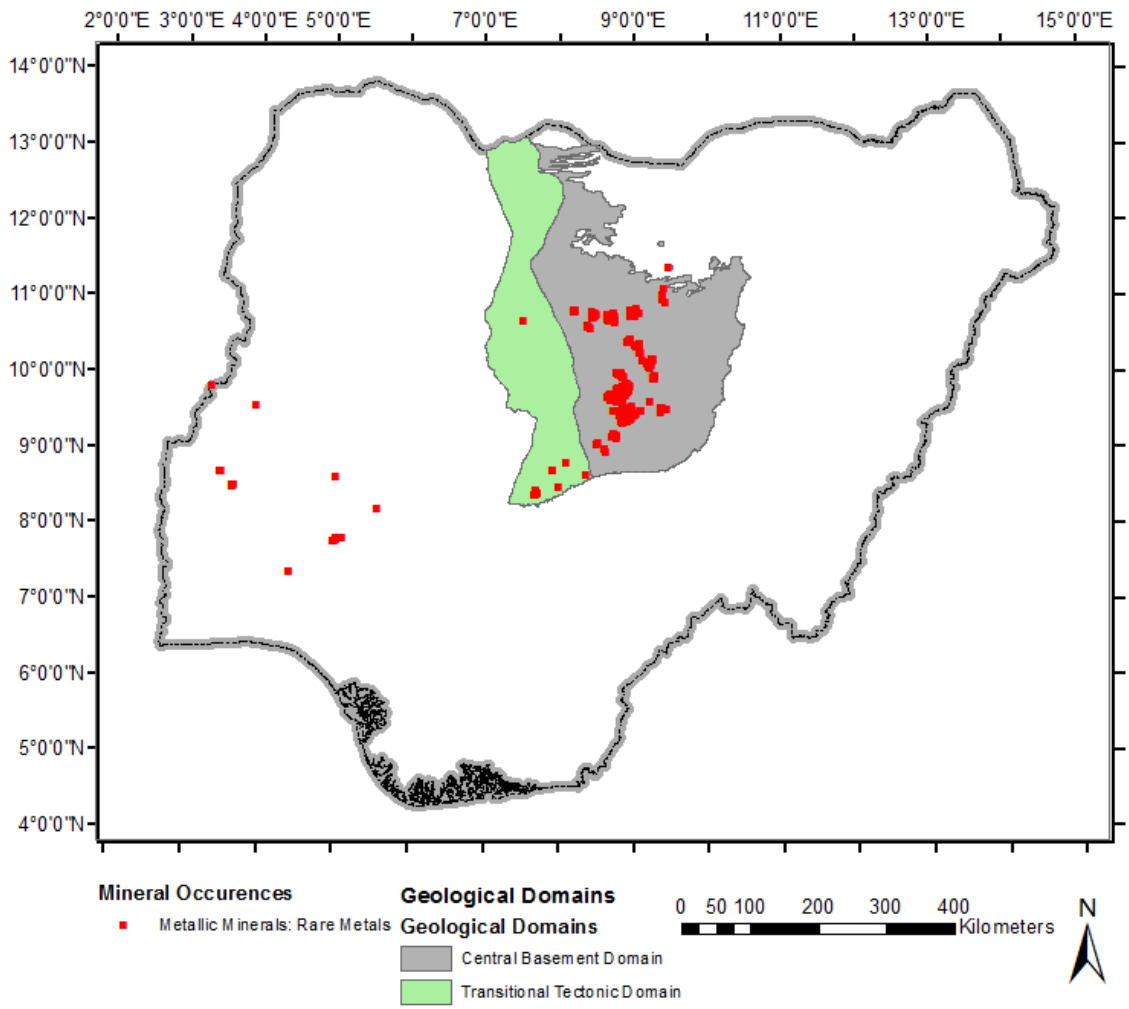


Figure 31: Location of confirmed Tin (Sn) occurrences in Nigeria.

5.2.2.2 Shape and interpreted type of occurrences

The tin occurrences in Nigeria can be divided into three main types of shapes:

- Lenticular (335 points) - These points, corresponding to placers, are characterized by an accumulation of minerals with a lateral extension much greater than its depth. Located close to their origin, are the result of in-situ weathering processes affecting primary tin lodes and granitic rocks. The mineralization type of this occurrences is "Sedimentary and diagenetic" (Figure 32). They are the predominant tin extraction type in the country (Lehmann, 1982).

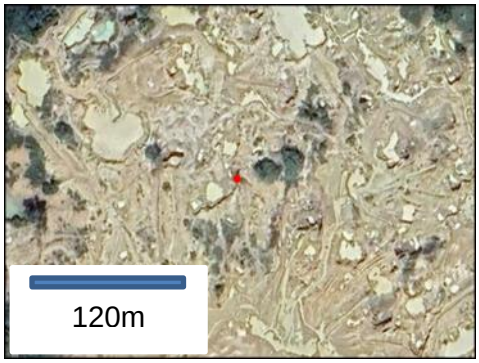


Figure 32: Lenticular tin deposits points in MIS Deposit 3527, Name: "Tongolo 2" placer-type deposit containing dispersed columbite and cassiterite, mineralization type: "Sedimentary and diagenetic".

- Vein / Lode / Reef (82 points) - Characterized by deep pits or excavations with distinct lineaments and variable lengths, all points within this classification include structural data such as dip and direction. The type of mineralization is either "Pneumatolytic or contact metasomatic" (Figure 33A) or "Pegmatitic" (Figure 33B).

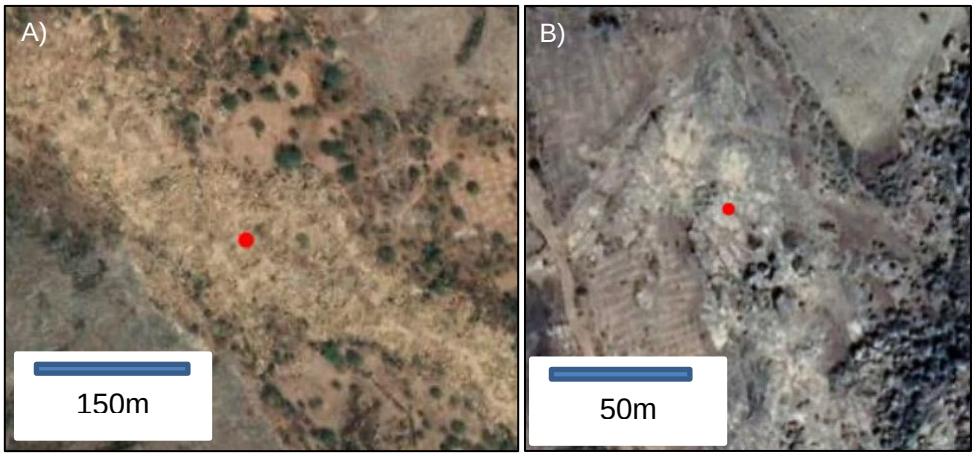


Figure 33: Examples of Vein / Lode / Reef tin deposits points in MIS: (A) Deposit 3056, Name: "Ririwai 5", lode 2km long oriented N35/90, mineralization type: "Pneumatolytic and contact metasomatic". (B) Deposit 3004, Name: "Bareda 2", pegmatite with tin, tantalum and niobium, vein 350 m long oriented N120/90, mineralization type: "Pegmatitic".

- Stockwork / domlike (disseminated, veinlets) (33 points): Pits are irregular and generally lack a preferential direction (Figure 34). Sometimes hard rock is visible underneath, and, unlike lenticular deposits, they are not situated near water channels. They are interpreted as "Pneumatolytic and metasomatic", mainly located within the Young Granite province. According to the literature (Abaa, Kinnaird, Ike, & Turaki, 1984), some tin occurrences are vein-controlled as pegmatitic bodies and happen as secondary mineralization.

Figure 34: Examples of Stockwork / domelike (disseminated, veinlets) tin deposits points in MIS: (A) Deposit 3417, Name: "Jos Bukuru 32" → mineralization type: "Pneumatolytic and contact metasomatic" (B) Deposit 1964, Name: "Olorunda" → mineralization type: "Pegmatitic".

The schematic cross-section in Figure 35 of the alkali intrusions shows three different zones where mineralization occurs:

- The roof zone: characterized by disseminated mineralization related to sodic or potassic metasomatism, sheeted vein systems with quartz (vein roots), pegmatite nodules and veins, irregularly shaped replacement bodies, and fissure-filling veins in the apical region,
- The contact zone spans approximately 200 meters on each side of the intrusive contact and is marked by fracture systems, filling veins, and intense alteration. If the original rock is of basement origin, chloritic alteration is often highly intense, and massive sulfide deposits may be formed, and

- The marginal zone, extending from 200 to 500 meters within the contact, is characterized by fracture systems, sheeted veins, alteration of the wall rock, and pegmatitic nodules.

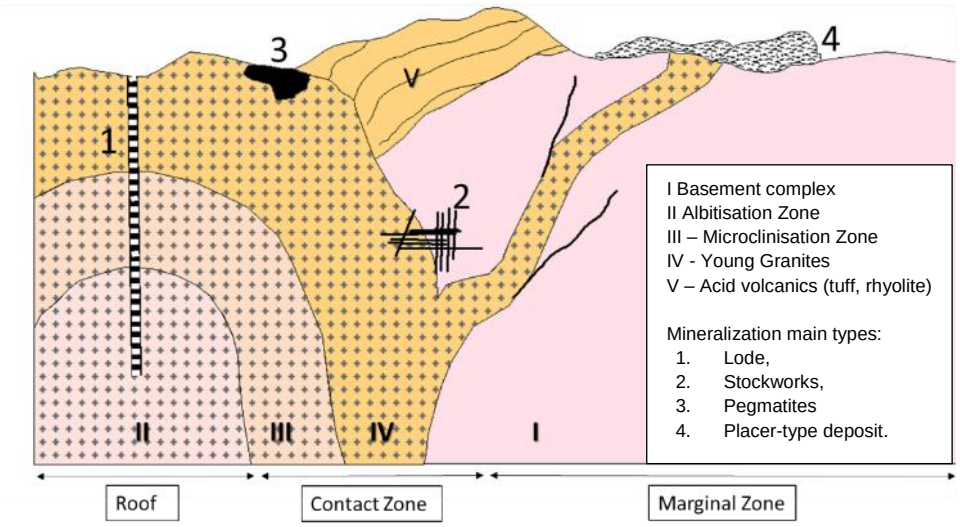


Figure 35: Schematic section representing geological setting in relation to Sn Young Granites remobilization and enrichment along the fault rocks, modified after (Kinnaird J. , 1984).

5.2.2.3 Genetic Model

The tin ores are mainly contained in lode-bearing veins within cooling joints, fractures and greisenized granites (Pastor, 1985) (Olade M. , 2020). According to (Kinnaird J. , Hydrothermal alteration and mineralization of the alkaline anorogenic ring complexes of Nigeria, 1985). The main two mechanisms understood to be responsible of mineralization of Sn, Zn, W, and Nb, along with trace amounts of Cu, Fe, Bi, U, and REE are:

- Hydrothermal alteration (considered the main one),
- Sodic metasomatism, potash metasomatism,
- Chloritization and argillization.

5.2.3 Lithium (Li) - Tantalum (Ta) - and Niobium (Nb) Pegmatites

5.2.3.1 Tantalum (Ta) and Niobium (Nb) locations

A total of 136 verified locations with tantalum were digitized, whereas 147 points are documented for niobium. Their spatial distribution is seen in Figure 36, within three areas:

- Basement Complex to the South-West, related to Pan-African Older Granites,
- The Transitional-Central Basement domains,
- The Central Basement Complex related to the Younger Granites, mainly Niobium (Nb).

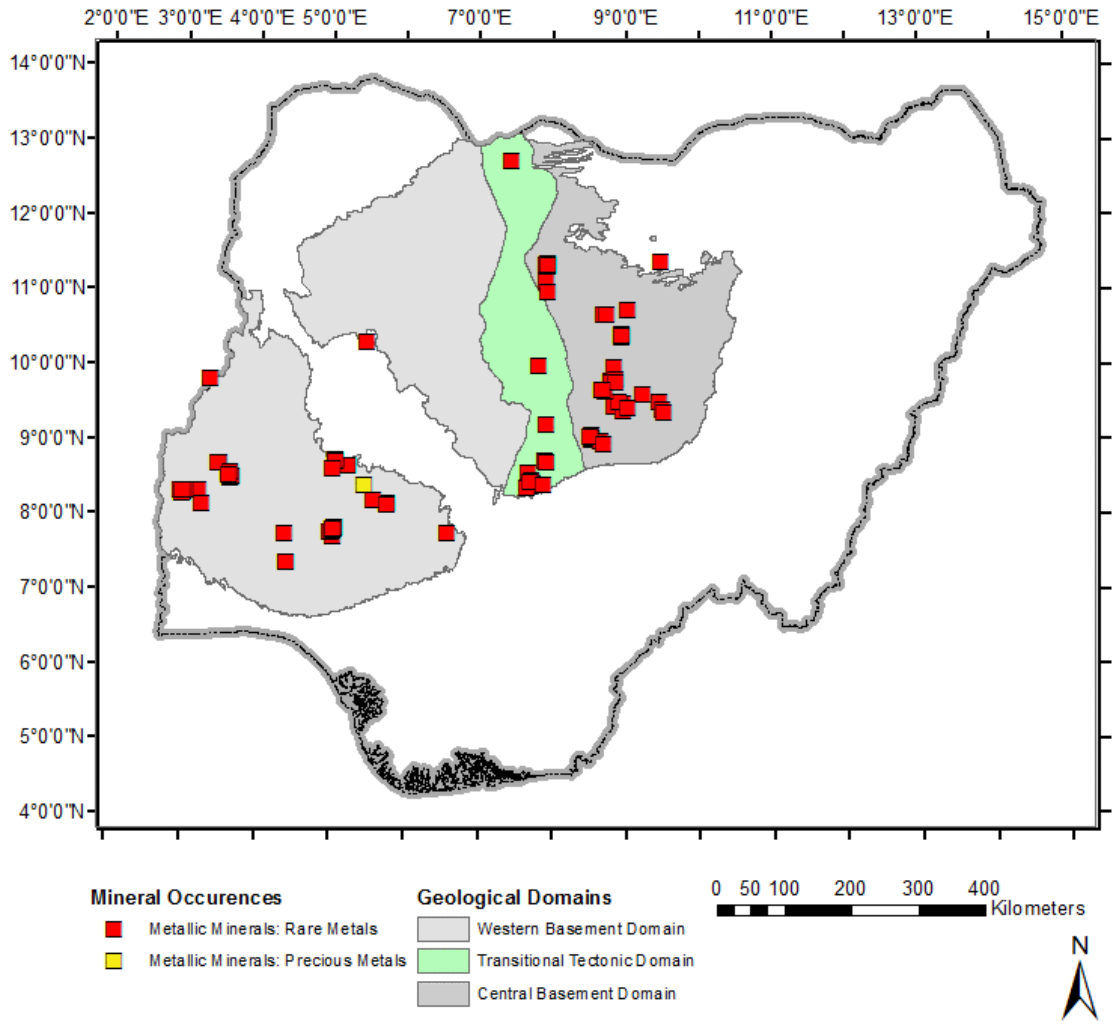


Figure 36: Location of confirmed Tantalum (Ta) occurrences in Nigeria.

5.2.3.2 Lithium (Li) location of occurrences

The distribution of the 76 occurrences is shown in Figure 37, separated into three areas:

- Basement Complex to the South-West, related to Pan-African Older Granites,
- The Transitional-Central Basement domains,
- The Central Basement Complex related to the Younger Granites.

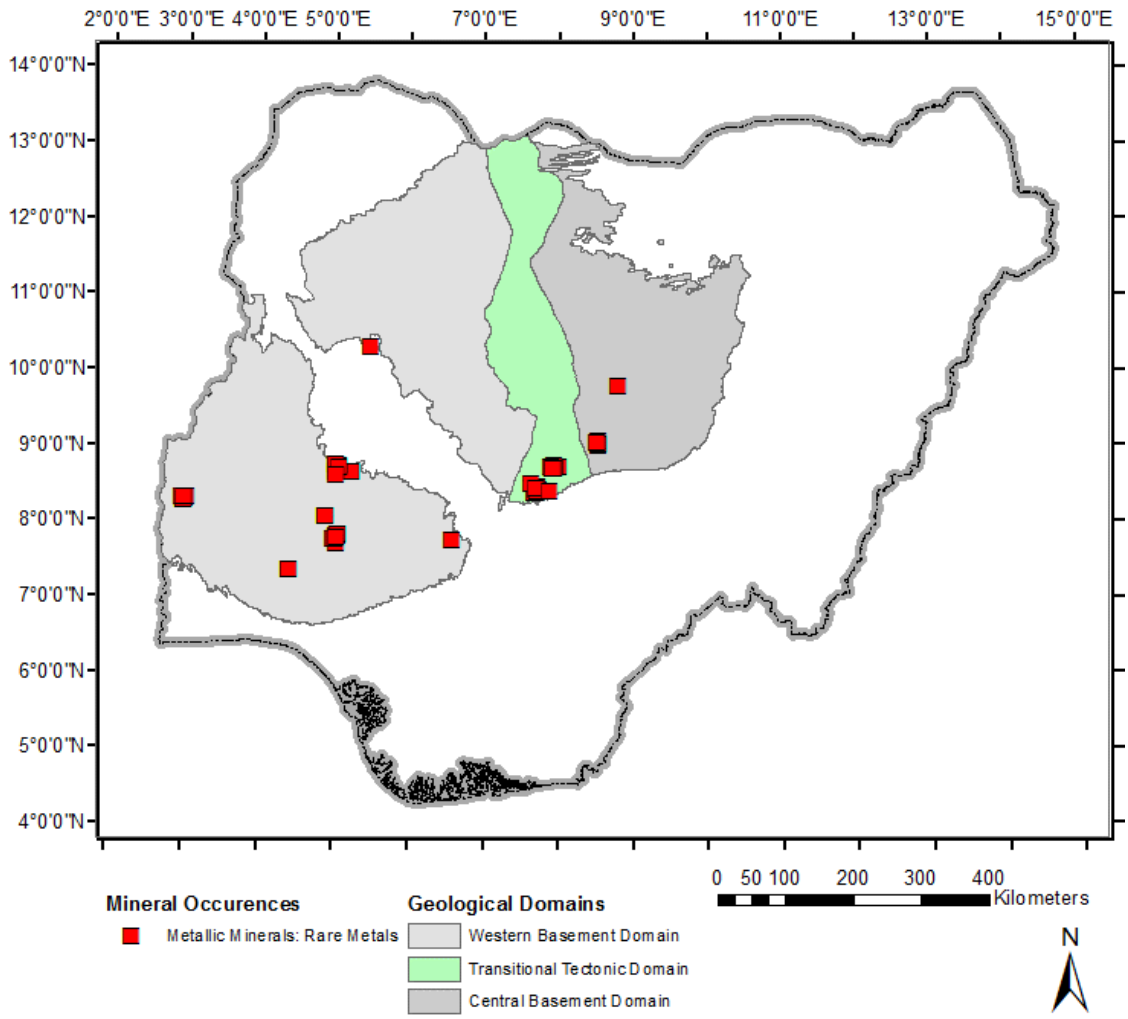


Figure 37: Location of confirmed Lithium (Li) occurrences in Nigeria.

5.2.3.3 Shape and interpreted type of occurrences

Lithium, Tantalum and Niobium in Nigeria occurs as Vein / Lode / Reef (363 occurrences): Digitized instances show a distinctive planar structure typical of vein-controlled mineralization, more specifically “Pegmatitic” (Figure 38). Orientations typically range from N-S to NE-SW.

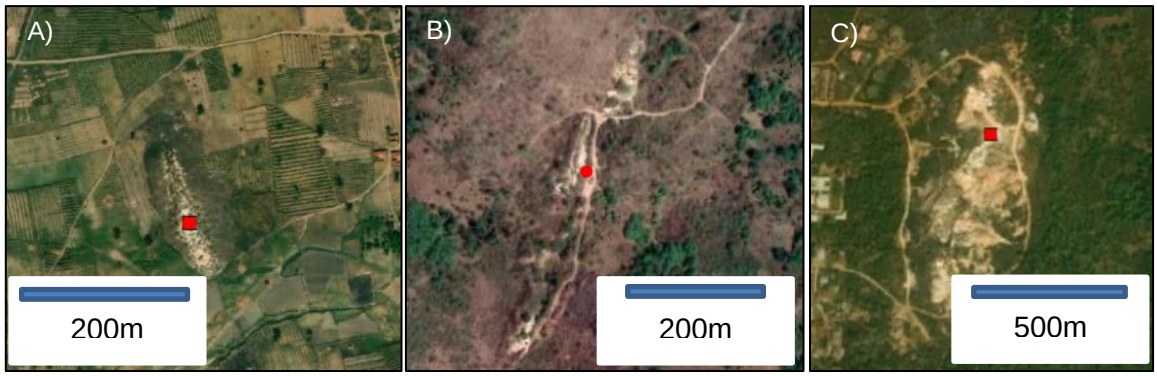


Figure 38: Examples of Pegmatitic mineralization with vein shape. (A) Deposit 249, Name: “Gana”. (B) Deposit 1809, Name: “Ilero”. (C) Deposit 1726, Name: “Ijero - 3”.

5.2.3.4 Genetic Model

The emplacement of Pegmatites in Nigeria has been linked to the final stages of the Pan-African Orogeny at around 553 to 555 Ma (Melcher, et al., 2015) under the following possible theories:

- Possibly not emplaced during the main cooling phase of the magmatism of this period, but during the metasomatism events of the post-collisional stage (Melcher, et al., 2015),
- emplacement is far from their source allowing further fractionation times, however, they seem not to be linked to the Older Granites,
- Nigerian pegmatites have magmatic and post-magmatic origins (Ibrahim & Hayatu, 2021).

Pegmatites can be grouped into two main categories (Oyebamiji, et al., 2018):

- LCT: Lithium-caesium-tantalum bodies associated with S-type quartz rich granites, and
- NYF: Niobium-yttrium-fluorine bodies associated with A-type granites.

Mineralogy of the pegmatites is as follows (Melcher, et al., 2015):

- Ta–Nb pegmatites around Oke–Ogun field belong to the LCT family,
- Tantalite-(Mn) is more common at the Lema–Share–Ndeji field,
- Cassiterite-rich tantalite-(Fe) and stibiotantalite are concentrated in the Ijero and Ibadan–Oshogbo fields,
- Fe-rich CGM are associated with the Nasarawa–Keffi and Isanlu–Kabba fields
- Zinnwaldite in the Younger Granites area (Abaa, Kinnaird, Ike, & Turaki, 1984).
- An overview of the paragenesis of the resulting minerals can be seen in Figure 39, noting that spodumene postdates the lepidolite and they do not crystalize simultaneously with Ta and Nb.

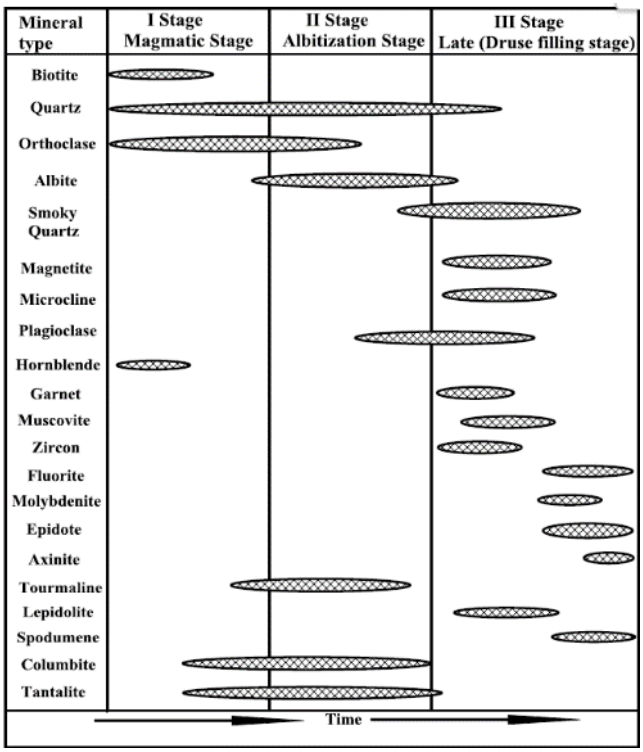


Figure 39: Paragenetic sequence of minerals in pegmatites in SW Nigeria. Image from (Oyebamiji, et al., 2018).

5.2.4 Lead (Pb) and Zinc (Zn)

5.2.4.1 Location of occurrences

There are 359 points registered for lead and/or zinc (Figure 40). This project focuses only on those deposits within the Benue Trough Domain where Pb and Zn occur as main commodities. As secondary, associated or accessory, it occurs in:

- Salt/Brine in the 'Lower Benue Trough',
- Barite mainly in the 'Middle Benue Trough',
- Copper occurrences described along Benue Trough,

Further associations with other commodities outside the Benue Trough with Pb-Zn as subordinate are:

- Gold in the Basement Complex, in Schist Belts at 'Kebbi' and in Migmatite-Gneiss Complex at 'Baban Tsauni'
- Tin, Tantalum and Niobium in the Young Granites'.

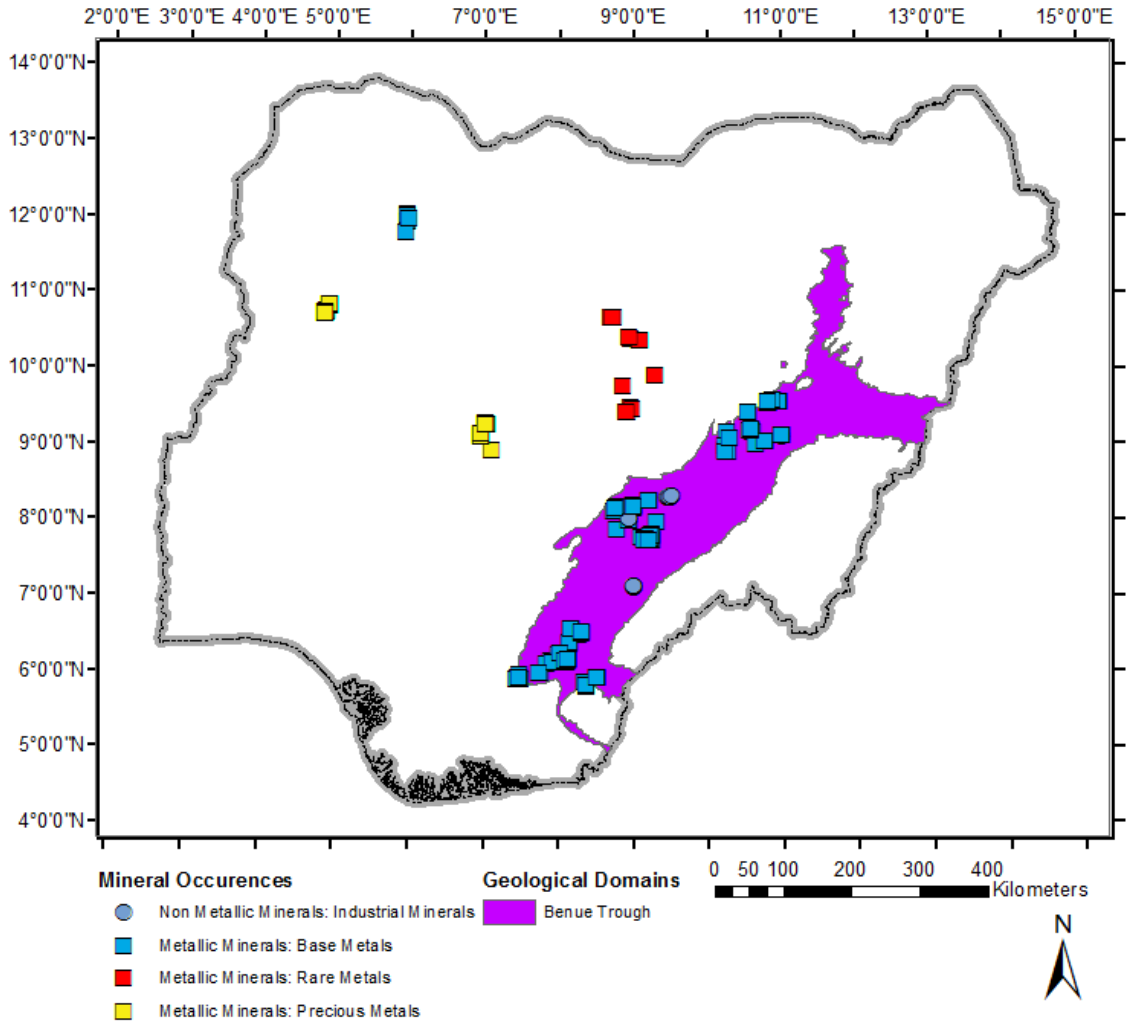


Figure 40: Location of confirmed Lead (Pb) – Zinc (Zn) occurrences in Nigeria.

5.2.4.2 Shape and interpreted type of occurrences

They are predominantly classified as 'Vein / Lode / Reef' and the mineralization type selected is 'Hydrothermal'. Examples of this mode of occurrence are shown in Figure 41.

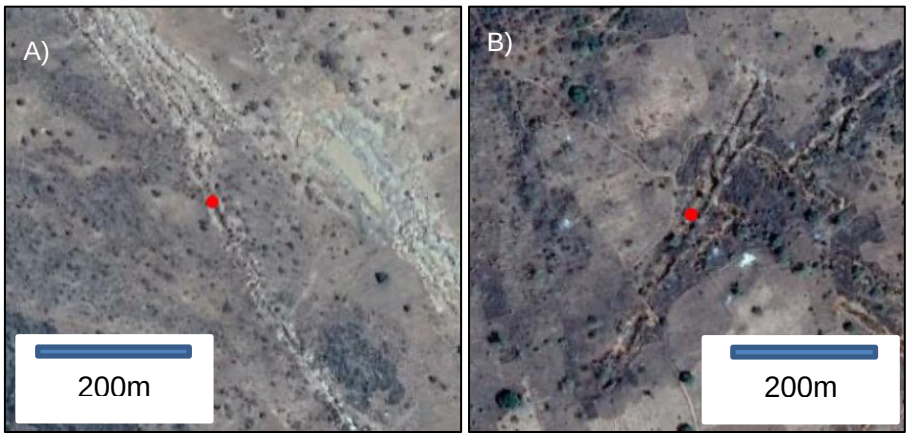


Figure 41: Examples of hydrothermal veins containing Pb and Zn. (A) Deposit 2614, Name: "EL-014461 – 4". (B) Deposit 2644, Name: "SSML-007986 – 3".

The preferential directions for the structures controlling the deposits are as shown in Figure 42 with preferential NNE-SSW directions, followed by a secondary WNW-ESE direction.

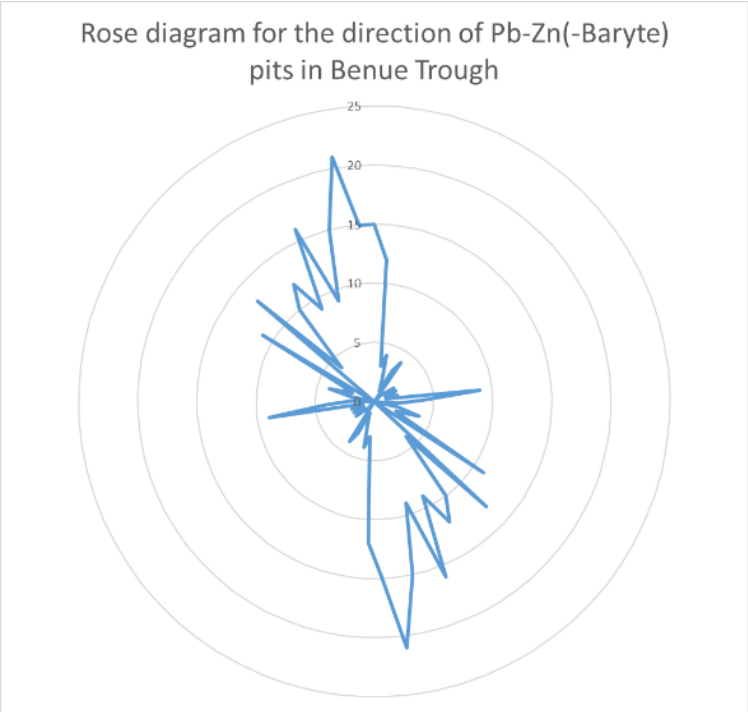


Figure 42: Rose diagram showing the direction of Pb-Zn (-Barite) pits, recorded in mineral occurrences database, for Benue Trough.

5.2.4.3 Genetic Model

The evolution of the area (Figure 43) is calculated to have the following phases:

- Lower- Cretaceous (Aptian-Albian): when extensional tectonics commenced as a rifting branch of the dismemberment of Gondwana with marine and continental sedimentation.
- Upper Cretaceous (ca. 80 Ma): a shift to compression, paired with magmatism, controlled the area with a reduction on the sedimentation. Intense metamorphism in this phase produced the folding and faulting allowing the flow of fluids from the magmatic activity to reach the upper part and generate the fault-controlled deposits in the area.
- Upper Cretaceous - Palaeocene (ca. 70 – 60 Ma): end of metamorphic stage and no more documented occurrences are documented.

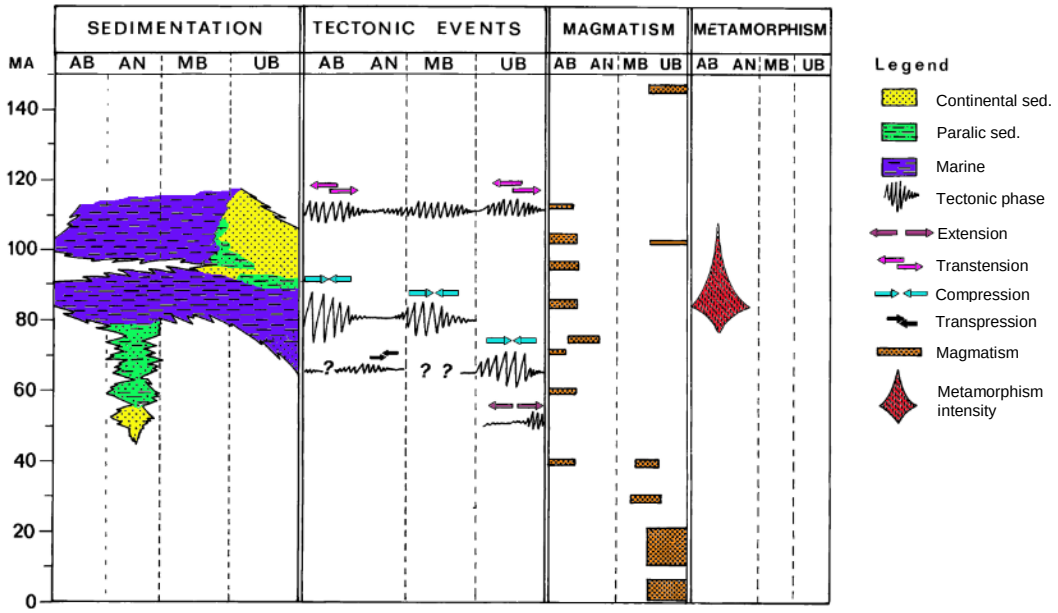


Figure 43: Chronological order of the main geological events that generated the Benue Trough. Modified after (Benkehlil, 1989).

5.2.5 Manganese (Mn)

5.2.5.1 Location of occurrences

Significant occurrences can be found about 6 km north-nothwest of Wasagu (points Duste Zagai Wasagu and Sabon Tunga Wasagu) in the Western Basement Complex. In the mineral occurrence database, there are 16 manganese points solely located in Kebbi State (Figure 44). Some reports identify some occurrences within the Young Granite suite which require further analysis and, therefore, are not included here.

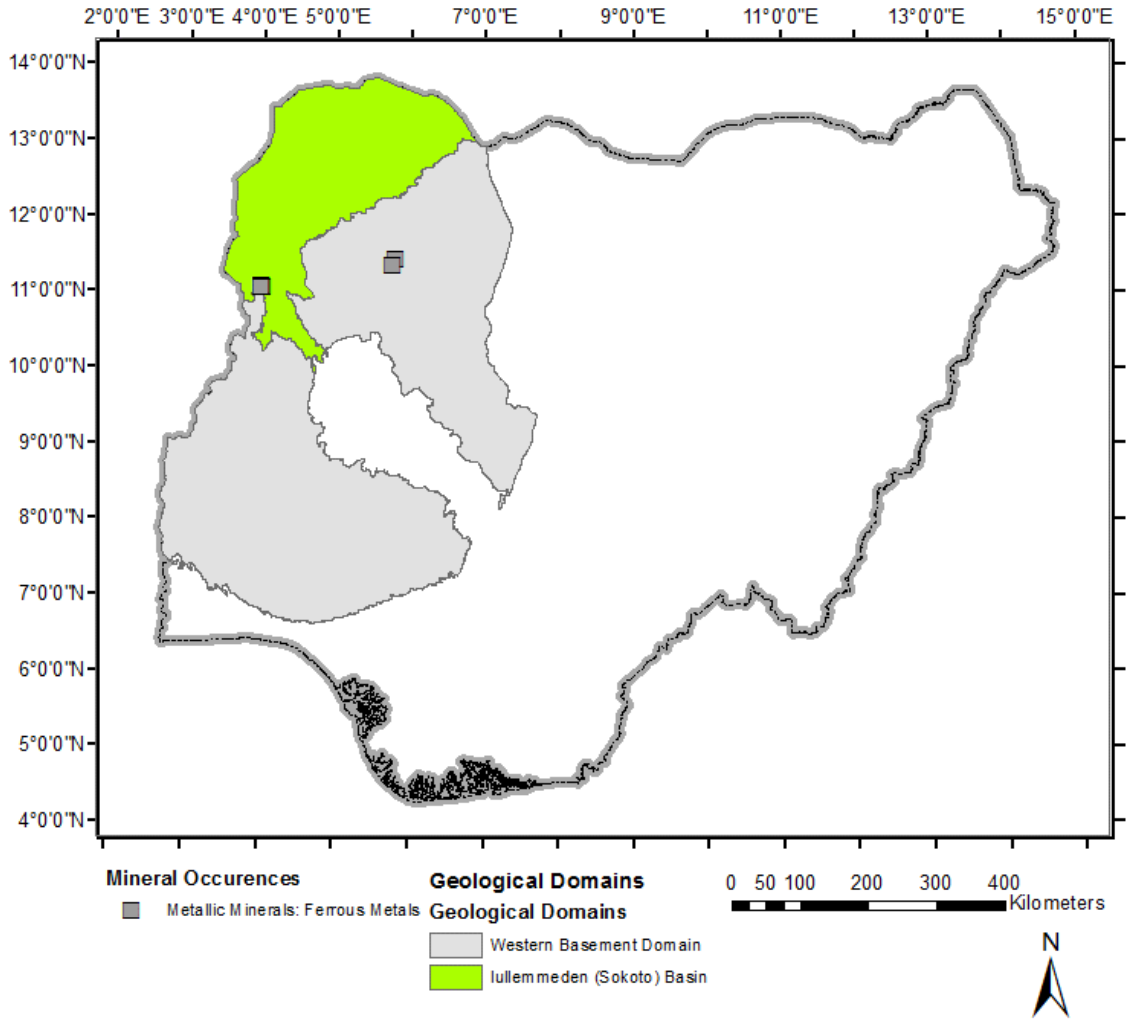


Figure 44: Location of confirmed Manganese (Mn) occurrences in Nigeria.

5.2.5.2 Shape and interpreted type of occurrences

The mode of occurrence of these deposits has been defined as “Vein / Lode / Reef” and identified to have a “Hydrothermal” origin. The main manganese occurrence is located 3km southwest of Darena (points Darena 1 to Darena 14) and is characterized by some pits aligned in the N140 direction (Figure 45).

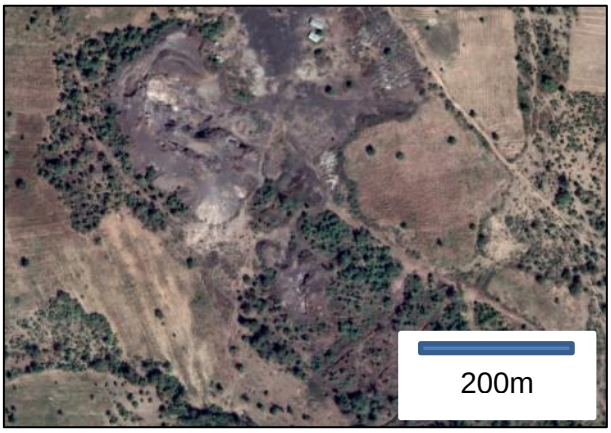


Figure 45: Manganese deposit 191, Name “Darena – 1“.

5.2.5.3 Genetic Model

This deposit is described as hydrothermal with sedimentary influence, inside some meta-sediments of the Basement Complex (Adamu, Obaje, Sidi, Aweda, & Liman, 2021). The following relationships are interpreted responsible for mineralization:

- Initial metamorphosed sediments carrying Mn-garnets where altered and concentrated the Mn into other phases, such as spessartine and almandine.
- From a carbonaceous protolith, a supergene process altered the original phases and precipitated mineral-bearing Fe and Mn phases (Mücke, 2005).

5.2.6 Uranium (U)

5.2.6.1 Location of occurrences

Only a 9 occurrences have been discovered and information on their subsurface geological setting and origin is scarce (Olade M. , 2020). Uranium is primarily located within igneous and sedimentary rocks in six states Figure 46) within the following two Domains:

- Benue Trough,
- Eastern Basement Complex.

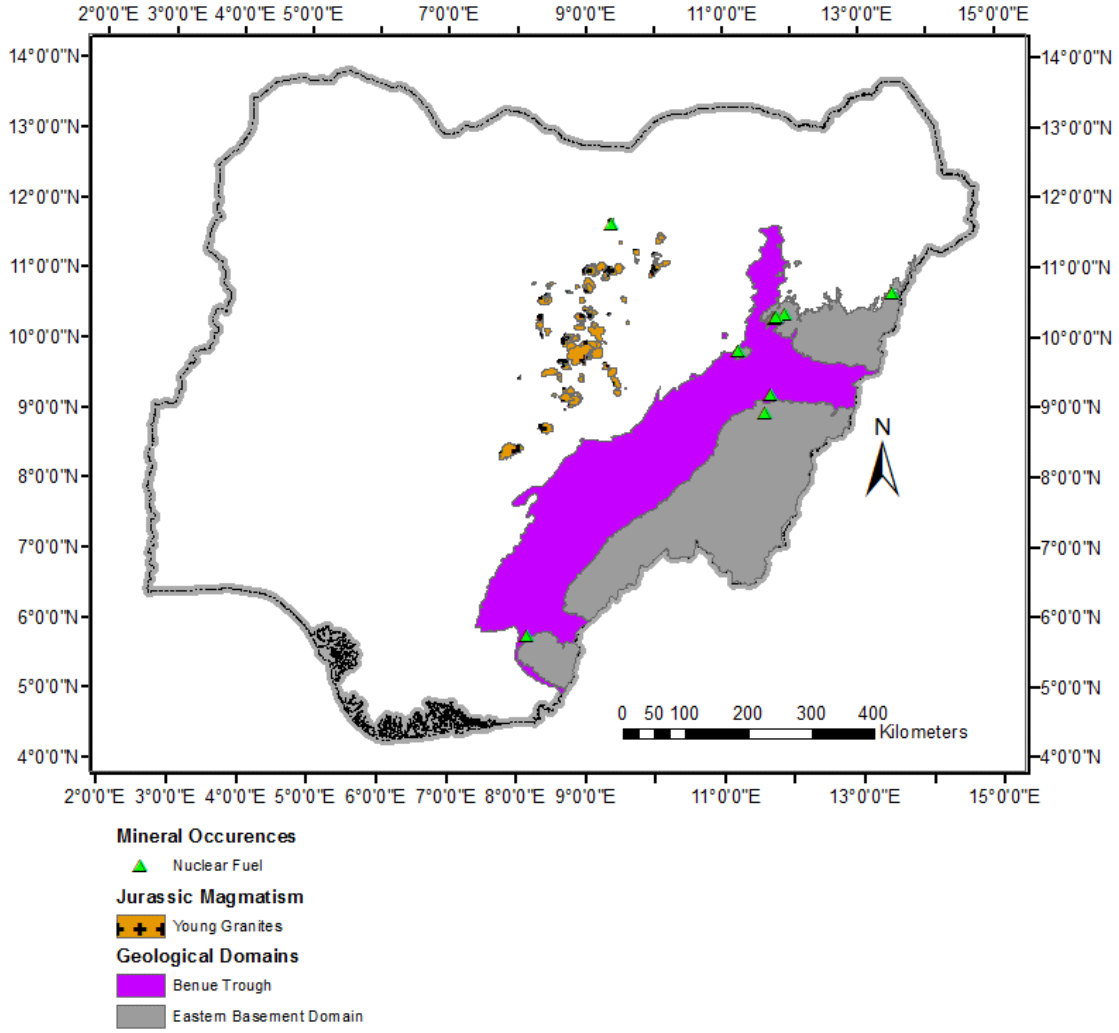


Figure 46: Location of confirmed Uranium (U) occurrences in Nigeria.

5.2.6.2 Shape and interpreted type of occurrences

Uranium occurrences in Nigeria can be distinguished into four types (Olade M. , 2020) in line with the IAEA classification scheme (IAEA, 2018), which is based on their geological setting:

- Dissemination in peralkaline granites: anorogenic granites (Oshin, 1986) with presence of uraniferous pyrochlore with concentrations of up to 3.5 wt. % UO2 and up to 4.3 wt. % ThO2 (Beer, 1952), and up to 190 ppm of uranium content in arfvedsonite albite granite (Girei et al., 2019) and 7 wt. % (Ogunleye P. O., 2006).
- Vein-type mineralization in brecciated granites and rhyolites: major occurrences are concentrated in the Adamawa Massif hosting the Mika uranium mineralization with significant economic interest (Suh, 1998). Estimated uranium resources at Mika total 52 tons at 0.63wt. % U with vertical extents of 130 meters, while at Ghumchi, 100 tons at 0.90wt. % U with vertical extents of 200 meters (Karniliyus & Akedegwa, 2018).
- Sandstone-hosted deposits: located in sediments of the Bima Formation in the Upper Benue Trough and in the Ezeaku Formation on Asu River Group and the Odukpani Formation in the Lower Benue Trough. Uranium minerals are disseminated or present as veinlets in brecciated sandstone at depth up to 200 meters, with 0.18 wt. % to 0.25 wt. % of U concentration (Olade M. , 2020).
- Phosphorite (rock phosphate): sedimentary marine origin within the Sokoto basin and Dahomey basin (Obaje, 2014). Average uranium concentrations along the phosphate nodules and pellets range from 29-65 ppm (Ogunleye P. O., 2002) (Mustapha, 2022).

5.2.6.3 Genetic Model

The following mechanisms are proposed for the mineralization of Uranium in Nigeria:

- Mesozoic volcanic rocks are the primary source of uranium in Nigeria, or,
- Uranium metal may have been remobilised by hot fluids from Pan-African granites (Bute et al., 2020).

Figure 47 provides a schematic interpretation of the processes that lead to the precipitation of the uranium along fracture zones of Pan-African orogeny in the volcanic-related U

deposits within the Eastern Nigeria Terrane (Bute et al., 2020). The vein-type mineralization model can be characterized by the emplacement of a volcanic body serving as a heat source for the mineralization fluid derived from granitic terrain. The fault structures functioned as channels and mechanical carriers, ultimately leading to the deposition of pitchblende. Surface and near-surface leaching of pitchblende resulted in the formation of secondary mineralization (Funtua, 1999).

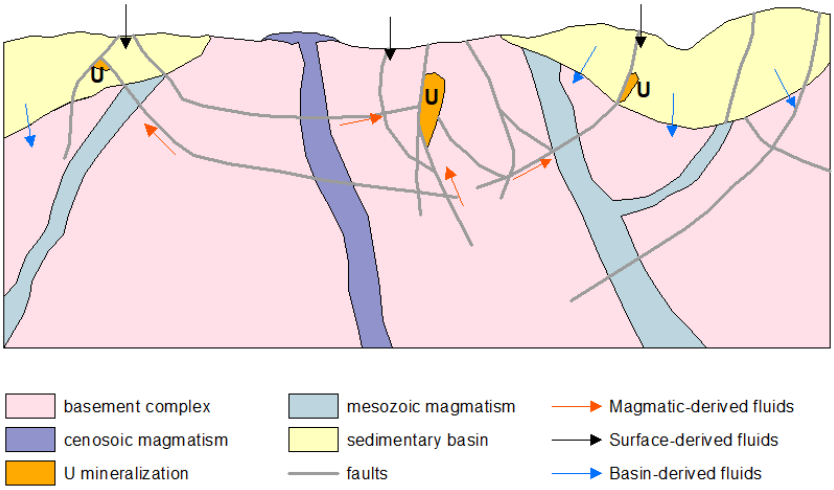


Figure 47: Schematic model section representing geological setting in relation to U remobilization and enrichment along the fault rocks, modified after (Bute et al., 2020).

According to the 1983 IUREP report (IAEA, 1983) speculative resources are estimated in the range 10,000–50,000 tons U, hosted in both sandstone and vein-type environments (in the Older Granites). Conventional uranium resources are further estimated at 152 tons, located in Mika and Ghumchi vein-type deposits associated to granites, featuring grades of 0.63% and 0.90% U, respectively (Karniliyus & Akedegwa, 2018).

5.2.7 Chromium (Cr)

5.2.7.1 Location of occurrences

A total of 7 occurrences of Chromium in the country are located in three main regions (Figure 48), all within the Western Basement Complex:

- The first, is to the west of the Anka Schist Belt in the north-west.
- The southern portion of the Wonaka Schist Belt.
- The Egbe-Isanlu region.

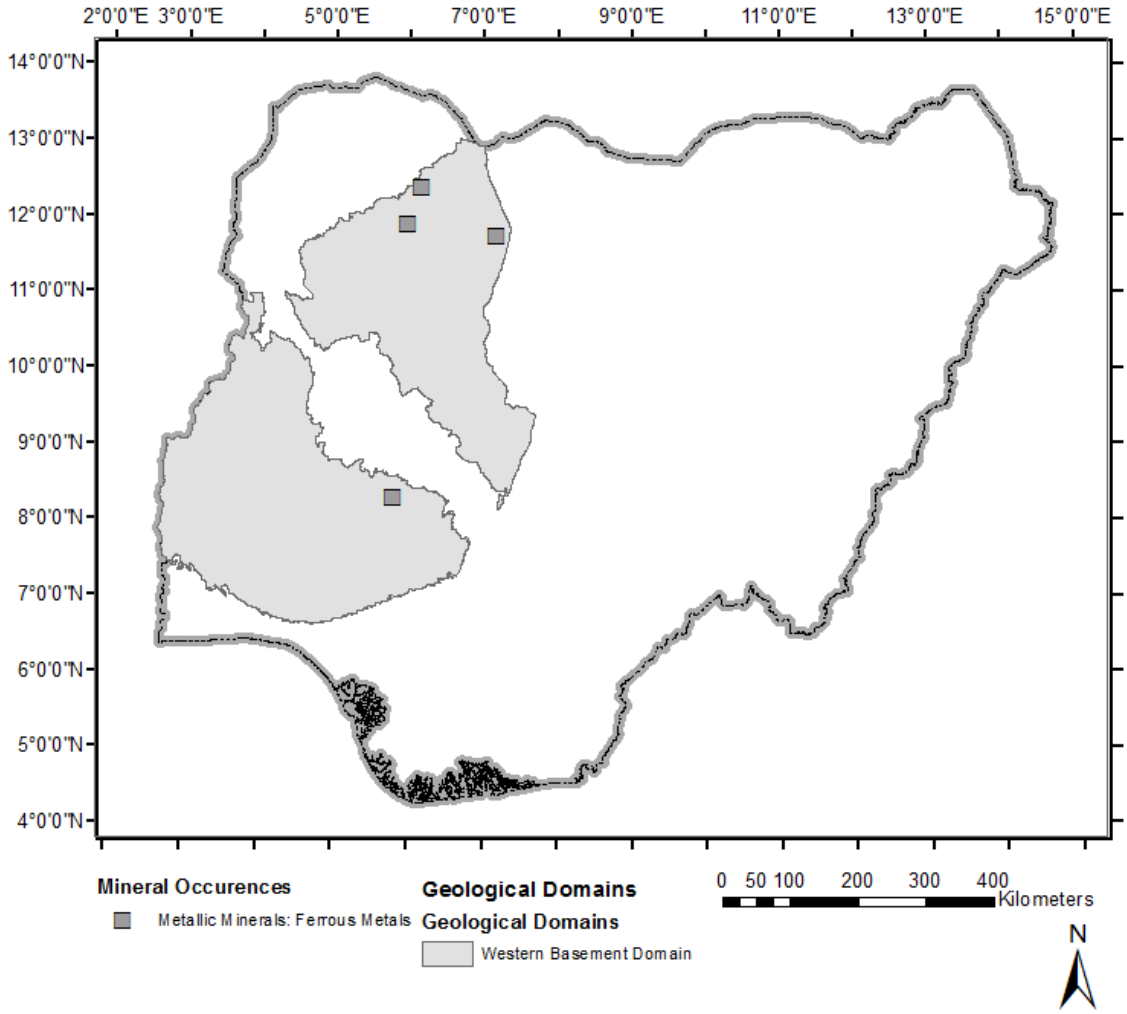


Figure 48: Location of confirmed Chromium (Cr) occurrences in Nigeria.

5.2.7.2 Shape and interpreted type of occurrences

The shape of these occurrences is of “Stockwork / domlike (disseminated, veinlets)”, as seen in Figure 49 and are identified as “Sedimentary mineralization”. These locations all fall within ultramafic complexes inside the mobile belts and tend to be highly deformed and serpentinized bodies.

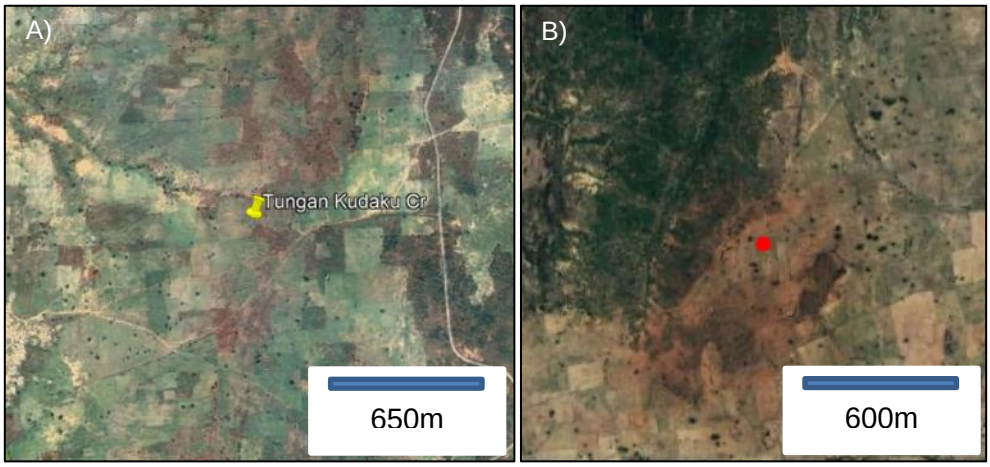


Figure 49: A) Chromium in serpentinite at occurrence 356, Name: Tungan Kudaku, within the “serpentinite belt” to the west of the Anka Schist Belt. B) Occurrence 3690, Name: Mallam Tanko of disseminated chromite.

5.2.7.3 Genetic Model

Although scarce information exists from these deposits in Nigeria, a correlation with the well-studied deposits in Brazil is possible. The process of formation of these occurrences is believed to have followed these steps:

- Active subduction zone with oceanic rocks,
- Close of subduction zone and slab roll-back,
- Volatilization of the underlying ultramafics emplaced new sills onto the overlying crust, allowing the formation of Ni-Cr rich globules,
- Further deformation along alteration in the following Periods within the shear zones affected these rocks, producing the observable serpentinized bodies.

A representation of the possibly geodynamic model for the emplacement of ultrabasic rocks is presented in Figure 50. PGE minerals under this setting has been reported in other cases and invite for further exploration (Ferreira, Filho, Danta, & Souza, 2019).

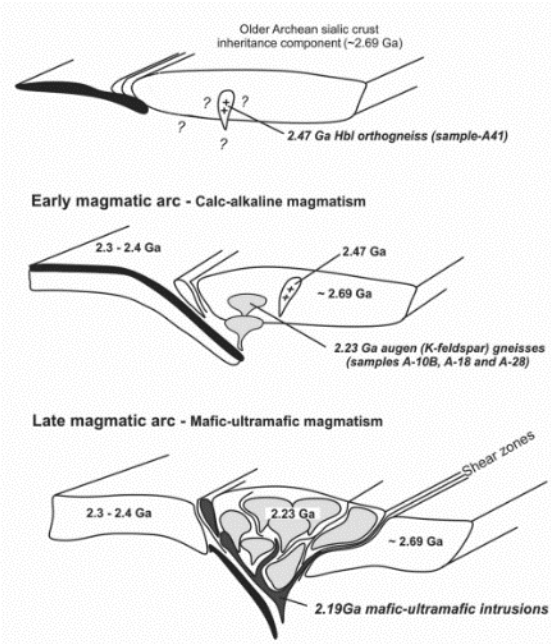


Figure 50: Geodynamic schema of the emplacement of ultramafic bodies in the Borborema Province, Brazil, linked to the Nigerian Shield suggesting a similar genesis. Modified after (Ferreira, Filho, Danta, & Souza, 2019).

5.2.8 Iron (Fe)

5.2.8.1 Location of occurrences

Iron is reported in several places in Nigeria, either as ironstone or as BIF, with a total of 49 locations. The distribution of the localities can be seen in Figure 51. The main locations where related infrastructure has been developed are in the Anambra Basin with some other relevant deposits in the Western Basement Complex.

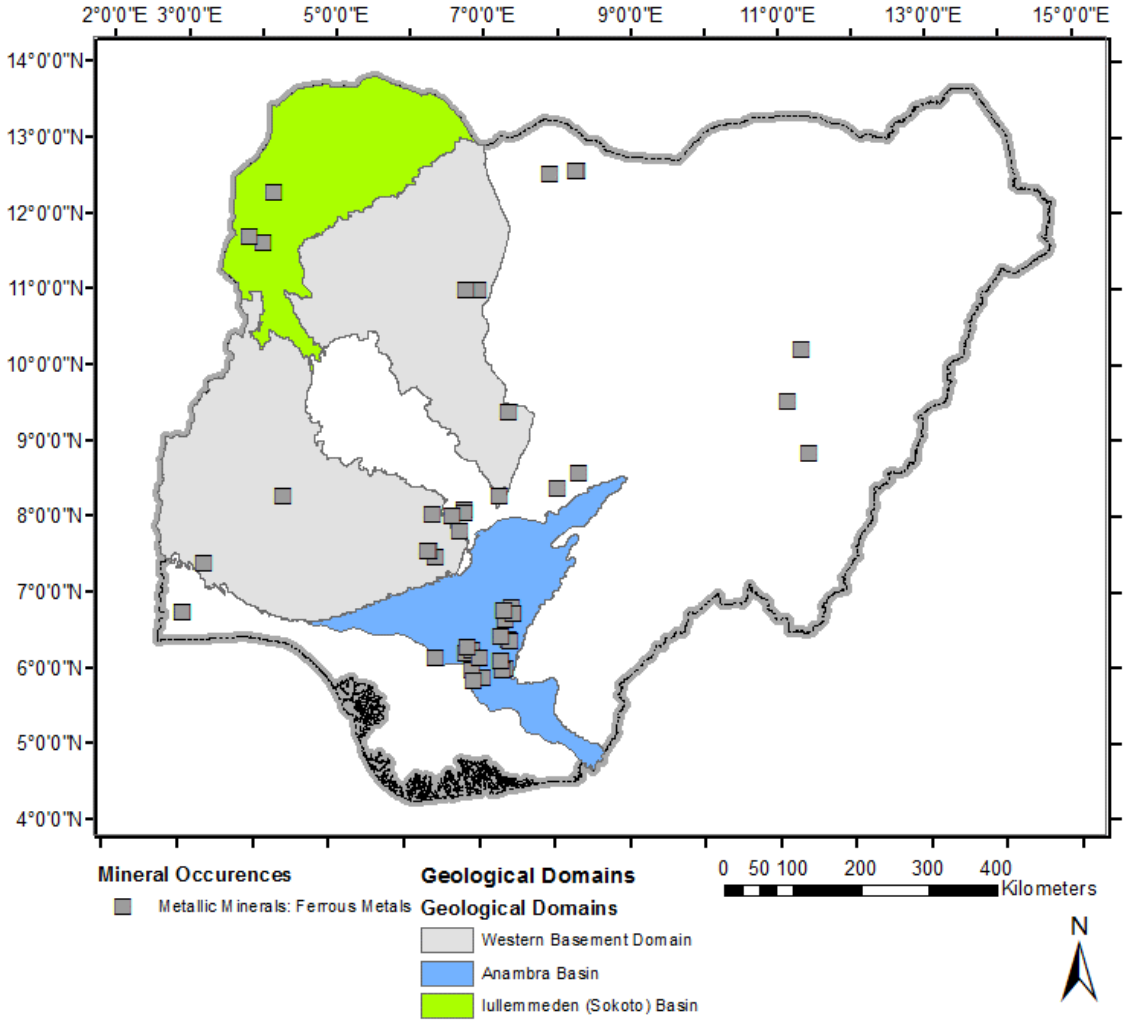


Figure 51: Location of confirmed Iron (Fe) occurrences in Nigeria.

5.2.8.2 Shape and interpreted type of occurrences

Some examples of these occurrences are shown in Figure 52. The type of shape has been identified as “Tabular / Bedded” and its genesis is defined as “Sedimentary” with the following sub-categories:

- Ferruginous Quartzites,
- Ferroginous Schists,
- Sedimentary Ironstone.

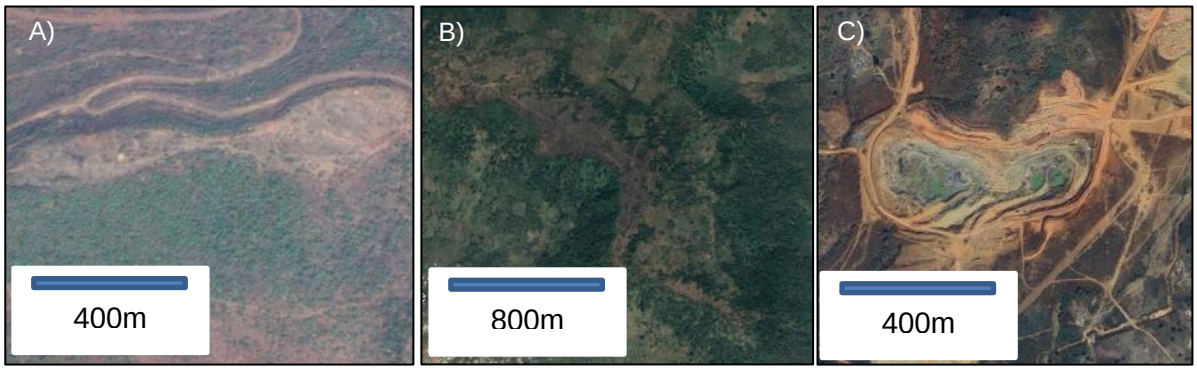


Figure 52: Examples of occurrences identified with a sedimentary genesis with a stratiform shape. A) Deposit 1632, Name: Itakpe as ferruginous quartzite. B) Deposit 3700 name: Agbaja – 1 as ferruginous schist. C) Deposit 2812, Name: Gujeni as sedimentary ironstone.

The main minerals that host the iron are hematite and magnetite. A total of 200 million tonnes of 30-50% have been identified as documented by the last Economic Viability Assessment in the hands of the Ministry. Ore grades for selected known iron ore deposits in Nigeria are shown in Table 9.

Table 9: Ore grades for selected iron ore deposits in Nigeria (Olade M. , 2020).

Deposit	Location	Fe (wt. %)
Itakpe	Kogi	36
Agbaja	Kogi	47
Gujeni	Kaduna	48
Jaruwa	Kaduna	61

5.2.8.3 Genetic Model

There are two main geological times when iron deposits have formed:

- Pan African Age: The work by (Mücke, 2005) and (Turner D. , 1983) identified a deep water basin sedimentary origin (possibly Eburnean), that during the Kibaran cycle (Turner D. , 1983) and the Pan-African pahse, concentrating the magnetite ore as hematite and specularite under metamorphic conditions along, in some cases, with Manganese phases. The schematic view of this process is seen in Figure 53. In many cases, where Older Granites intruded, contact metamorphism recrystallized the hematite into magnetite as retrograde reaction. This type of genesis correlates with the ores found in Brazil, like the extractive activities by the Minereste Company in Seridó, geologically linked to Nigeria.

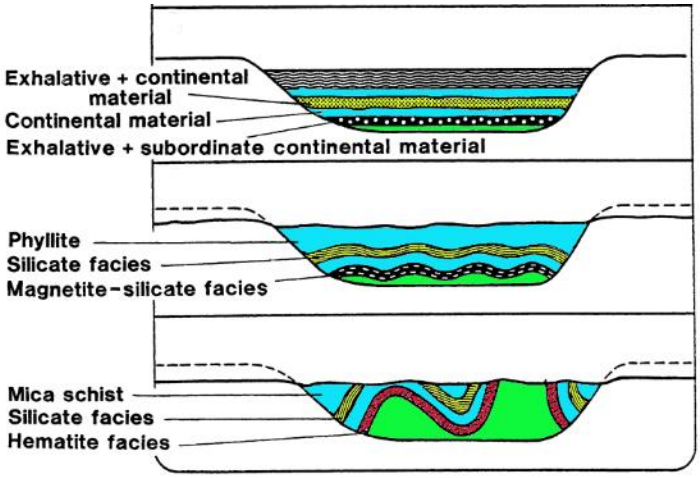


Figure 53: Schematic representation of the formation of iron ore deposits during the Pan-African orogeny. Modified after (Mücke, 2005).

- Cretaceous: Mainly found in the Agbaja and Enugu areas, have their origin in alluvial deposition as high-energy shallow-marine environment ooids (Olade M. , 2020). These deposits tend to form large extensions of plateaus due to their depositional environment, showing no deformational features and a lateritic crust (Figure 54).

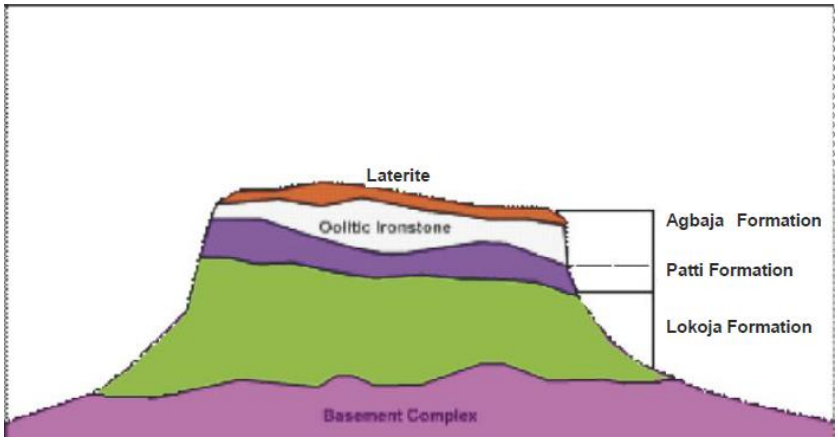


Figure 54: Schematic cross-section of the ironstone formations in Nigeria, a combination of the oolitic rock overlain by a lateritic cover. Modified from (Olade M. , 2020).

5.2.9 Phosphate (P)

5.2.9.1 Location of occurrences

Phosphates in Nigeria has been identified in the following geological domains (Figure 55):

- The Upper Benue Trough,
- Sokoto Basin and
- The Dahomey Basin.

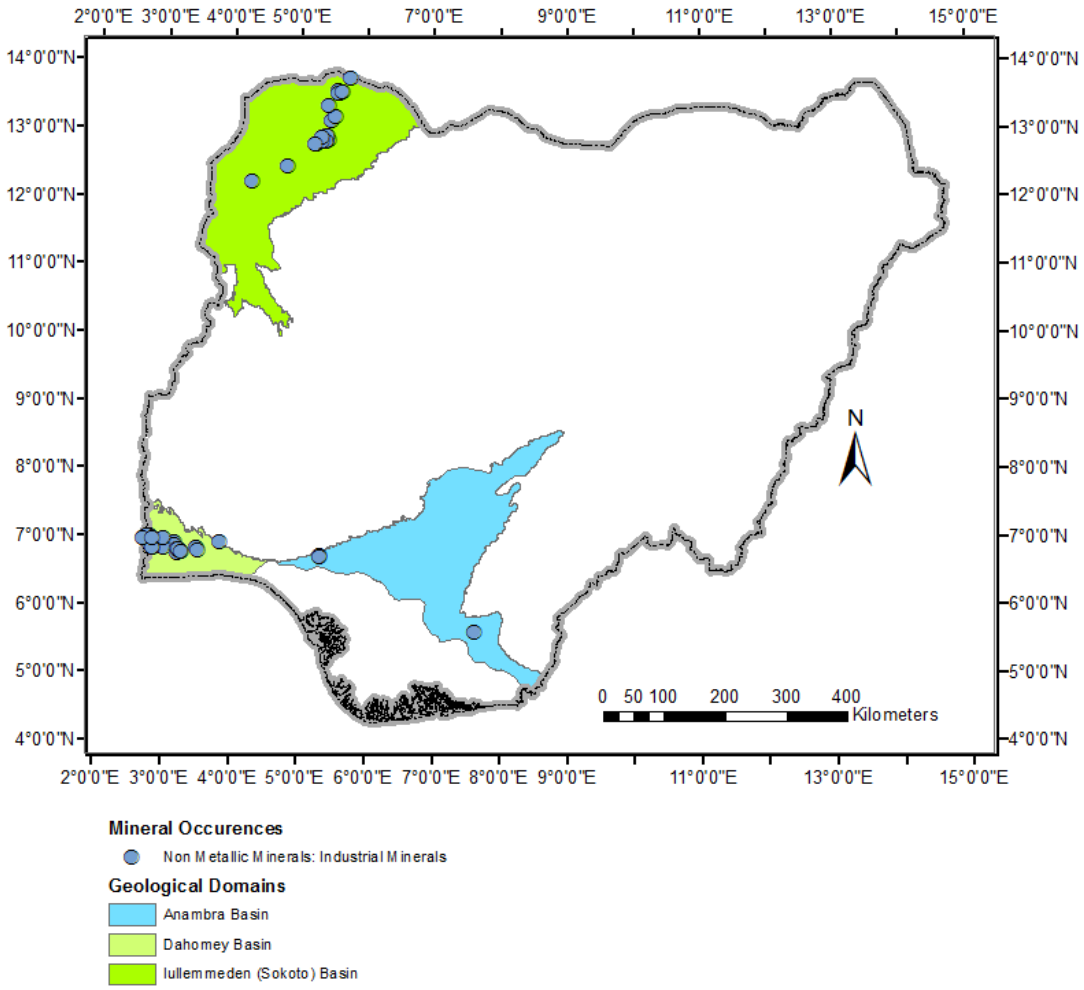


Figure 55: Location of confirmed Phosphorous (P) occurrences in Nigeria.

5.2.9.2 Shape and interpreted type of occurrences

Phosphates in Nigeria occurs as large sedimentary phosphorite consolidates in sedimentary basins. The form of mineralization is identified as “Tabular / Bedded (stratiform)” with a “Sedimentary and diagenetic” mineralization type. An example of a Phosphate deposit being mined is shown in Figure 56 on one of the sedimentary layers in Sokoto State.

Figure 56: Examples of occurrence of Phosphate. Deposit 3687, Name: Dange.

5.2.9.3 Genetic Model

The formation of these deposits is identified to be under this stages:

- Bioclastic source related to gypsum accumulation (Abimbola, Olatunji, Akande, & Borode, 2005).
- Sediment deposition during the Cretaceous with a combination of high-energy environment and reworking of indurated apatite muds (Figure 57) under oxic conditions (Adekeye & Akande, 2004).
- Further weathering due to humid conditions during the Paleocene enriched the concentration of the original nodules.

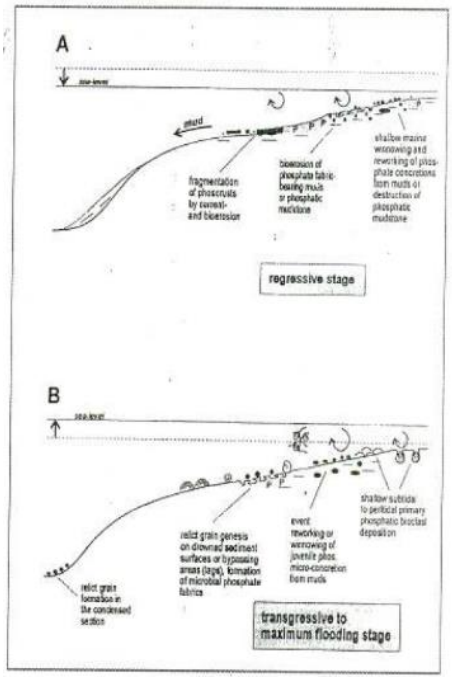


Figure 57: Mechanisms forming phosphate deposits in Nigeria (Adekeye & Akande, 2004).

The probable reserves of phosphates in Nigeria range in the millions of tones. However, detailed investigations are required to precisely determine the actual reserves of the deposits (Obaje, 2014). As a by-product of these deposits, uranium concentrations of 54-65 ppm have been identified related to the presence of phosphate-bearing rocks (Mustapha, 2022) (Olowofela, Okeyode, & Idowu, 2019).

5.3 Metallogeny

The metallogeny of Nigeria is a compilation of several mechanisms and events determined by the geological tectonic development of the country as described in chapter 5.1

5.3.1 Schist Belts

The schist belts in Nigeria are correlated to the accretion of several different terranes with island arc affinity, amalgamating to the West of the Nigerian Shield and creating a densely packed faulted area. This concept can be summarized in Figure 58. A schematic view of the configuration of the layers can be seen in Figure 59, containing greenstone belts, the migmatite-gneiss complex and ultramafic intrusives. Related deposits are structure related, stratiform, and disseminated, containing stockwork type sulphides and native gold.

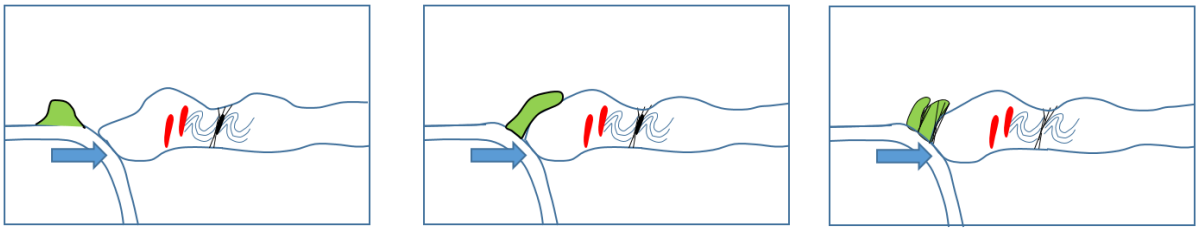


Figure 58: Accretion of terranes and generating further fault zones (swarms).

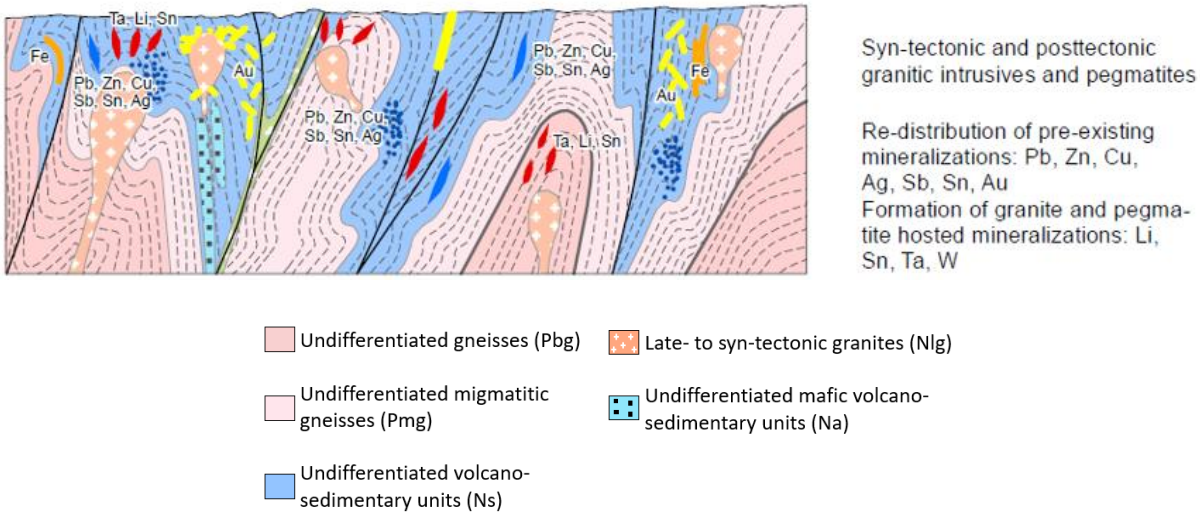


Figure 59: Schematic representation of the geology during the Paleoproterozoic-Archean.

5.3.2 Pan-African Orogenesis

The final phase of deformation and activity in the basement complex is linked to the intrusion of the Older Granites. Their age ranges between 750-450Ma and are almost entirely barren (Woakes, Rahama, & Ajibade, 1987). However, these bodies are responsible for the majority of the known mineral occurrences in the Basement Complex. Cross-cutting all the pre-existing rocks, these granites probably remobilized previous mineralizations. Toward the latter part of this period, pegmatites and gold deposits are identified and are restricted within the shear zones. Related commodities are: Au, Li, Sn, Ta, Nb, gemstones, and secondary Pb and Zn (Figure 60).

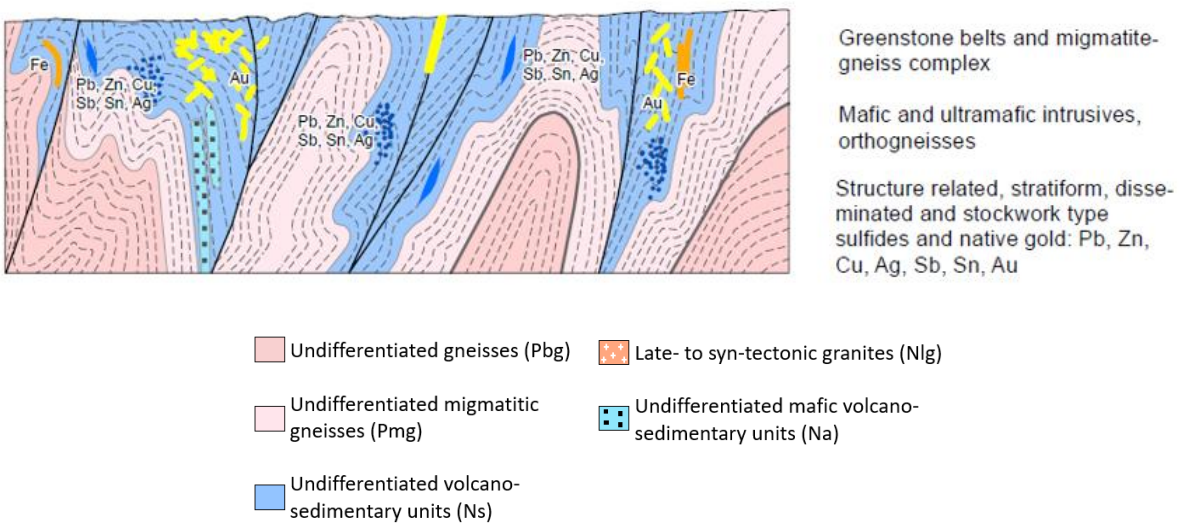


Figure 60: Schematic representation of the intrusion of the Older Granites.

5.3.3 Jurassic Magmatism

This stage is mainly represented by the intrusion of Young Granites into the Basement Complex, marking a geological reactivation after the pause since the Pan-African Orogeny. These intrusives are discordant high-level intrusions which succeed the extensive acid volcanics and are emplaced into the Precambrian to early Palaeozoic basement (Kinnaird, Bowden, Ixer, & Odling, 1985). These intrusions cut through all pre-existing lithologies and are linked to the upwelling of the crust do to a regional extension event pre Gondwana break-up

(Figure 61). This period marks the formation of alkaline complex related mineralizations: Li, Sn, Ta, Nb, W, Mo and REE.

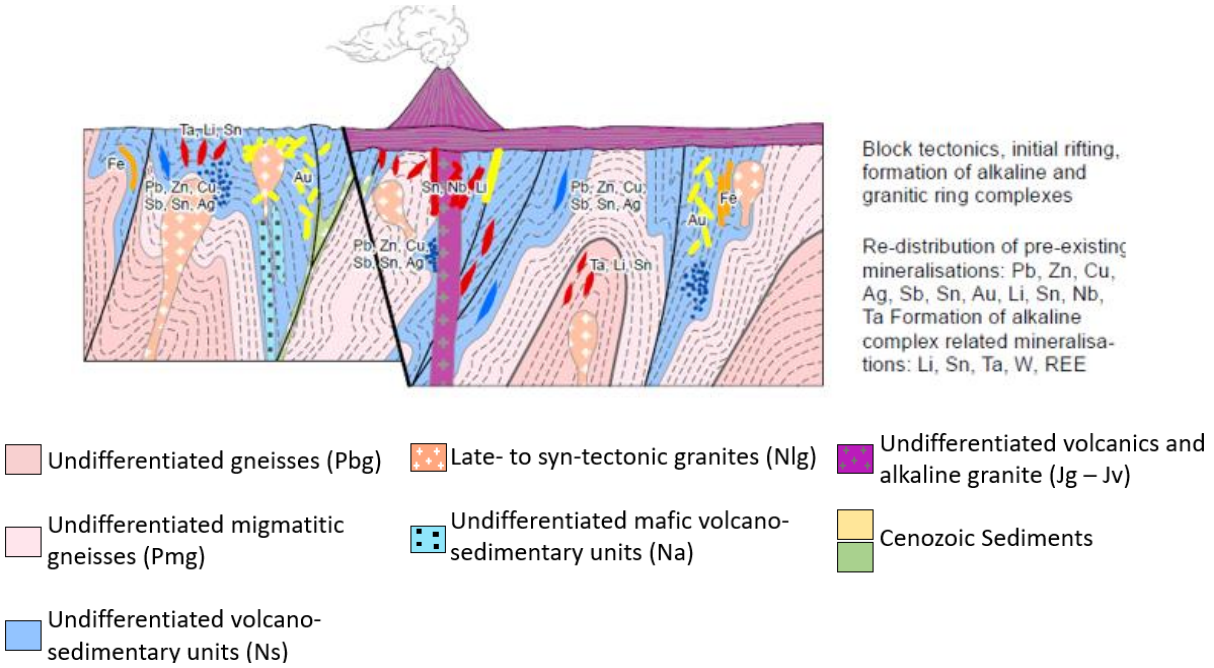


Figure 61: Schema of the anorogenic intrusions (Young Granites) into the Basement Complex.

5.3.4 Cretaceous Rifting and Benue Trough Basin

Further extension commenced with normal faulting of the crust followed by a rift zone (the Benue Trough). Mantle upwelling meant further magmatism, fracturing and folding in the area. Hydrothermal fluids permeated the upper sediments/rocks and precipitated commodity related deposits (also possibly re-distributed earlier deposits) as shown in Figure 62. Further activity formed the U-hosted sandstones through infiltration of porous sediments (e.g., sandstones).

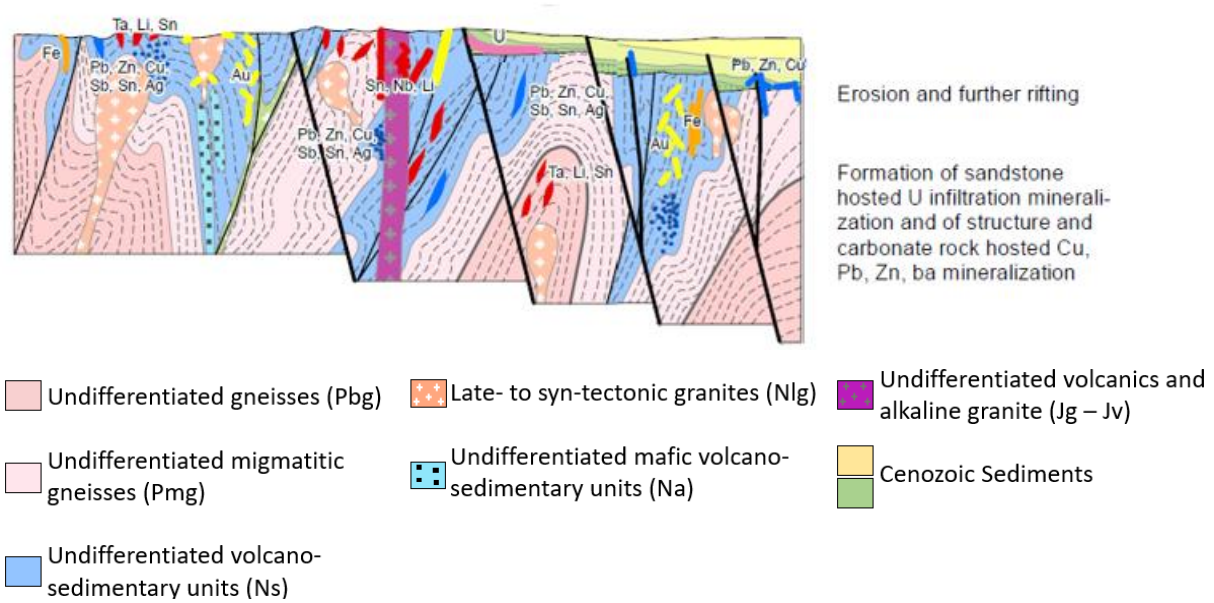


Figure 62: Schematic representation of the rifting of the Benue Trough and respective sedimentation.

5.3.5 Cenozoic Sediments

Further sedimentation, erosion and tropical weathering (e.g., laterites) shaped the landscape of Nigeria during the Cenozoic (Figure 63). The most important deposits here are terraces, recent alluvial placers (e.g., Au and Ta-Nb) and residual mineralization in laterites (e.g., Fe and P). Further basaltic volcanism is observed towards the norther part of the Benue Trough.

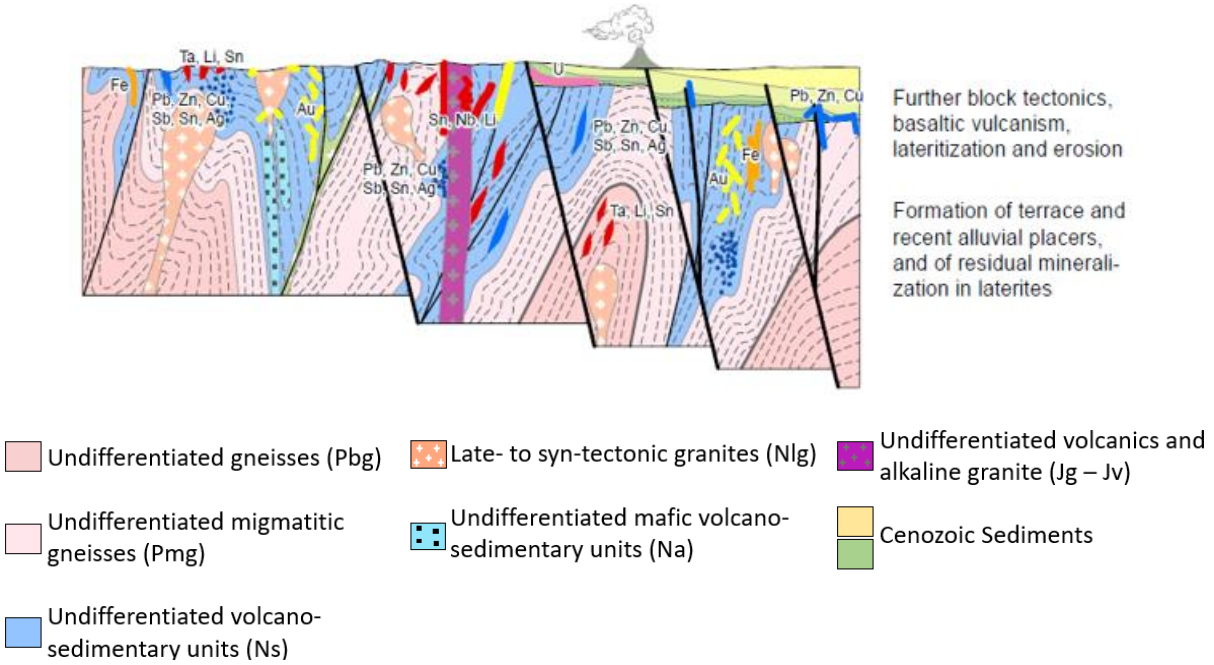
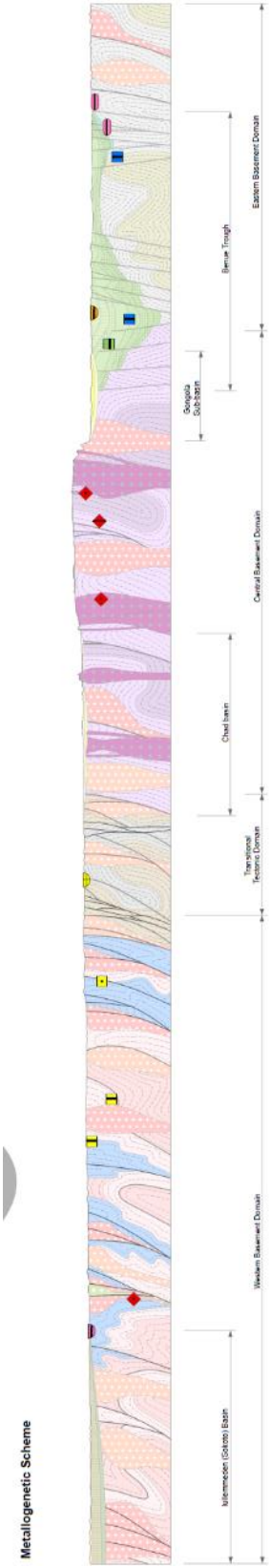


Figure 63: Simplified representation of the final configuration.

5.3.6 Synthetic Cross-section of Nigeria

This section includes the interpreted locations of the identified commodities in relation with the reconstructed geology. For further information, please refer to the Map Annex: Map 1: Map of Metallic Minerals and Metallogeny of Nigeria 1:2M



6. Mineral Potential Mapping

6.1 Methodology

The identification of prospective areas consists of the following steps (see Figure 64):

- Collection of spatially accurate base data (as possible), including but not limited to:
  - Mineral occurrence data, covering important properties of the commodities:
    - genetic type,
    - size and,
    - other important parameters
  - Geological maps
  - Tectonic and other relevant geoscientific maps
  - Geophysical datasets
  - Geochemical datasets
  - Remote sensing data
  - Exploration models (for identification of potentially mineralisation controlling factors)
- Base data processing:
  - extraction of mineralisation controlling parameters from the base data, and
  - calculation of derivatives of the raw and extracted data
- Data integration and analysis, using:
  - None supervised and
  - Supervised approaches and algorithms

The unsupervised approaches identify relationships between the different datasets (e.g. cluster and factor analysis). The results of unsupervised approaches can be used as input parameters for supervised approaches. In the supervised approach, the locations of known mineral occurrences are used to train AI algorithms (e.g. artificial neural networks) to identify

sites with similar properties as those which have been used to train the algorithm. The calculations create maps showing favourabilities on a scale between 0 (not favourable) and 1 (very favourable) for the identification of occurrences of the searched commodity.

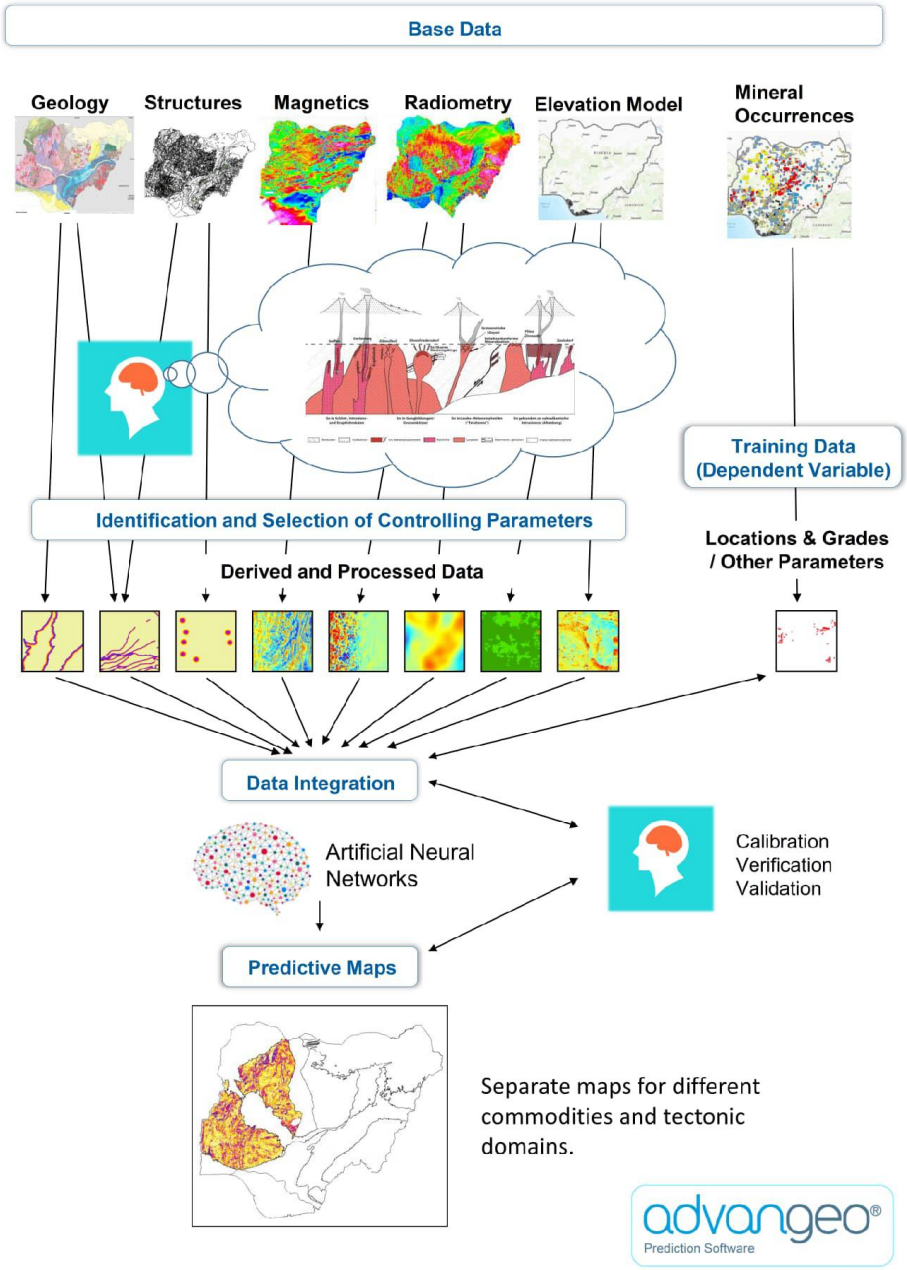


Figure 64: Methodology for the usage of Machine Learning for the identification of favourable areas for selected commodities in Nigeria.

A deep understanding of mineral occurrence formation processes is necessary to extract the important controlling parameters from the available datasets.

The mineral systems approach concept states that the formation of a mineral deposit requires a series of processes and events, which are expressions of larger earth systems existing at different scales and times (McCuaig, Beresford, & Hronsky, 2010). This approach allows the flexibility of a common analysis over different mineral systems, constrained by data at all scales, leading to new discoveries with different styles instead of analogue deposits.

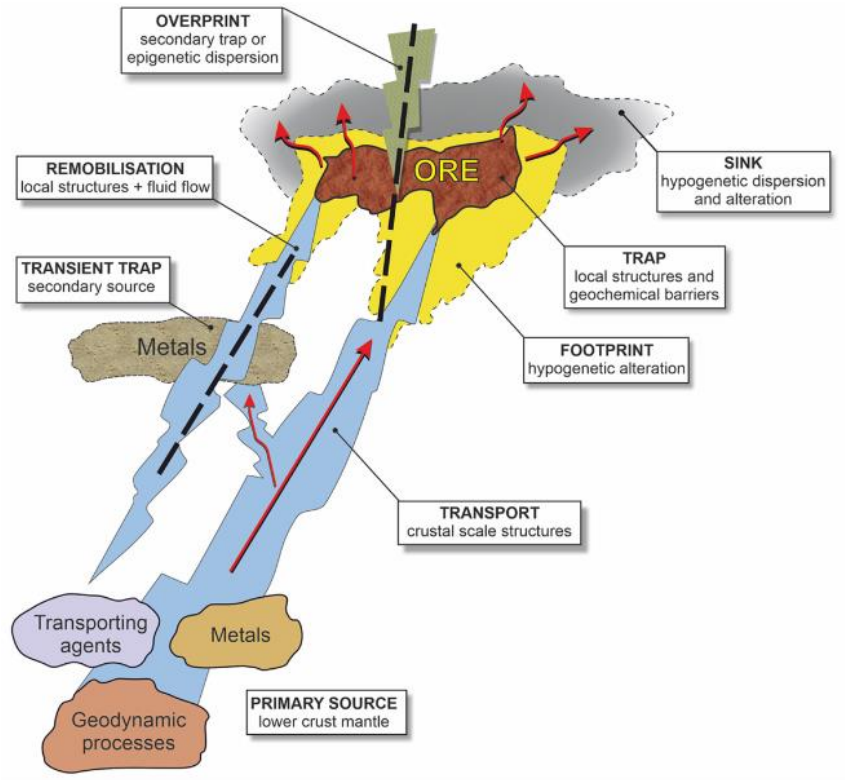


Figure 65: Minerals system concept with the main processes required for a mineral deposit to be formed. Modified after (Geological Survey of Finland, 2020).

In order to use the concept shown in Figure 65 for creation of input datasets for ANN based exploration targeting, the fundamental processes must be translated into mapable criteria extracted from available datasets. As stated by (McCuaig, Beresford, & Hronsky, 2010), the following successive steps are needed:

1. Recognise the critical processes of the mineral system.
2. What are the constituent processes of the system?
3. Ascertain the geological expressions of the system as targeting elements.
4. Identify the mapable criteria that allow the detection of those targeting elements.

In this project, we use exclusively the hybrid modelling: a combination of knowledge driven and data driven approaches (. We combine the knowledge from the mineral system analysis expressed in exploration models with the ANN based data driven approach.

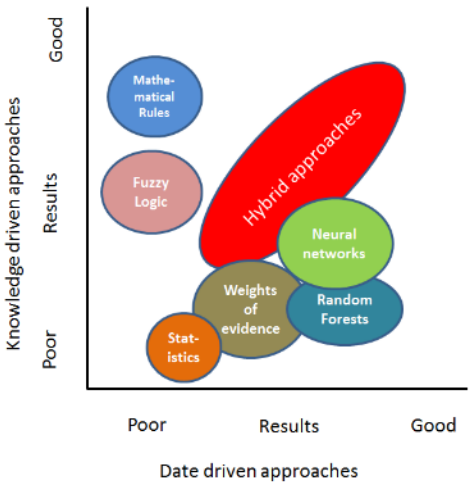


Figure 66: Relationship between knowledge driven and data driven methods

6.2 Single commodities

6.2.1 Gold (Au)

According to current knowledge, in Nigeria the following three genetic types of Au occurrences (see also chapter 5.2.1) exist:

- Gold related to metamorphic belts,
- Granite related gold occurrences,
- Placers.

For each genetic type a separate Mineral Predictive Map (MPM) was calculated.

6.2.1.1 Gold related to Metamorphic Belts (file: Nigeria_AuLiTa_100m, model # 31)

For mineral potential mapping of gold in metamorphic belts the following frame conditions were applied:

- Model application area: The Western Domain
- Mineral occurrence points: exact and verified locations of 369 Au occurrences in schist belts, without spatial relation to post kinematic granitic intrusives

As controlling parameters for ANN calculations, derivatives of the following datasets have been used:

- Geological datasets → The litho-structural map of Nigeria (NGSA, 2022):
    - Shear zones (early and late)
    - lithologies of metamorphic rocks
    - Terrain boundaries
- Geophysical datasets:
    - Processed airborne magnetic data (Fugro, 2009), resolution 125 m
    - Processed airborne radiometric data (Fugro, 2009), resolution 125 m

The following dataset was used as input:

- Training data: the respective Au-occurrences have been buffered with a radius of 200 m creating circles of 400 m diameter simulating the area of the supposed mineralised area.

For the ANN model, the following parameters have been used:

- Number of iterations: 100
- Number of hidden layers: 1
- Balancing: 50:50
- Number of input neurons: 22
- Number of output neurons: 1
- Number of neurons in the hidden layer: 67
- Number of connections: 1541

The model quality and reliability can be evaluated by learning curve and the histograms of the favourability values of all data points compared with the known mineral occurrence (the “yes” points) data points (Figure 67). The “yes” point favourability value data histogram ideally shows the maximum towards the right side (close to te value 1). In the given case the maximum is between 0.7 and 0.8, indicating the heterogeneity in the data, possibly to:

- wrong labelling of mineralization type, being actually, for instance, a placer deposit and not a metamorphic belt related deposit,
- Different genetic history of the mineral occurrences,
- Wrong registered commodity / gold is not the main commodity,
- Other reasons (e.g.: the used data do not sufficiently describe the mineralisation, uncertainties of the geological borders…)

With further collection of correct data, the output of the ML algorithm with provide better results.

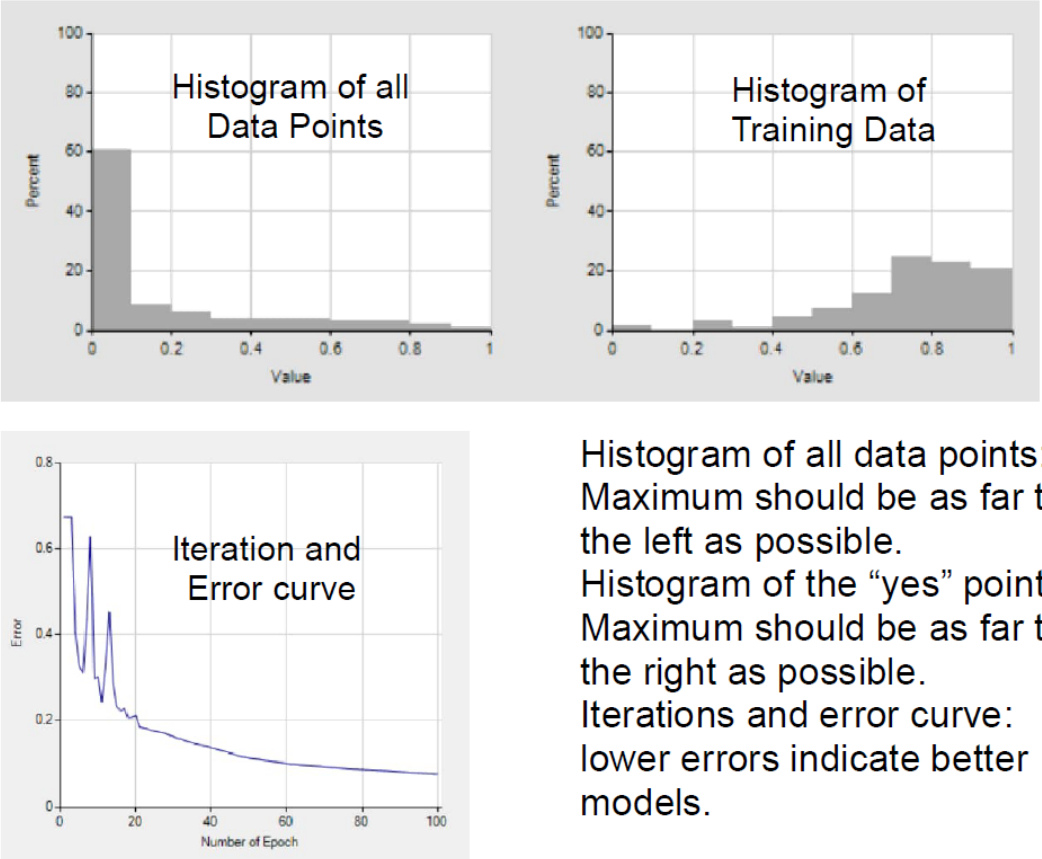


Figure 67: Important model #31 quality parameters

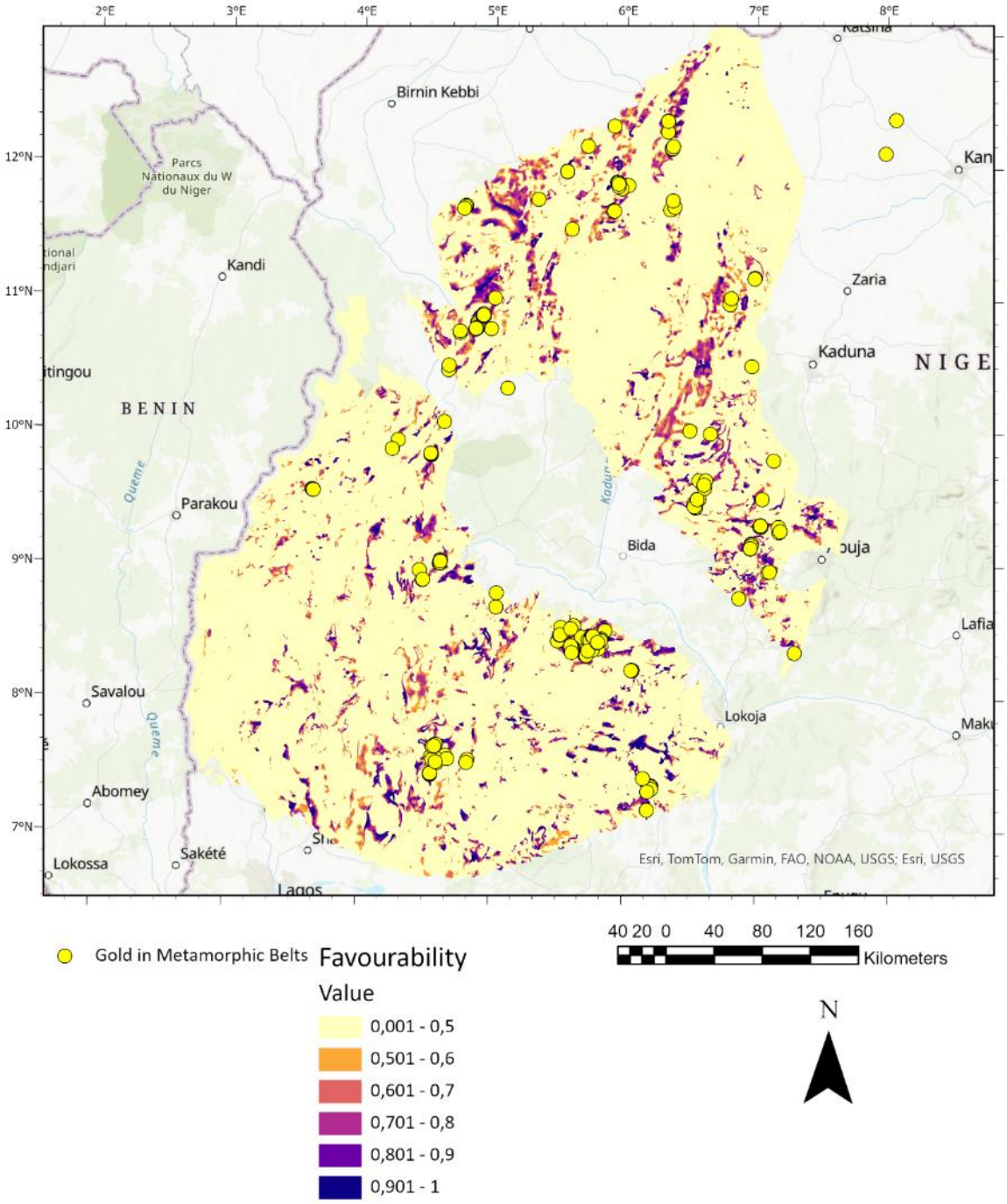


Figure 68: Favourability map for the schist-belt related gold (Au) occurrences.

6.2.1.2 Gold related to Granites (file: Nigeria_AuLiTa_100m, model # 32)

For mineral potential mapping of gold related to granites the following frame conditions were applied:

- Model application area: The Western Domain
- Mineral occurrence points: exact and verified locations of 173 Au occurrences inside granite intrusions and with spatial relation to post kinematic granitic intrusives

As controlling parameters for ANN calculations, derivatives of the following datasets have been used:

- Geological datasets → The litho-structural map of Nigeria (NGSA, 2022):
  - lithologies of metamorphic rocks
  - types of granitic intrusives:
    - syn-tectonic,
    - post-tectonic,
    - Spectral classification of granites
- Geophysical datasets:
  - Processed airborne radiometric data (Fugro, 2009), resolution 125 m

The following dataset was used as input:

- Training data: the respective Au-occurrences have been buffered with a radius of 200 m creating circles of 400 m diameter simulating the area of the supposed mineralised area.

For the ANN model, the following parameters have been used:

- Number of iterations: 100

- Number of hidden layers: 1
- Balancing: 50:50
- Number of input neurons: 24
- Number of output neurons: 1
- Number of neurons in the hidden layer: 59
- Number of connections: 1475

The model quality and reliability can be evaluated by learning curve and the project histograms (Figure 69).

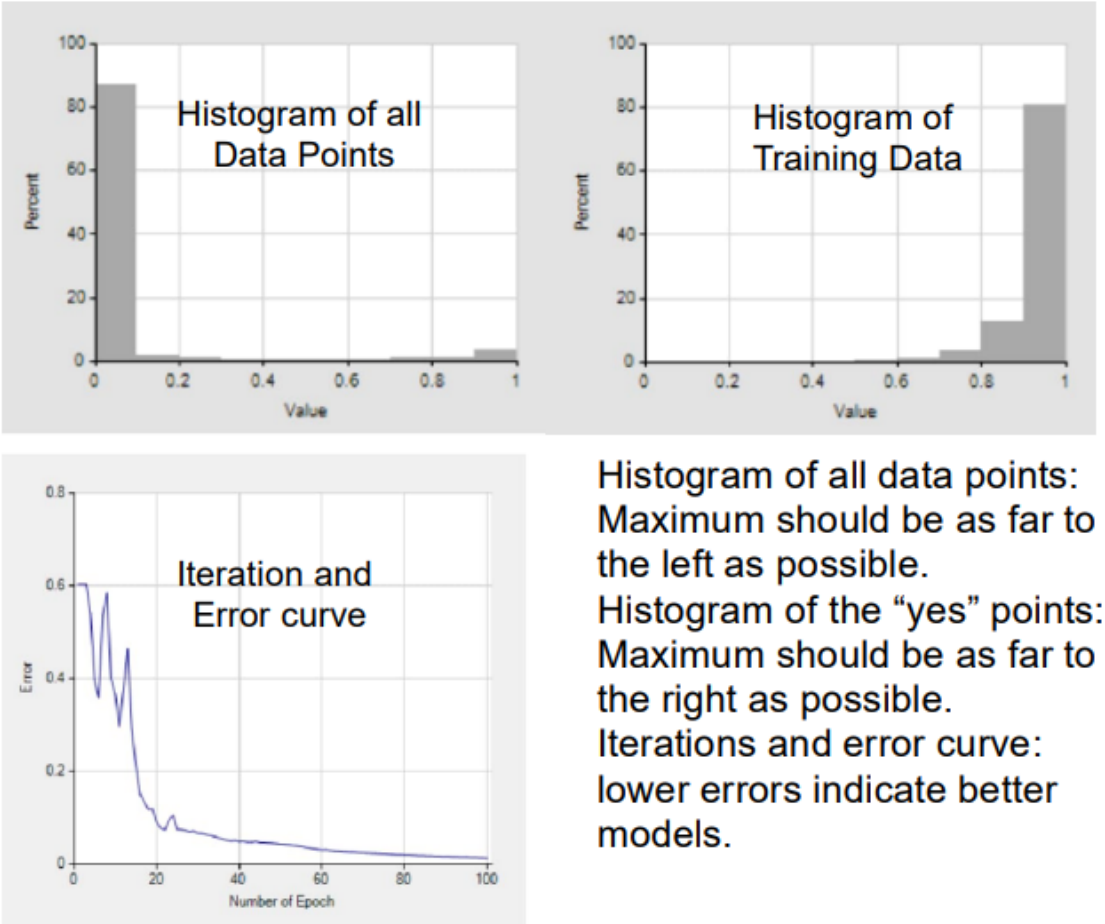


Figure 69: Important model #032 quality parameters

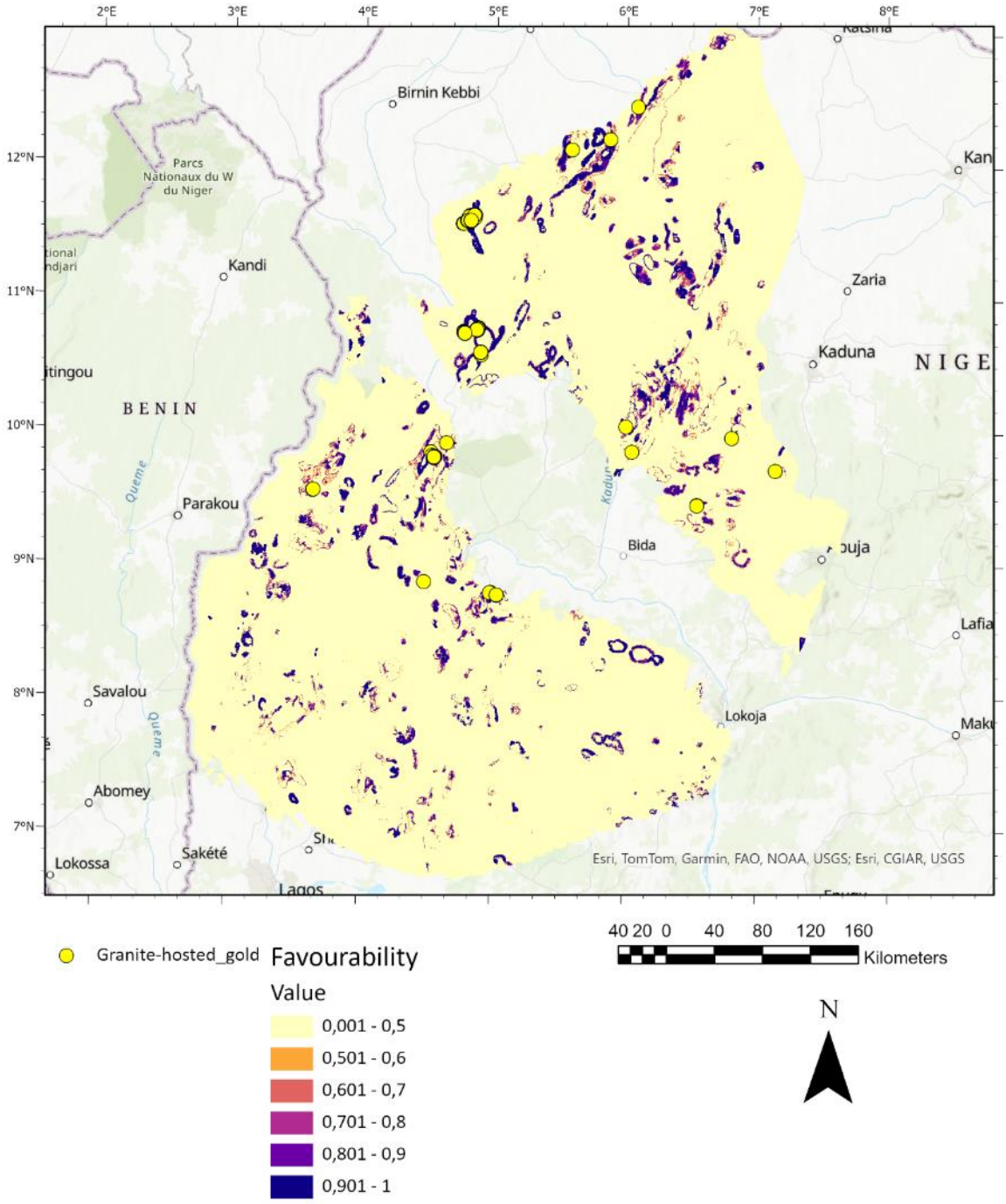


Figure 70: Favourability map for the granite related gold (Au) occurrences.

6.2.1.3 Gold related to Placers (file: Nigeria_AuLiTa_100m, model # 30)

For mineral potential mapping of gold in placers the following frame conditions were applied:

- Model application area: The Western Domain
- Mineral occurrence points: exact and verified locations of 1,088 Au occurrences in placer deposits. Additionally, hard-rock occurrences for gold in main areas (total of 64 points) have been used to simulate potential sources for these deposits.

As controlling parameters for ANN calculations, derivatives of the following datasets have been used:

- Digital Elevation Model (DEM) of Nigeria datasets:
    - Slope of the DEM resolution 100 m,
    - Topographic Position Index (TPI) resolution 300 m,
    - Stream paths
- Geophysical datasets:
    - Processed airborne radiometric data (Fugro, 2009), resolution 125 m

The following dataset was used as input:

- Training data: the respective Au-occurrences have been buffered with a radius of 200 m creating circles of 400 m diameter simulating the area of the supposed mineralised area.

For the ANN model, the following parameters have been used:

- Number of iterations: 100
- Number of hidden layers: 1
- Balancing: 50:50

- Number of input neurons: 9
- Number of output neurons: 1
- Number of neurons in the hidden layer: 19
- Number of connections: 190

The model quality and reliability can be evaluated by learning curve and the project histograms (Figure 71).

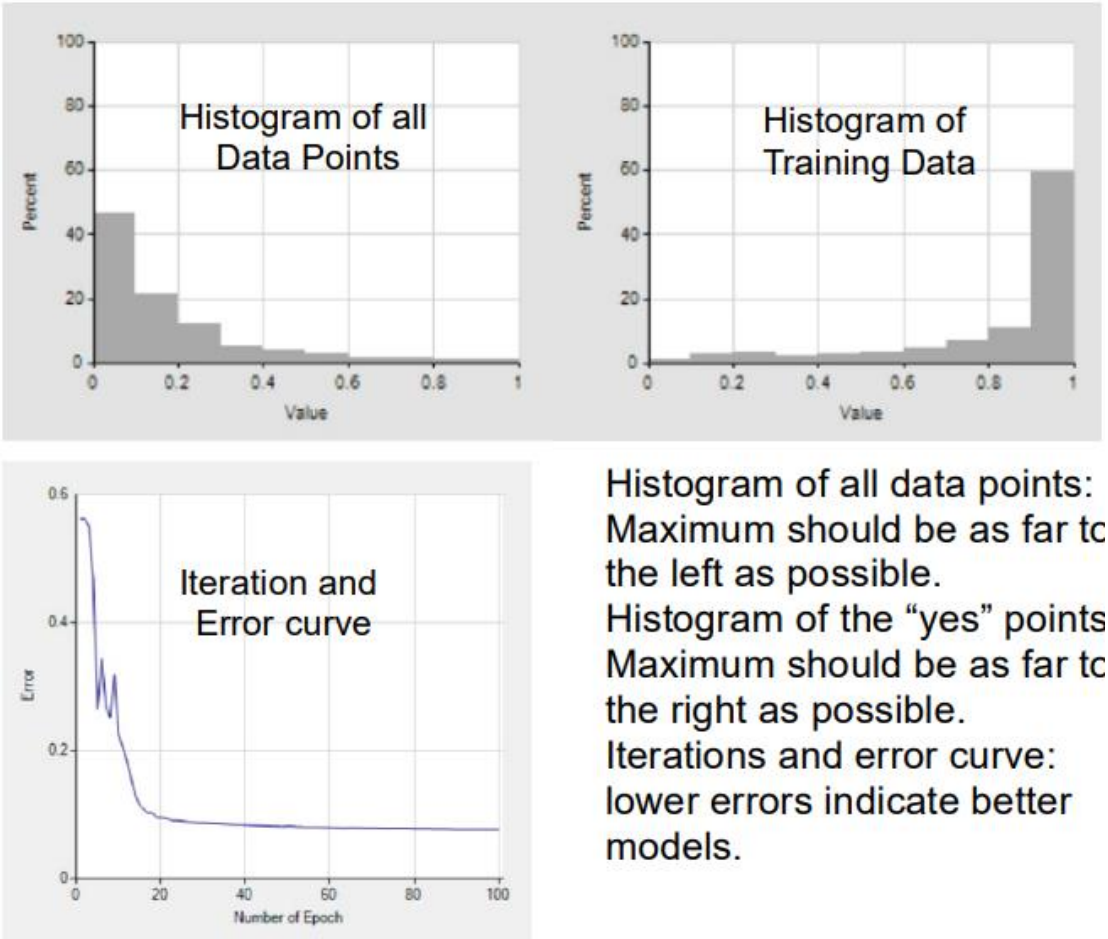


Figure 71: Important model #30 quality parameters.

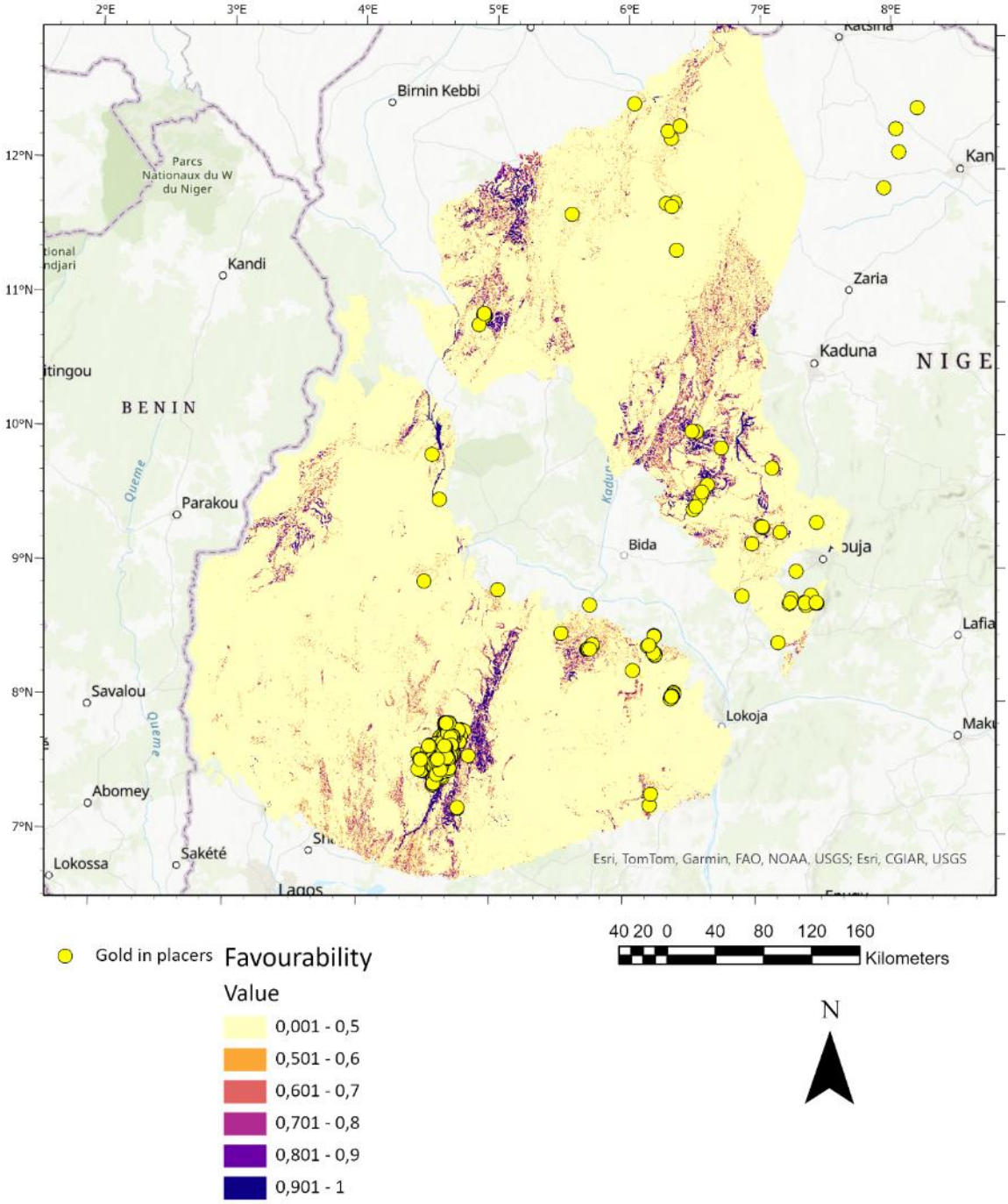


Figure 72: Favourability map for the placer gold (Au) occurrences.

6.2.2 Tin (Sn) and Niobium (Nb)

According to current knowledge, in Nigeria the following three genetic types of Sn occurrences (see also chapter 5.2.2) exist:

- Pneumatolytic and contact metasomatic,
- Placers.

For each genetic type a separate Mineral Predictive Map (MPM) was calculated.

6.2.2.1 Tin related to Young Alkaline Complexes (file: Nigeria_Central_100m, model # 01)

For mineral potential mapping of gold in metamorphic belts the following frame conditions were applied:

- Model application area: The Central Domain and Transitional Tectonic Domain
- Mineral occurrence points: exact and verified locations of 60 Sn-Nb occurrences with spatial relation to the Younger Granites

As controlling parameters for ANN calculations, derivatives of the following datasets have been used:

- Geological datasets → The Litho-structural map of Nigeria (NGSA, 2022):
  - Dykes
- Detailed mapping of ring complexes (Abaa, Kinnaird, Ike, & Turaki, 1984):
  - Types of volcanic structures (Feeder, Sub-volcanic, Volcanic)
  - Types of granitic intrusives (Porphyry, Gabbro, etc.)
- Geophysical datasets:
  - Processed airborne radiometric data (Fugro, 2009), resolution 125 m
  - Processed airborne Bouguer gravity data (4.2), resolution 125 m

The following dataset have been created and used as input dataset:

- Training data: the respective Tin-occurrences have been buffered with a radius of 200 m creating circles of 400 m diameter simulating a mineralised area.

For the ANN model, the following parameters have been used:

- Number of iterations: 100
- Number of hidden layers: 1
- Balancing: 50:50
- Number of input neurons: 42
- Number of output neurons: 1
- Number of neurons in the hidden layer: 85
- Number of connections: 3655

The model quality and reliability can be evaluated by learning curve and the project histograms (Figure 73).

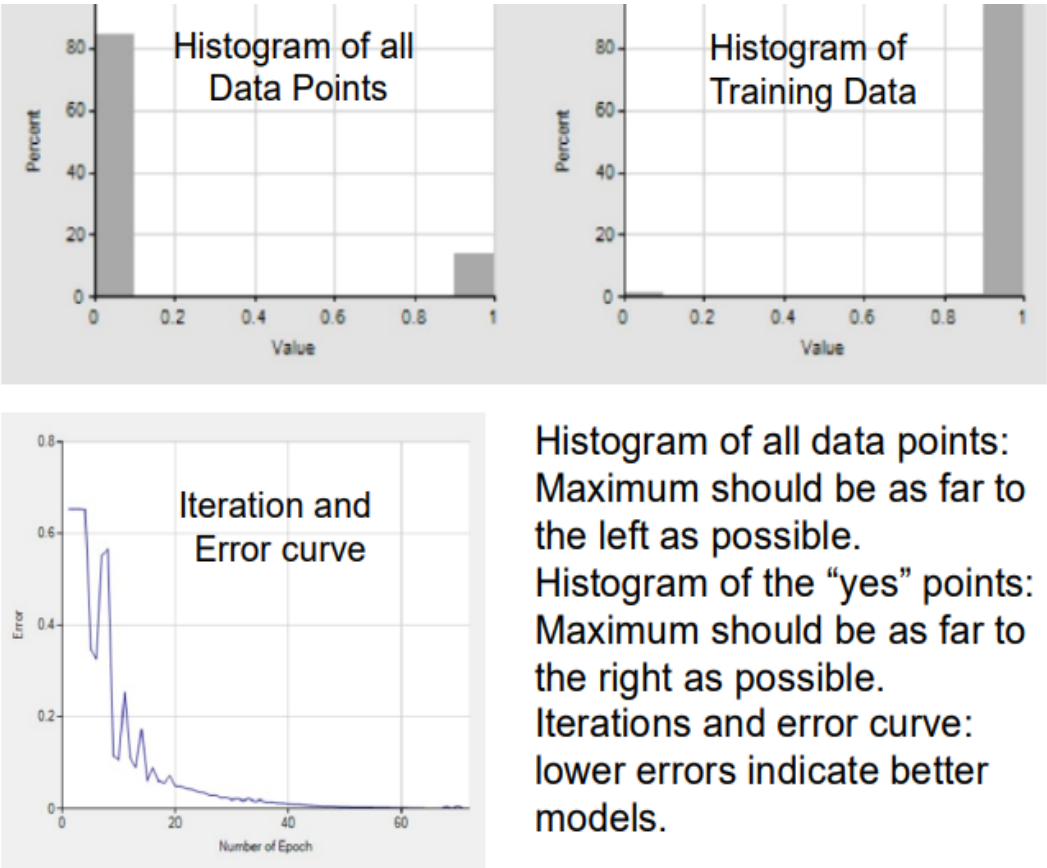


Figure 73: Important model #01 quality parameters

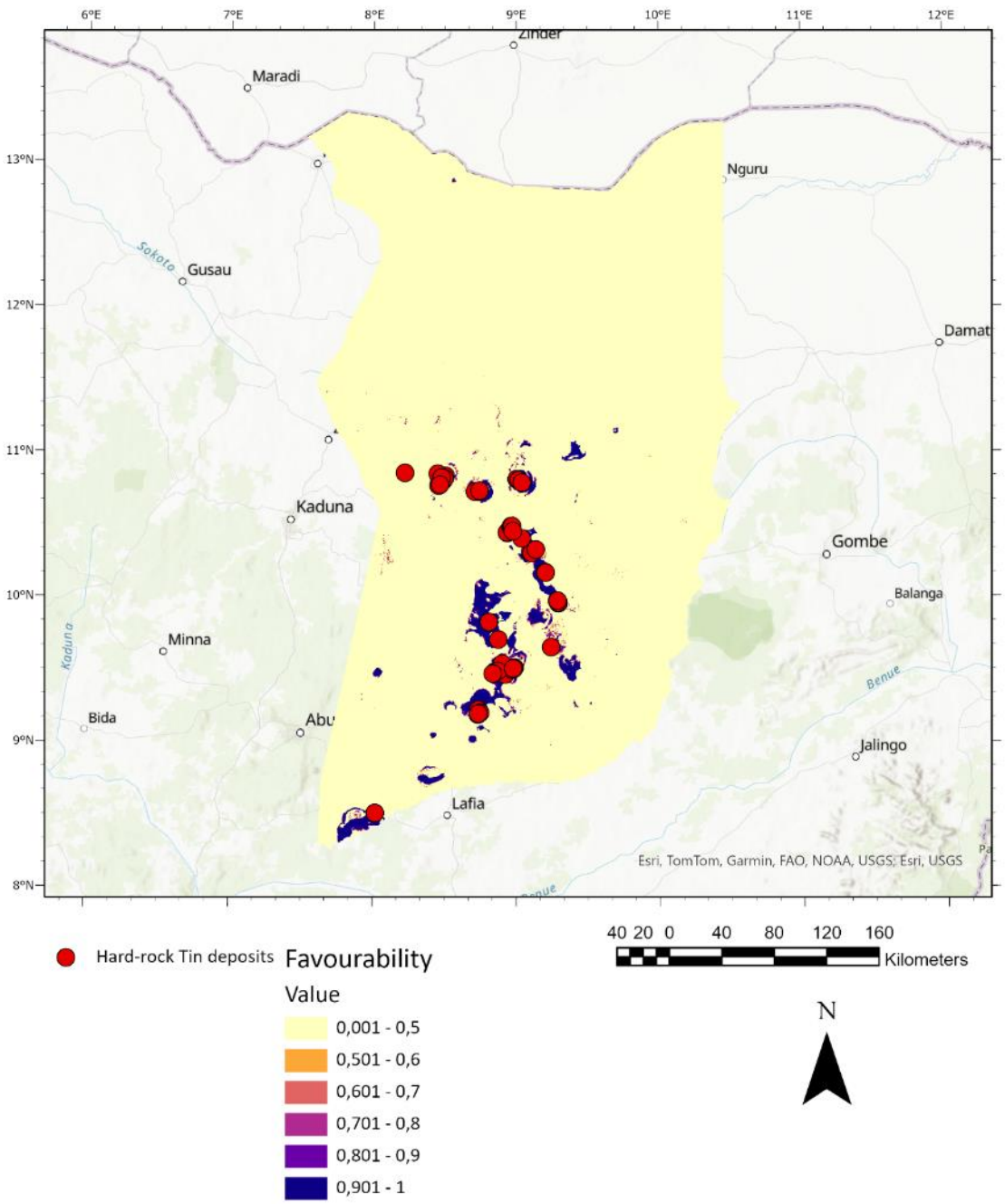


Figure 74: Favourability map for granite related Tin (Sn) – Nb (Nb).

6.2.2.2 Tin in Placer Deposits (file: Nigeria_Central_100m, model # 06)

For mineral potential mapping of gold in metamorphic belts the following frame conditions were applied:

- Model application area: The Central Domain and Transitional Tectonic Domain
- Mineral occurrence points: exact and verified locations of 303 Sn-Nb occurrences identified as placer deposits,

As controlling parameters for ANN calculations, derivatives of the following datasets have been used:

- Digital Elevation Model (DEM) of Nigeria datasets:
  - Slope of the DEM resolution 100 m,
  - Landform classification,
  - Topographic Position Index (TPI) resolution 300 m,
  - Stream paths

The following datasets have been created and used as input datasets:

- Training data: the respective Tin-occurrences have been buffered with a radius of 200 m creating circles of 400 m diameter simulating the area of the supposed mineralised area.

For the ANN model, the following parameters have been used:

- Number of iterations: 100
- Number of hidden layers: 1
- Balancing: 50:50
- Number of input neurons: 13

- Number of output neurons: 1
- Number of neurons in the hidden layer: 27
- Number of connections: 378

The model quality and reliability can be evaluated by learning curve and the project histograms (Figure 75). The “yes” point’s histogram shows a varied distribution possibly due to:

- Heterogeneous input data with possibly hard-rock deposits masked by sediments,
- Old placer deposits with a different genetic history.

With further data collection and database entries correction, the output of the ML algorithm with provide better results.

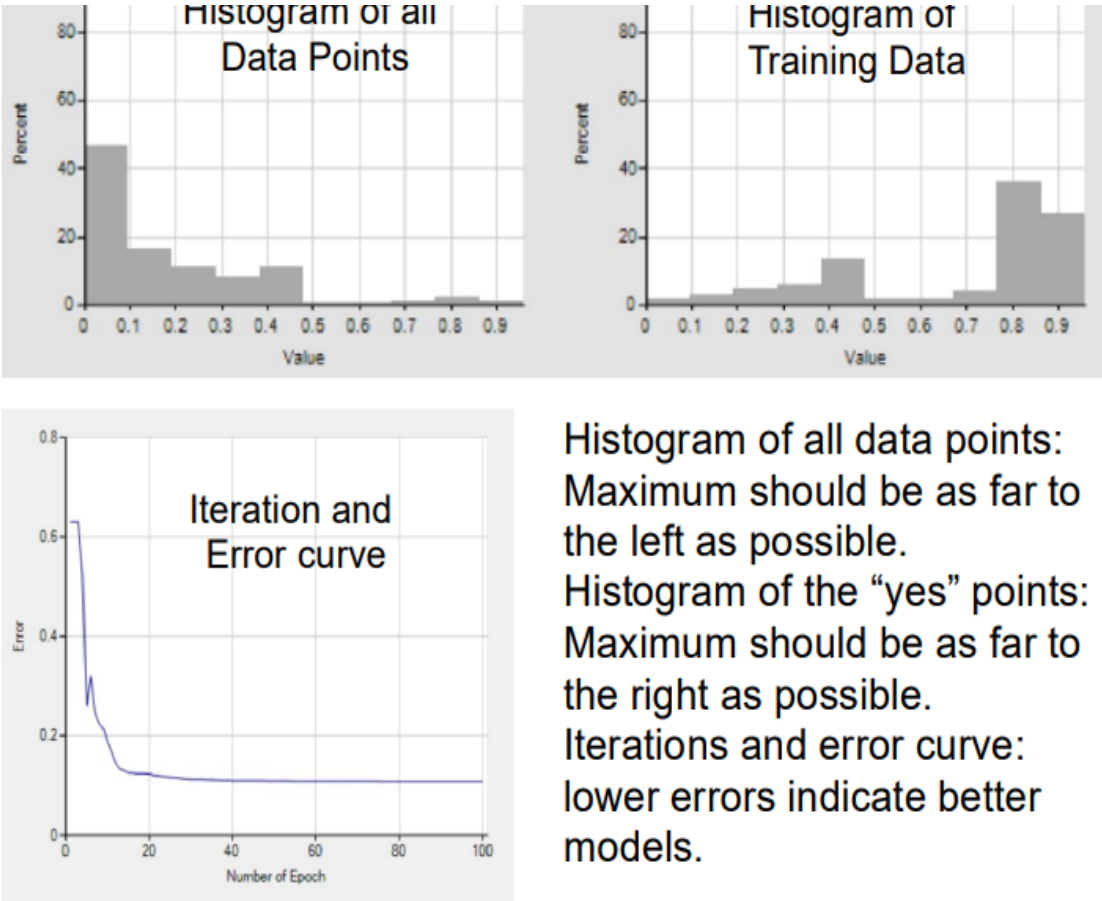


Figure 75: Important model #06 quality parameters

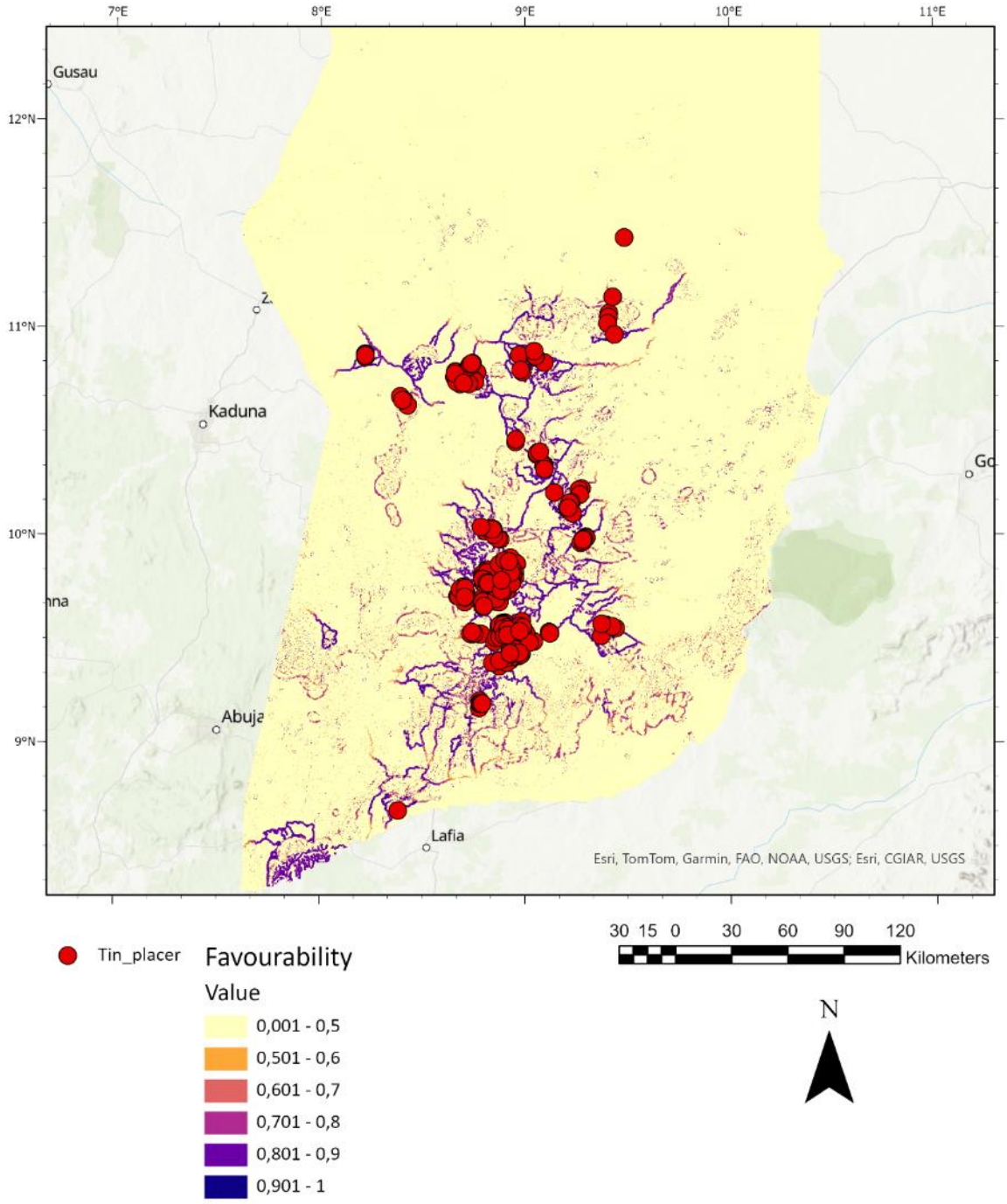


Figure 76: Favourability map for placer related Tin (Sn) – Nb (Nb).

6.2.3 Lithium (Li) – Tantalum (Ta) Pegmatites (file: Nigeria_LiTa, model # 08)

For mineral potential mapping of Lithium and Tantalum pegmatites the following frame conditions were applied:

- Model application area: Transitional Zone, Central and Western Basement Complex
- Mineral occurrence points: exact and verified locations of 192 Li-Ta occurrences only positioned in the Benue Trough

As controlling parameters for ANN calculations, derivatives of the following datasets have been used:

- Geological datasets → The litho-structural map of Nigeria (NGSA, 2022):
    - Shear zones (early and late)
    - Spectral classification of lithologies
    - Metamorphic rocks
- Geophysical datasets:
    - Processed airborne magnetic data (Fugro, 2009), resolution 125 m
    - Processed airborne radiometric data (Fugro, 2009), resolution 125 m

The following dataset have been created and used as input:

- Training data: the respective Lithium-Tantalum occurrences have been buffered with a radius of 200 m creating circles of 400 m diameter simulating the area of the supposed mineralised area.

For the ANN model, the following parameters have been used:

- Number of iterations: 100
- Number of hidden layers: 1

- Balancing: 50:50
- Number of input neurons: 23
- Number of output neurons: 1
- Number of neurons in the hidden layer: 67
- Number of connections: 1608

The model quality and reliability can be evaluated by learning curve and the project histograms (Figure 77).

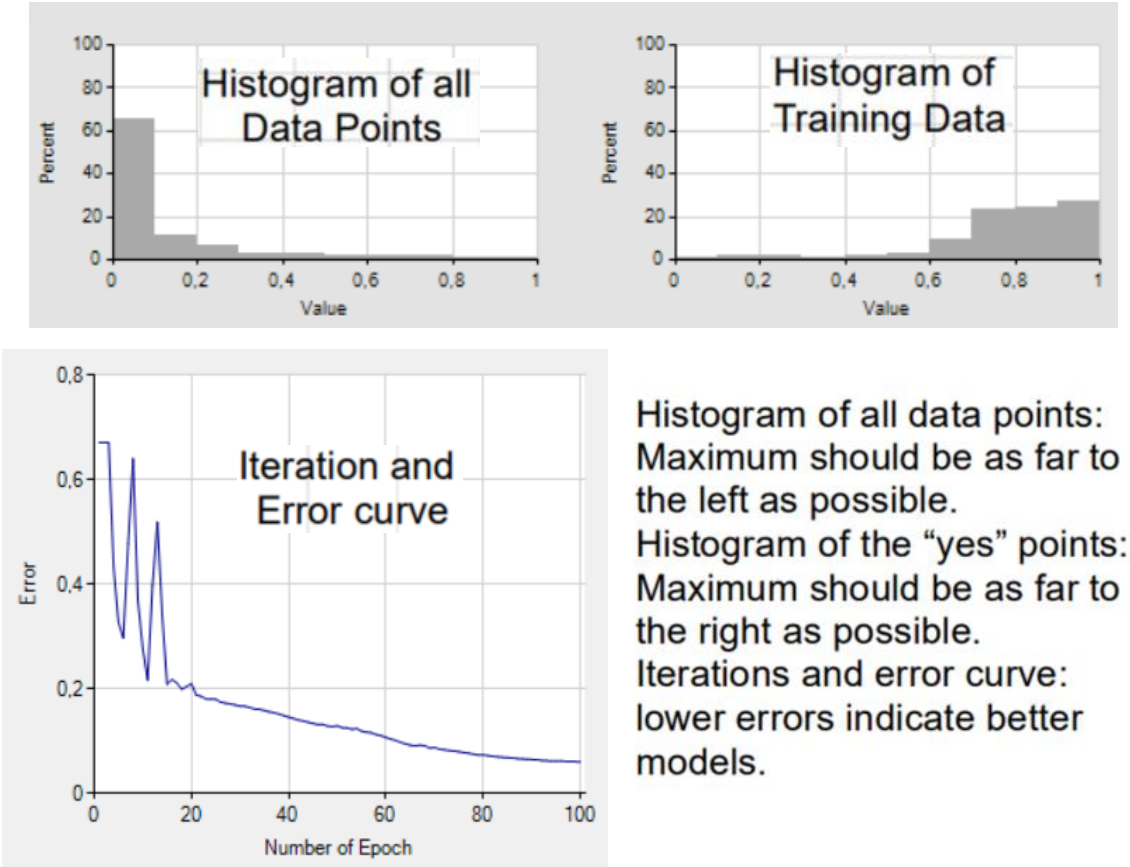


Figure 77: Important model #06 quality parameters.

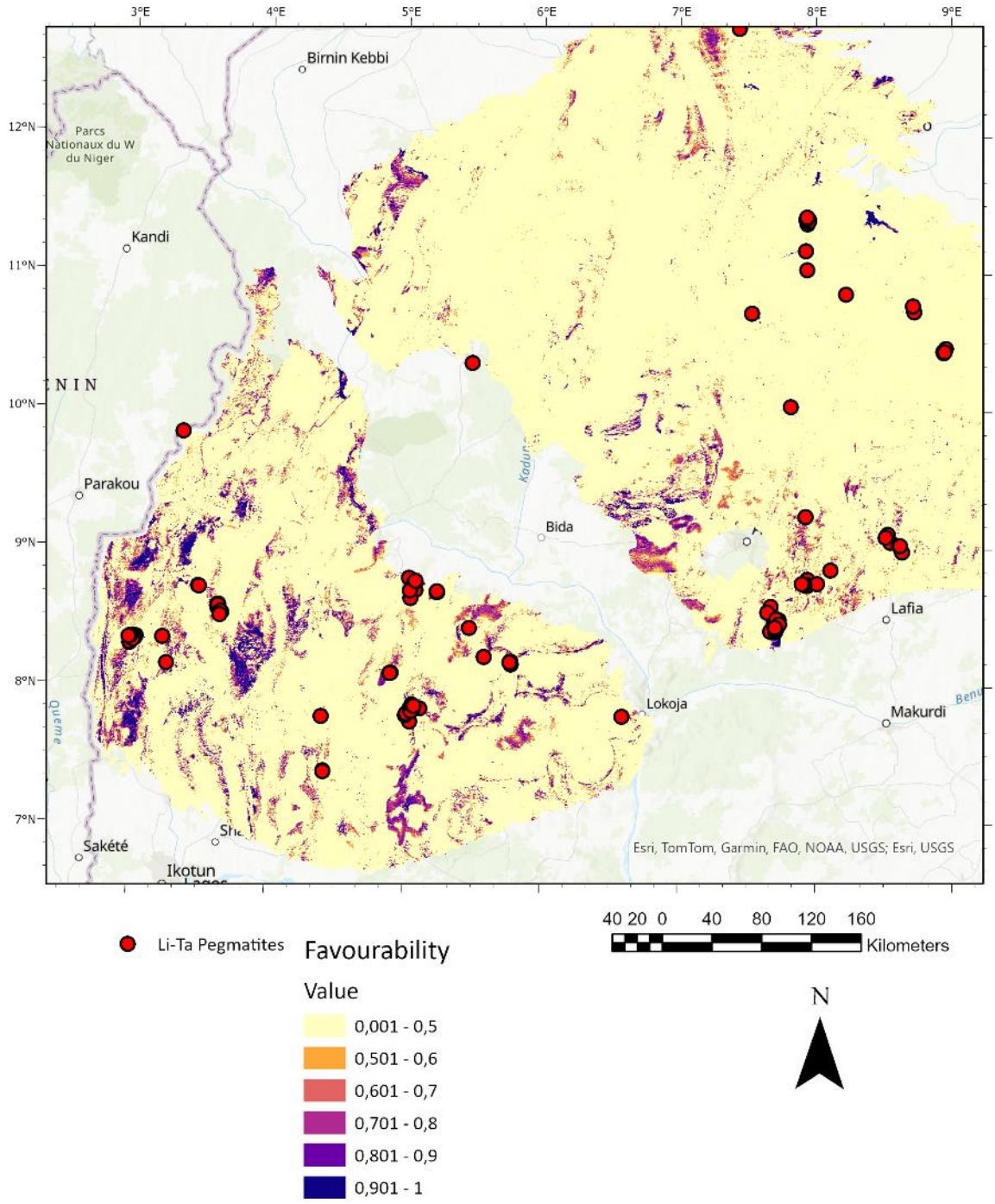


Figure 78: Favourability map for pegmatite related Lithium (Li) – Tantalum (Ta).

6.2.4 Lead (Pb) and Zinc (Zn) in the Benue Trough (file: Nigeria_Benue_100m, model # 02)

For mineral potential mapping of Lead and Zinc in the Benue Trough the following frame conditions were applied:

- Model application area: Benue Trough
- Mineral occurrence points: exact and verified locations of 192 Pb-Zn and barite occurrences only positioned in the Benue Trough

As controlling parameters for ANN calculations, derivatives of the following datasets have been used:

- Geological datasets (location and distance) → The Litho-structural map of Nigeria (NGSA, 2022):
  - Synclines,
  - Faults
- Interpreted structural data extracted from the available geology.
- Digitalized Benue basement slope and depth to basement (Benkhelil, Dainelli, Ponsard, Popoff, & Saugy, 1988).
- Geophysical datasets:
  - Processed airborne magnetic data (Fugro, 2009), resolution 125 m
  - Processed airborne radiometric data (Fugro, 2009), resolution 125 m
  - Processed airborne Bouguer gravity data (4.2), resolution 125 m

The following datasets have been created and used as input:

- Training data: the respective Pb/Zn-occurrences have been buffered with a radius of 200 m creating circles of 400 m diameter simulating the area of the supposed mineralised area.

For the ANN model, the following parameters have been used:

- Number of iterations: 100
- Number of hidden layers: 1
- Balancing: 50:50
- Number of input neurons: 34
- Number of output neurons: 1
- Number of neurons in the hidden layer: 69
- Number of connections: 2415

The model quality and reliability can be evaluated by learning curve and the project histograms (Figure 79).

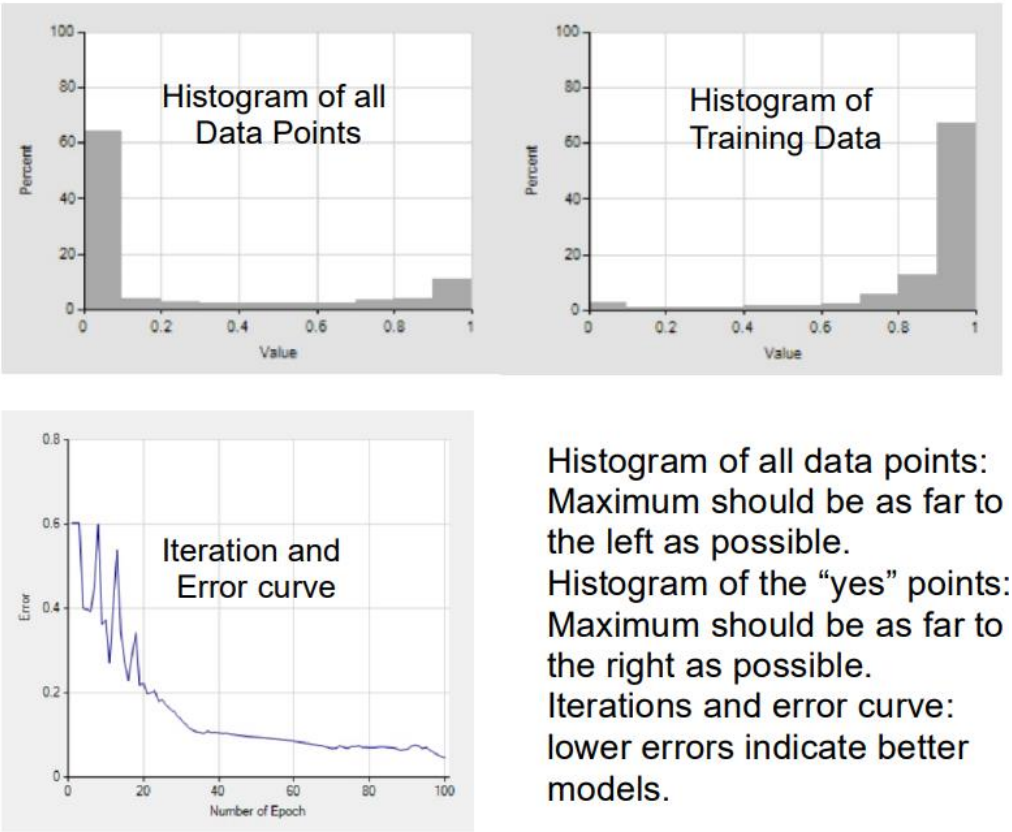


Figure 79: Important model #02 quality parameters.

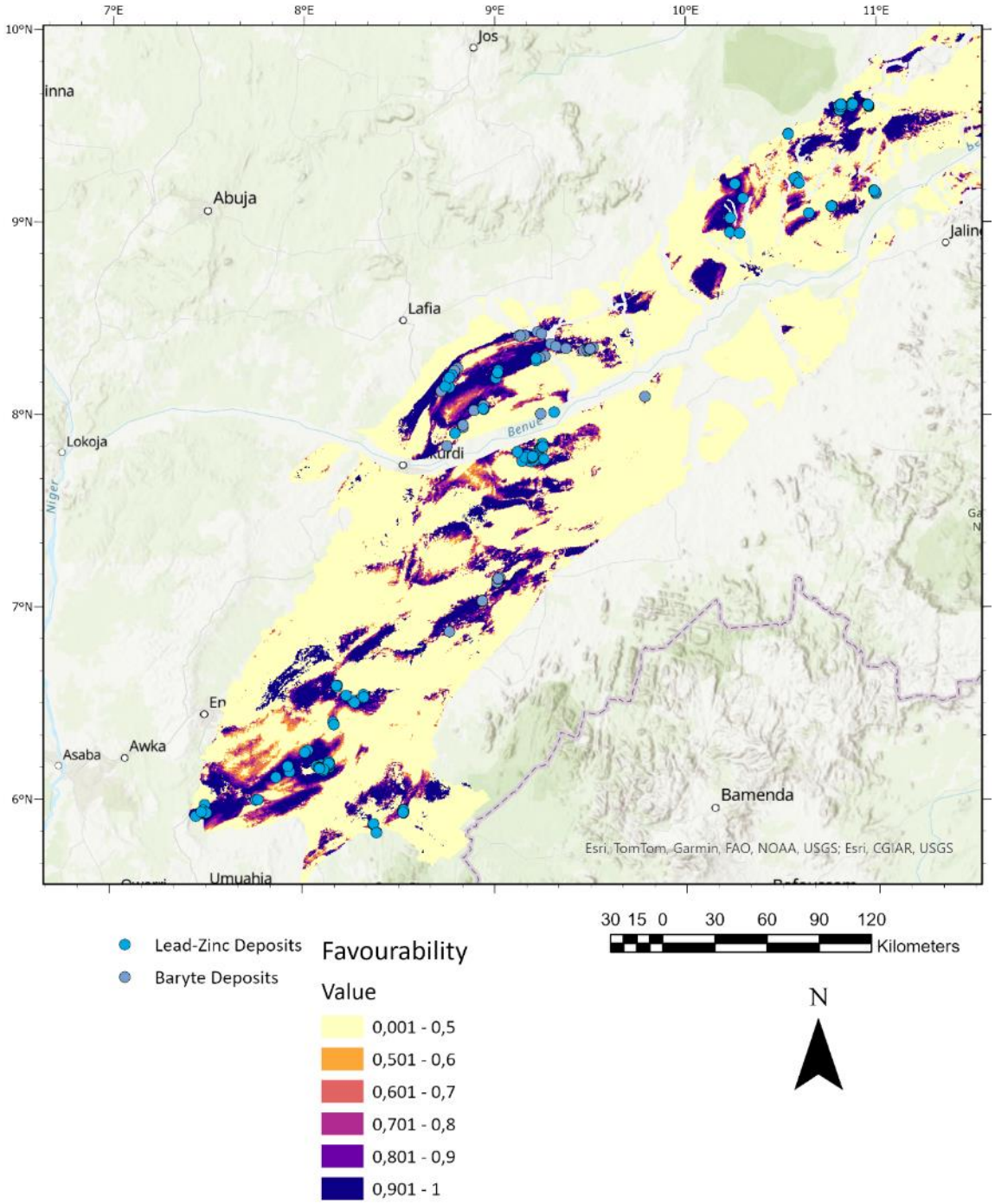


Figure 80: Favourability map for Pb-Zn (+/-barite) occurrences in the Benue Trough.

7. Target Selection and Ranking

For the selection of targets, specific criteria has been selected for each corresponding commodity to allow the identification of the most prospective areas. The two highest ranked targets for each group have been selected and further explained as key prospective areas. Nonetheless, the remaining targets are by no means less relevant and shall not be ignored, mainly ranking lower due to lack of knowledge. Further exploration is recommended to increase geological knowledge and de-risk the areas for interested parties.

7.1 Gold (Au) Targets

7.1.1 Ranking and Location

7.1.1.1 Criteria Catalogue

From the general Au Favourability Map (combination of Figure 68 and Figure 70), a selection of single targets was selected and recommended for further evaluation. This selection represents, to the current knowledge and understanding of the Consultant, the most prospective sites along with a set of typical cases within the target areas.

The selected target areas were ranked using the following catalogue of criteria:

- MPM shape and intensity:

MPM pattern and favourability value (FV)	Score
Compact pattern and FV > 0.9	5
Compact pattern and FV > 0.8	4
Compact pattern and FV > 0.7	3
Diffuse pattern and FV > 0.9	2
Diffuse pattern and FV > 0.8	1

- Within schist belt:

Within schist belt	Score
Yes	5
No	1

- Within ultramafic complex:

Within Ultramafic complex	Score
Yes	5
No	1

- Gold occurrences known:

Gold Occurrences known	Score
Yes	5
No	1

- Gold deposits being mined:

Gold deposits mined	Score
Yes	5
No	1

- Existence of placer deposits pinpointing to source:

Existence placer deposits	Score
Yes	5
Partially	3
No	1

- Contains cluster of deposits (e.g. from vein to stockwork deposit):

Cluster of deposits	Score
Yes	5
No	1

- Number of veins in the target:

Number of veins in the target	Score
More than > 15	5
Between 15 and 10	4
Between 10 and 6	3
Between 6 and 3	2
Less than 3	1

- Length of mayor identified vein:

Length of the major identified vein (m)	Score
More than 1000	5
Between 1000 and 500	4
Between 500 and 250	3
Between 250 and 60	2
Less than 60	1

- NIMEP data available (ground truth data):

NIMEP Data Available	Score
Yes	5
No	1

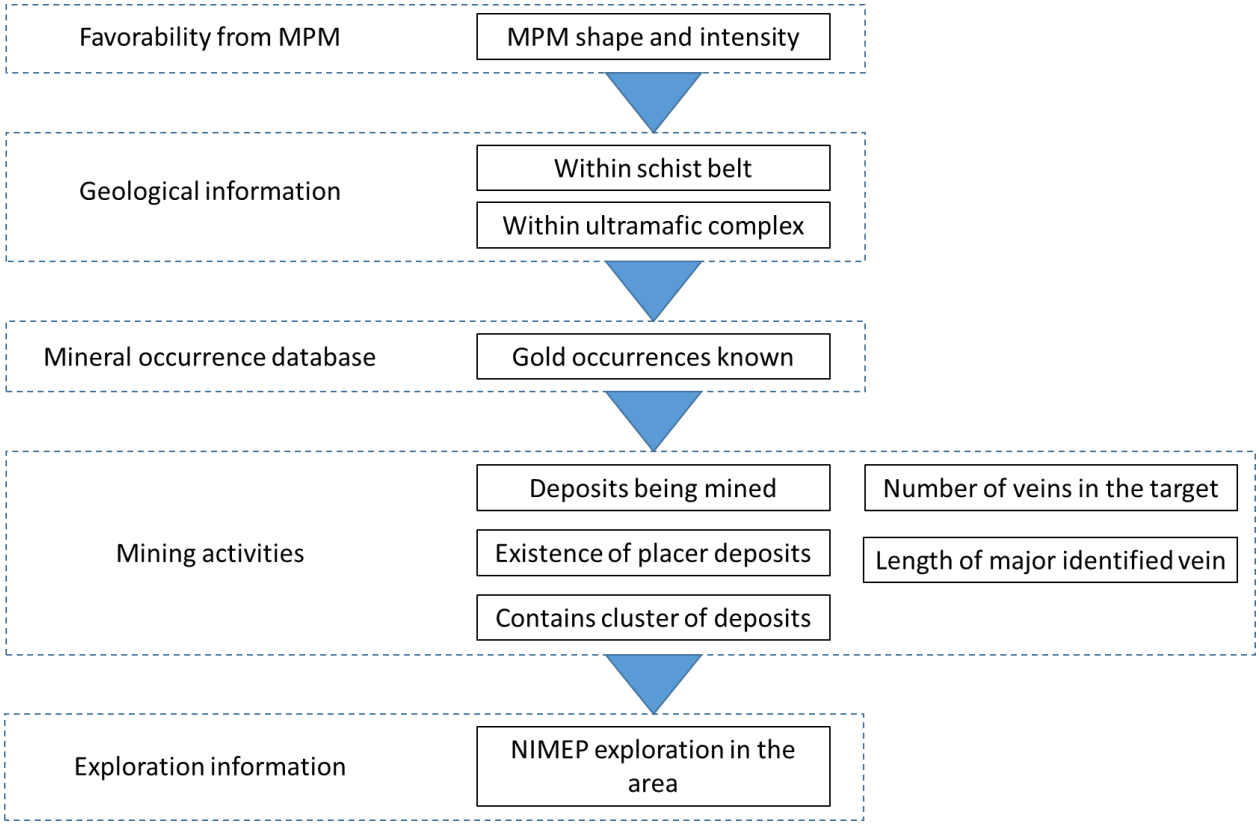


Figure 81: Criteria for the ranking of Au Targets.

7.1.1.2 Ranking and location of targets

The identified targets are located in different positions throughout the Benue Trough. Their ranking against the described criteria is in Table 14 and their spatial location is in Figure 82.

Table 10: The ranking of the Au targets

Criteria	Points per Criterium	Au Targets and their scoring per criterium								
		Au 1	Au 2	Au 3	Au 4	Au 5	Au 6	Au 7	Au 8	Au 9
MPM Shape and intensity										
Compact pattern above 0.9	5	5							5	5
Compact pattern and above 0.8	4		4		4					
Compact pattern and above 0.7	3			3						
Diffuse pattern and above 0.9	2					2	2			
Diffuse pattern and above 0.8	1							1		
Within schist belt?										
Yes	5	5	5	5	5	5	5	5		
No	1								1	1
Within ultramafic complex?										
Yes	5	5					5			
No	1		1	1	1	1		1	1	1
Gold occurrences known?										
Yes	5	5	5		5	5	5	5	5	5
No	1			1						
Gold currently being mined?										
Yes	5	5	5			5	5	5	5	5
No	1			1	1					
Existence of placer deposits pinpointing to source?										
Yes	5	5				5			5	
Partially	3		3	3						
No	1				1		1	1		1
Contains cluster of deposits?										
Yes	5	5	5		5		5		5	5
No	1			1		1		1		
Number of veins in the target										
>15	5	5	5						5	5
15-10	4					4				
10-6	3				3		3			
6-3	2									
<3	1			1				1		
Length of major identified vein (m)										
>1000	5		5			5		5		
500-1000	4						4		4	4
250-500	3	3								
60-250	2									
<60	1			1	1					
NIMEP Data Available?										
Yes	5	5	5							
No	1			1	1	1	1	1	1	1
Total Score										
Score		48	43	18	27	34	36	26	37	33
Rank										
Rank Order		1	2	5	5	4	3	5	3	3

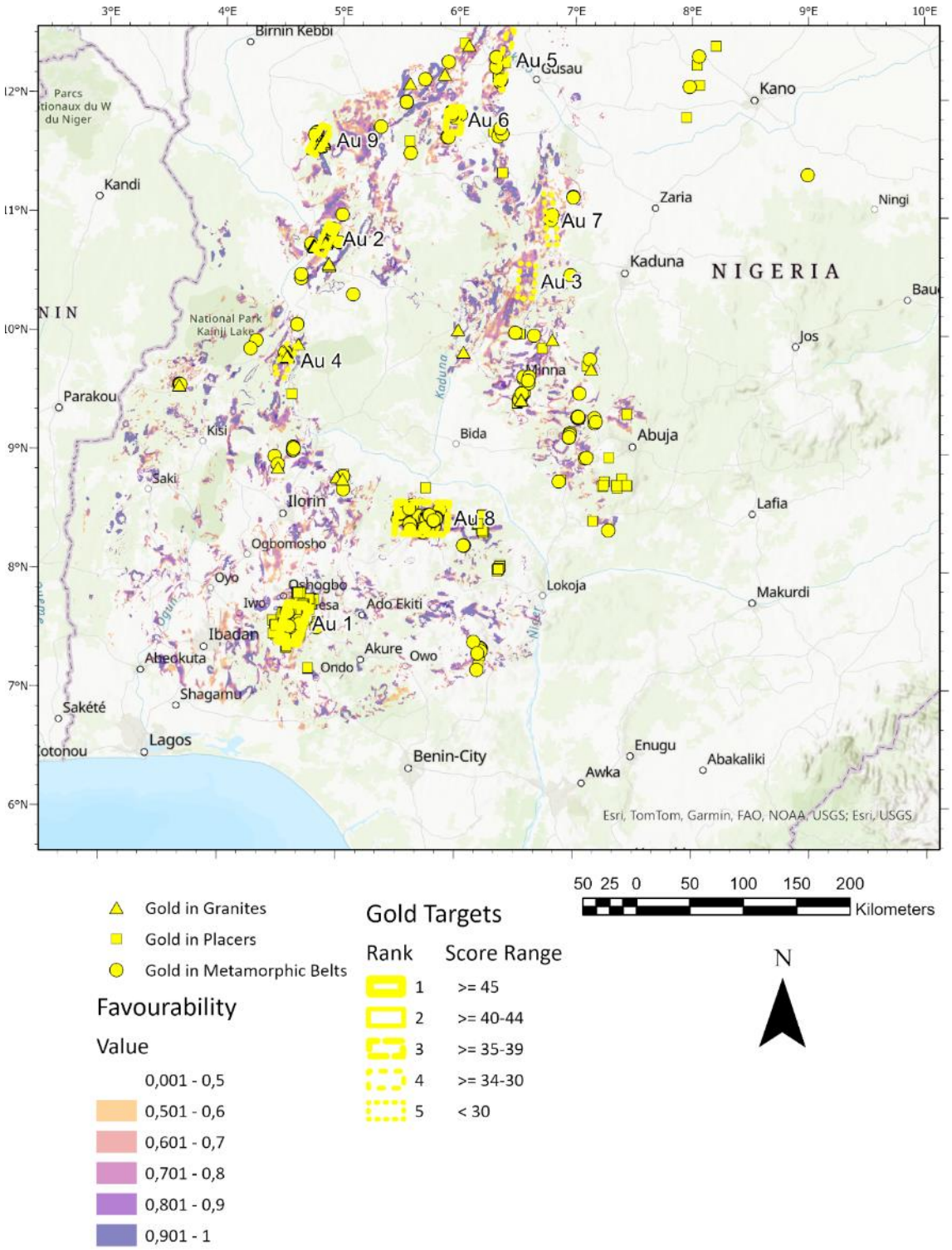


Figure 82: Location and ranking of selected targets for Gold (Au).

7.1.2 Description of single targets

Only the highest ranked Targets are selected and described more into detail. They are Target Gold 1 (Au 1: Ife-Ilesha), Target Gold 2 (Au 2: Kimu), and Target Gold 8 (Au 8: Pategi).

7.1.2.1 Target Gold 1

7.1.2.1.1 Summary

Located between the towns of Ilesha and Ife-Ife in Osun State, the target contains at least 17 known occurrences of Au, related to hydrothermal veins, and over 100 placer deposits, all hosted in Na and Ns rocks. Presently, all mining activities are artisanal and active. Favourability mapping suggests a diffuse shape with values exceeding 0.8. The total area of this target is 699.37 km^2.

7.1.2.1.2 Characterization of the target

7.1.2.1.2.1 Favourability

The favourability map shows a very diffuse overall shape with a total coverage of about 40%, composed of several smaller continuous profiles with values over 0.8 (Figure 86). Correlation is clear with hard-rock deposits and with some placer deposits.

7.1.2.1.2.2 History

Mining activities in the area are only observable on placer deposits starting sometime around 2016 with minor ravines or gullies affected. By the end of 2020, the impact in the area is evident extending to river valleys but has remained artisanal. By 2023, all major active sites are fully developed, however, no main source of the body (hard-rock) has been definitely reported.

7.1.2.1.2.3 Geological Setting

The target is located in the Ifewara Schist Belt part of a regional mobile belt crossing Nigeria from North to South. The rocks are composed of early- to mid-Neoproterozoic mafic to ultramafic gneisses interlayered with meta-volcanosediments including psammitic to

psammopelitic schists (Na) along with greenschist to amphibolite facies clastic and volcanic sequences (Ns) and within 4 major shear zones. Bordering to the West, migmatites and anatectic granites indicate the Archean to Paleoproterozoic (Neoproterozoic reworked) Western Basement Complex (Pmg).

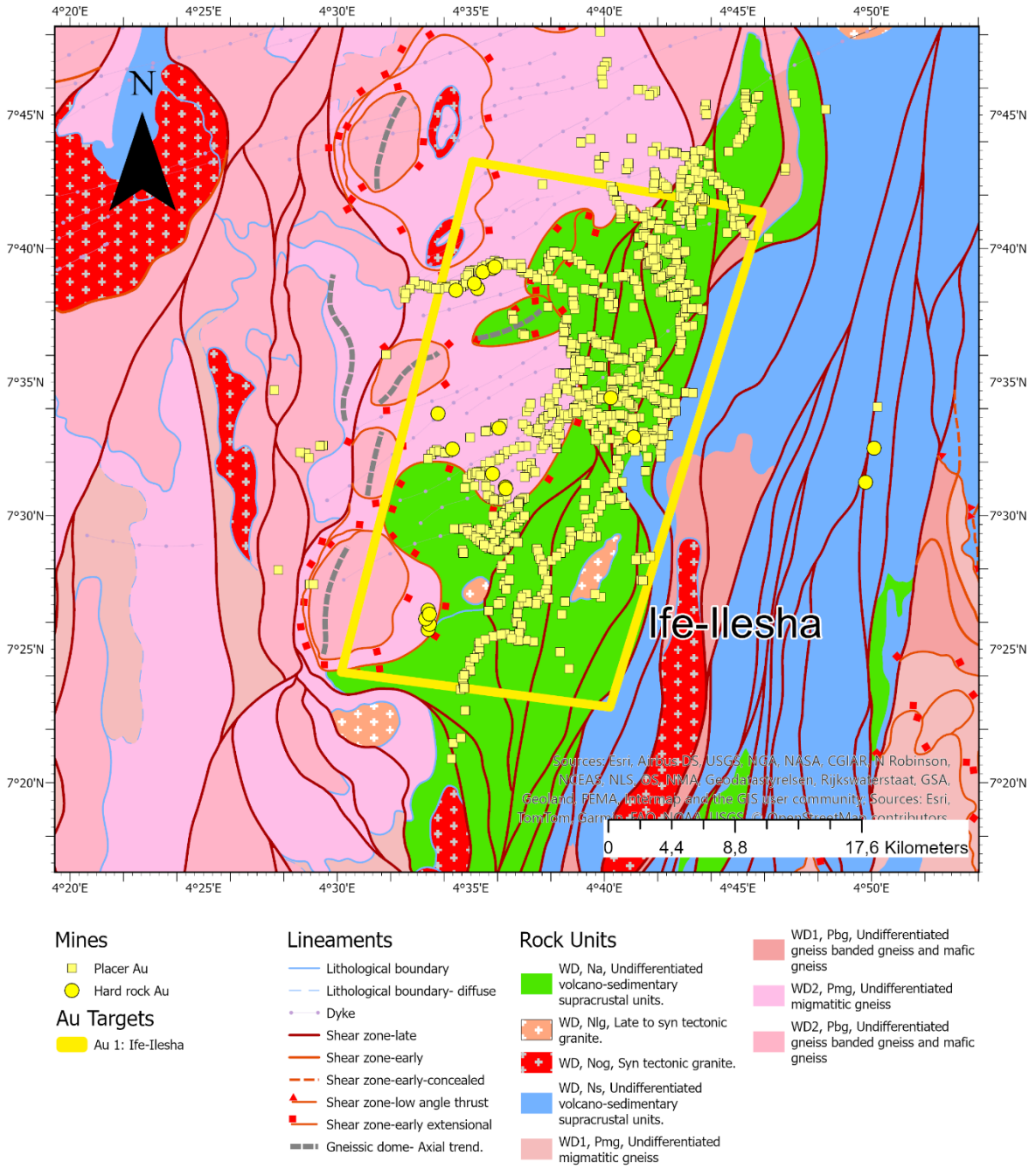


Figure 83: Geology for Gold Target 1 (Au 1: Ife-Ilesha).

7.1.2.1.2.4 Mineralization

The NIMEP project has identified several soil anomalies towards this areas with N-S to NNE-SSW trends. Au values are low suggesting the source is concealed. When compared with the RTP signal of the area, a series of anomalies can be correlated with the traced sources. Mineralization in the area is interpreted as hydrothermal veins with substantial amount of placer gold deposits (>100). Drainage pathways and DEM indicate the existence of nearby gold sources that may extend over the entire length of the proposed target area. The selected extent contains at least 17 known locations of hard-rock mineral occurrences divided into three main clusters.

- Mining is distributed on topographic lows like gullies, ravines and river valleys (Figure 85),
- All mining activities in the area are artisanal and remain active,
- Production in the area has been reported from 26 up to 123.319 ounces of gold.

7.1.2.1.2.5 Distribution of Mineral Tenements (MCO 11.2023)

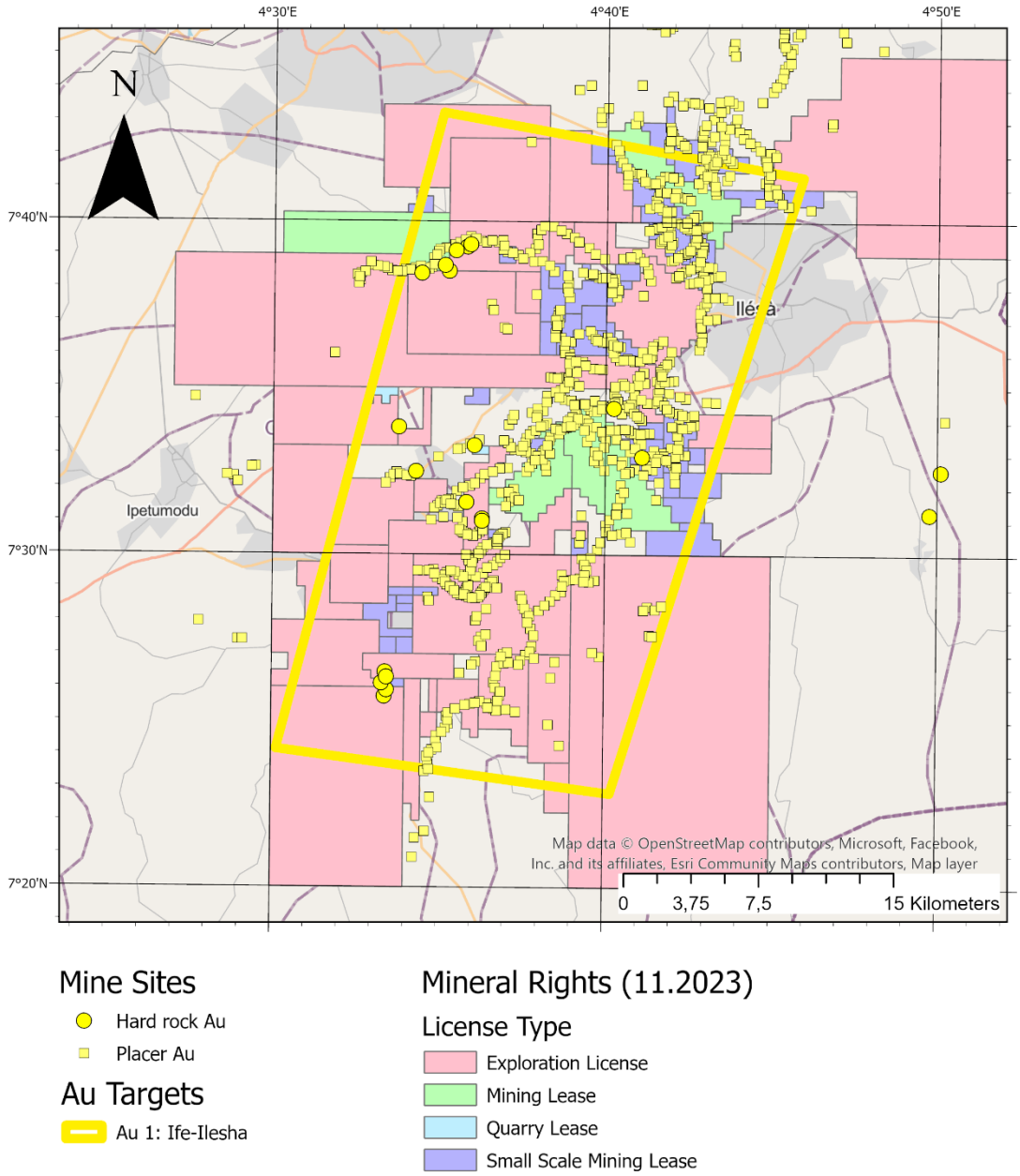


Figure 84: Distribution of Mineral Licenses in Gold Target 1 (Au 1: Ife-Ilesha).

7.1.2.1.3 Suggested prospective area

The area of about 40,71km^2 contains the following characteristics:

- Length of the main exploited valley: 3.000m
- Average width: 100m
- Number of occurrences: 2 hard-rock, >60 placer deposits
- Type of mining: artisanal
- Status: active

Figure 85: Target 1 area showing placer deposits surrounding a topographic high suggesting a concealed source (7°32'06"N 4°35'59"E).

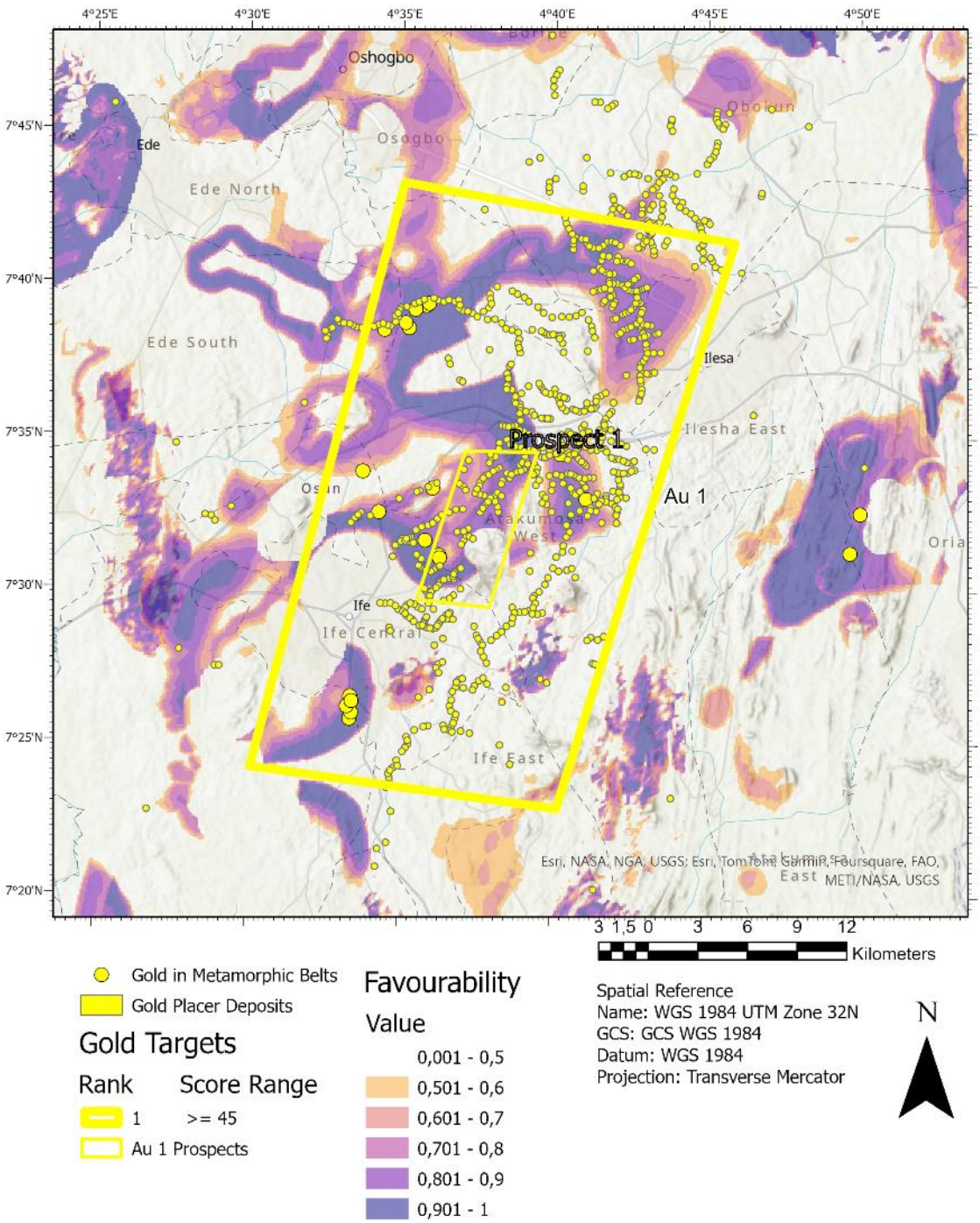


Figure 86: Favourability map for target Au 1.

7.1.2.2 Target Gold 2

7.1.2.2.1 Summary

Located close to Bin Yauri, Kebbi State, the target contains at least 101 active hard-rock deposits of Au of hydrothermal genesis within Ns and Nlg rocks. Presently, all mining activities are artisanal and active. Favourability mapping suggests a diffuse shape with values exceeding 0.8. The total area of this target is 287.47 km^2.

7.1.2.2.2 Characterization of the target

7.1.2.2.2.1 Favourability

The favourability map (superimposing favourability of gold in granites and metamorphic belts) shows a very compact overall shape with a total coverage of about 80% (Figure 91). Correlation is clear with hard-rock deposits.

7.1.2.2.2.2 History

Some sporadic mine trenches are visible in satellite imagery from 2009 followed by a rapid extension during 2017 and partial abandonment (seasonal reasons?). Peak activities are observed during 2022 after which pits remain active with some expansion towards the east.

7.1.2.2.2.3 Geological Setting

The target is located in the Upper Anka Shear zone part of a regional mobile belt crossing Nigeria in a NE-SW trend. The rocks are composed of early- to mid-Neoproterozoic greenschist to amphibolite facies clastic and volcanic sequences (Ns) and within 3 major shear structures and sandwiched between two Neoproterozoic to Cambrian late- to syn-tectonic granitoids including leucogranites, porphyritic granites and micro granites (Nlg).

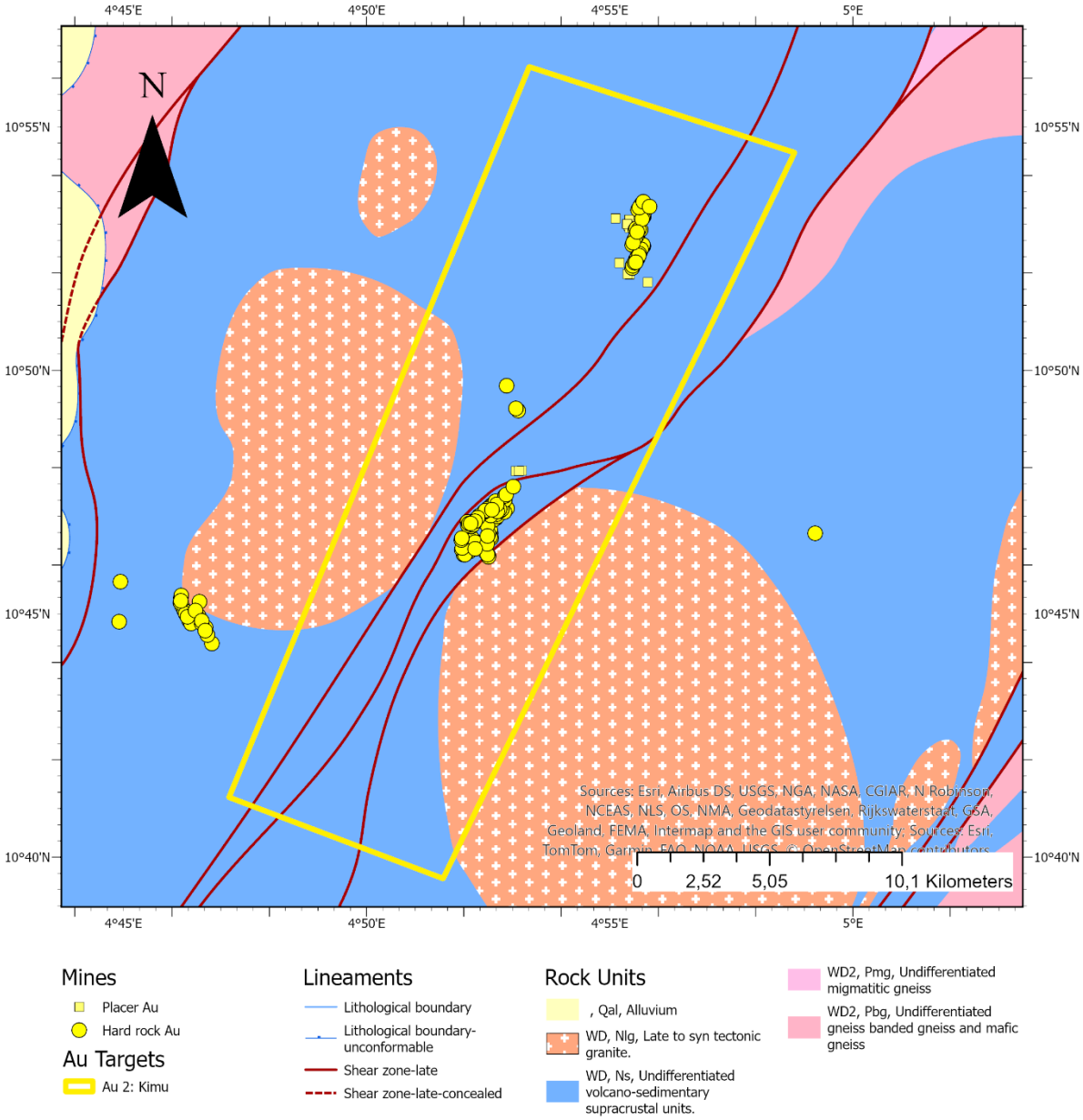


Figure 87: Geology for Gold Target 2 (Au 2: Kimu).

7.1.2.2.2.4 Mineralization

The NIMEP project indicated some close by area with up to 8 g/t along with ultramafic bodies. By means of the magnetic signal, the intrusives can be distinguished and several “pressure shadows” can be identified, possibly as a product of the regional shear and rotation of the inelastic behaviour of the granites. Mineralization in the area is interpreted as hydrothermal veins related with related diagenetic placer deposits. More than 101 active mines on veins and a number of placer deposit mines are documented in this target. The veins follow a SW-NE trend (Figure 89) and are grouped into two clusters, one of them with an approximate area of 10 km^2.

- Mining is mainly done on veins with a NE-SW trend (Figure 85),
- All mining activities in the area are artisanal and remain active,
- No production reports are available from this site.

7.1.2.2.2.5 Distribution of Mineral Tenements (MCO, 11.2023)

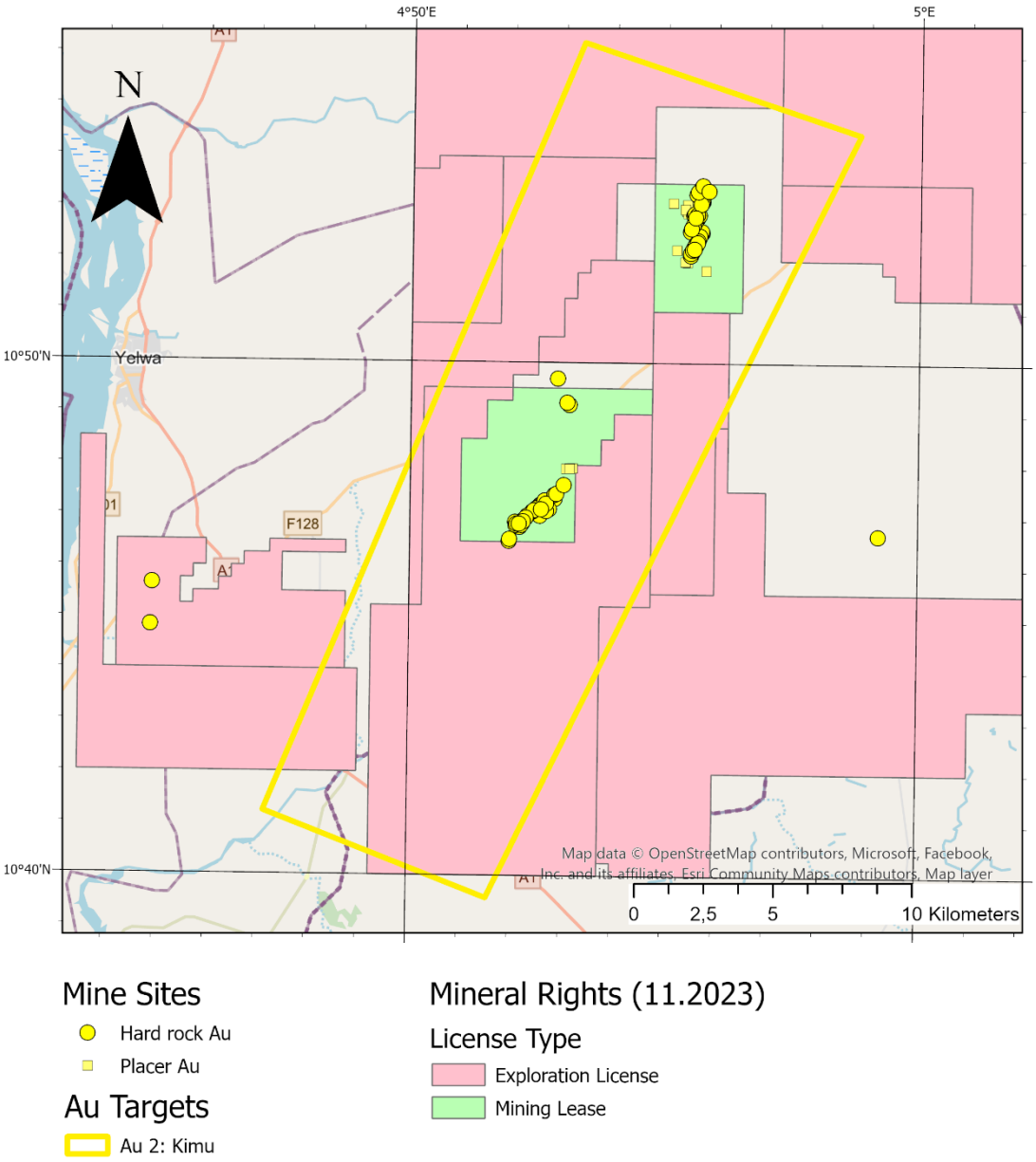


Figure 88: Distribution of Mineral Licenses in Gold Target 2 (Au 2: Kimu)

7.1.2.2.3 Suggested prospect areas

7.1.2.2.3.1 Prospect 1

The area of about 6,64km^2 contains the following characteristics:

- Length of the main structure: 1.200m
- Average width: 6m
- Thickness of cluster: 900m
- Number of occurrences: 36 hard-rock, 12 placer deposits
- Type of mining: artisanal
- Status: active

Figure 89: Hydrothermal vein deposits of target 2 with a SW-NE trend (10°46'52"N 4°52'6"E and 10°46'52"N 4°52'6"E). Image taken from Google Earth.

7.1.2.2.3.2 Prospect 2

The area of about 6,20km^2 contains the following characteristics:

- Length of the main structure: 900m
- Average width: 5m
- Thickness of cluster: 600m
- Number of occurrences: 65 hard-rock, 2 placer deposits
- Type of mining: artisanal
- Status: active

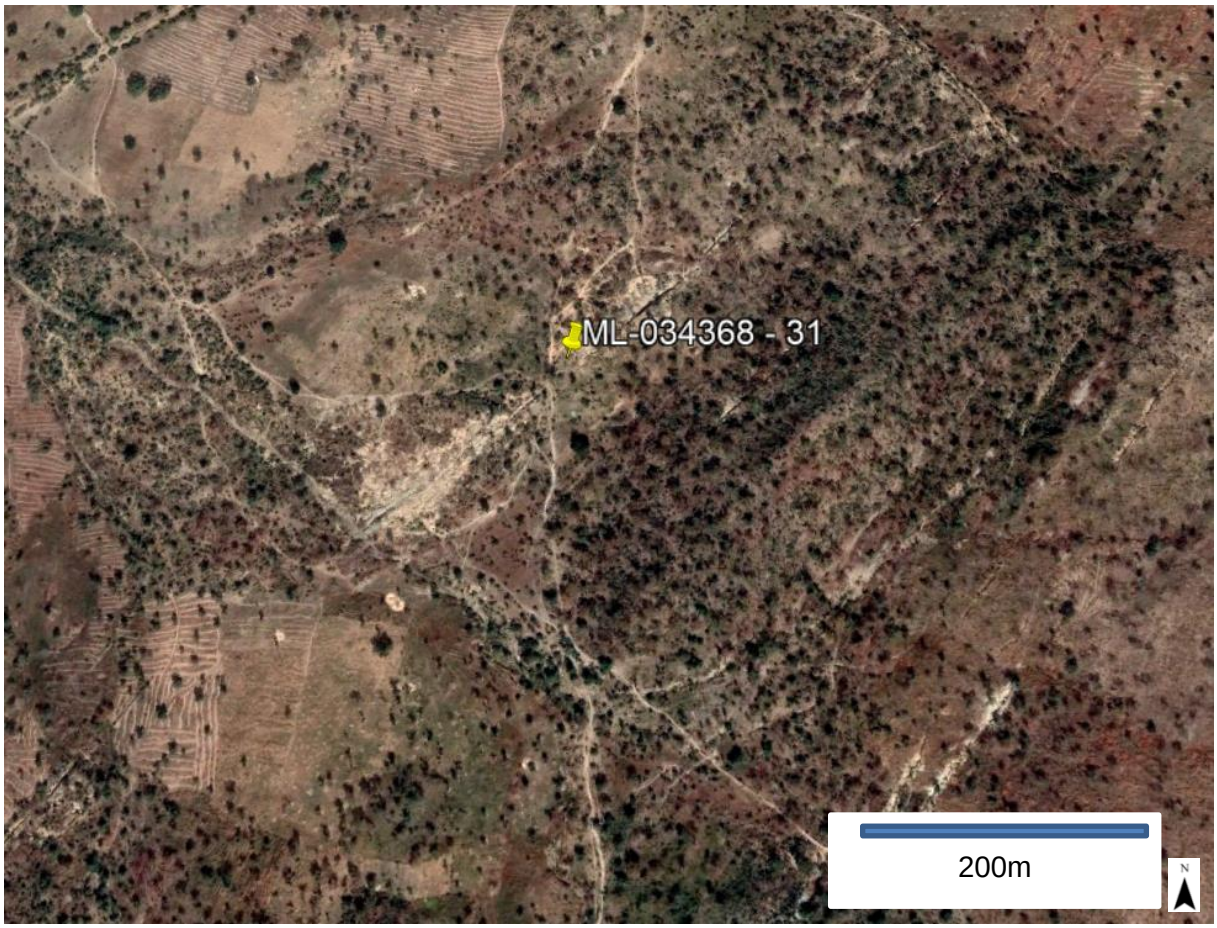


Figure 90: Hydrothermal vein deposits of target 2 with a SW-NE trend (10°47'10"N 4°52'30"E). Image taken from Google Earth.

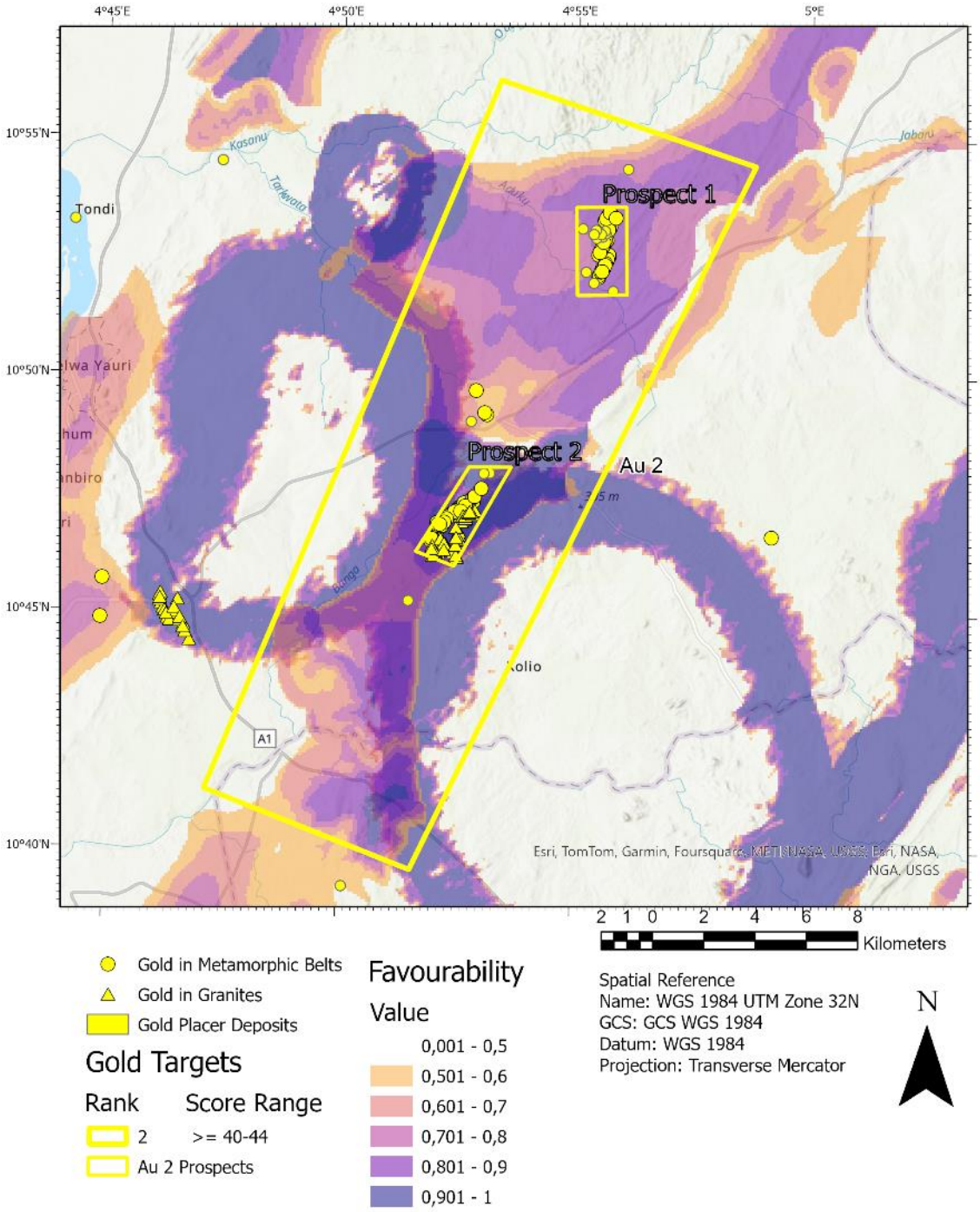


Figure 91: Favourability map for target Au 2.

7.1.2.3 Target Gold 3

7.1.2.3.1 Summary

Located close to Kusheriki in Niger State, the target is devoid of any documented hard-rock mineral occurrences and only contains 2 placer deposits, all hosted in Ns and close to Nog rocks. Favourability mapping suggests a diffuse shape with values exceeding 0.8 highlighting significant potential for further exploration and development. The total area of this target is 482.37 km^2.

7.1.2.3.2 Characterization of the target

7.1.2.3.2.1 Favourability

The favourability map (superimposing favourability of gold in granites and metamorphic belts) shows an intermediate between compact and diffuse shape with values averaging 0.7, with some cases reaching to 0.97, and covering up to 80% of the whole area (Figure 93).

7.1.2.3.2.2 History

Currently, there are only exploration licenses without any main area of mining and no main work area, suggesting it remains underexplored and with potential.

7.1.2.3.2.3 Geological Setting

The target is located in the Ifewara - Birnin Wari Shear Zone part of a regional mobile belt crossing Nigeria from North to South in a NNE-SSW trend. The rocks are composed of early- to mid-Neoproterozoic greenschist to amphibolite facies clastic and volcanic sequences (Ns) and lie within 3 major shear structures. Sandwiched between, Neoproterozoic to Cambrian syn-tectonic granitic plutons and batholiths (Nog) are mapped. Partial coverage of geochemistry throws high values of Barium (ca. 1250 ppm) linked with hydrothermal ore veins. These anomalies can be correlated with the response found in the Radiometric Potassium and aligns well with the DEM of the area suggesting two dilational jogs product of the shear zone and allowing the emplacement of the Older Granites.

7.1.2.3.2.4 Mineralization

Mineralization in the area has only been identified as diagenetic placer deposits. Drainage pathways and DEM indicate the existence of nearby gold sources. The selected extent contains only 2 known locations of placer deposits. Mining activities are rather recent and only observable starting 2023.

- the area is devoid of known hard-rock gold mining, however two gold placer deposits occur in the neighbourhood,
- Further study of the satellite imagery and with values over 0.65, undocumented mining activities were spotted (Figure 92),
- All current types of licenses are exploration.

Figure 92: Undocumented hard-rock mining activity with MPM above 0.65 (10°20'36"N 6°30'24"E). Image taken from Google Earth.

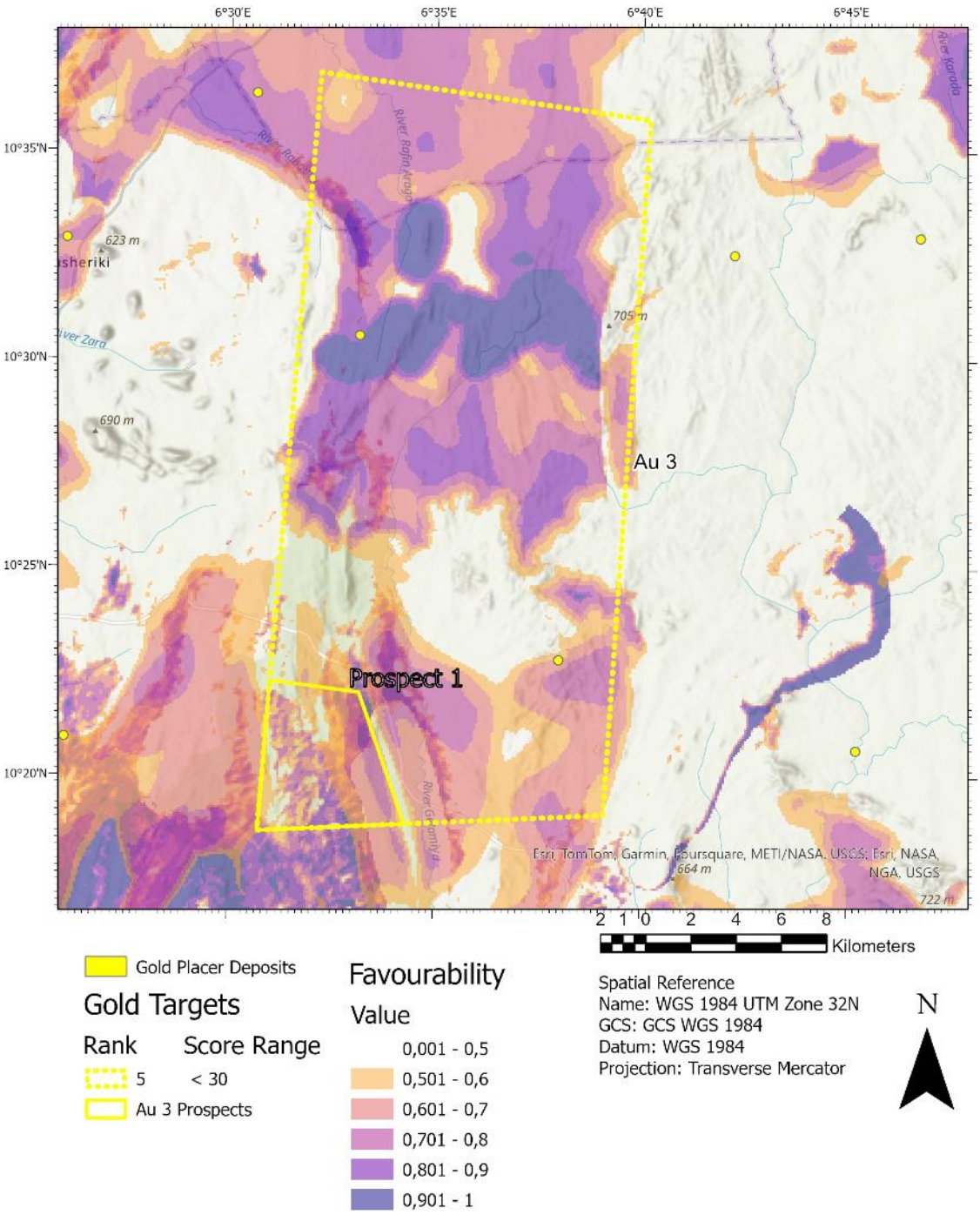


Figure 93: Favourability map for target Au 3.

7.1.2.4 Target Gold 4

7.1.2.4.1 Summary

Located to the southeast of New Bussa, Niger State, the target contains at least 27 active hard-rock deposits of Au of hydrothermal genesis within Ns and Nlg rocks. Presently, all mining activities are artisanal and active under a mining lease. Favourability mapping suggests a compact and continuous shape with values exceeding 0.8. The total area of this target is 333.34 km^2.

7.1.2.4.2 Characterization of the target

7.1.2.4.2.1 Favourability

The favourability map (superimposing favourability of gold in granites and metamorphic belts) shows a very compact and continuous shape with values above 0.8 with a total coverage of about 90% (Figure 95). Correlation is clear with hard-rock deposits.

7.1.2.4.2.2 History

Activities in the area only started around 2012 with two mall pits of no more than 80m. Imagery from 2016 indicates additional activities to the NW but seem all but active. Only towards 2019, activities picked up pace with several additional workings following the trend of the initial pits.

7.1.2.4.2.3 Geological Setting

The target is located in the south-east of the Anka Shear Zone part of a regional mobile belt crossing Nigeria in a NE-SW trend. The rocks are composed of early- to mid-Neoproterozoic greenschist to amphibolite facies clastic and volcanic sequences (Ns) along Neoproterozoic to Cambrian late- to syn-tectonic granitoids including leucogranites, porphyritic granites and micro granites (Nlg) and syn-tectonic granitic plutons and batholiths (Nog). Magnetic signal in the area suggests some bodies trending NW-SE that suggest a control on mineral occurrences.

7.1.2.4.2.4 Mineralization

Mineralization in the area is interpreted as hydrothermal veins relating both to granites and metamorphic belts trending NW-SE, along with related diagenetic placer deposits. A total of 27 hydrothermal veins and 2 placer deposits are documented in the area. The veins follow a NW-SE trend (Figure 94) grouped into one main clusters with an area of 12 km^2.

- Mining is mainly done on veins with a NE-SW trend (Figure 85),
- All mining activities in the area are artisanal and remain active,
- No production reports are available from this site.

7.1.2.4.3 Prospect area

The area of interest of 13,22km^2 contains the following characteristics:

- Length of the main structure: 600m
- Average width: 10m
- Thickness of cluster: 200m
- Number of occurrences: 27 hard-rock, 2 placer deposits
- Type of mining: artisanal
- Status: active

The current mining license in the area has the following data:

	ML-017414

Company Name (after MCO)	Sunrise Minerals Ltd
Type of License	Mining Lease
Expiry date	2041
Commodities	Gold

Figure 94: Target area number 4 indicating several pits aligned NW-SE in a length of at least 7 km (9°49'29"N 4°32'34"E). Image taken from Google Earth.

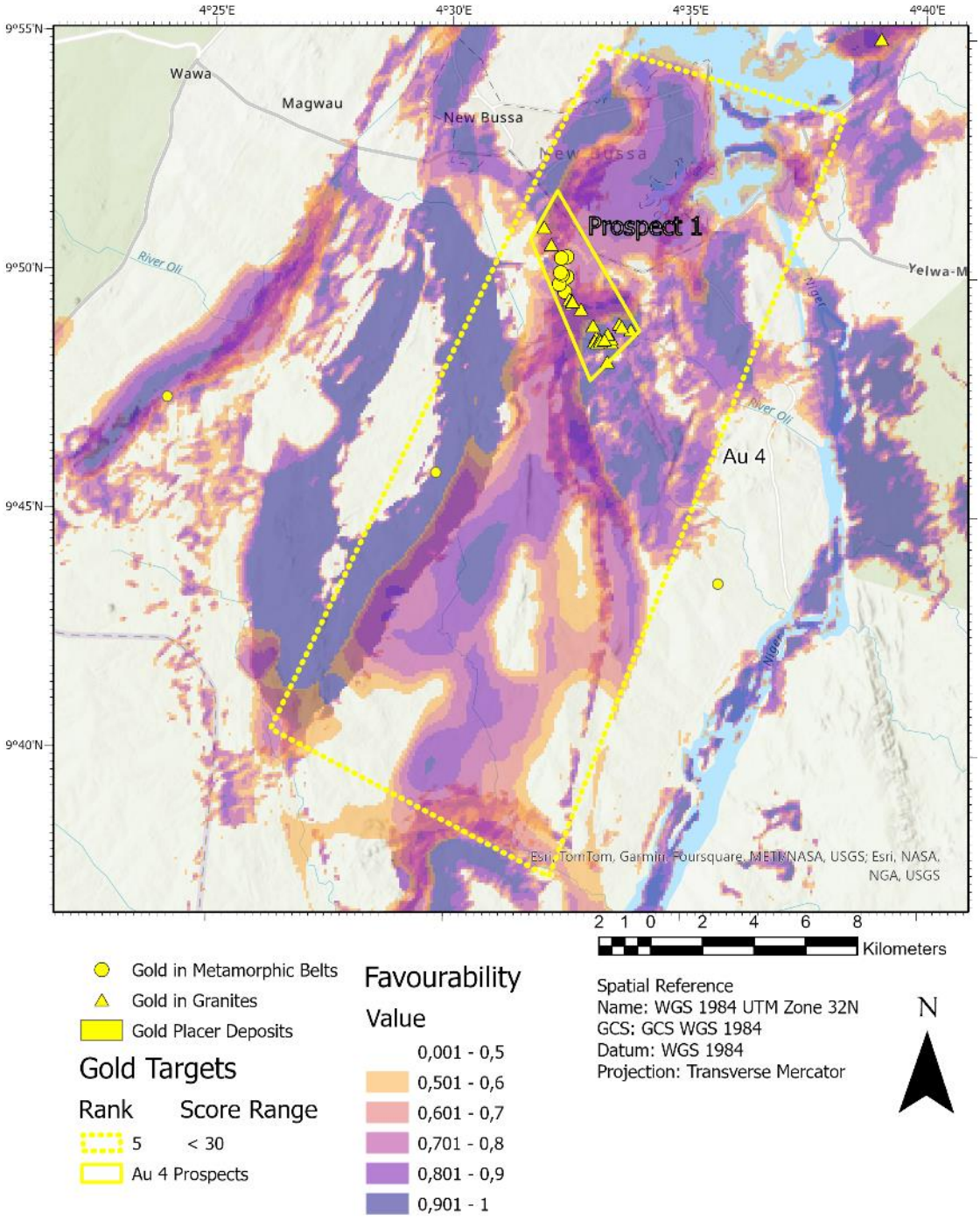


Figure 95: Favourability map for target Au 4.

7.1.2.5 Target Gold 5

7.1.2.5.1 Summary

Located north of Dogon Daji, Zamfara State, the target contains at least 21 active hard-rock deposits of Au of hydrothermal genesis hosted on Ns rocks. Presently, all mining activities are artisanal and active, and are partially covered by a mining lease. Favourability mapping suggests a compact continuous shape shapes with values exceeding 0.8. The total area of this target is 410.25 km2.

7.1.2.5.2 Characterization of the target

7.1.2.5.2.1 Favourability

The favourability map (superimposing favourability of gold in granites and metamorphic belts) shows a sectioned map with 4 compact shapes (with values above 0.8) covering a total of 70% of the target (Figure 97). Relative good correlation with documented hard-rock deposits.

7.1.2.5.2.2 History

Activities in the area only started around 2012 with two mall pits of no more than 80m. Imagery from 2016 indicates additional activities to the NW but seem all but active. Only towards 2019, activities picked up pace with several additional workings following the trend of the initial pits.

7.1.2.5.2.3 Geological Setting

The target is located in the northern part of the Anka Shear Zone part of a regional mobile belt crossing Nigeria in a NE-SW trend. The rocks are composed almost exclusively of early- to mid-Neoproterozoic greenschist to amphibolite facies clastic and volcanic sequences (Ns) with small intrusions of Neoproterozoic to Cambrian syn-tectonic granitic plutons and batholiths (Nog). Magnetic signal in the area indicates a continuous structure trending NE-SW following the local geology.

7.1.2.5.2.4 Mineralization

Mineralization in the area is interpreted as hydrothermal veins related to metamorphic belts trending NE-SW and structurally/geologically controlled. A total of 21 hydrothermal veins are documented in the area. The veins follow a NW-SE trend (Figure 94) grouped into one main cluster with an area of 0,77 km^2 within a topographic low.

- Mining is mainly done on veins with a NE-SW trend (Figure 96),
- All mining activities in the area are artisanal and remain active,
- No production reports are available from this site.

7.1.2.5.3 Prospect area

The area of interest of 4,20km^2 contains the following characteristics:

- Length of the main structure: 1.700m
- Average width: 5m
- Thickness of cluster: 250m
- Number of occurrences: 21 hard-rock, 3 placer deposits
- Type of mining: artisanal
- Status: active

The current mining license in the area has the following data:

	ML-024062
Company Name (after MCO)	Shinkafi Investment Ltd
Type of License	Mining Lease
Expiry date	2042
Commodities	Gold

Figure 96: Gold-hosting hydrothermal veins in target 5 following the bedding in the area (12°08'38"N 6°20'50"E). Image taken from Google Earth.

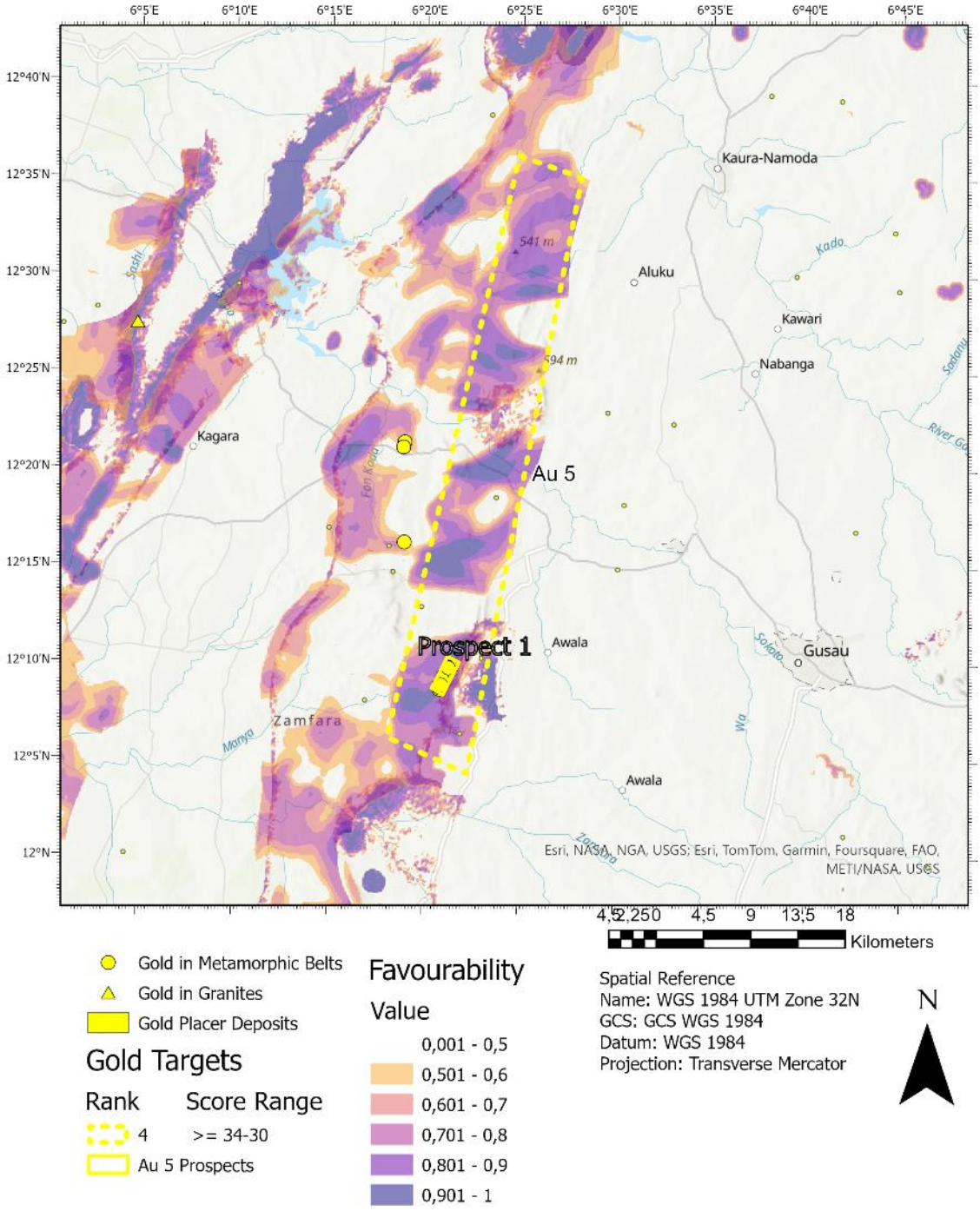


Figure 97: Favourability map for target Au 5.

7.1.2.6 Target Gold 6

7.1.2.6.1 Summary

Located west of Bagega town, Zamfara State, the target contains at least 15 active hard-rock deposits of Au of hydrothermal genesis hosted on Ns rocks. Presently, all mining activities are artisanal and active following an N-S mineralization trend, and are covered by a mining lease. Favourability mapping indicates a continuous shape with values averaging 0.7 on three main spots. The total area of this target is 334.95 km2.

7.1.2.6.2 Characterization of the target

7.1.2.6.2.1 Favourability

The favourability map (superimposing favourability of gold in granites and metamorphic belts) shows 3 compact shapes (with average values above 0.7) covering a total of 50% of the target (Figure 99), and showing relative good correlation with all but one documented hard-rock deposits.

7.1.2.6.2.2 History

Mining in the area seem to have only commenced sometime during 2011 with a small cluster of artisanal pits to the north of the target. The sites seem to have been abandoned and only until 2023 renewed events are perceptible again, with 3 main trenches (one up to 100m) aimed to understand the spatial thickness of the local mining cluster. From images of 2019, it is evident the exploration in the area expanded dramatically including at least two new mining areas (around 1 km away from the original site) and more than 15 new trenches. Recent imagery (2023) and valid mining leases indicate that mining has expanded both north and south following the local geology.

7.1.2.6.2.3 Geological Setting

The target is located in the northern part of the Anka Shear Zone part of a regional mobile belt crossing Nigeria in a NE-SW trend. The rocks are composed almost exclusively of early- to

mid-Neoproterozoic greenschist to amphibolite facies clastic and volcanic sequences (Ns) with small intrusions of Neoproterozoic to Cambrian syn-tectonic granitic plutons and batholiths (Nog) and bordered to the right by migmatites and anatectic granites indicate the Archean to Paleoproterozoic (Neoproterozoic reworked) Western Basement Complex (Pmg). Three main late shear planes run N-S through the target that correlate perfectly with the magnetic signal.

7.1.2.6.2.4 Mineralization

Mineralization in the area is interpreted as hydrothermal veins related to metamorphic belts. Due to the distribution of the sites, a stockwork deposit may be suggested. A total of 15 hydrothermal veins are documented in the area. The principal direction of the veins is N-S structurally/geologically controlled, as suggested by the magnetic signal (Figure 98), with some minor conjugate NE-SW conjugate bodies, grouped into one main cluster with an area of 9,31 km^2.

- Mining is mainly done on veins with a N-S trend,
- All mining activities in the area are artisanal (unclear which remain active),
- No production reports are available from this site.

7.1.2.6.3 Prospect area

The area of interest of 23,86km^2 contains the following characteristics:

- Length of the main structure: 920m (interpreted)
- Average width: 6m (interpreted)
- Thickness of cluster: 1.300m
- Number of occurrences: 14 hard-rock
- Type of mining: artisanal
- Status: active

The current mining license in the area has the following data:

	ML-017471
Company Name (after MCO)	Ohil – Global Mining Company Ltd
Type of License	Mining Lease
Expiry date	2042
Commodities	Copper, Gold, Lead, Silver

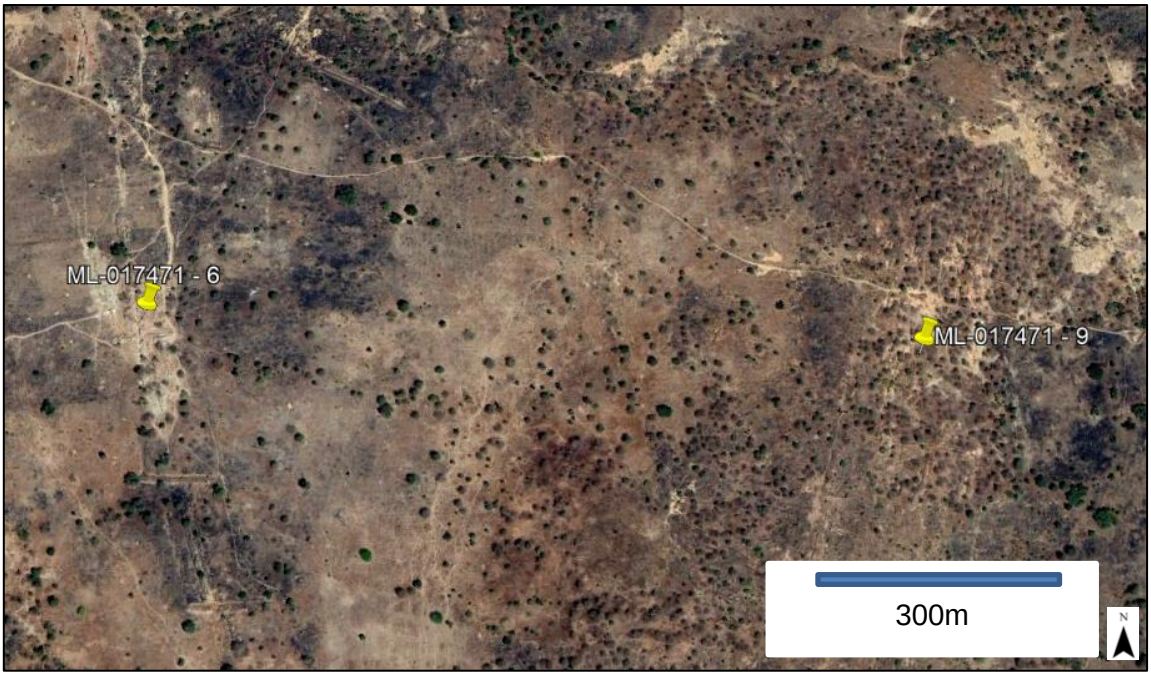


Figure 98: Two main mine sites in the area suggesting a bigger vein system, the left site being followed for at least 1 km (11°53'12"N 5°56'15"E and 11°53'08"N 5°56'37"E)

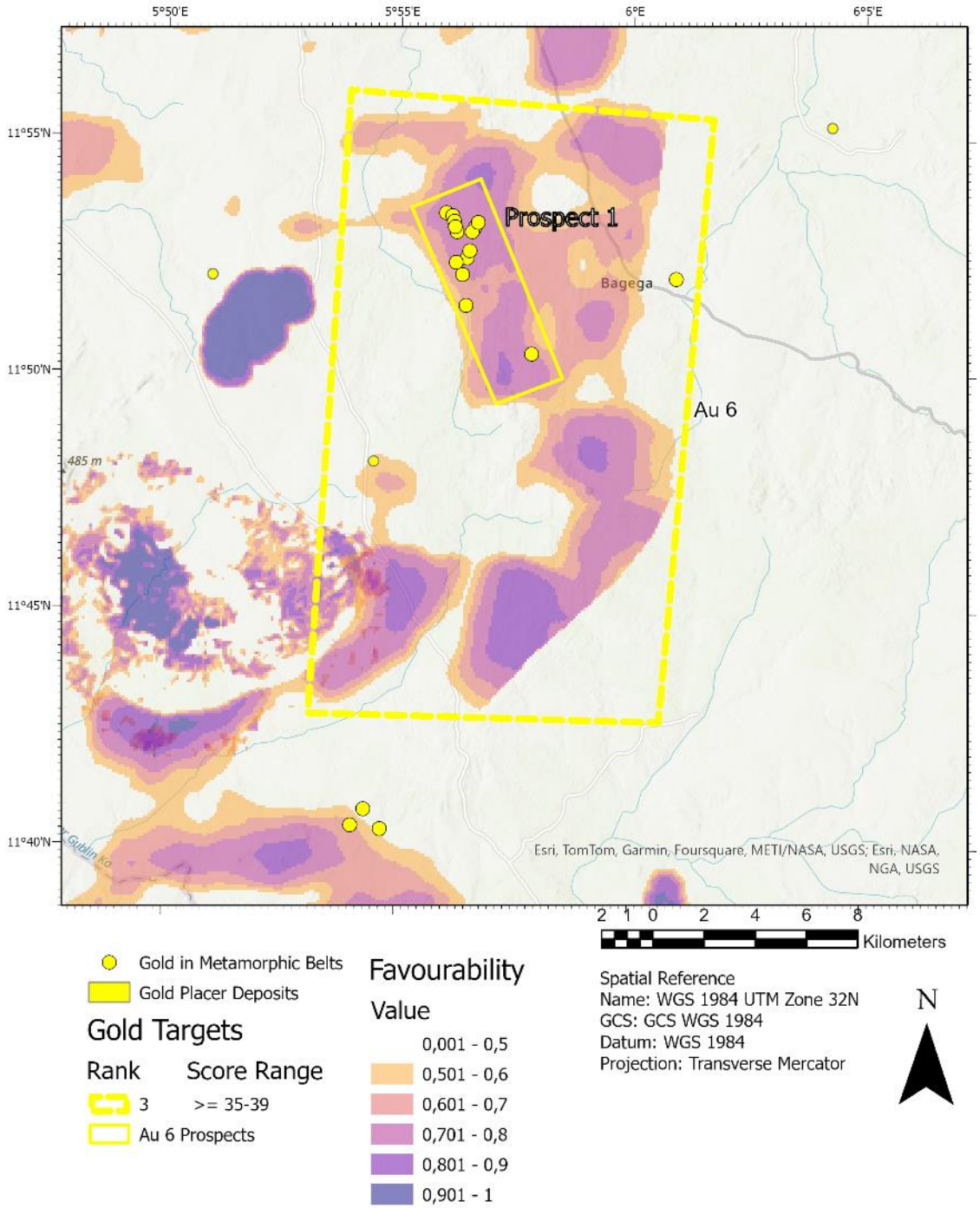


Figure 99: Favourability map for target Au 6.

7.1.2.7 Target Gold 7

7.1.2.7.1 Summary

Located east of Birni-Gwari town, between Kaduna and Niger States, the target contains at least two active hard rock deposits of Au part of a massive hydrothermal vein system (stockwork) hosted in Ns rocks. Presently, all mining activities are artisanal and active following an N-S mineralization trend, and are covered by a mining lease. Favourability mapping indicates a diffuse shape with values averaging 0.7 on two main spots. The total area of this target is 410.28 km2.

7.1.2.7.2 Characterization of the target

7.1.2.7.2.1 Favourability

The favourability map (superimposing favourability of gold in granites and metamorphic belts) is a very diffuse shape only covering 20% of the target (Figure 101), however, a more regional view indicates this area is part of a set of compact figures. Values over 0.8 correlate well with existing mineral occurrences.

7.1.2.7.2.2 History

Mining in the area seem to have only commenced sometime during 2011 with a small cluster of artisanal pits to the north of the target. The sites seem to have been abandoned and only until 2023 renewed events are perceptible again, with 3 main trenches (one up to 100m) aimed to understand the spatial thickness of the local mining cluster. From images of 2019, it is evident the exploration in the area expanded dramatically including at least two new mining areas (around 1 km away from the original site) and more than 15 new trenches. Recent imagery (2023) and valid mining leases indicate that mining has expanded both north and south following the local geology.

7.1.2.7.2.3 Geological Setting

The target is located in the northern part of the Ifewara – Birnin Guari Shear Zone part of a regional mobile belt crossing Nigeria in a NE-SW trend. The rocks are composed almost exclusively of early- to mid-Neoproterozoic greenschist to amphibolite facies clastic and volcanic sequences (Ns) with small intrusions of Neoproterozoic to Cambrian syn-tectonic granitic plutons and batholiths (Nog). One main late shear plane runs N-S through the target and correlates perfectly with the magnetic signal.

7.1.2.7.2.4 Mineralization

Mineralization in the area is interpreted as hydrothermal veins related to metamorphic belts. Due to the distribution of the sites, a stockwork deposit may be suggested. A total of 2 hydrothermal veins are documented in the area. The principal direction of the veins is N-S (Figure 100) and structurally/geologically controlled, as suggested by the magnetic signal and the geology, grouped into one main cluster with an area of 15,18 km^2.

- Mining is mainly done on veins with a N-S trend following a topographic low,
- All mining activities in the area are artisanal (all seem to be active),
- No production reports are available from this site.
- Structures can be followed up to 13 km within a 600 m band.

7.1.2.7.3 Prospect area

The area of interest of 21,23km^2 contains the following characteristics:

- Length of the main structure: 6.300m
- Average width: 7m
- Thickness of cluster: 200m
- Number of occurrences: 2 hard-rock
- Type of mining: artisanal

- Status: active

The current mining license in the area has the following data:

	ML-023393	EL-030476
Company Name (after MCO)	Goidel Resources Ltd	Kaduna Mining Development Company Ltd
Type of License	Mining Lease	Exploration
Expiry date	2041	2022 (expired)
Commodities	Gold, Silver, Tantalum	Copper, Graphite, Iron

Figure 100: Active mining sites on a vein system with length of at least 13 km inside target 6 (11°01'22"N 6°48'21"E). Image taken from Google Earth.

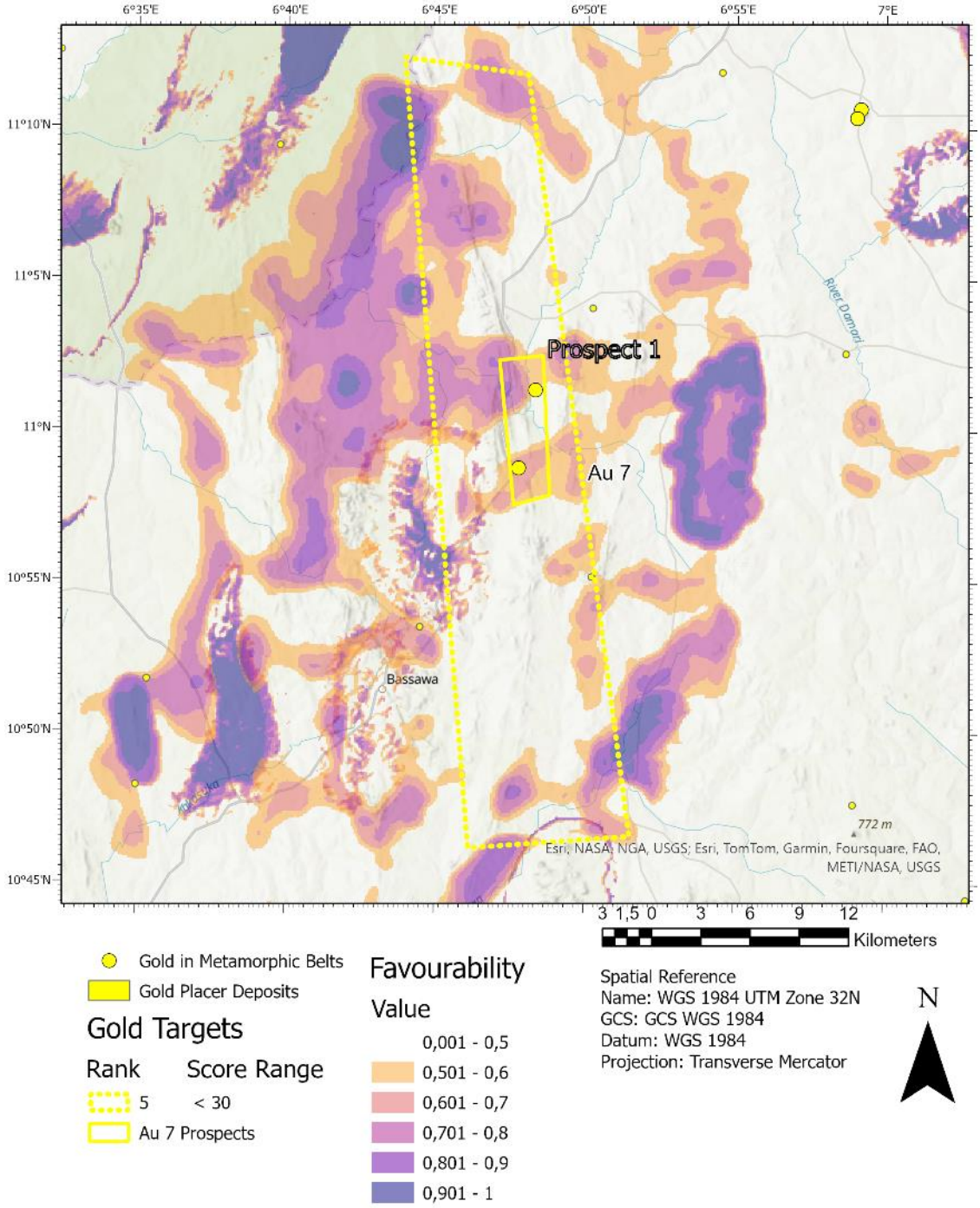


Figure 101: Favourability map for target Au 7.

7.1.2.8 Target Gold 8

7.1.2.8.1 Summary

Located south of Pategi, in Kwara State, the target contains at least 99 active hard-rock deposits of Au suggesting two massive hydrothermal vein systems (stockwork) hosted in Pbg rocks. Presently, all mining activities are artisanal and active following an NE-SW mineralization trend, and are covered by several mining licenses. Favourability mapping indicates a compact shape with values over 0.8 on two main provinces. The total area of this target is 1,446.02 km2.

7.1.2.8.2 Characterization of the target

7.1.2.8.2.1 Favourability

The favourability map (superimposing favourability of gold in granites and metamorphic belts) is a very compact shape covering over 60% of the target (Figure 106), with two main shapes (one on the eastern part, another on the western part) suggesting two different provinces. Values over 0.8 correlate well with existing mineral occurrences.

7.1.2.8.2.2 History

Mining in the area seem to have only commenced sometime during 2011 with a small cluster of artisanal pits to the north of the target. The sites seem to have been abandoned and only until 2023 renewed events are perceptible again, with 3 main trenches (one up to 100m) aimed to understand the spatial thickness of the local mining cluster. From images of 2019, it is evident the exploration in the area expanded dramatically including at least two new mining areas (around 1 km away from the original site) and more than 15 new trenches. Recent imagery (2023) and valid mining leases indicate that mining has expanded both north and south following the local geology.

7.1.2.8.2.3 Geological Setting

The target is located in the central area of the Western Basement Complex with at least three well defined early Shear-zones. The rocks are composed of Archean to Paleoproterozoic (Neoproterozoic reworked) domains of coherent suites of gneisses with limited disruption attributed to anataxis and migmatisation (Pbg) with slivers of migmatites to anatectic granites commonly comprising enclaves of relict gneiss (Pmg) and small intrusions of Neoproterozoic to Cambrian syn-tectonic granitic plutons and batholiths (Nog).

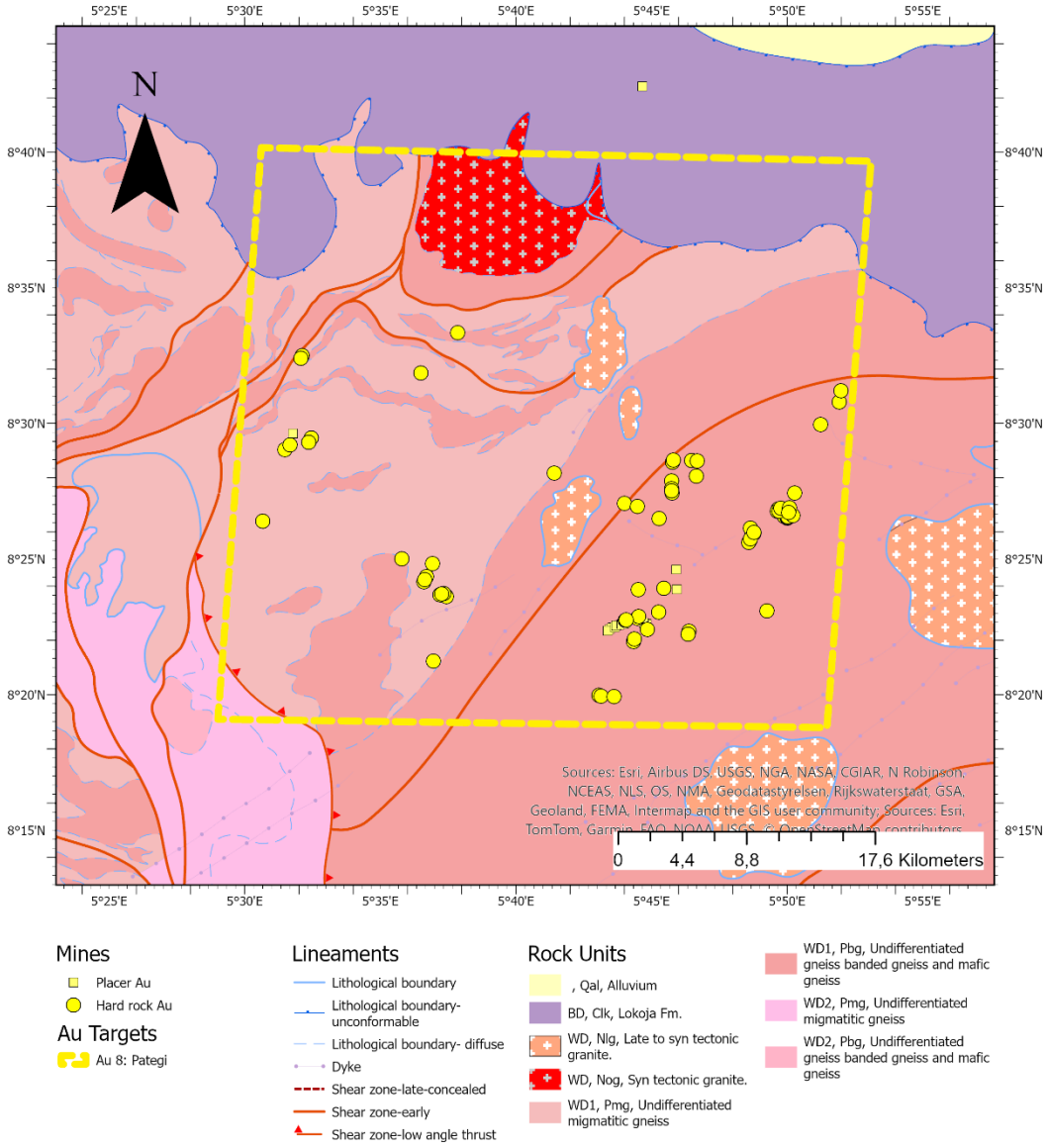


Figure 102: Geology for Gold Target 8 (Au 8: Pategi).

7.1.2.8.2.4 Mineralization

Mineralization in the area is interpreted as hydrothermal veins related to metamorphic belts. Due to the distribution of the sites, a stockwork deposit may be suggested. 99 known hard-rock deposits have been identified, separated into and east section with an area of 169,94 km^2, and a western section with 96,34 km^2. The principal direction of the veins is NE-SW (Figure 104). The analysis of the magnetic signal (especially the RTP DX derivative) shows several NE-SW trending structures.

- Mining is mainly done on veins with a NE-SW trend following a topographic low,
- All mining activities in the area are artisanal (all seem to be active),
- No production reports for Au are available from this area.

7.1.2.8.2.5 Distribution of Mineral Tenements (MCO, 11.2023)

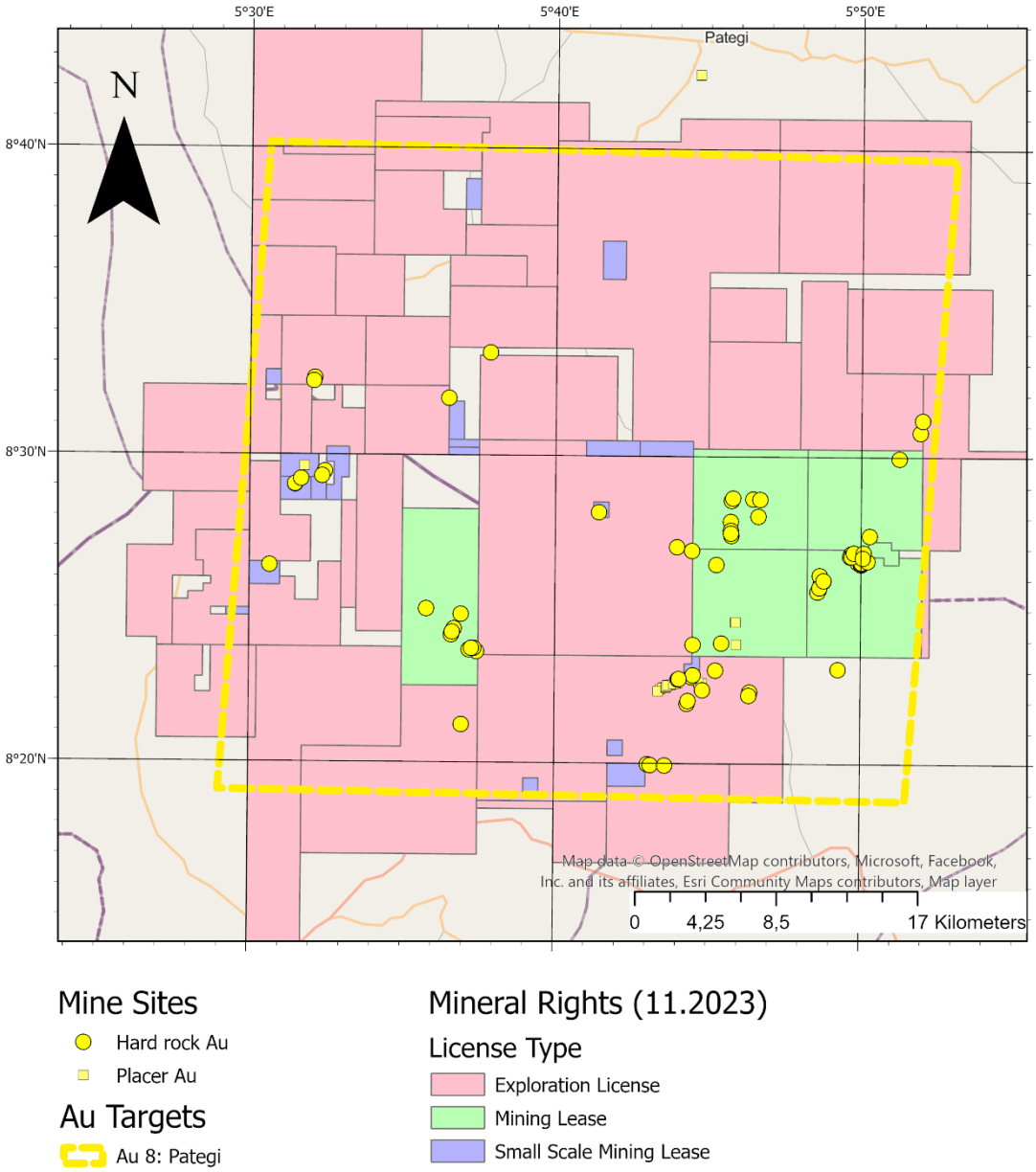


Figure 103: Distribution of Mineral Licenses in Gold Target 8 (Au 8: Pategi)

7.1.2.8.3 Suggested prospect areas

7.1.2.8.3.1 Prospect 1

The area of 10,26km^2 interest contains the following characteristics:

- Length of the main structure: 760m
- Average width: 20m
- Thickness of cluster: 1.100m
- Number of occurrences: 24
- Type of mining: artisanal
- Status: active

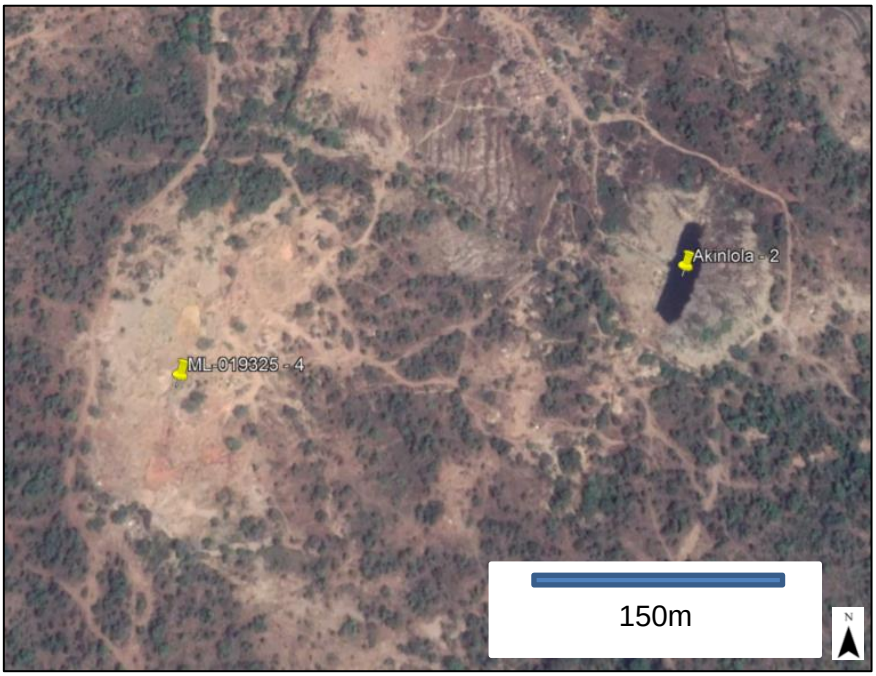


Figure 104: Active mines in the area with MPM values over 0.95 (8°26'33"N 5°50'01"E). Image taken from Google Earth.

7.1.2.8.3.2 Prospect 2

The area of 13,75km^2 interest contains the following characteristics:

- Length of the main structure: 720m
- Average width: 20m
- Thickness of cluster: 460m
- Number of occurrences: no documented
- Type of mining: artisanal
- Status: active

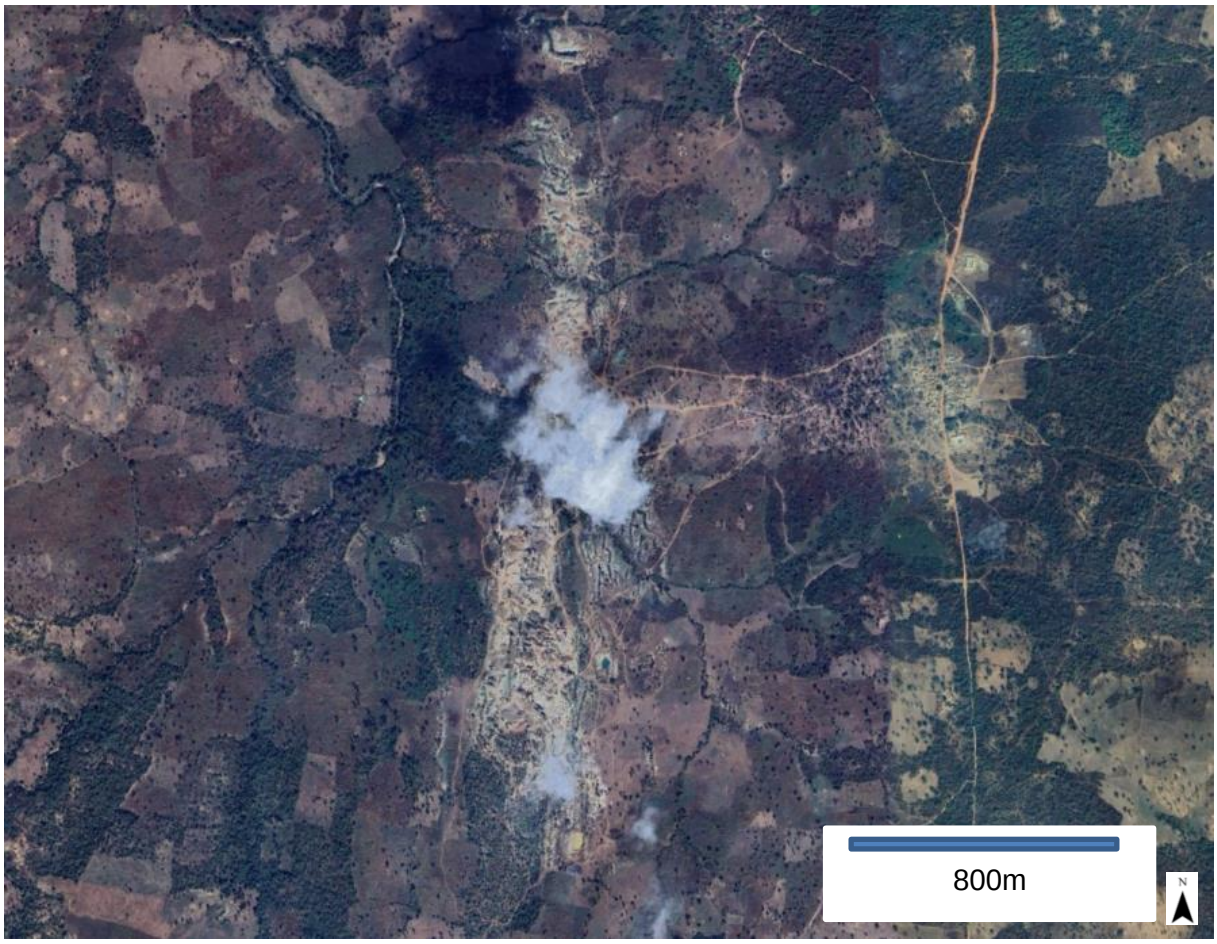


Figure 105: Active mines in the area with MPM values over 0.95 (8°38'40"N 5°36'30"E). Image taken from Google Earth.

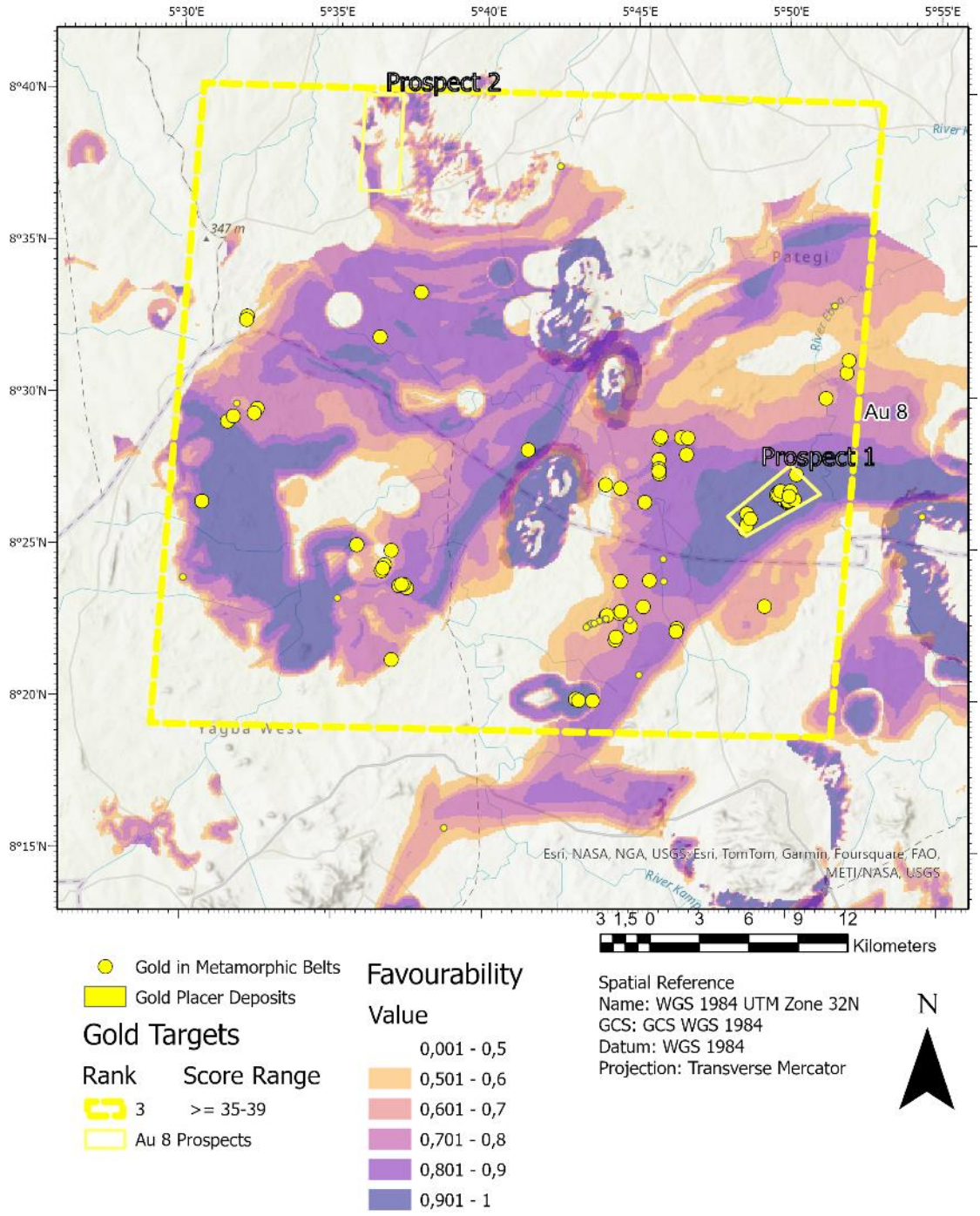


Figure 106: Favourability map for target Au 8.

7.1.2.9 Target Gold 9

7.1.2.9.1 Summary

Located around the towns of Maikendi and Runtu Fulani, in Kebbi State, the target contains at least 67 mineral occurrences of Au suggesting a stockwork deposit hosted in Nlg rocks. Presently, all mining activities are artisanal and active following an NE-SW mineralization trend, and are only partially covered by licenses. Favourability mapping indicates a compact shape with values over 0.8 on two main provinces. The total area of this target is 269.93 km2.

7.1.2.9.2 Characterization of the target

7.1.2.9.2.1 Favourability

The favourability map (superimposing favourability of gold in granites and metamorphic belts) has two very compact shapes covering over 60% of the target (Figure 108), one very rounded to the SE of the target, the second an elongated continuous province. Values over 0.9 correlate very well with existing mineral occurrences.

7.1.2.9.2.2 History

From the available imagery, already by 2013 some pits and shafts from artisanal miners existed and apparently were abandoned (towards the central part of the target). Only until 2017, the northern section (NE of the intrusive body) started experiencing activity from miners which seem to have remained active since. By 2022, some abandoned central sites seem to have been reactivated, and further activities expanded further north and south towards the other two intrusive bodies.

7.1.2.9.2.3 Geological Setting

The target is located in the north-west area of the Western Basement Complex. The rocks are composed of Archean to Paleoproterozoic (Neoproterozoic reworked) domains of coherent suites of gneisses with limited disruption attributed to anataxis and migmatisation (Pbg) and three main intrusive bodies of Neoproterozoic to Cambrian late- to syn-tectonic granitoids

including leucogranites, porphyritic granites and micro granites (Nlg). The whole target area is enclosed between one late and one early shear zone.

7.1.2.9.2.4 Mineralization

Mineralization in the area is interpreted as hydrothermal veins related to metamorphic belts. Due to the distribution of the sites, a stockwork deposit may be suggested. The area has 67 known occurrences of hard-rock gold deposits and are spatially linked with the intrusions within a 27,07 km^2 area. The main cluster of occurrences in the middle intrusion follow a SW-NE trend seemingly radiating from the centre, however, the active sites to the south-western side of the Granite seem to bend around it (Figure 107). The analysis of the magnetic signal (RTP 2VD) shows several NE-SW trending structures suggesting a control on the mineralization.

- Mining is mainly done on veins with a NE-SW trend,
- Activities are concentrated in an apparent contact metamorphism halo,
- All mining activities in the area are artisanal (all seem to be active),
- No production reports for Au are available from this area.

7.1.2.9.3 Prospect area

The area of interest of 7,40km^2 contains the following characteristics:

- Length of the main structure: 350m
- Average width: 7m
- Thickness of cluster: 2.000m
- Number of occurrences: 23 hard-rock
- Type of mining: artisanal
- Status: active

No current mining license is covering the area. The closest title information is:

	EL-033073
Company Name (after MCO)	Maishiga Mining & Constrution Company Ltd
Type of License	Exploration
Expiry date	2023 (expired)
Commodities	Gold

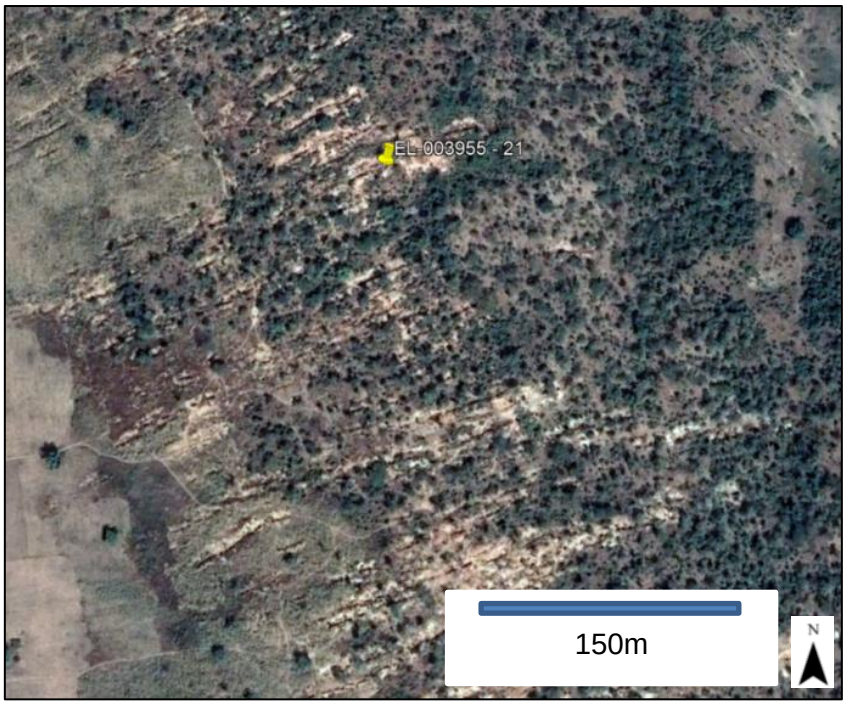


Figure 107: Several active mine sites of granite hosted veins with MPM values of 1.0 (11°37'39"N 4°50'28"E). Image taken from Google Earth.

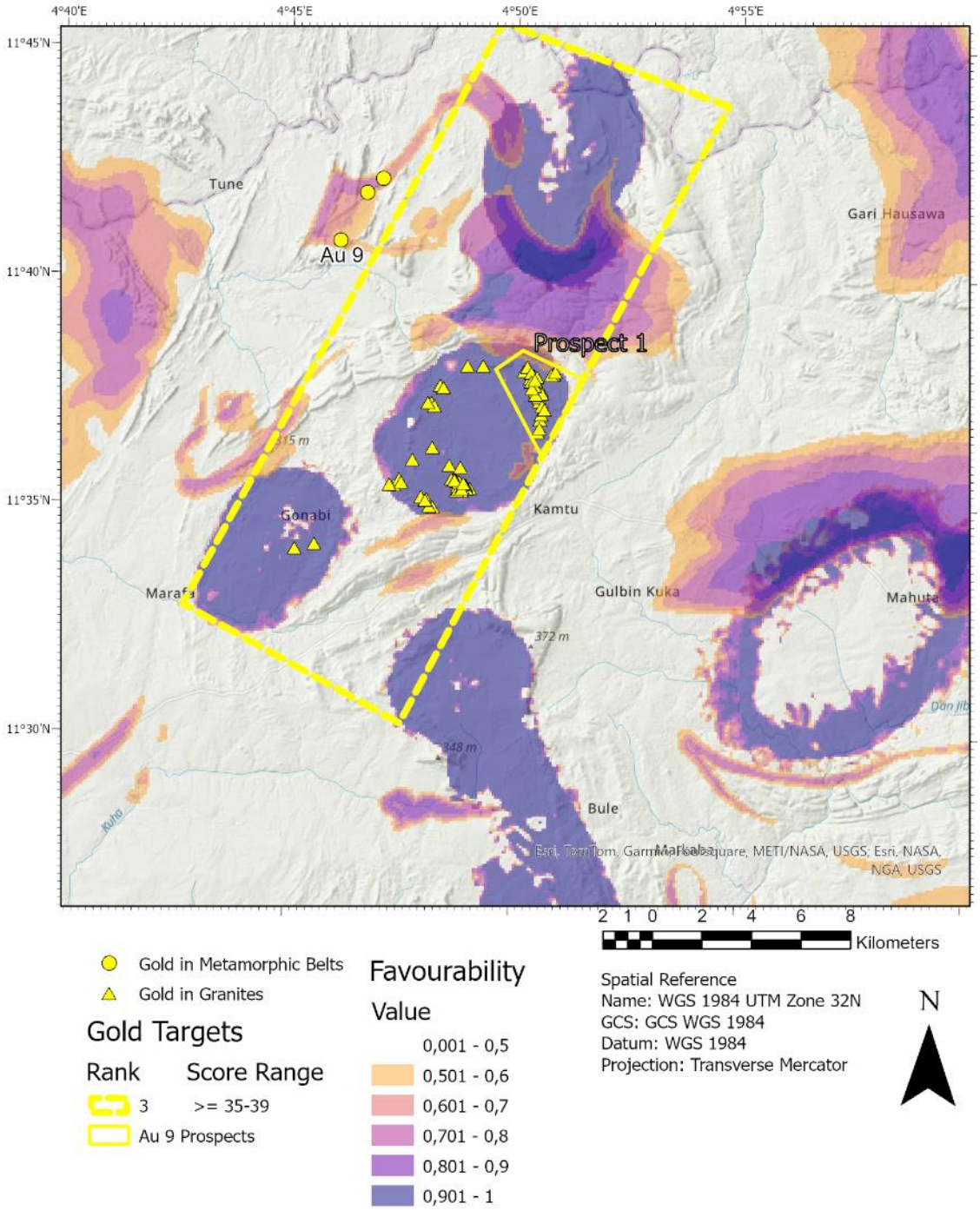


Figure 108: Favourability map for target Au 9.

7.2 Tin (Sn) – Niobium (Nb) Targets

7.2.1 Ranking and Location

7.2.1.1 Criteria Catalogue

From the general Sn-Nb Favourability Map (Figure 74), a selection of single targets was selected and recommended for further evaluation. This selection represents, to the current knowledge and understanding of the Consultant, the most prospective sites along with a set of typical cases within the target areas.

The selected target areas were ranked using the following catalogue of criteria:

- MPM shape and intensity:

MPM pattern and favourability value (FV)	Score
Compact pattern and FV > 0.9	5
Compact pattern and FV > 0.8	4
Compact pattern and FV > 0.7	3
Diffuse pattern and FV > 0.9	2
Diffuse pattern and FV > 0.8	1

- Potential for old placers:

Potential for old placers	Score
Yes	5
No	1

- Niobium in the mineral suite:

Niobium in mineral suite	Score
Yes	5
No	1

- Tin occurrences known:

Tin Occurrences known	Score
Yes	5
No	1

- Tin deposits being mined:

Tin deposits mined	Score
Yes	5
No	1

- Undocumented deposits found:

Undocumented deposits	Score
Yes	5
No	1

- Existence of placer deposits pinpointing to source:

Existence placer deposits	Score
Yes	5
Partially	3
No	1

- Number of hard rock occurrences:

Number hard-rock occurrences	Score
More than > 15	5
Between 15 and 10	4
Between 10 and 6	3
Between 6 and 3	2
Less than 3	1

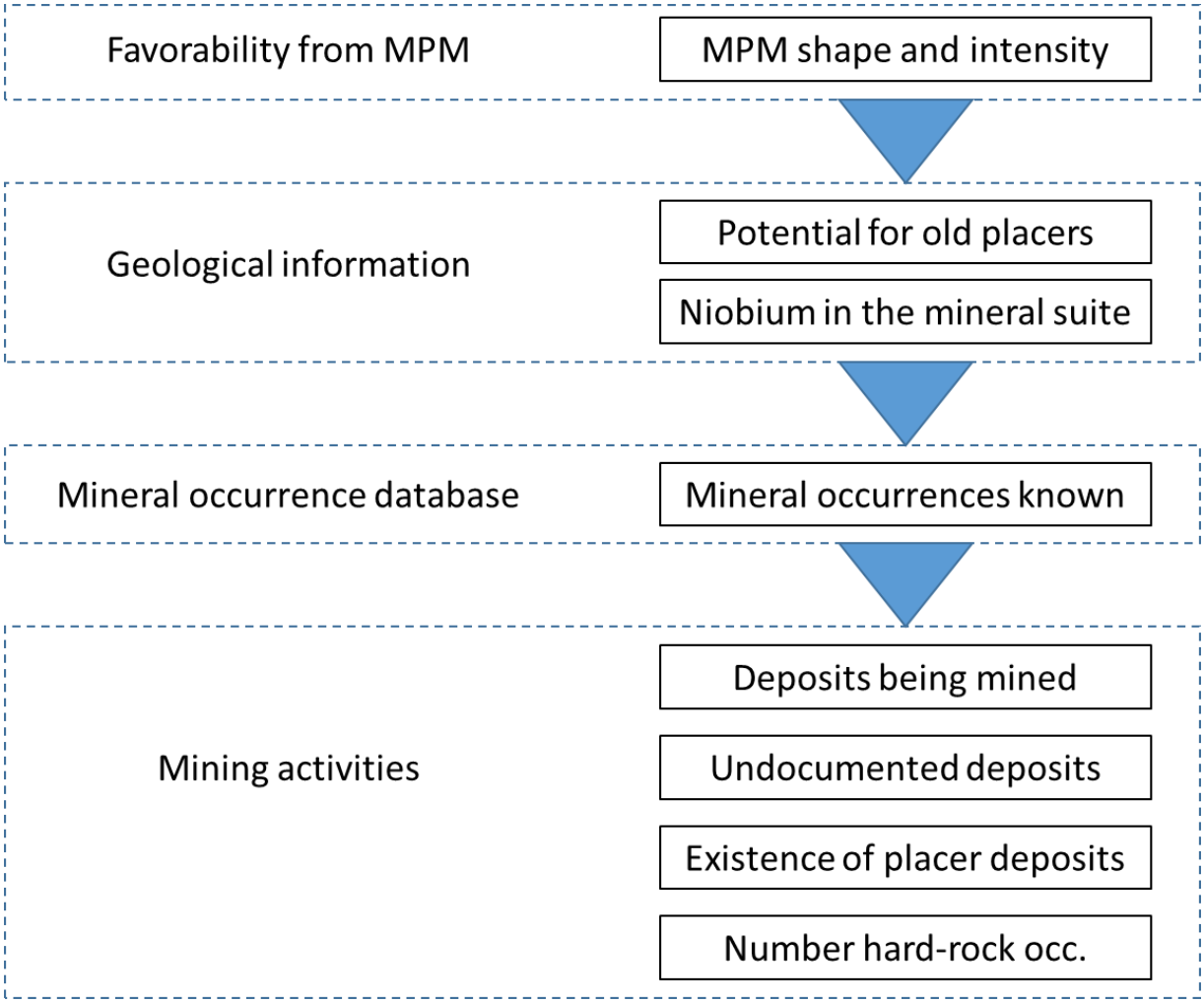


Figure 109: Criteria for the ranking of Sn-Nb Targets

7.2.1.2 Ranking and location of targets

The identified targets are located in different positions throughout the Benue Trough. Their ranking against the described criteria is shown in Table 11 and their spatial location is shown in Figure 110.

Table 11: The ranking of the Sn-Nb targets.

Criteria	Points per Criterium	Sn Targets and their scoring per criterium							
		Sn-Nb 1	Sn-Nb 2	Sn-Nb 3	Sn-Nb 4	Sn-Nb 5	Sn-Nb 6	Sn-Nb 7	Sn-Nb 8
MPM Shape and intensity									
Compact pattern above 0.9	5		5	5		5			
Compact pattern and above 0.8	4	4					4		
Compact pattern and above 0.7	3				3				3
Diffuse pattern and above 0.9	2							2	
Diffuse pattern and above 0.8	1								
Tin occurrences known?									
Yes	5	5				5		5	5
No	1		1	1	1		1		
Tin deposits being mined?									
Yes	5	5	5			5	5	5	5
No	1			1	1				
Niobium within the mineral suite?									
Yes	5	5	5				5	5	5
No	1			1	1	1			
Undocumented deposits found?									
Yes	5	5		5	5	5	5		5
No	1		1					1	
Potential for old placers?									
Yes	5		5			5			
No	1	1		1	1		1	1	1
Existence of placer deposits pinpointing to source?									
Yes	5		5					5	
Partially	3			3		3			3
No	1	1			1		1		
Number of hard rock occurrences									
>15	5								
15-10	4		4						
10-6	3	3							3
6-3	2					2		2	
<3	1			1	1		1		
Total Score									
Score	40	29	31	18	14	31	23	26	30
Rank									
Rank order	7	2	1	4	5	1	3	2	2

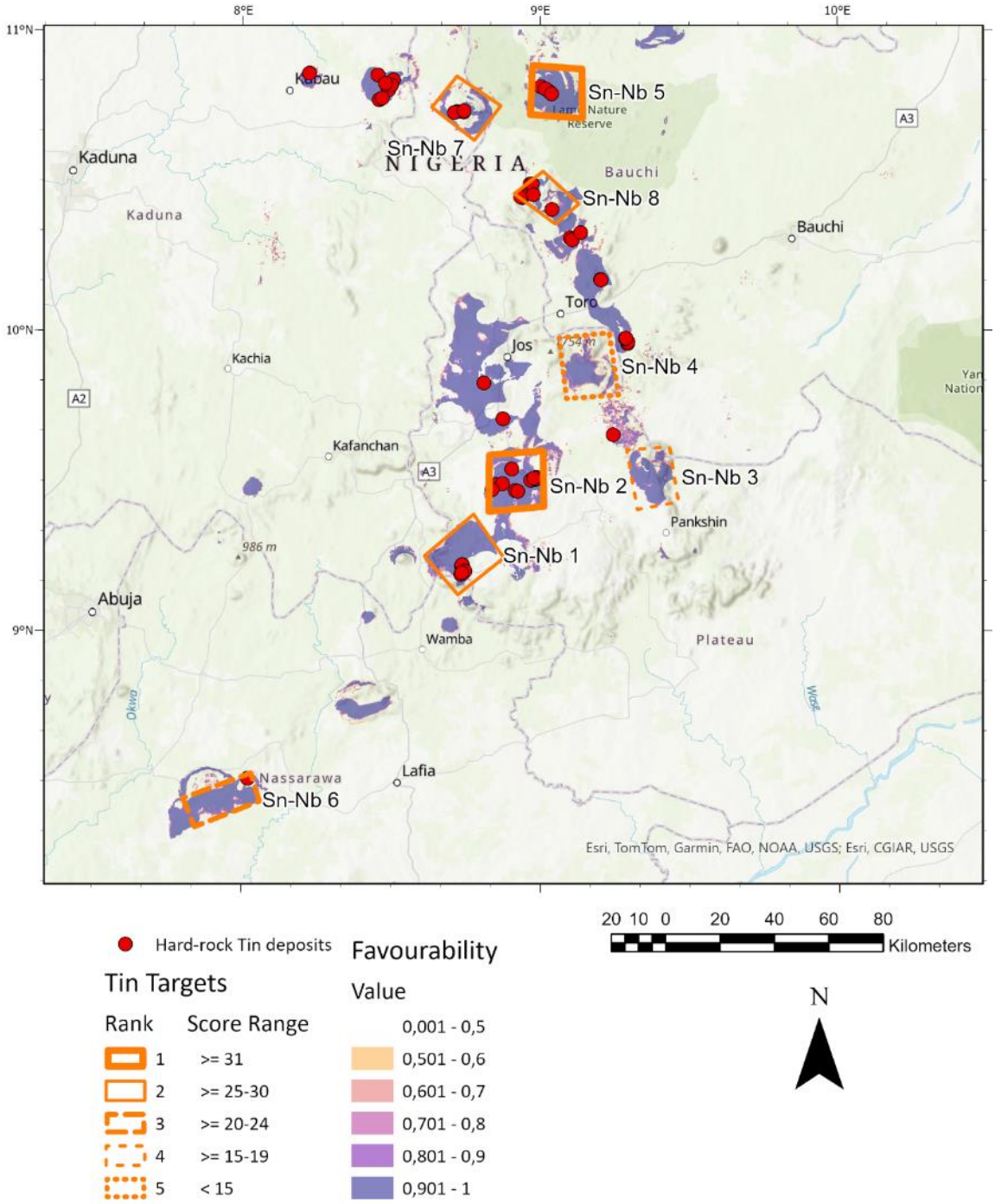


Figure 110: Location and ranking of selected targets for Tin (Sn) and Niobium (Nb).

7.2.2 Description of single targets

7.2.2.1 Target Tin 1

7.2.2.1.1 Summary

Located in the Kerifa Hills of Plateau State, the target area boasts six occurrences of Sn-Nb within supergene enriched sediments, aligned along east-west structures within the alkaline ring complex. Presently, all mining activities in the region are artisanal, with no active licenses reported as of 2023, although Topwide Ventures Ltd had previously conducted exploration in the area. Favourability mapping suggests a cohesive shape with values exceeding 0.9. The total area of this target is 434.95 km^2.

7.2.2.1.2 Characterization of the target

7.2.2.1.2.1 Favourability

The favourability map shows a very compact shape with values over 0.9 covering around 60% of the target (Figure 112) and correlating with the known Sn-Nb occurrences.

7.2.2.1.2.2 History

Activities in the area can be traced back at least to 2003 where several sites were visible through satellite imagery in artisanal scale. Around 2017, activities reached their maximum with at least 4 main sites, followed by a reduction in visible changes to just some sporadic cases.

7.2.2.1.2.3 Geological Setting

The rocks are composed of undifferentiated felsic to mafic alkaline volcanics including flood basalts (Jv) and undifferentiated alkaline granites predominantly biotite granite with subordinate arfvedsonite granite and Fayalite granite (Jg). The complex is called Sha-Kaleri.

7.2.2.1.2.4 Mineralization

At least 6 known mineral occurrences are located inside this target identified as veins. The target is located in the area of the Younger Granites identified as alkaline intrusives and classified as ring complexes. The magnetic response (RTP Tilt) indicates NE-SW trending continuous highs that correlate with the known mineral occurrences suggesting a geological or structural control in the area. The identified occurrences are identified as supergene enrichment of veins/lodes related to a Pneumatolytic genesis.

- Mining is not concentrated but rather distributed on topographic highs (Figure 111),
- Mining seems to only to target an enriched overburden/sediments and not directly on hard-rock, however, the trend seems continuous with an E-W trend,
- Recent workings are sporadic and unclear if they remain active,
- No production information is available from this area.

7.2.2.1.3 Prospect area

The area of 10,87km^2 contains the following characteristics:

- Length of the main structure: 800m
- Average width: 80m
- Number of occurrences: 6
- Type of mining: artisanal, supergene lode deposit
- Status: active?

The current mining license in the area has the following data:

	EL-025061
Company Name (after MCO)	Topwide Ventures Ltd
Type of License	Exploration
Expiry date	2022 (expired)
Commodities	Tin, Wolframite

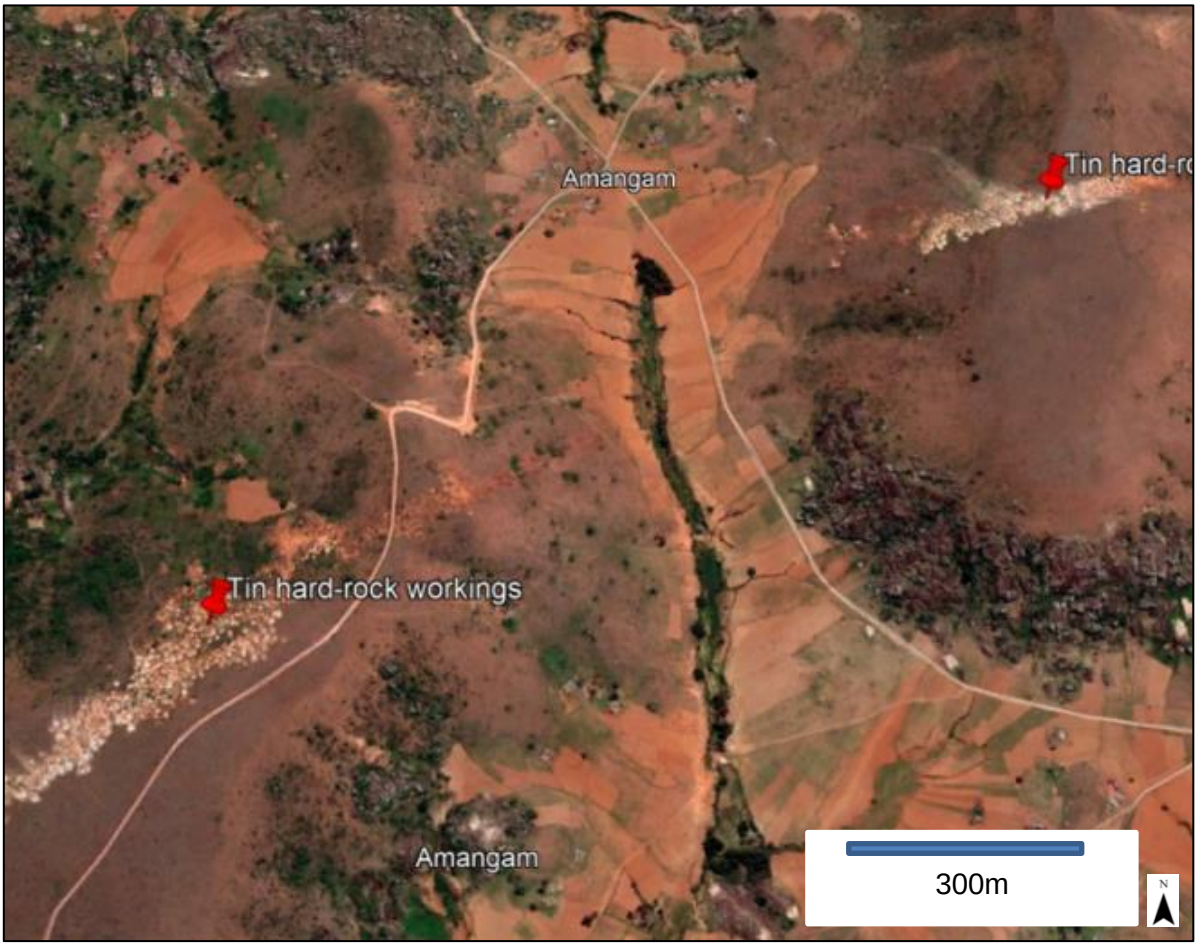


Figure 111: Occurrence Sha 5 showing mining for Tin on overlying sediments along a SW-NE trend (9°11'46"N 8°44'15"E and 9°12'05"N 8°44'53"E). Image taken from Google Earth.

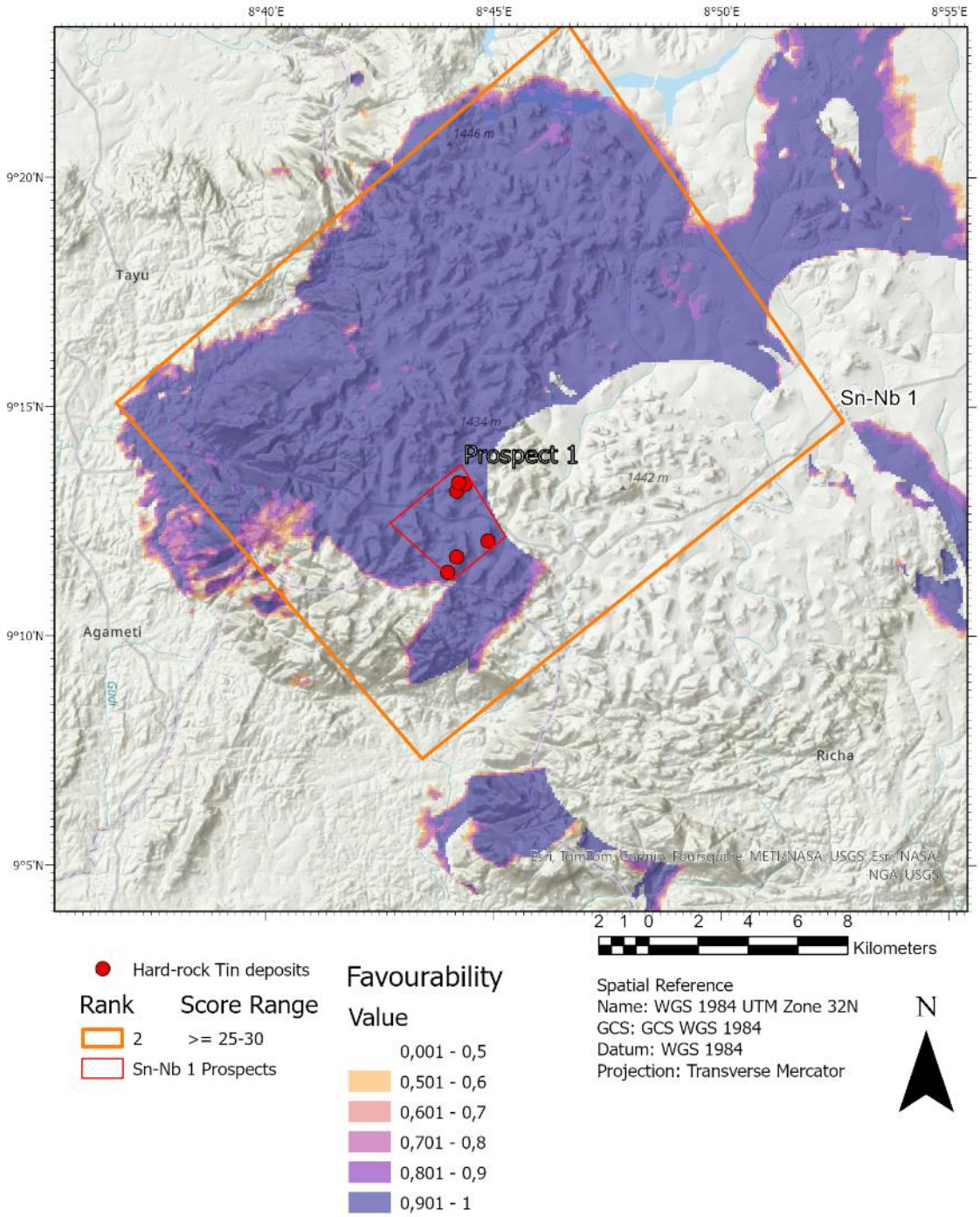


Figure 112: Favourability map for target Sn-Nb 1.

7.2.2.2 Target Tin 2

7.2.2.2.1 Summary

The target area situated near Barkin Ladi town in Plateau State, close to Jos, boasts 11 occurrences of Sn-Nb within supergene enriched sediments, aligned along east-west structures within the alkaline ring complex. Presently, all mining operations in the vicinity are artisanal, with no active licenses reported as of 2023, although Topwide Ventures Ltd had previously conducted exploration in the area. Favourability mapping reveals a compact shape with values surpassing 0.9. The total area of this target is 412.61 km^2.

7.2.2.2.2 Characterization of the target

7.2.2.2.2.1 Favourability

The favourability map shows a very compact shape with values over 0.9 covering around 80% of the target (Figure 115) and correlating with the known Sn-Nb occurrences.

7.2.2.2.2.2 History

Activities in the area started in colonial times and can be seen in satellite imagery dating back to 1985. No major pit or industrial activity has surfaced since then with only some new small-scale sites visible after 2017, most of which are placer deposits close to the major abandoned pits. Main activities seem to concentrate towards the south-west of the target.

7.2.2.2.2.3 Geological Setting

The rocks are composed of undifferentiated felsic to mafic alkaline volcanics including flood basalts (Jv) and undifferentiated alkaline granites predominantly biotite granite with subordinate arfvedsonite granite and Fayalite granite (Jg). The complex is called Ropp and has intruded older migmatitic gneisses (Pmg).

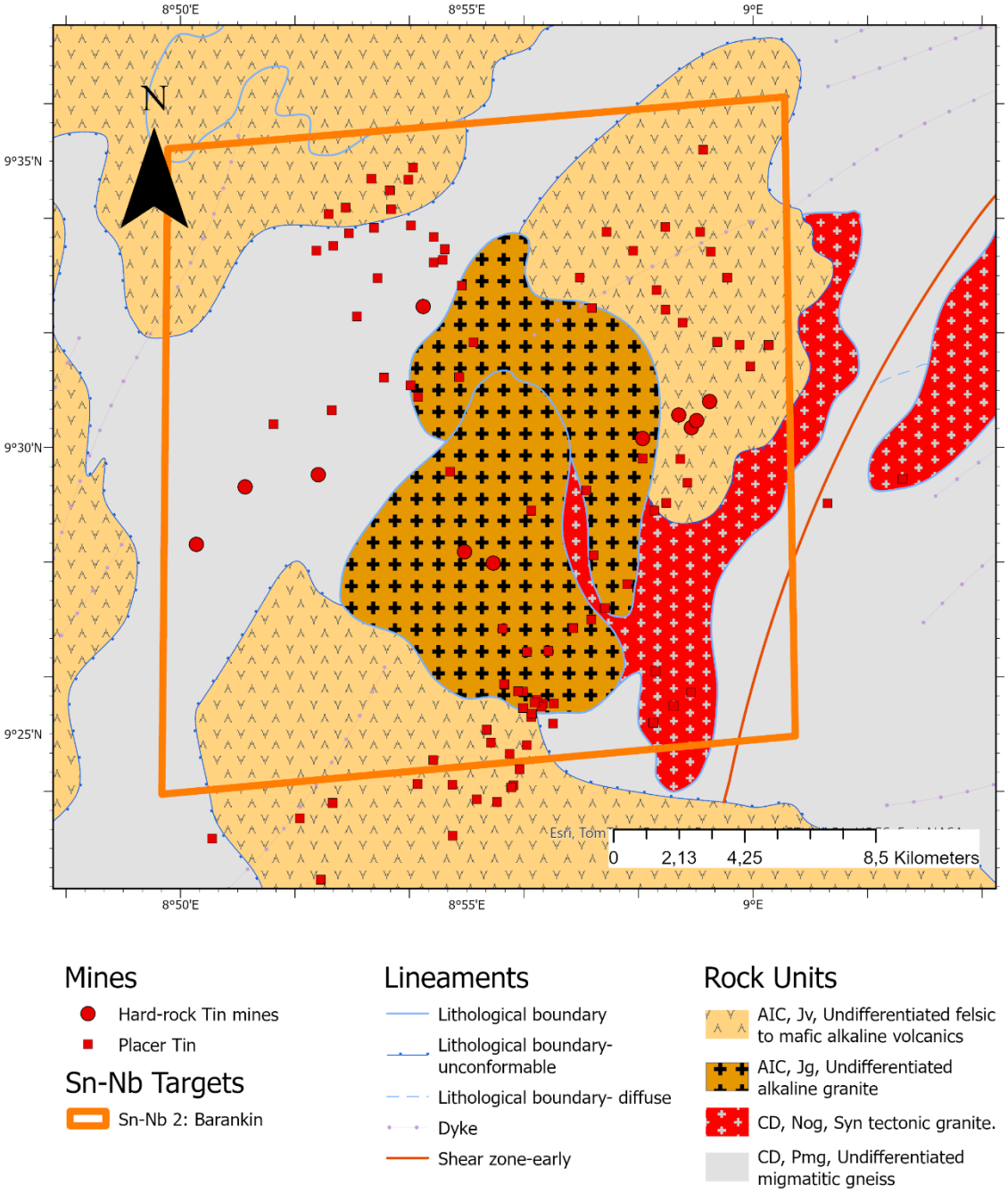


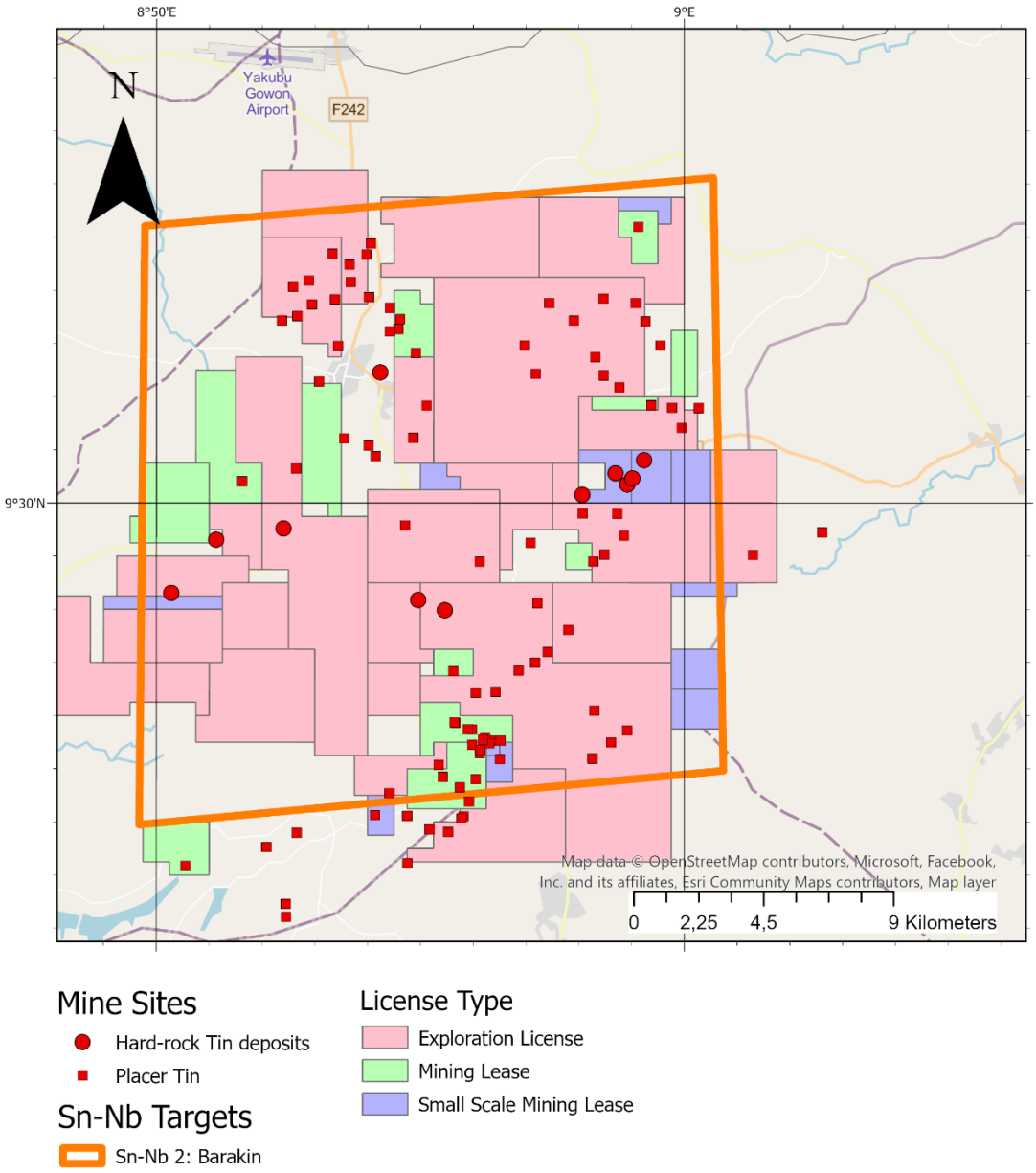
Figure 113: Geology for Tin Target 2 (Sn-Nb 2: Barakin).

7.2.2.2.2.4 Mineralization

At least 11 known mineral occurrences are located inside this target identified as veins besides more than 30 placer deposits. The target is located in the area of the Younger Granites identified as alkaline intrusives and classified as ring complexes. The magnetic signal (RTP) indicates a prominent source that lies within a low magnitude response, whereas the Tilt derivative identifies features oriented SW-NE possibly related to the mineralizations, where some coincide with abandoned extraction pits, allowing the identification of further mining activities. The identified mineralization in the area is Pneumatolytic producing veins/lodes that were subsequently weathered to form placer deposits and supergene enrichment.

- All main pits for hard-rock seem abandoned and water-filled,
- South-west of the target hard-rock activities are currently active (Figure 111),
- All activities are artisanal without trace of industrial processes or heavy machinery,
- Placer deposits is the main target of mining in the area,
- Around 17 tons of Tin concentrate are reported to be produced per year.

7.2.2.2.2.5 Distribution of Mineral Tenements (MCO, 11.2023)



7.2.2.2.3 Suggested prospect areas

The 5.59 km^2 area contains the following characteristics:

- Type of mineralization: supergene enriched sediments
- Average size of topographic highs: 500mx600m
- Number of occurrences: 1 (recent activities not documented)
- Type of mining: artisanal, supergene lode deposit
- Status: active

Figure 114: Hard-rock mines for Tin in the Ropp ring complex (9°26'53"N 8°52'03"E) with MPM values of 0.97. Image taken from Google Earth.

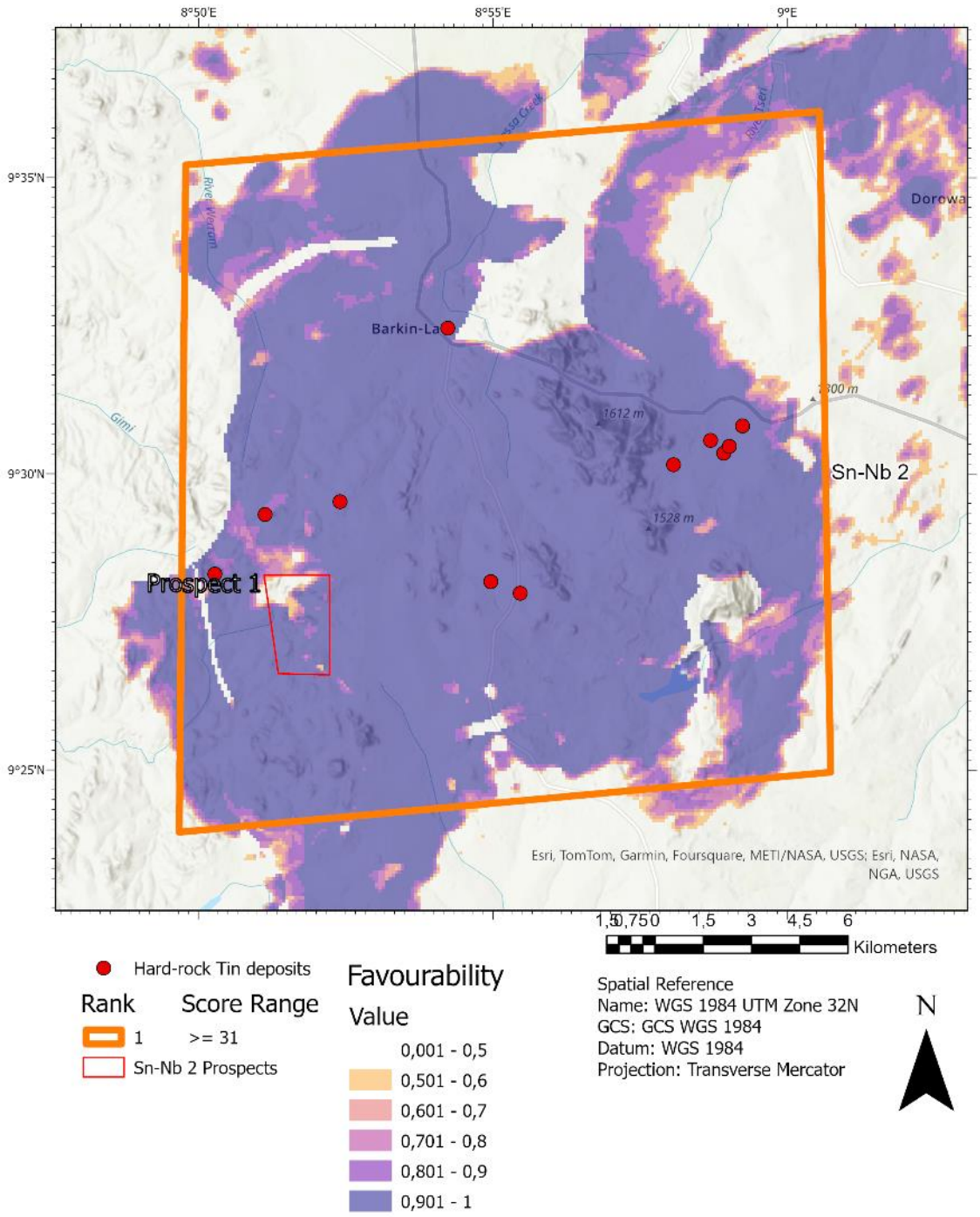


Figure 115: Favourability map for target Sn-Nb 2.

7.2.2.3 Target Tin 3

7.2.2.3.1 Summary

The target area situated in Pankshin, Plateau State, does not currently host any known hard-rock occurrences of Sn-Nb, but it does possess identified placer deposits. Mining activities in the region are predominantly artisanal, with two recent sites showing renewed interest, albeit all active licenses are exploratory in nature. Favourability mapping indicates a cohesive shape with values exceeding 0.9. The total area of this target is 331.63 km^2.

7.2.2.3.2 Characterization of the target

7.2.2.3.2.1 Favourability

The favourability map shows a very compact shape closely following the existing geology. The observed values are over 0.9 covering around 60% of the target (Figure 117).

7.2.2.3.2.2 History

Although no clear evidence is seen in satellite imagery, activities in this area started already by 1990s without any posterior noticeable uptake in happenings, except 2 small sites around 2023 (unclear from available information if they are indeed mining activities).

7.2.2.3.2.3 Geological Setting

The rocks are composed of undifferentiated felsic to mafic alkaline volcanics including flood basalts (Jv) and undifferentiated alkaline granites predominantly biotite granite with subordinate arfvedsonite granite and Fayalite granite (Jg). The complex is called Sara-Fier.

7.2.2.3.2.4 Mineralization

No hard-rock mineral occurrence has been reported inside the selected target. However, at least 4 placer deposits are documented within the ring complex. The target is located in the area of the Younger Granites identified as alkaline intrusives and classified as ring complexes.

Two small features on the Tilt derivative of the magnetic signal correlate with two new artisanal activities exploiting an N-S trending valley. Several kilometre sized fractures offer the potential for lode mineralization. The identified occurrences are identified as sediment concentration of weathered Pneumatolytic lodes suggesting the original source is near.

- Extraction of minerals is only found as artisanal activities (Figure 111),
- The only type of deposit identified is placer,
- Two new sites have been spotted,
- No production information is available from this area.

7.2.2.3.3 Prospect area

Currently unclear to assess the prospectivity of a certain area, but a prospect is suggested.

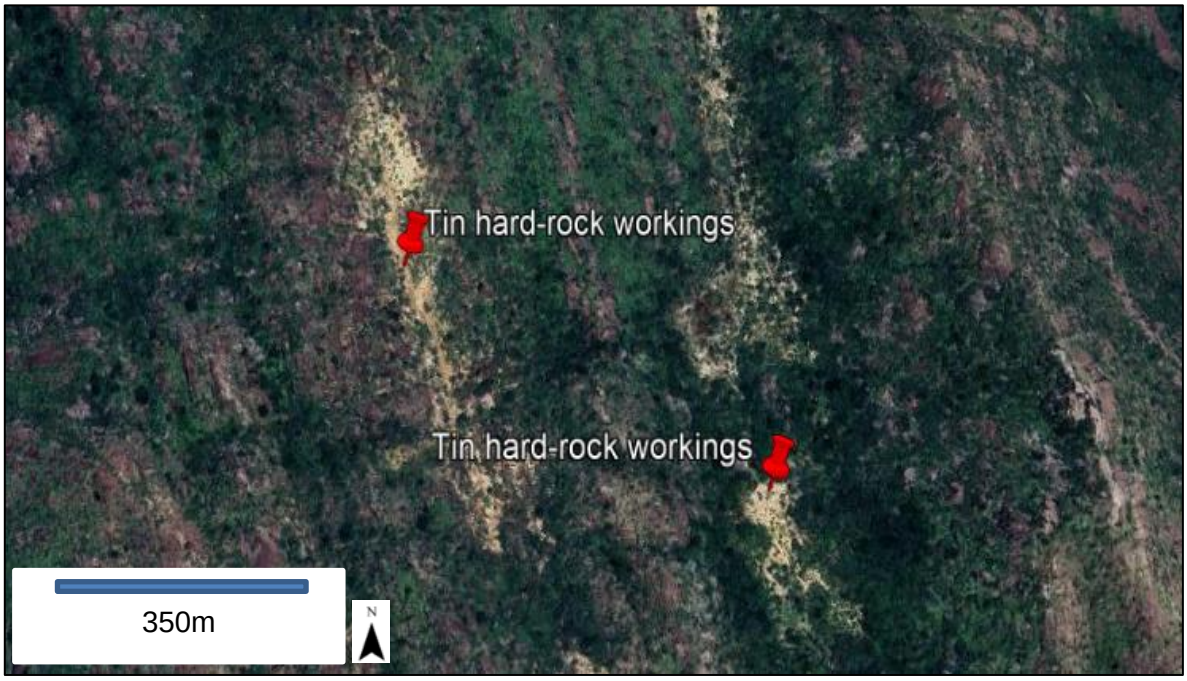


Figure 116: Artisanal workings on hard rock indicating a relevant source and identified by the MPM with values over 0.8 (9°35'50"N 9°23'45"E). Image taken from Google Earth.

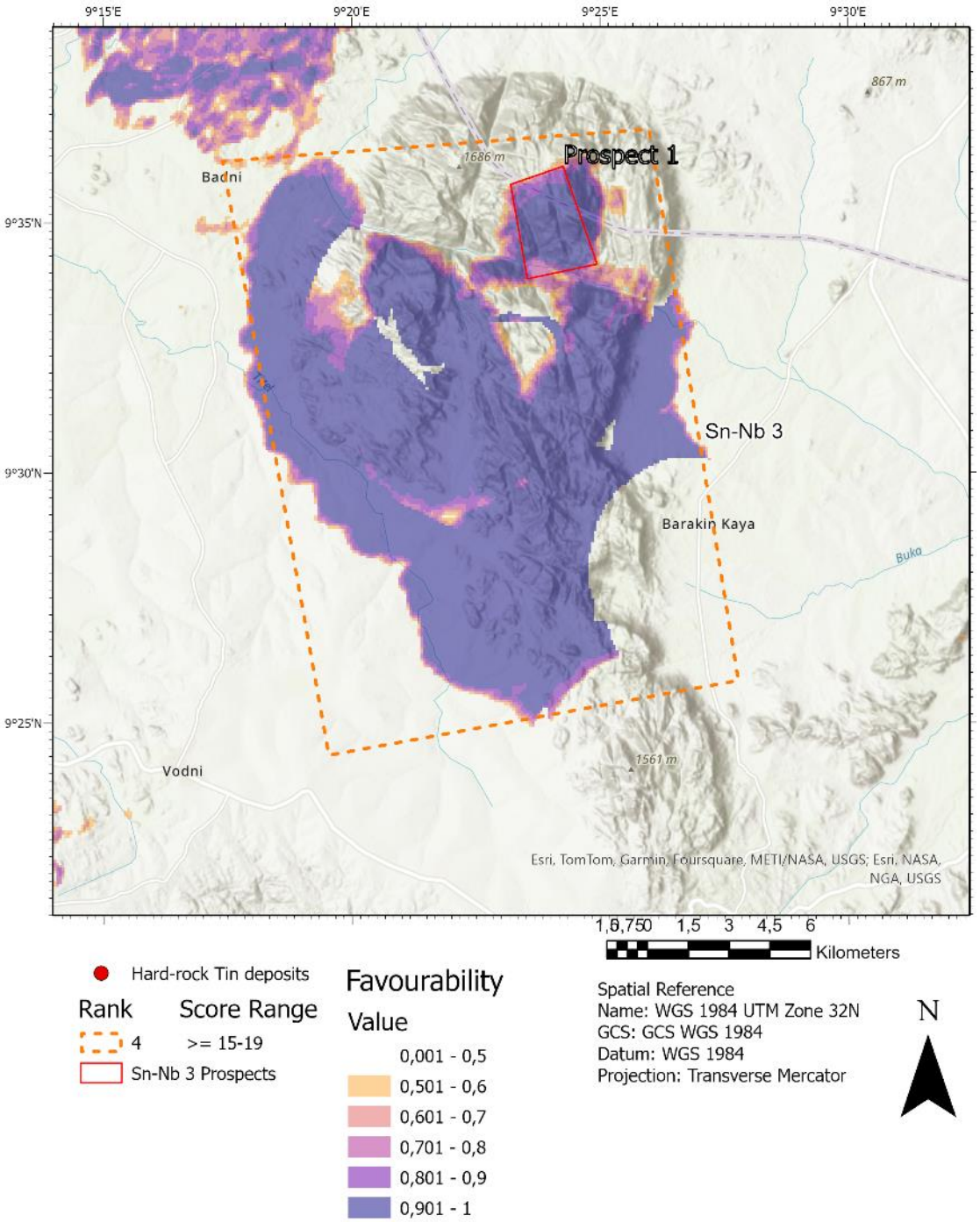


Figure 117: Favourability map for target Sn-Nb 3.

7.2.2.4 Target Tin 4

7.2.2.4.1 Summary

The target area situated near Dutsen Daji in Plateau State hosts just one known hard-rock occurrence, aligning with a north-south trend within the alkaline ring complex. Presently, all mining operations in the vicinity are artisanal, with I.G.I. Global Investment Ltd holding the license for a prospective area. Favourability mapping reveals a cohesive shape with values exceeding 0.9. The total area of this target is 429.01 km^2.

7.2.2.4.2 Characterization of the target

7.2.2.4.2.1 Favourability

The favourability map shows a very compact shape with values over 0.9 covering around 50% of the target (Figure 119) and correlating with the local geology.

7.2.2.4.2.2 History

No major pit or industrial activity can be spotted in the expanse of the target suggesting mining has not really kick-started in the area. Some spots do suggest artisanal miners may have worked prior 2020s, however, only until 2023 evidence of mining is observed.

7.2.2.4.2.3 Geological Setting

The target is located in the area of the Younger Granites identified as alkaline intrusives and classified as ring complexes. The rocks are composed of undifferentiated felsic to mafic alkaline volcanics including flood basalts (Jv) and undifferentiated alkaline granites predominantly biotite granite with subordinate arfvedsonite granite and Fayalite granite (Jg). The complex is called Jarawa and has intruded older migmatitic gneisses (Pmg).

7.2.2.4.2.4 Mineralization

Only one known deposit of wolframite bearing quartz vein with abundant cassiterite along with only one directly linked placer deposit are documented. The magnetic signal indicates the area is contained within a large SE-NW trending magnetic high (correlated with other deposits to the SW). The identified mineralization in the area is Pneumatolytic producing veins/lodes along with placer deposits from their subsequent weathering.

- Only one central spot is currently being mined by artisanal miners,
- The location of the mines suggest a hard-rock occurrence (Figure 118),
- No trace of industrial processes or heavy machinery,
- Around 8 tons of Tin concentrate are reported to be produced per year.

7.2.2.4.3 Prospect areas

The prospect area of 4,56km^2 contains the following characteristics:

- Length of the main structure: 800m
- Average width: 180m
- Number of occurrences: 0 (recent activities not documented)
- Type of mining: artisanal, supergene lode deposit
- Status: active

The current mining license in the area has the following data:

	EL-035561
Company Name (after MCO)	I.G.I. Global Investment Ltd
Type of License	Exploration
Expiry date	2026
Commodities	Niobium, Tantalum, Tin

Figure 118: Artisanal workings on hard rock (length ca. 600m) and identified by the MPM with values over 0.95 (9°50'56"N 9°08'13"E). Image taken from Google Earth.

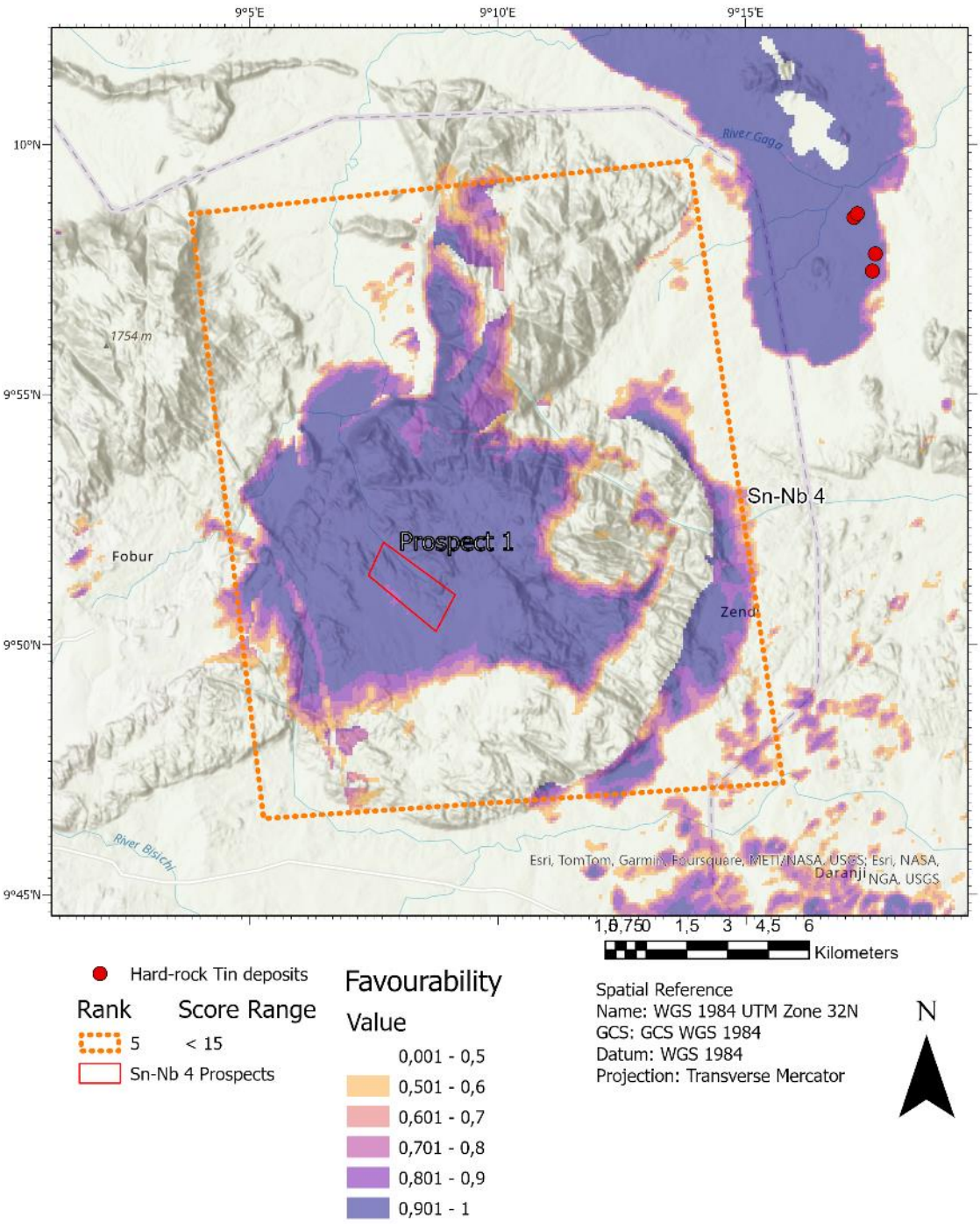


Figure 119: Favourability map for target Sn-Nb 4.

7.2.2.5 Target Tin 5

7.2.2.5.1 Summary

The target area situated around Tibchi in Bauchi State boasts at least four known hard-rock occurrences along with several placer deposits. Pneumatolytic veins within the alkaline ring complex follow an NNW-SSE trend. Presently, all mining activities in the region are artisanal, and as of November 2023, no valid license has been issued for this area (the previous license, held by Eso Terra Investment Ltd, has expired). Favourability mapping illustrates a compact shape with values surpassing 0.9. The total area of this target is 339.14 km^2.

7.2.2.5.2 Characterization of the target

7.2.2.5.2.1 Favourability

The favourability map shows two very compact shapes with values over 0.9 covering around 50% of the target (Figure 123) and correlating with known Sn-Nb mineral occurrences.

7.2.2.5.2.2 History

Placer deposits towards the western flank of the target can be traced back to have started sometime before 1985 with further expansion in towards the end of 2019. However, no hard-rock mine site can be spotted until 2023 with at least 5 sites popping-up towards the centre of the target. No industrial workings are spotted and no industrial development can be seen.

7.2.2.5.2.3 Geological Setting

The target is located in the area of the Younger Granites identified as alkaline intrusives and classified as ring complexes. The rocks are composed of undifferentiated alkaline granites predominantly biotite granite with subordinate arfvedsonite granite and Fayalite granite (Jg). The complex is called Tibchi and has intruded older migmatitic gneisses (Pmg).

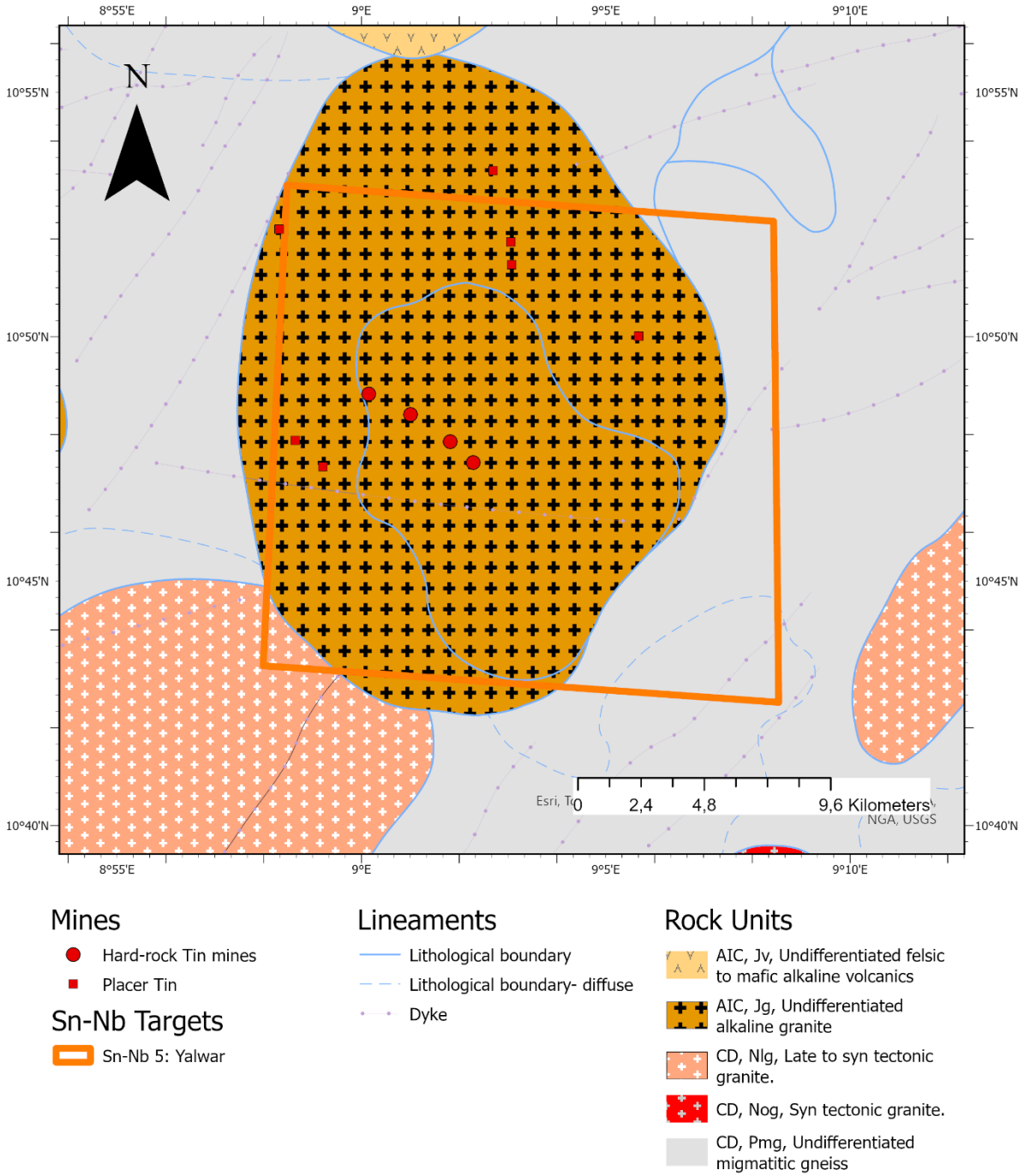


Figure 120: Geology for Tin Target 5 (Sn-Nb 5: Yalwar).

7.2.2.5.2.4 Mineralization

Four known hard-rock Sn-Nb mineral occurrences are documented along with at least 8 placer deposits. The identified mineralization in the area is Pneumatolytic producing veins/lodes along with placer deposits from their subsequent weathering. According to the DEM of the area, placer deposits radiate away from the area, suggesting additional undiscovered sources inside the target. A deeper analysis of the area identifies at least two recent artisanal activities on hard-rock.

- Main mine site is a placer deposit on the outer rim of the ring complex and all activities are artisanal,
- Recent mining activities (2023) focused on new hard-rock occurrences (Figure 122) and some placers,
- No trace of industrial processes or heavy machinery,
- No production values reported as only exploration licenses are active.

7.2.2.5.2.5 Distribution of Mineral Tenements (MCO, 11.2023)

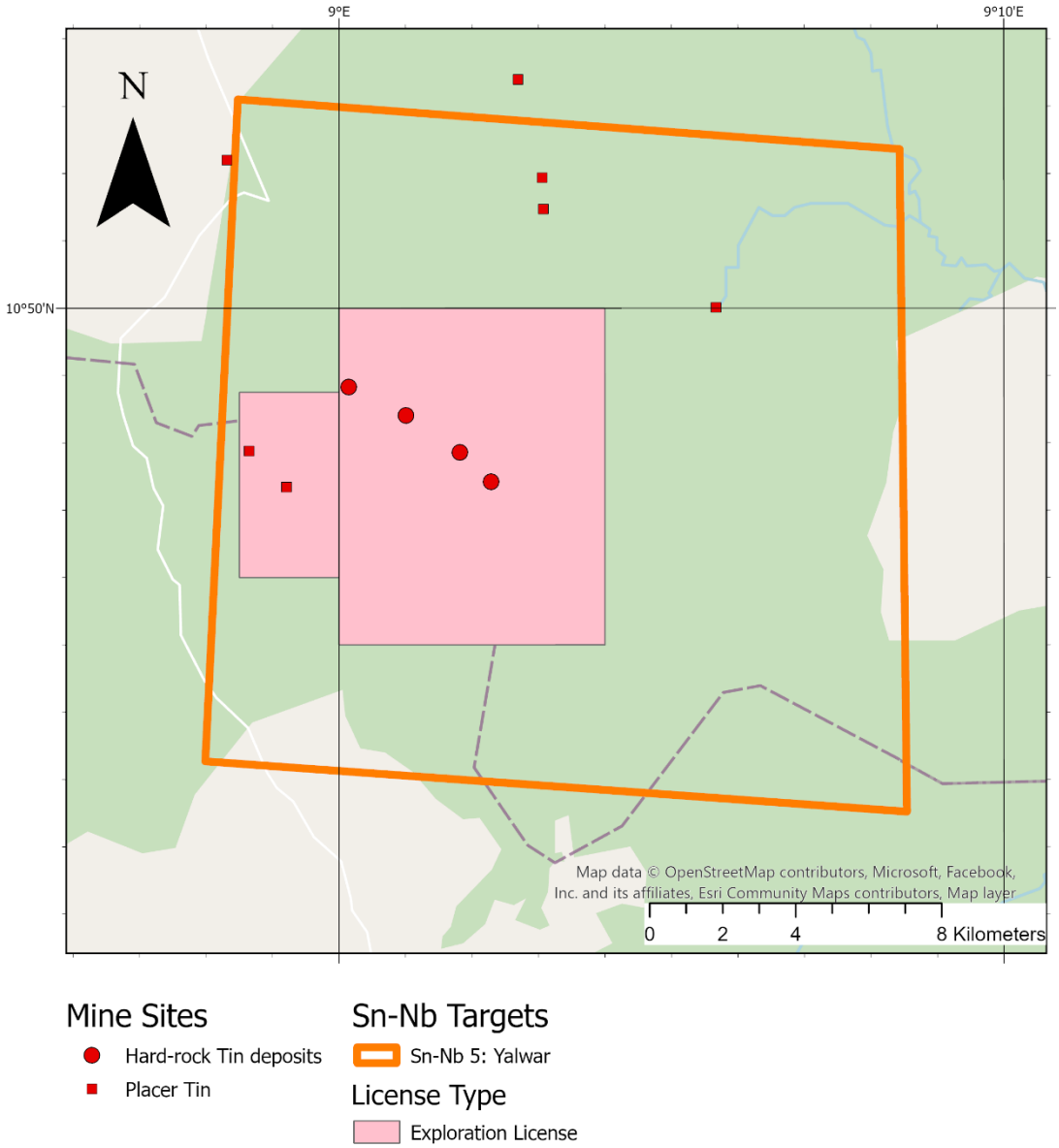


Figure 121: Distribution of Mineral Licenses in Tin Target 5 (Sn-Nb 5: Yalwar).

7.2.2.5.3 Suggested prospect areas

The prospect area of 1,79km^2 contains the following characteristics:

- Length of the main structure: 1.300m
- Average width: 60m
- Number of occurrences: 1 (recent activities not documented)
- Type of mining: artisanal, lode deposit
- Status: active

Figure 122: Artisanal workings on unidentified hard-rock deposits with MPM values of 1.0 within Target 5 (10°48'18"N 9°01'23"E). Image taken from Google Earth.

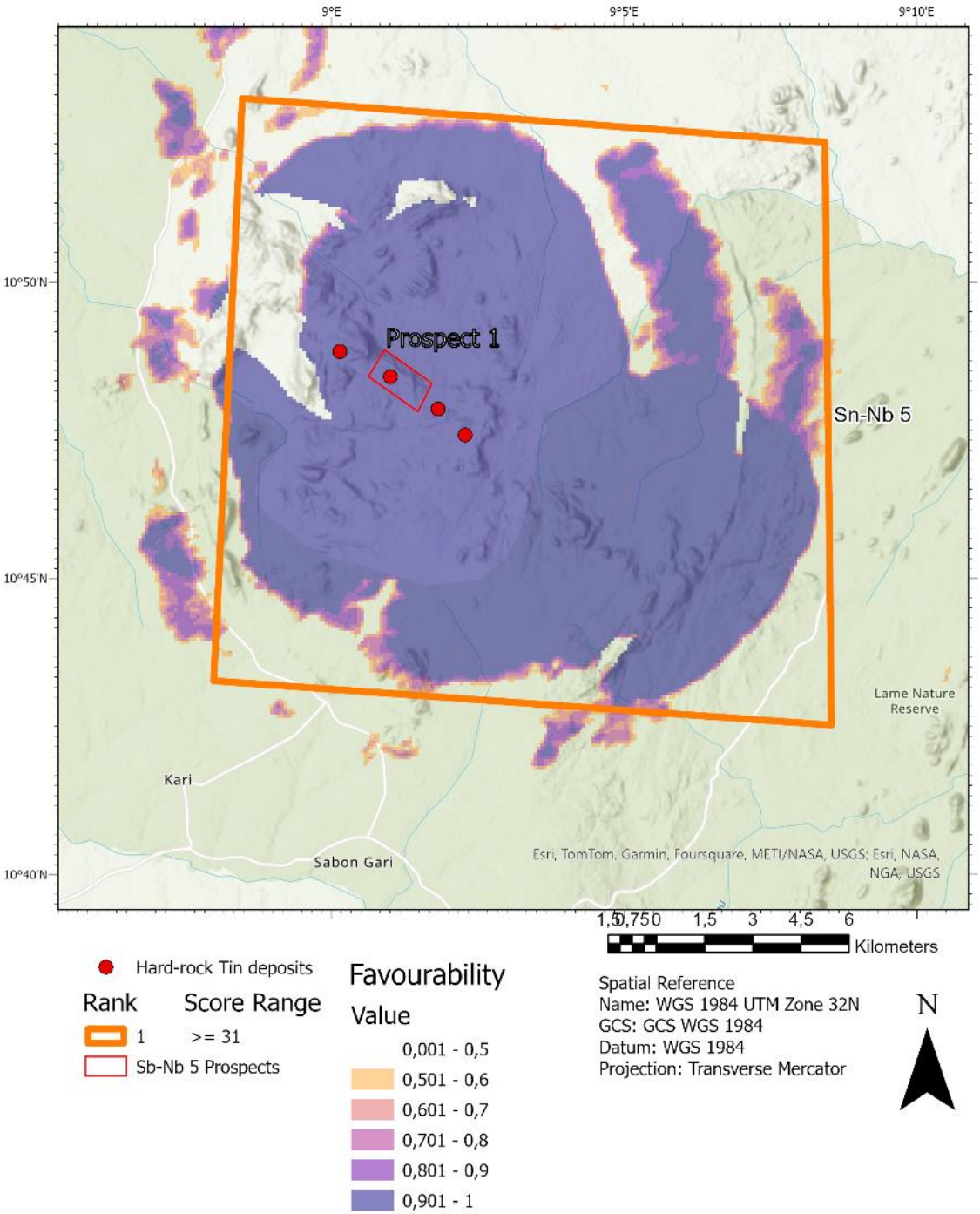


Figure 123: Favourability map for target Sn-Nb 5.

7.2.2.6 Target Tin 6

7.2.2.6.1 Summary

The target area situated around Ombi in Nasarawa State is characterized by one known hard-rock occurrence and one substantial placer deposit, which includes tantalum. Structures within the area appear to follow an NE-SW trend within the alkaline ring complex. Presently, all mining activities except for the significant placer deposit, which is controlled by Kenyang Mining Company Limited, are artisanal. Favourability mapping reveals a compact elongated shape with values exceeding 0.9. The total area of this target is 289.72 km^2.

7.2.2.6.2 Characterization of the target

7.2.2.6.2.1 Favourability

The favourability map shows a very compact and elongated shape with values over 0.9 covering around 80% of the target (Figure 125) and correlating with one known Sn-Nb mineral occurrence and the geology.

7.2.2.6.2.2 History

The main placer mine is probably linked to colonial times (pits can be spotted in satellite imagery of 1985) but remained inactive until sometime around 2012 when activities resumed. Only in this area machines and trucks are visible, suggesting an industrial process along with a central compound (processing?). All other sites in this target remain exploited by artisanal workers.

7.2.2.6.2.3 Geological Setting

The target is located in the area of the Younger Granites identified as alkaline intrusives and classified as ring complexes. The rocks are composed of undifferentiated alkaline granites predominantly biotite granite with subordinate arfvedsonite granite and Fayalite granite (Jg). The complex is called Afu.

7.2.2.6.2.4 Mineralization

One known hard-rock Sn-Nb mineral occurrence is documented along with at least 4 placer deposits, one of which is the main mining centre of the area. The identified mineralization in the area is sedimentary and diagenetic originating from undiscovered Pneumatolytic lodes. The magnetic signal suggests several structures spanning NE-SW that may control mineralization, roughly shown by existing pits. Further studies on high values of the MPM allowed the identification of two additional undocumented mining sites.

- Main mine site is a placer deposit exploited industrially with trucks and heavy machinery (Figure 124),
- All other pits are artisanal,
- Production in the area for Columbite reached 1,229 tons.

7.2.2.6.3 Prospect areas

The prospect area of 31,09km^2 contains the following characteristics:

- Length of the main structure: 1.600m
- Average width: 400m
- Number of occurrences: 1
- Type of mining: industrial, placer
- Status: active

The current mining license in the area has the following data:

	ML-010216
Company Name (after MCO)	Kenyang Mining Company Limited
Type of License	Mining Lease
Expiry date	2035
Commodities	Niobium, Tantalum, Tin, Lead

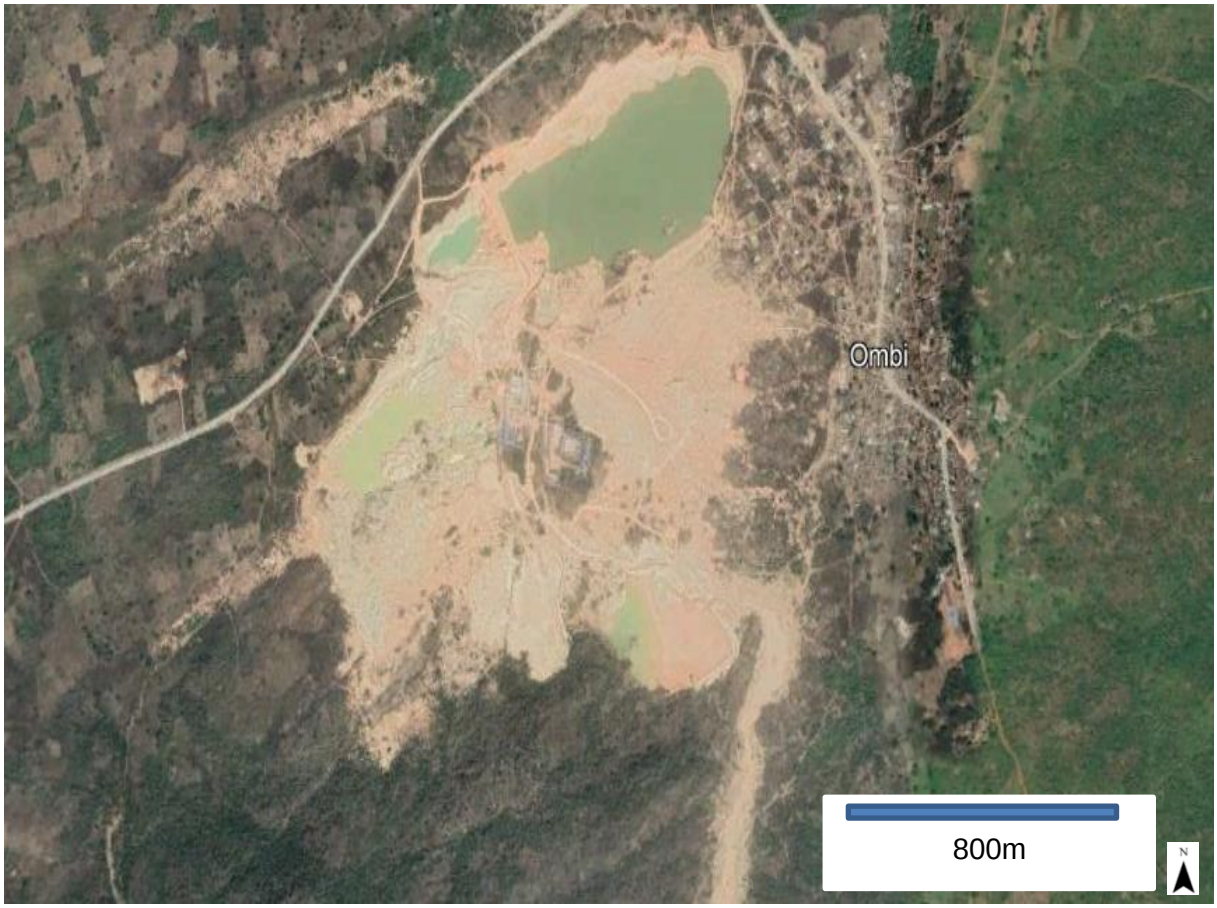


Figure 124: Industrial mine workings on placer deposits with MPM values of 1.0 within Target 6 (8°24'48"N 7°53'08"E). Image taken from Google Earth.

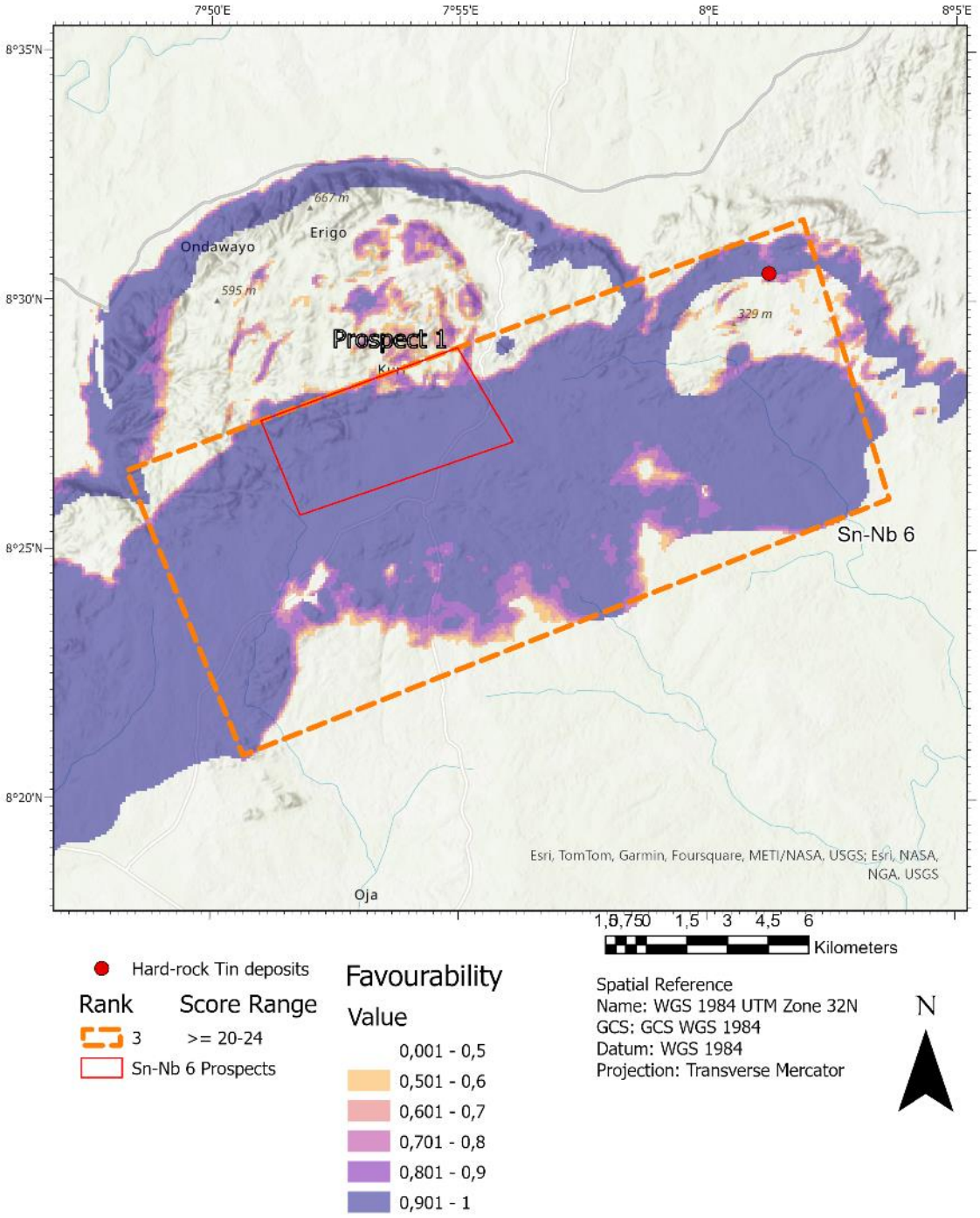


Figure 125: Favourability map for target Sn-Nb 6.

7.2.2.7 Target Tin 7

7.2.2.7.1 Summary

The target area situated around Ririwai in Kano State boasts a minimum of four known hard-rock occurrences, characterized as pneumatolytic veins alongside diagenetic placer deposits. The magnetic anomaly in the area is low (RTP) within the alkaline ring complex. Primary mining operations in the region are industrial, with some additional artisanal sites. Favourability mapping depicts a compact rounded shape with values exceeding 0.9. The total area of this target is 301.02 km^2.

7.2.2.7.2 Characterization of the target

7.2.2.7.2.1 Favourability

The favourability map shows a very compact and elongated shape with values over 0.9 covering around 50% of the target (Figure 127) and correlating with one known Sn-Nb mineral occurrence and the geology.

7.2.2.7.2.2 History

The area has been worked since colonial times (pits can be spotted in satellite imagery from 1985) but remained barely active before 2020. Sometime between 2021 and 2023 and expansion of mining activities can be seen, transforming from artisanal to industrial with the addition of heavy-duty machinery, compounds and trucks, followed by clear tailing mounds. Nonetheless, areas outside the central area show hefty artisanal workings.

7.2.2.7.2.3 Geological Setting

The target is located in the area of the Younger Granites identified as alkaline intrusives and classified as ring complexes. The rocks are composed of undifferentiated felsic to mafic alkaline volcanics including flood basalts (Jv) and undifferentiated alkaline granites predominantly biotite granite with subordinate arfvedsonite granite and Fayalite granite (Jg).

The complex is called Jarawa and has intruded older migmatitic gneisses (Pmg). The complex is called Riruwai.

7.2.2.7.2.4 Mineralization

At least four main hard-rock deposits are documented following a NW-SE tending mineral lode. Several placer deposits mine the overlying sediments with supergene tin mineralization. The identified mineralization in the area is mainly pneumatolytic lodes with diagenetic placer deposits. RTP magnetic signal indicates a strong magnetic-low area and corresponding with the last phase of the intrusives of the Younger Granites. By further inspection of the satellite imagery, new mining activities (starting on the second half of 2023) are spotted supporting the potential of this area for additional resources.

- Main mine site is a on lode deposits and apparently exploited industrially, including trucks and heavy machinery (Figure 126), and underground,
- Artisanal workings populate the area, number of spots increased dramatically starting 2019,
- No production data is available from this site.

7.2.2.7.3 Prospect areas

The prospect area of 8,99km^2 contains the following characteristics:

- Length of the main structure: 3.000m
- Average width: 5m
- Number of occurrences: 4
- Type of mining: industrial, lode deposit
- Status: active

The current mining license in the area has the following data:

	ML-021164
Company Name (after MCO)	Century Mining Company Ltd
Type of License	Mining Lease
Expiry date	2044
Commodities	Copper, Tin, Zinc

Figure 126: Industrial mine workings on hard-rock deposits with MPM values of 1.0 within Target 7 (10°43'50"N 8°44'13"E). Images taken from Google Earth.

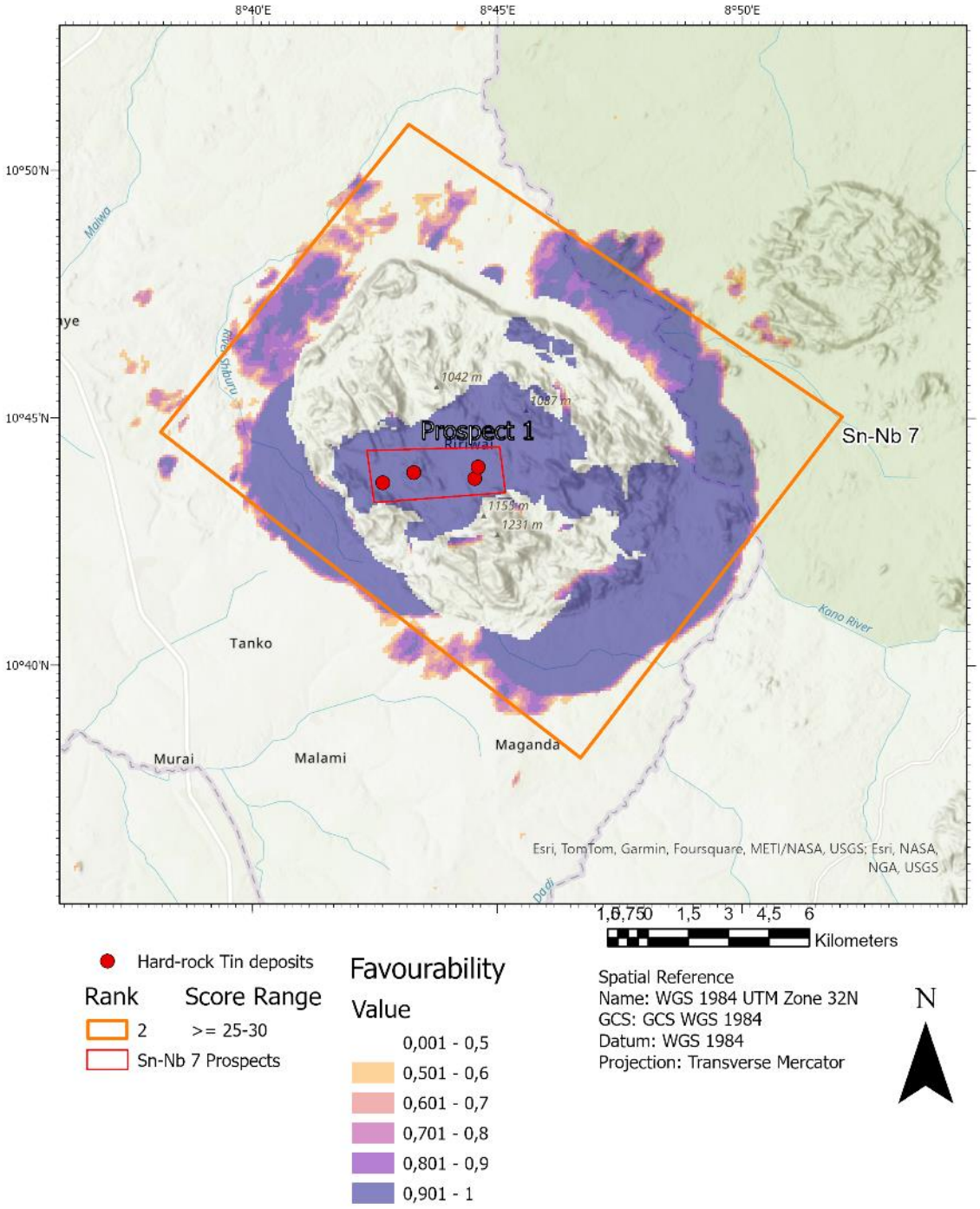


Figure 127: Favourability map for target Sn-Nb 7.

7.2.2.8 Target Tin 8

7.2.2.8.1 Summary

The target area situated around Rishi in Bauchi State boasts a minimum of six known hard-rock occurrences, characterized as pneumatolytic veins alongside diagenetic placer deposits. The magnetic anomaly suggests mineralization controlled by geological structures. Primary mining operations in the region are artisanal, particularly focused on placer deposits. As of November 2023, the main mining site lacks a license owner. Favourability mapping illustrates a compact rounded shape with values surpassing 0.9. The total area of this target is 222.39 km^2.

7.2.2.8.2 Characterization of the target

7.2.2.8.2.1 Favourability

The favourability map shows two compact areas with values over 0.95 for the NW and over 0.85 for the SE covering around 60% of the target (Figure 129) and correlating with almost all known Sn-Nb mineral occurrences and the geology.

7.2.2.8.2.2 History

The area has been worked since colonial times (pits can be spotted in satellite imagery from 1985) but remained barely active before 2020. Sometime between 2021 and 2023 and expansion of mining activities can be seen, transforming from artisanal to industrial with the addition of heavy-duty machinery, compounds and trucks, followed by clear tailing mounds. Nonetheless, areas outside the central area show hefty artisanal workings.

7.2.2.8.2.3 Geological Setting

The target is located in the area of the Younger Granites identified as alkaline intrusives and classified as ring complexes. The rocks are composed of undifferentiated felsic to mafic alkaline volcanics including flood basalts (Jv) and undifferentiated alkaline granites predominantly biotite granite with subordinate arfvedsonite granite and Fayalite granite (Jg).

The complex is called Jarawa and has intruded older migmatitic gneisses (Pmg). The complex is called Tongolo.

7.2.2.8.2.4 Mineralization

Over six known Pneumatolytic mineral occurrences are documented, some reaching up to 700 m in length, along with eight placer deposits pinpointing to several potential sources. The identified mineralization in the area is mainly pneumatolytic lodes with diagenetic placer deposits. The north-western section shows a low-magnetic region (RTP) that comprises all deposits and shows resemblance with other Younger Granites mineralized areas. On close inspection, some new unknown hard-rock workings were identified.

- Main mine site is a on lode deposits and apparently exploited industrially, including trucks and heavy machinery (Figure 128), and underground,
- Artisanal workings populate the area, number of spots increased dramatically starting 2019,
- No production data is available from this site.

7.2.2.8.3 Prospect areas

The prospect area of 10,22km^2 contains the following characteristics:

- Length of the main structure: 1.500m
- Average width: 700m
- Number of occurrences: 2
- Type of mining: artisanal, placer
- Status: active

The current mining license in the area has the following data:

	EL-030725
Company Name (after MCO)	Adahally Mining & General Business Ltd.
Type of License	Exploration
Expiry date	2023 (expired)
Commodities	Copper, Gold, Tantalum, Tin, Zinc

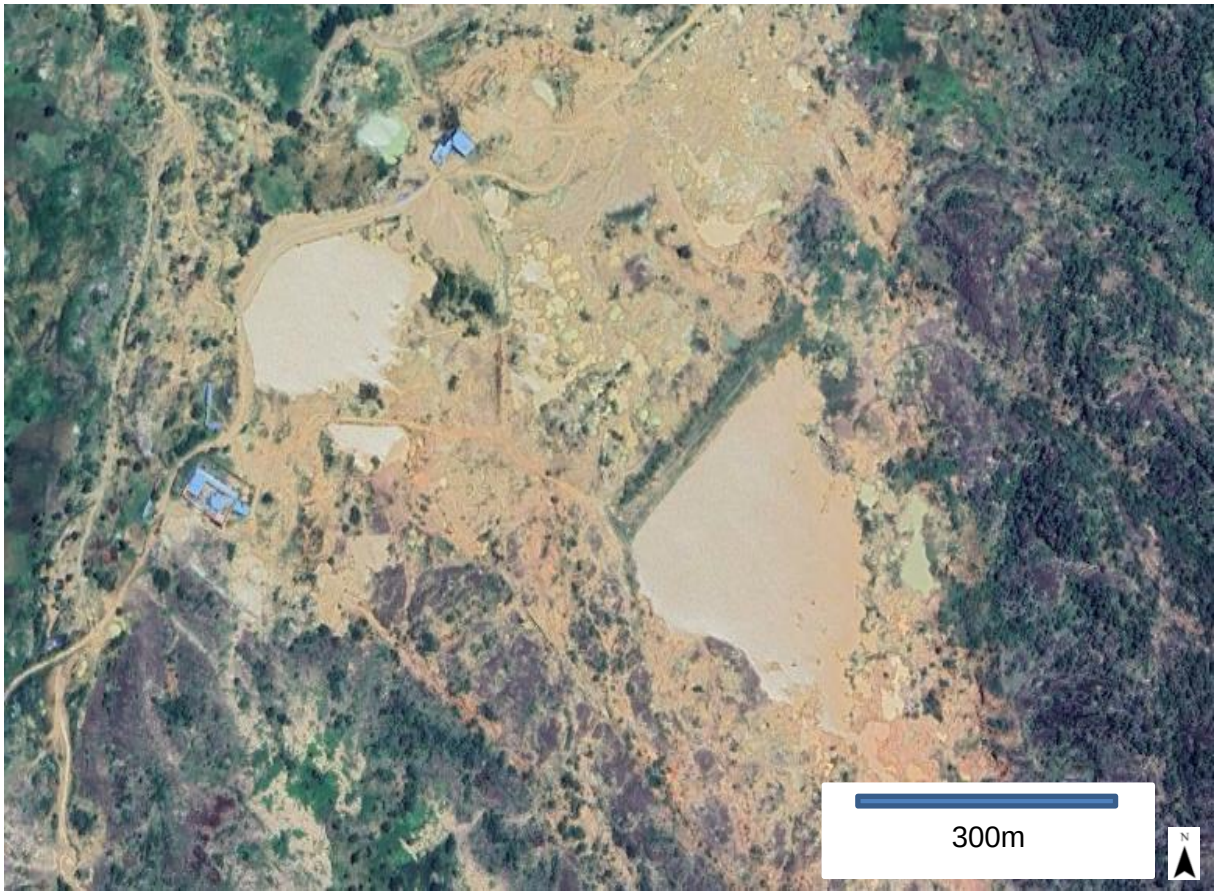


Figure 128: Artisanal workings on unidentified deposits with MPM values of 1.0 within Target (10°27'52"N 8°58'45"E). Image taken from Google Earth.

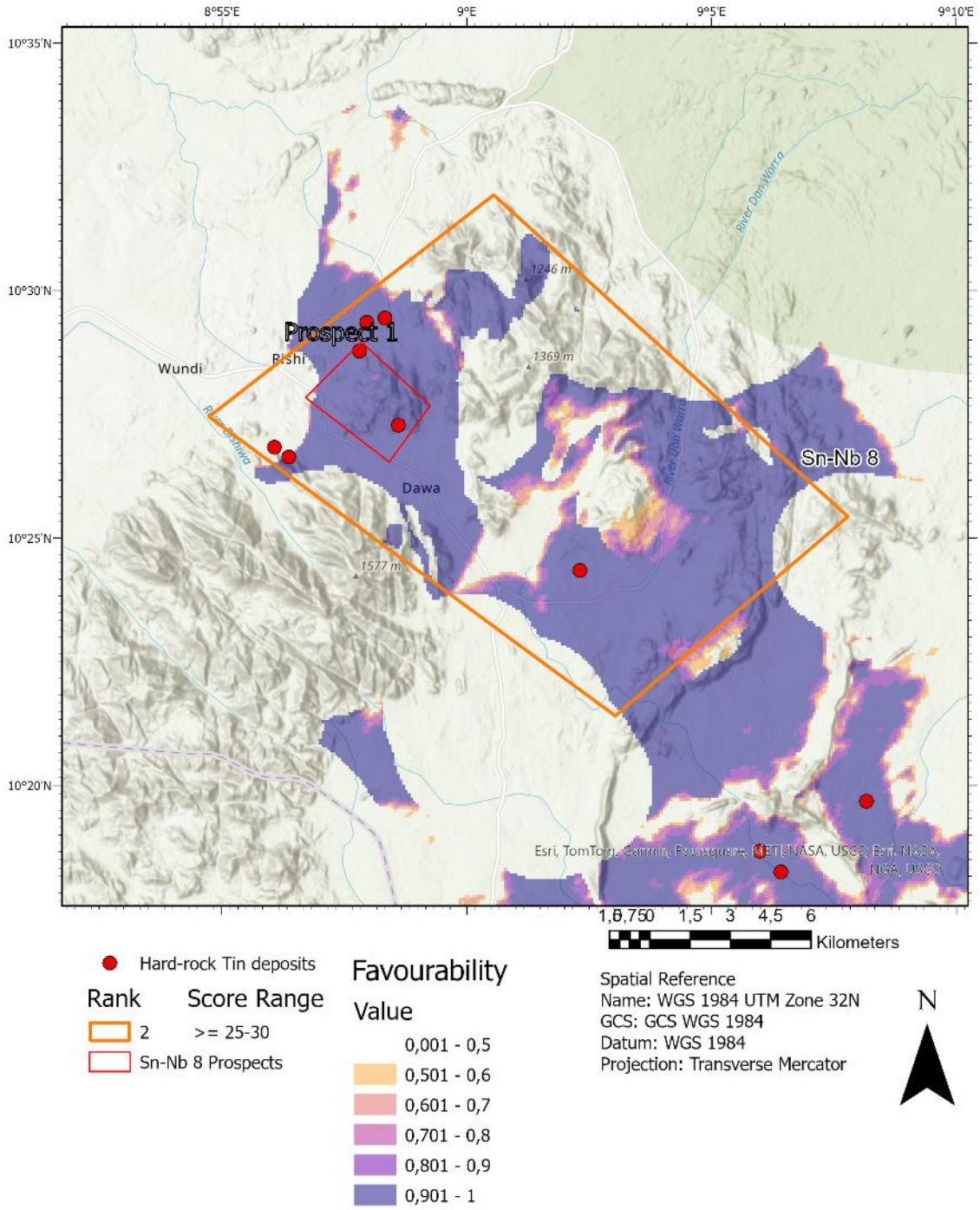


Figure 129: Favourability map for target Sn-Nb 8.

7.3 Lithium (Li) – Tantalum (Ta) Pegmatite Targets

7.3.1 Ranking and Location

7.3.1.1 Criteria Catalogue

From the general Li-Ta Favourability Map (Figure 78), a selection of single targets was selected and recommended for further evaluation. This selection represents, to the current knowledge and understanding of the Consultant, the most prospective sites along with a set of typical cases within the target areas.

The selected target areas were ranked using the following catalogue of criteria:

- MPM shape and intensity:

MPM pattern and favourability value (FV)	Score
Compact pattern and FV > 0.9	5
Compact pattern and FV > 0.8	4
Compact pattern and FV > 0.7	3
Diffuse pattern and FV > 0.9	2
Diffuse pattern and FV > 0.8	1

- Close to young shear zone:

Close to young shear zone	Score
Yes	5
No	1

- Lithium stream sediment anomalies:

Li stream sediment anomalies (ppm)	Score
More than > 100	5
Between 100 and 80	4
Between 80 and 60	3
Between 60 and 40	2
Less than 40	1

- Tantalum stream sediment anomalies:

Ta stream sediment anomalies (ppm)	Score
More than > 15	5
Between 15 and 10	4
Between 10 and 6	3
Between 6 and 3	2
Less than 3	1

- Caesium stream sediment anomalies: vector element in geochemistry for mineralized pegmatites.

Cs stream sediment anomalies (ppm)	Score
More than > 15	5
Between 15 and 10	4
Between 10 and 6	3
Between 6 and 3	2
Less than 3	1

- Pegmatite occurrences known:

Peg. Occurrences known	Score
Yes	5
No	1

- Number of pegmatite points:

Number of pegmatite points	Score
More than > 15	5
Between 15 and 13	4
Between 13 and 10	3
Between 10 and 5	2
Less than 3	1

- Pegmatite deposits being mined:

Peg. deposits mined	Score
Yes	5
No	1

- Proven thickness of pegmatites:

Proven thickness of pegmatites (m)	Score
More than > 50	5
Between 50 and 30	4
Between 30 and 20	3
Between 20 and 10	2
Less than 10	1

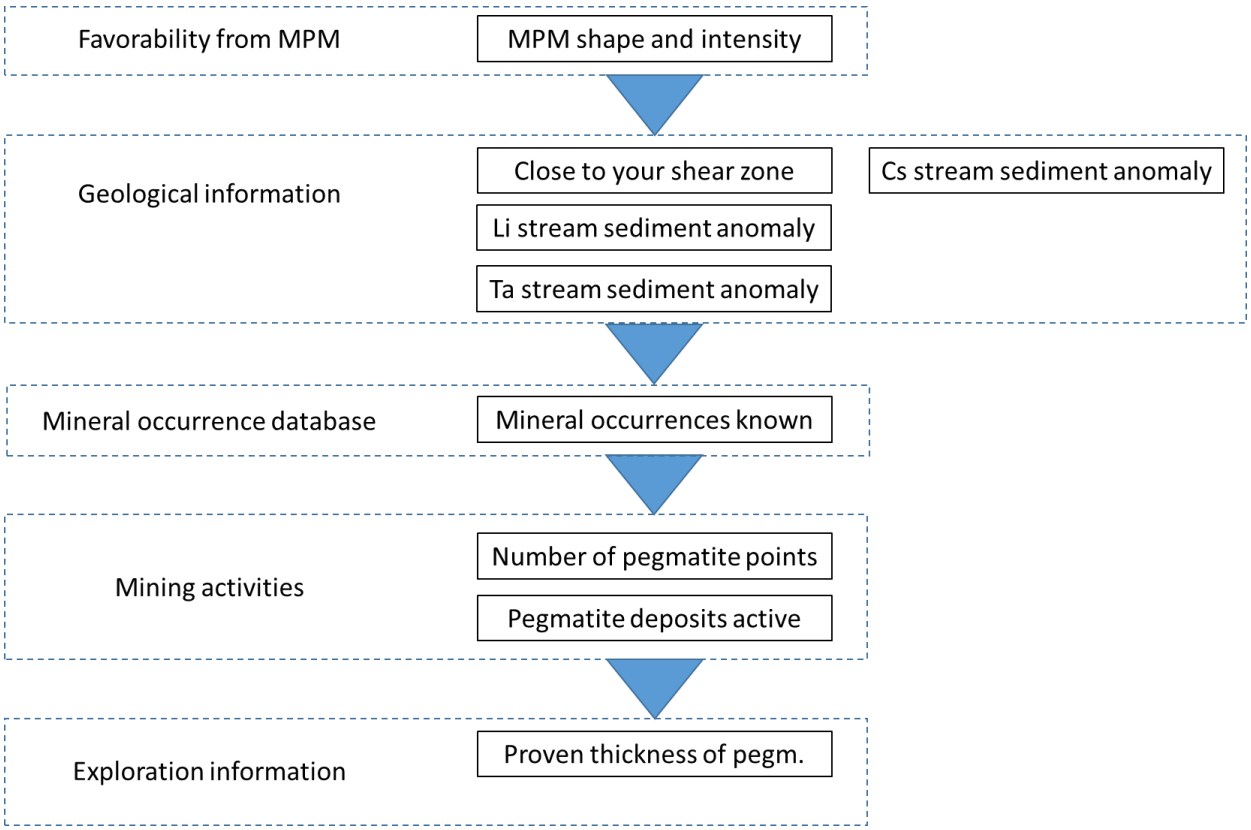


Figure 130: Criteria for the ranking of Li-Ta Targets.

7.3.1.2 Ranking and location of targets

The identified targets are located in different positions throughout the Benue Trough. Their ranking against the described criteria is shown in Table 12 and their spatial location is shown in Figure 131.

Table 12: The ranking of the Li-Ta targets.

Criteria for Li-Ta Pegmatite Targets												
Criterum	Points	Li-Ta 1	Li-Ta 2	Li-Ta 3	Li-Ta 4	Li-Ta 5	Li-Ta 6	Li-Ta 7	Li-Ta 8	Li-Ta 9	Li-Ta 10	Li-Ta 11
MPM Shape and intensity												
Compact pattern above 0.9	5	5									5	
Compact pattern and above 0.8	4								4			
Compact pattern and above 0.7	3					3	3			3		
Diffuse pattern and above 0.9	2		2	2	2			2				
Diffuse pattern and above 0.8	1											1
Close to young shear zone?												
Yes	5		5	5	5	5			5	5	5	5
No	1	1					1	1				
Li stream sediment anomalies												
>100	5											
100-80	4											
80-60	3				3							
60-40	2	2				2		2				
<40	1		1	1			1		1	1	1	1
Ta stream sediment anomalies												
>15	5											
15-10	4	4	4					4				
10-6	3				3	3						
6-3	2			2			2					
<3	1								1	1	1	1
Cs stream sediment anomalies												
>15	5											
15-10	4		4					4				
10-6	3			3	3	3						
6-3	2	2					2					
<3	1								1	1	1	1
Pegmatites occurrences known?												
Yes	5	5	5	5		5			5	5	5	5
No	1				1		1	1				
Number of pegmatite points												
>15	5	5										
15-13	4								4	4		4
13-10	3		3									
10-5	2			2								
<5	1				1	1	1	1			1	
Pegmatites being mined?												
Yes	5	5	5	5					5	5	5	5
No	1				1	1	1	1				
Proven thickness of pegmatites (m)												
>50	5								5			
50-30	4									4		
30-20	3	3										
20-10	2		2	2		2						
<10	1				1		1	1			1	1
Total Score												
Total Points		32	31	27	20	25	13	17	31	29	25	24
Total Score												
Rank order		1	1	2	3	3	5	4	1	2	2	3

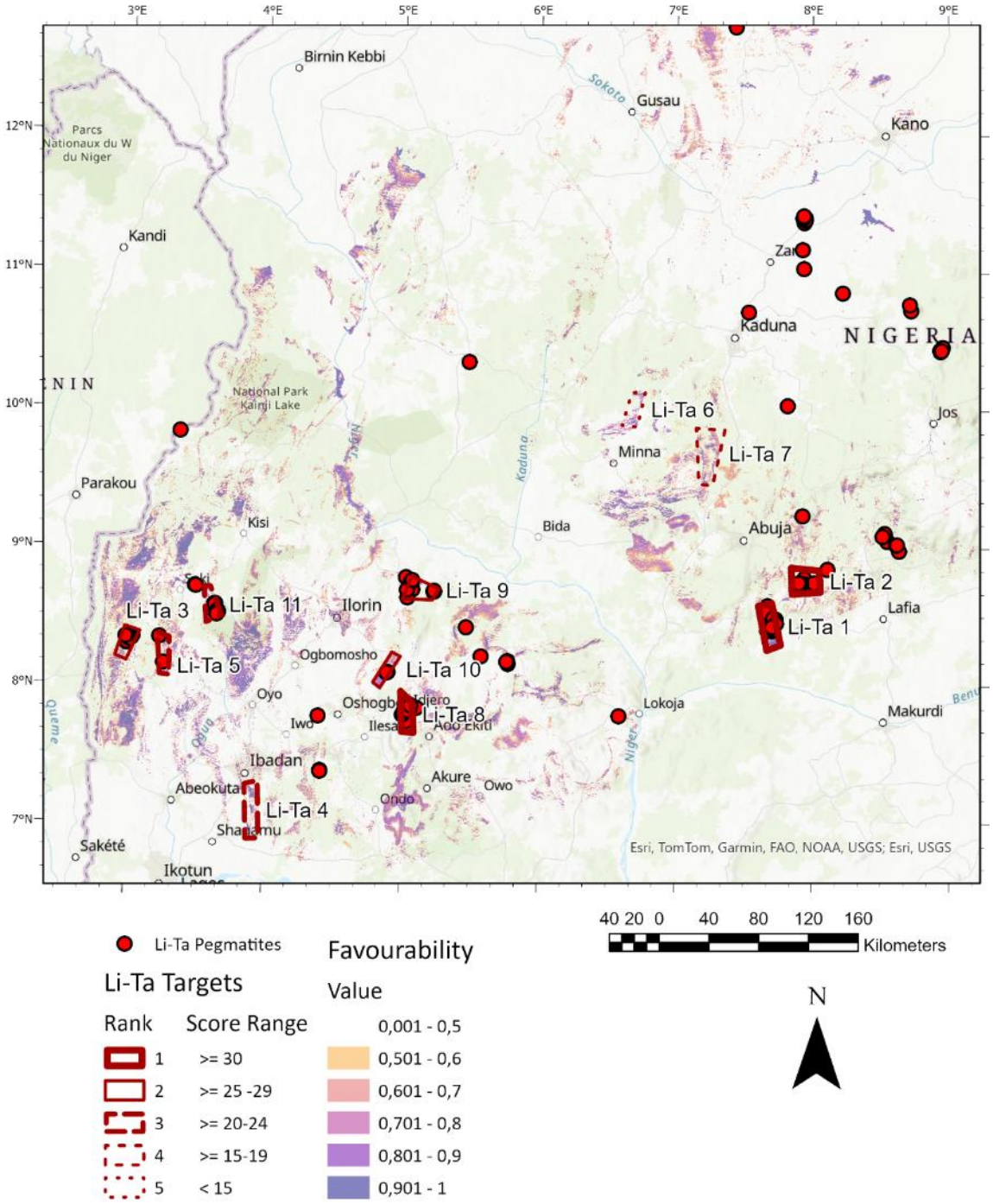


Figure 131: Location and ranking of selected targets for Lithium (Li) – Tantalum (Ta) Pegmatites.

7.3.2 Description of single targets

7.3.2.1 Target Pegmatite 1

7.3.2.1.1 Summary

The target area situated around Keffi in Nasarawa State containing 17 pegmatitic veins hosted in gneisses. The magnetic anomaly suggests mineralization geologically and structurally controlled. Primary mining operations in the region are artisanal. Currently, there area is covered both by mining leases and exploration licenses. Favourability mapping illustrates a compact elongated shape with values over 0.9. The total area of this target is 403.24 km^2.

7.3.2.1.2 Characterization of the target

7.3.2.1.2.1 Favourability

The favourability map shows one compact elongated area (some blur to the north) with values over 0.9 and covering around 80% of the target and correlating well with known Li-Ta pegmatite occurrences (Figure 135).

7.3.2.1.2.2 History

The area has been worked since colonial times (pits can be spotted in satellite imagery from 1985) but remained barely active before 2020. Sometime between 2021 and 2023 and expansion of mining activities can be seen, transforming from artisanal to industrial with the addition of heavy-duty machinery, compounds and trucks, followed by clear tailing mounds. Nonetheless, areas outside the central area show hefty artisanal workings.

7.3.2.1.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) and undifferentiated banded felsic gneisses, subordinate leucogneiss layers, mafic gneisses and paragneisses (Pbg), within the transitional tectonic domain. One main early shear zone runs N-S.

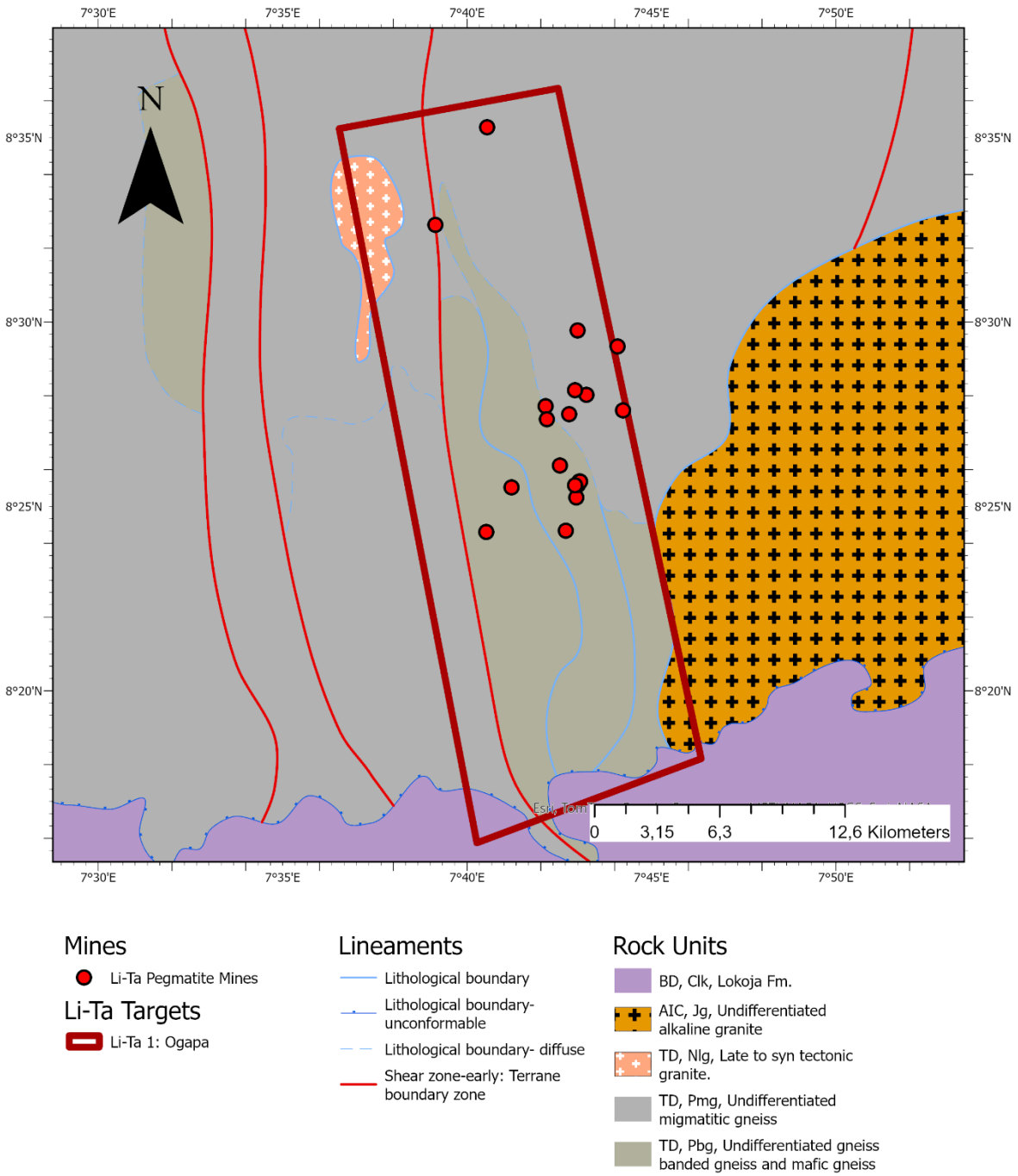


Figure 132: Geology for Pegmatite Target 1 (Li-Ta 1: Ogapa).

7.3.2.1.2.4 Mineralization

Over 17 known pegmatite occurrences are documented sitting all on topographic highs, with one body interpreted to run for more than 1.5km in length. The identified mineralization in the area is pegmatitic veins intruding into older rocks. The magnetic signal (RTP 2VD) indicates there is a main magnetic body with NNW-SSE trend that can be spatially correlated with the documented deposits. The whole cluster of pegmatites are within an area of about 70 km^2.

- NIMEP project identified:
  - body thickness of 20m (drilling),
  - Li2O values up to 1.56% and up to 527ppm Ta,
- Rubidium and Tantalum stream sediment anomalies,
- All mine sites but one seem to be exploited by artisanal miners (Figure 134),
- Production of Lithium in the area has been reported to be between 60 to 280t per annum.

7.3.2.1.2.5 Distribution of Mineral Tenements (MCO, 11.2023)

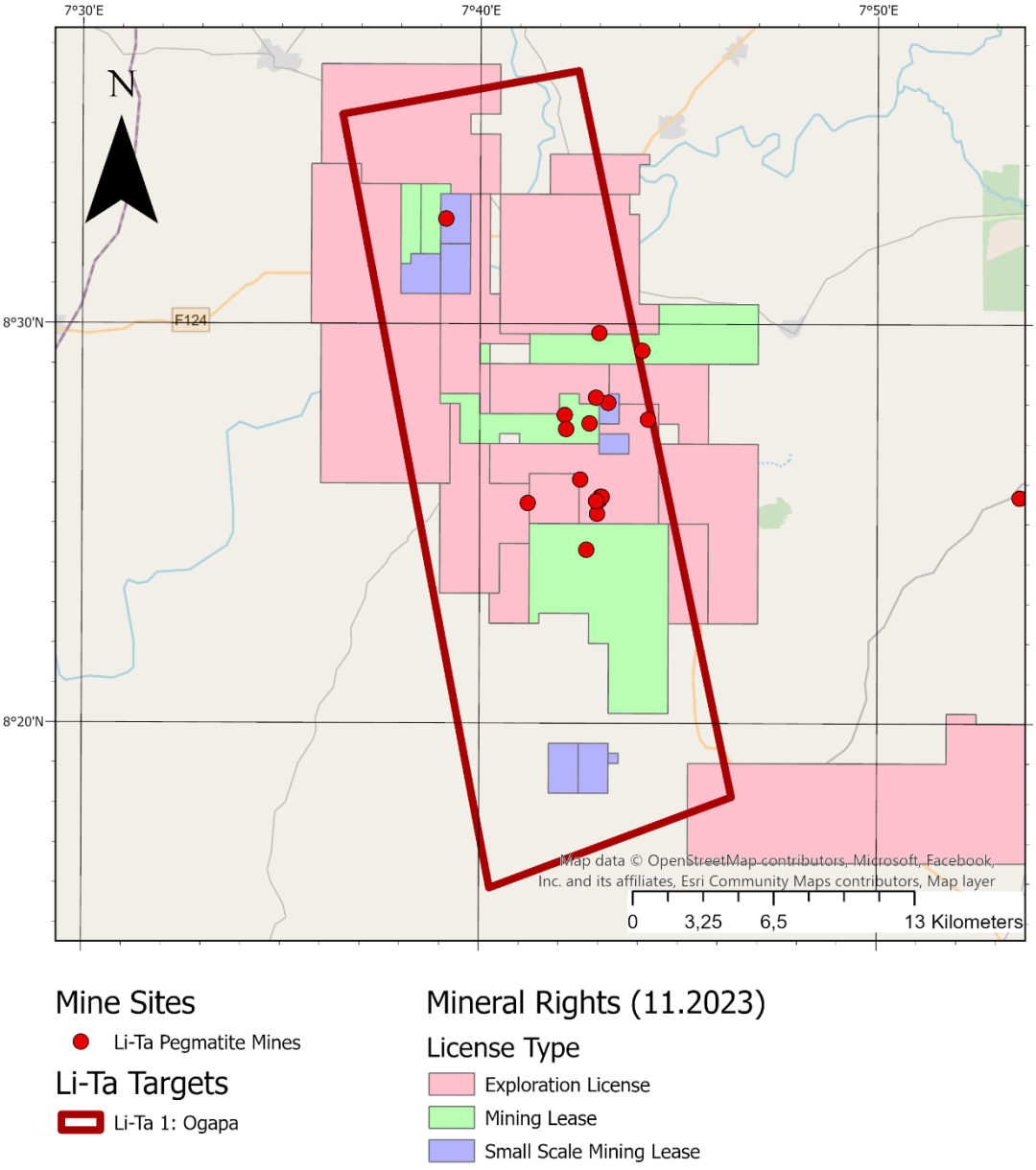


Figure 133: Distribution of Mineral Licenses in Pegmatite Target 1 (Li-Ta 1: Ogapa).

7.3.2.1.3 Suggested prospect areas

The prospect area of 15,94km^2 contains the following characteristics:

- Length of the main structure: 1.500m
- Average width: 20m
- Number of occurrences: 11
- Type of mining: artisanal
- Status: active

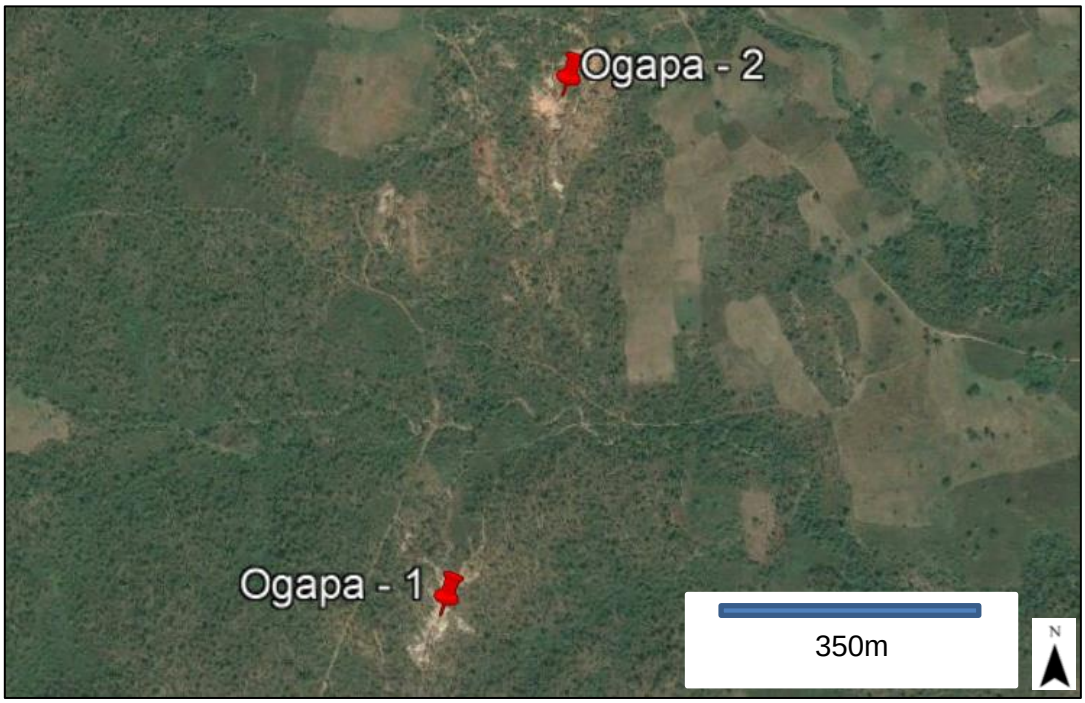


Figure 134: Active mine sites in the Ogapa area a favourable area for pegmatites with a SW-NE trend (8°25'13"N 7°42'57"E). Image taken from Google Earth.

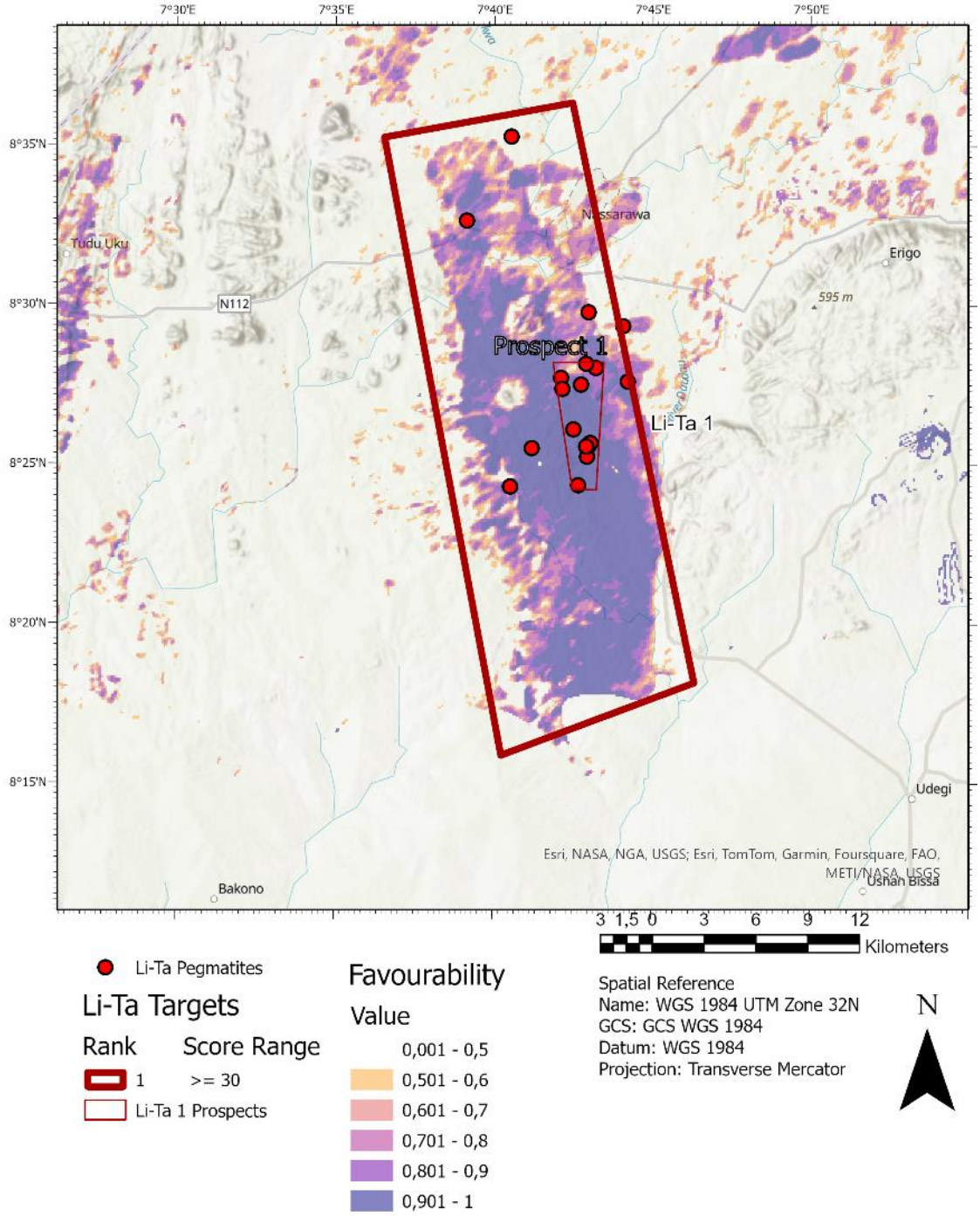


Figure 135: Favourability map for target Li-Ta 1.

7.3.2.2 Target Pegmatite 2

7.3.2.2.1 Summary

The target area situated around Keffi in Nasarawa State containing 12 pegmatitic veins hosted in gneisses. The magnetic anomaly suggests mineralization is structurally controlled. Mining in the region is artisanal and concentrates in 2 main areas with bodies of at least 20m thickness. Currently, there area is covered both by mining leases and exploration licenses. Favourability mapping illustrates a diffuse shape with several independent bodies with values over 0.8. The total area of this target is 438.21 km^2.

7.3.2.2.2 Characterization of the target

7.3.2.2.2.1 Favourability

The favourability map shows a diffuse shape made up of several independent continuous shapes, suggesting favourability follows a possible NNE-SSW pegmatite trend of several independent bodies. Although covering less than 40% of the target selected, values over 0.8 correlate well with documented mineral occurrences (Figure 139).

7.3.2.2.2.2 History

Satellite imagery records from 2005 already indicated that the area was mined by then, with at least 2 sites showing minor artisanal workings in shafts. By 2014, one site rapidly developed one major pit suggesting machinery was used, but became abandoned by 2016. In 2017, another main site southwards developed into the main mine area with a mixture of shafts and pits in two main pegmatite bodies. Further sites appeared the following years, all but one have artisanal workings while the exception indicates the usage of machinery for the opening of pits. Up to 2023, only records of three areas indicate active sites.

7.3.2.2.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) and undifferentiated banded felsic gneisses,

subordinate leucogneiss layers, mafic gneisses and paragneisses (Pbg), within the transitional tectonic domain. Two main Neoproterozoic to Cambrian late-tectonic granitoids have been interpreted to have intruded the area. Two main early shear zones run N-S.

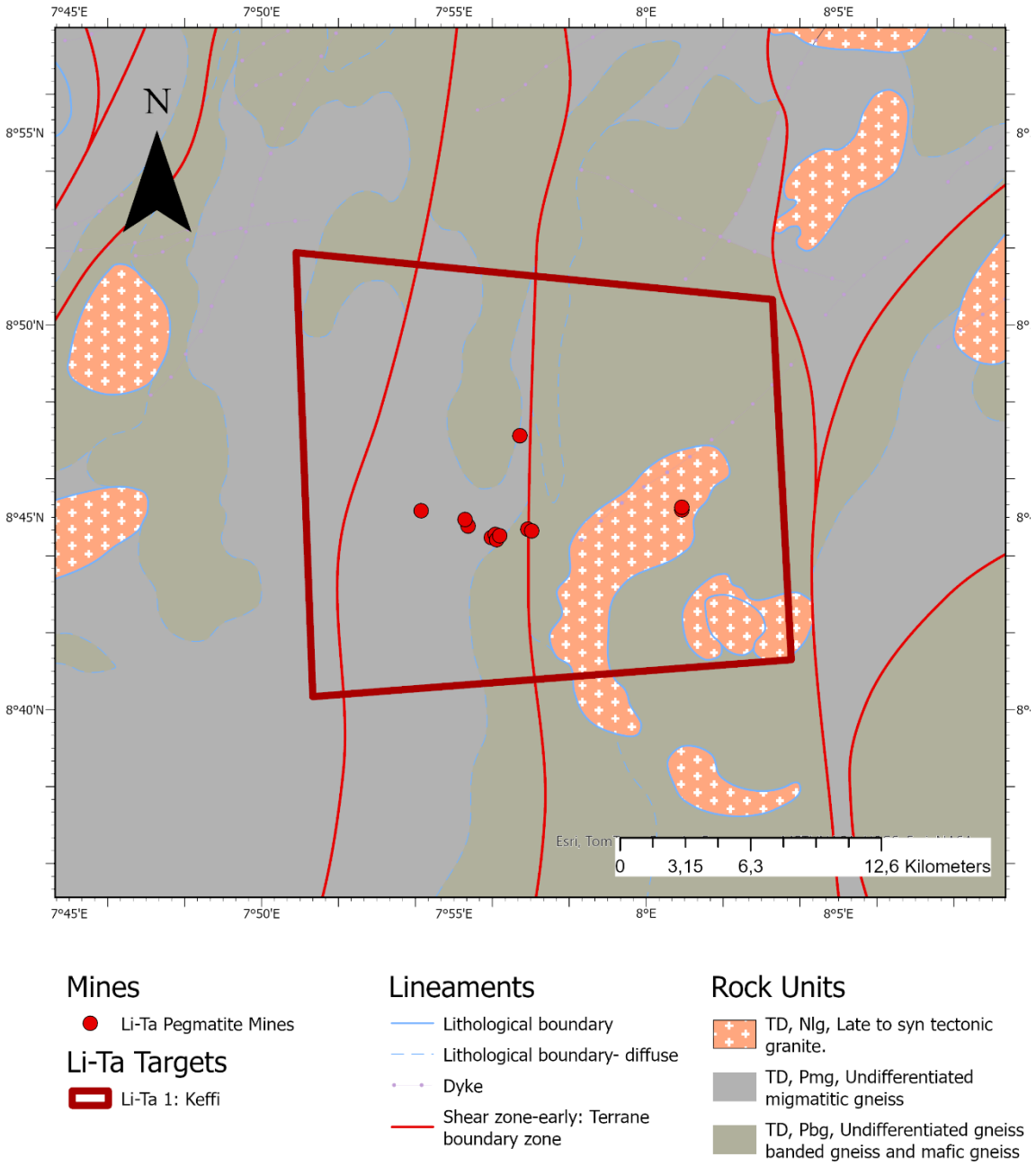


Figure 136: Geology for Pegmatite Target 2 (Li-Ta 2: Keffi).

7.3.2.2.2.4 Mineralization

12 known pegmatite occurrences are documented (with additional ones currently unregistered) sitting all on topographic highs, with one body interpreted to run for more than 600m in length. The identified mineralization in the area is pegmatitic veins intruding into older rocks. The magnetic signal (Tilt derivative) indicates there are several main structures running NE-SW correlating well with the documented occurrences and suggesting a structural control of the mineralized bodies. The whole cluster of pegmatites, are within an area of about 40 km^2.

- NIMEP project identified:
  - body thickness of 20m (drilling),
  - Li2O values up to 1%, Sn values reaching 1228ppm and up to 733ppm Ta,
- Caesium and Tantalum stream sediment anomalies,
- All mine sites but one seem to be exploited by artisanal miners (Figure 138),
- Production of Lithium in the area has been reported to be 169t per annum.

7.3.2.2.2.5 Distribution of Mineral Tenements (MCO, 11.2023)

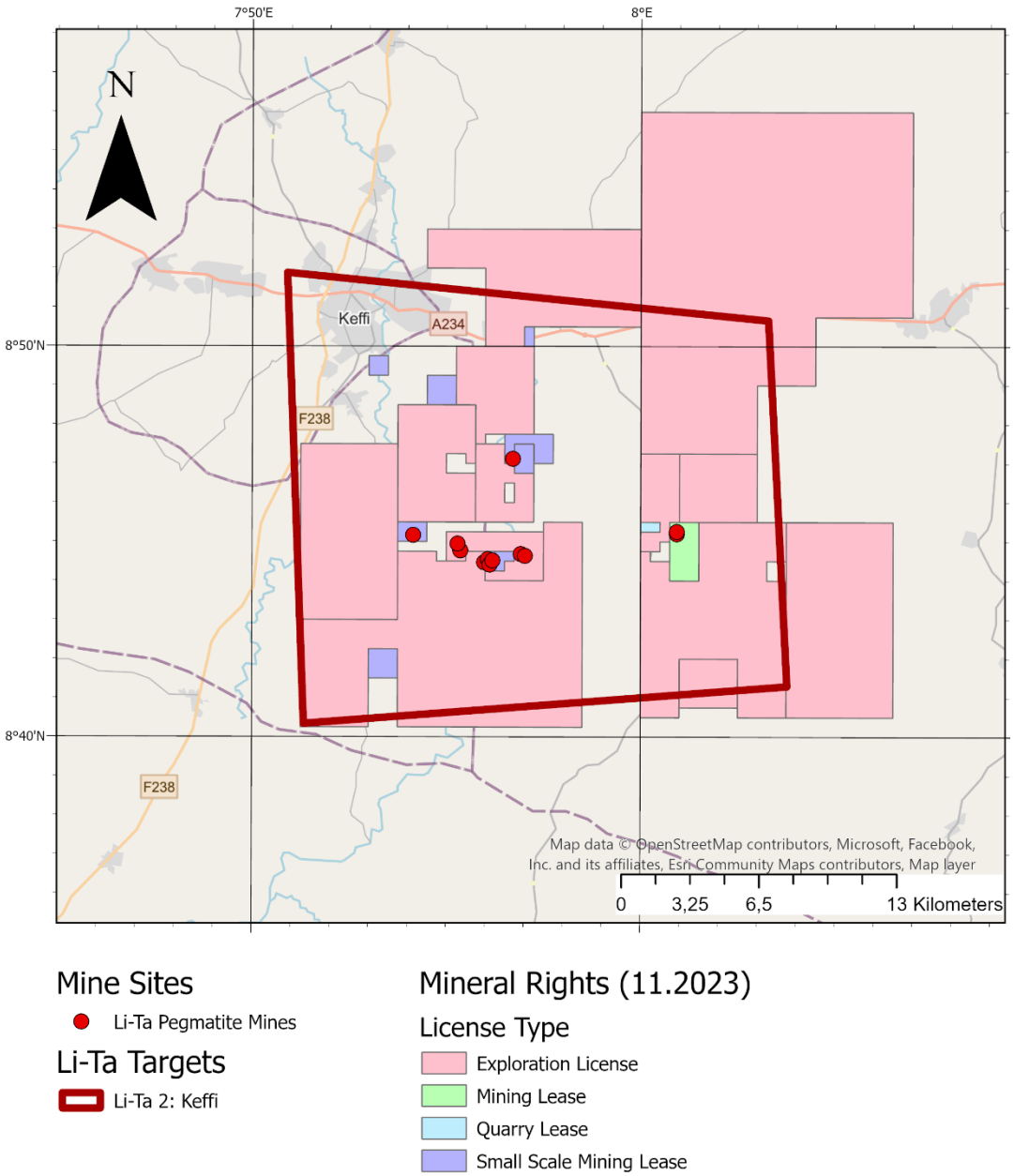


Figure 137: Distribution of Mineral Licenses in Pegmatite Target 2 (Li-Ta 2: Keffi).

7.3.2.2.3 Suggested prospect areas

The prospect area of 14,36km^2 contains the following characteristics:

- Length of the main structure: 600m
- Average width: 50m
- Number of occurrences: None currently registered
- Type of mining: artisanal (some usage of excavator machinery)
- Status: partially active

Figure 138: Active mine site for pegmatites with values of 0.8 (8°48'54"N 7°54'35"E). Image taken from Google Earth.

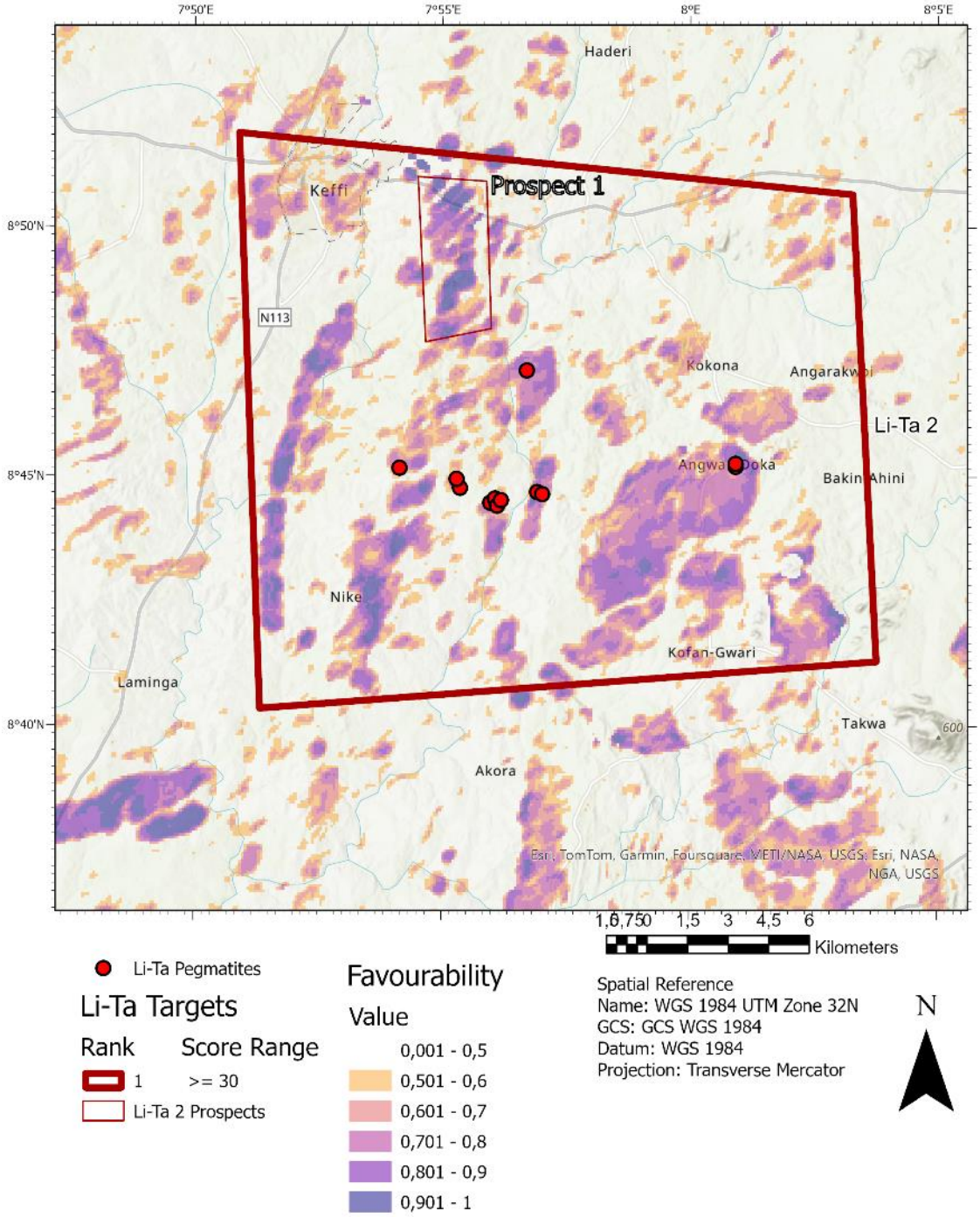


Figure 139: Favourability map for target Li-Ta 2.

7.3.2.3 Target Pegmatite 3

7.3.2.3.1 Summary

The target area situated Close to Atabo town, Oyo State, containing 9 pegmatitic veins hosted in gneisses close to granitic intrusions. The magnetic anomaly suggests mineralization is structurally controlled. Mining in the region is artisanal but is mainly abandoned except one main pit. Currently, there area is covered by a mining lease. Favourability illustrates a diffuse but elongated area with values over 0.8. The total area of this target is 284.50 km^2.

7.3.2.3.2 Characterization of the target

7.3.2.3.2.1 Favourability

The favourability map shows indicates a diffuse shape but suggesting a continuous and elongated favourable region with similar characteristics (Figure 141). All documented mineral occurrences fall within values over 0.9 and correlate well with this shape.

7.3.2.3.2.2 History

Satellite imagery is only available starting 2011 and already shows at least 2 main mining sites with well-developed pits (e.g., NR-Komu 1) suggesting machinery, and some other artisanal areas with several shafts. By 2018, new artisanal sites appeared with their distinctive shafts, while other sites became abandoned (e.g., one of the original major sites). By 2018, another main site had opened showing machinery activities and a distinct pit. Last available images from 2020 as well as current data from MI and MCO indicate areas remained active until today.

7.3.2.3.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) and undifferentiated banded felsic gneisses, subordinate leucogneiss layers, mafic gneisses and paragneisses (Pbg), within the Western Basement Complex. Two main Neoproterozoic to Cambrian late-tectonic granitoids have been

interpreted to have intruded the area (Nlg). One main late shear zone run NE-SW lightly bifurcating and giving space for greenschist to amphibolite facies sequences (Ns).

7.3.2.3.2.4 Mineralization

A cluster of 9 known pegmatite deposits with associated tantalum and beryl minerals exists to the north of which half remain active. Figure 140 shows one active pegmatite mine that extends for 600 m with related activities identified further north. The total area of the cluster of points measures ca. 34 km^2. The magnetic signal (Tilt derivative) indicates there is one main structural break in the geology running NE-SW and suggesting a structural control of the mineralized bodies.

- Caesium and Tantalum stream sediment anomalies in the vicinity,
- All mine sites seem to be exploited by artisanal miners (Figure 138),
- Production of Lithium in the area has been reported to be 1000t per annum,
- Production of Kunzite is reported to be 56t per annum.

7.3.2.3.3 Suggested prospect areas

The prospect area of 3,08km^2 contains the following characteristics:

- Length of the main structure: 580m (interpreted)
- Average width: 100m (interpreted)
- Number of occurrences: 3
- Type of mining: artisanal (some usage of excavator machinery)
- Status: active

Figure 140: Active mine site of a pegmatite running NNE-SSW for a length of ca. 600m (8°19'25"N 3°02'39"E). Image taken from Google Earth.

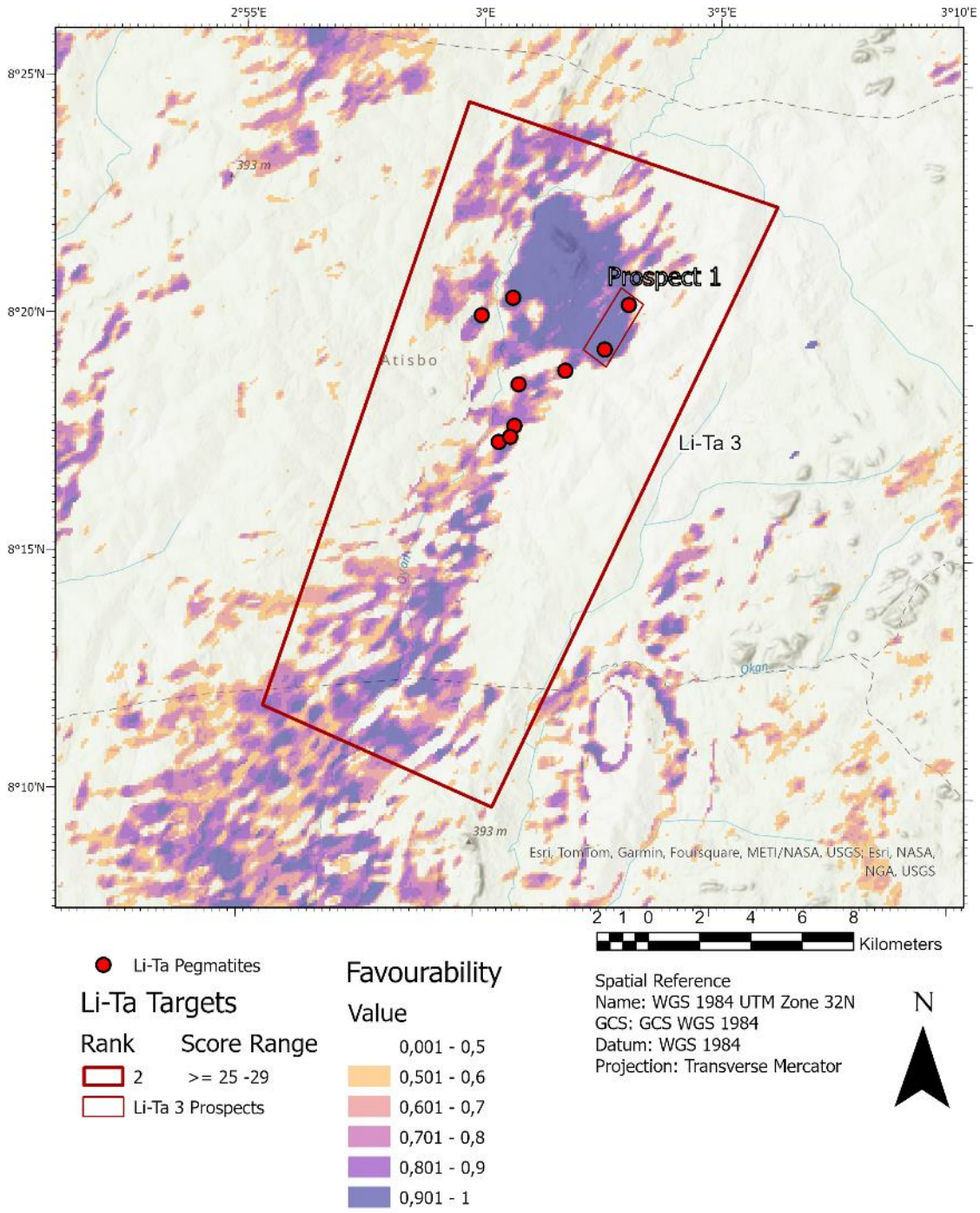


Figure 141: Favourability map for target Li-Ta 3.

7.3.2.4 Target Pegmatite 4

7.3.2.4.1 Summary

The target area situated around south-east of Ibadan, Oyo State, containing no known lithium or tantalum pegmatitic veins, but several aquamarine sites within gneisses and close to a granitic intrusion. The magnetic anomaly suggests mineralization is probably structurally controlled. Mining in the region is artisanal aided with excavator machinery. Currently, there area is partially covered by mining leases. Favourability mapping illustrates a diffuse elongated shape with several independent bodies with values over 0.8. The total area of this target is 475.35 km^2.

7.3.2.4.2 Characterization of the target

7.3.2.4.2.1 Favourability

The favourability map shows two shapes roughly compact and continuous suggesting two main favourable areas almost entirely limited to Pbg rocks. Approximately 50% of the target selected is covered by values over 0.8 where, although no Li-Ta pegmatites are documented, correlate well with at least two known aquamarine and tourmaline artisanal mines (Figure 143).

7.3.2.4.2.2 History

Activities, according to satellite imagery, started mainly as exploitation mainly for granite some time before 2014, with only one small aquamarine site containing 3 small shallow pits. This initial site saw constant development through the years, joined in 2017 by another aquamarine site to the south east of the local older granite. By 2019, several other sites popped-up in the area suggesting more mineralized bodies. By 2022, all sites seemed to remain active but in an artisanal level.

7.3.2.4.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) and undifferentiated banded felsic gneisses,

subordinate leucogneiss layers, mafic gneisses and paragneisses (Pbg), within the Western Basement Complex. One Neoproterozoic to Cambrian late-tectonic granitoid has been interpreted to have intruded the area (Nlg). Several late shear zones run N-S and encompass some interpreted greenschist to amphibolite facies sequences (Ns).

7.3.2.4.2.4 Mineralization

No known pegmatite mineralized with lithium or tantalum is documented in the area, however at least 2 known mines for pegmatite related gemstones exist (e.g., tourmaline, aquamarine). The identified mineralization in the area is pegmatitic veins intruding into older rocks. The magnetic signal (RTP 2VD) shows one long structure to the west of the target where favourability is high is seemingly delimited by two shear zones, while the second suggests a relationship with the intruded Older Granite (Nlg).

- Caesium and Tantalum stream sediment anomalies,
- Known pegmatite-related gemstone mines in the area (Figure 142),
- No production information in the area is available.

7.3.2.4.3 Suggested prospect areas

The prospect area of 16,26km^2 contains the following characteristics:

- Length of the main structure: 320m (interpreted)
- Average width: 50m (interpreted)
- Number of occurrences: None currently registered
- Type of mining: artisanal (some usage of excavator machinery)
- Status: partially active

Figure 142: Mine workings for aquamarine and tourmaline registered in the database and MPM values above 0.7 (7°09'42"N 3°57'25"E) Image taken from Google Earth.

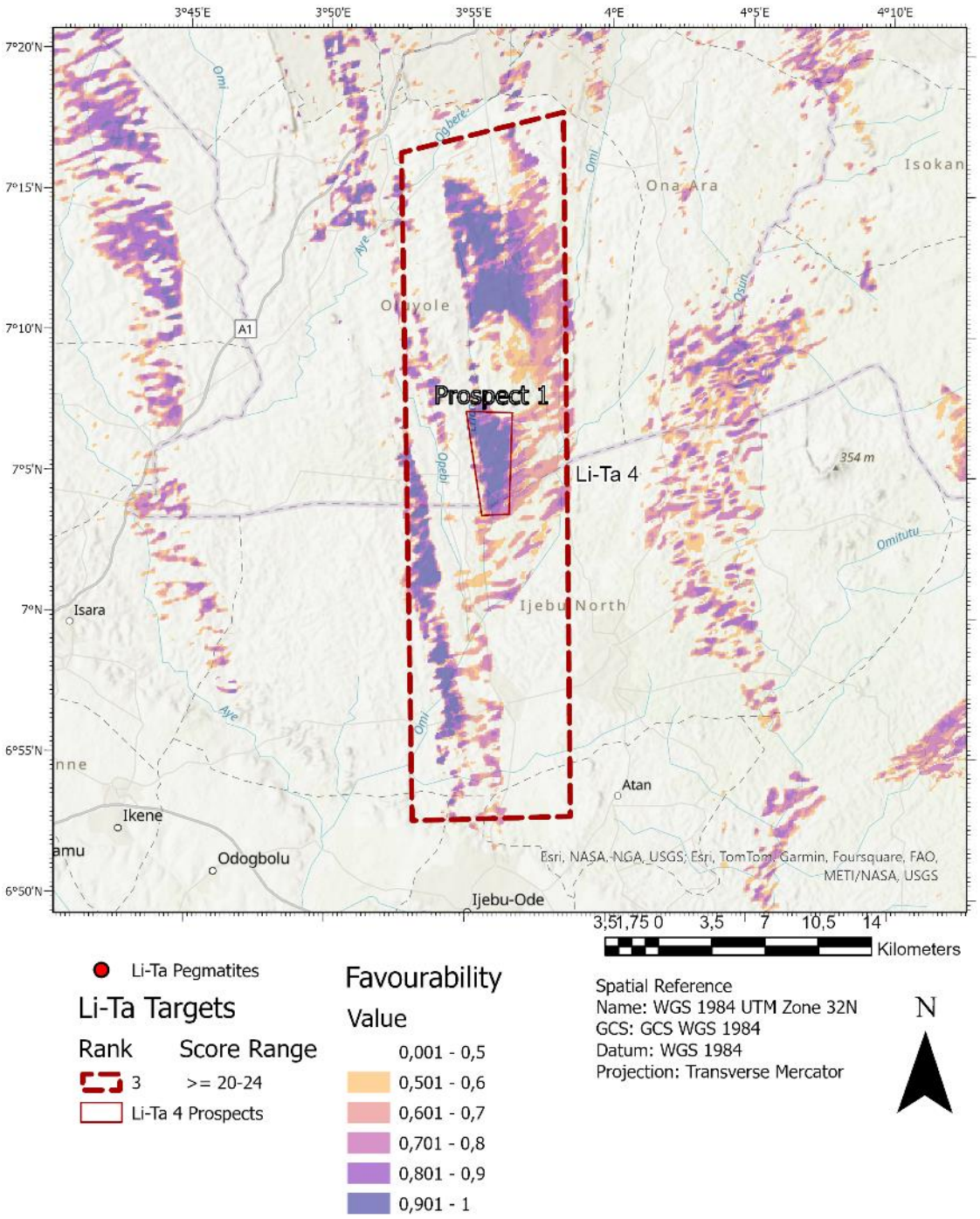


Figure 143: Favourability map for target Li-Ta 4.

7.3.2.5 Target Pegmatite 5

7.3.2.5.1 Summary

The target area situated around Saki East in Oyo State, containing two known mineralized pegmatitic veins within gneisses close to granitic intrusions. The magnetic anomaly suggests mineralization is probably structurally controlled. Mining in the region is solely artisanal. Currently, there area is partially covered by one mining lease. Favourability map has a diffuse elongated shape with values over 0.8. The total area of this target is 575.27 km^2.

7.3.2.5.2 Characterization of the target

7.3.2.5.2.1 Favourability

The shape of the favourability map indicates one main continuous shape with a very diffuse nature and following roughly the regional shear zone. Approximately 50% of the target selected is covered by values over 0.6 where the only two mineral occurrences documented are roughly contained (Figure 145).

7.3.2.5.2.2 History

Satellite imagery indicates that mining in the area had started sometime before 2012 with already countless visible shafts by that year in the length of around 1.700m, many seemingly abandoned with only around 400m of active shafts. Between 2018 and 2021, the second pegmatite site operated, but was then abandoned. By 2022, the major site saw a reduction and concentration of its activities within only 200m.

7.3.2.5.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) within the Western Basement Complex. Two Neoproterozoic to Cambrian late-tectonic granitoids are interpreted, one of which has considerable regional size (Nlg). Only one late shear zone running N-S has been mapped in the area.

7.3.2.5.2.4 Mineralization

Two known mineralized pegmatites are documented in the area. The identified mineralization in the area is pegmatitic veins intruding into older rocks. The magnetic signal (RTP 2VD) indicated a continuous rock body running N-S that in several places is interpreted to be cross-cut by NE-SW trending structures (faults?) concentrated on the southern part of the target, while the northern section suggest a deformed area between the two Nlg granitoids.

- Caesium and Tantalum stream sediment anomalies,
- Two known mineralized pegmatites in the area (Figure 144),
- A total of 4928t of tourmaline are reported to be produced per annum.

7.3.2.5.3 Suggested prospect areas

The prospect area of 13,95km^2 contains the following characteristics:

- Length of the main structure: 1.700m (interpreted)
- Average width: 100m (interpreted)
- Number of occurrences: 1
- Type of mining: artisanal
- Status: active

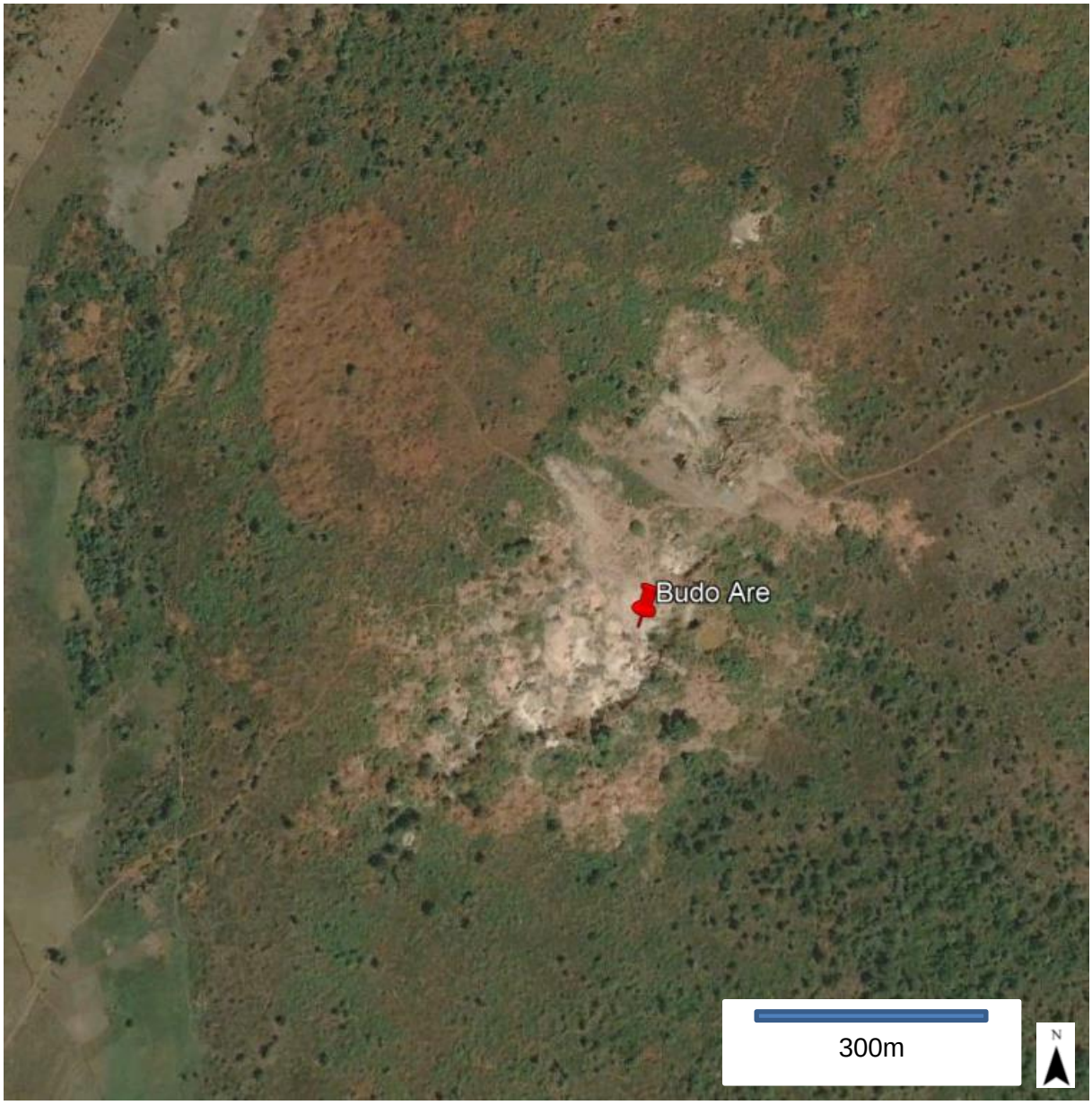


Figure 144: Pegmatite mine working in the selected target area number 5 (8°20'12"N 3°14'39"E). Image taken from Google Earth.

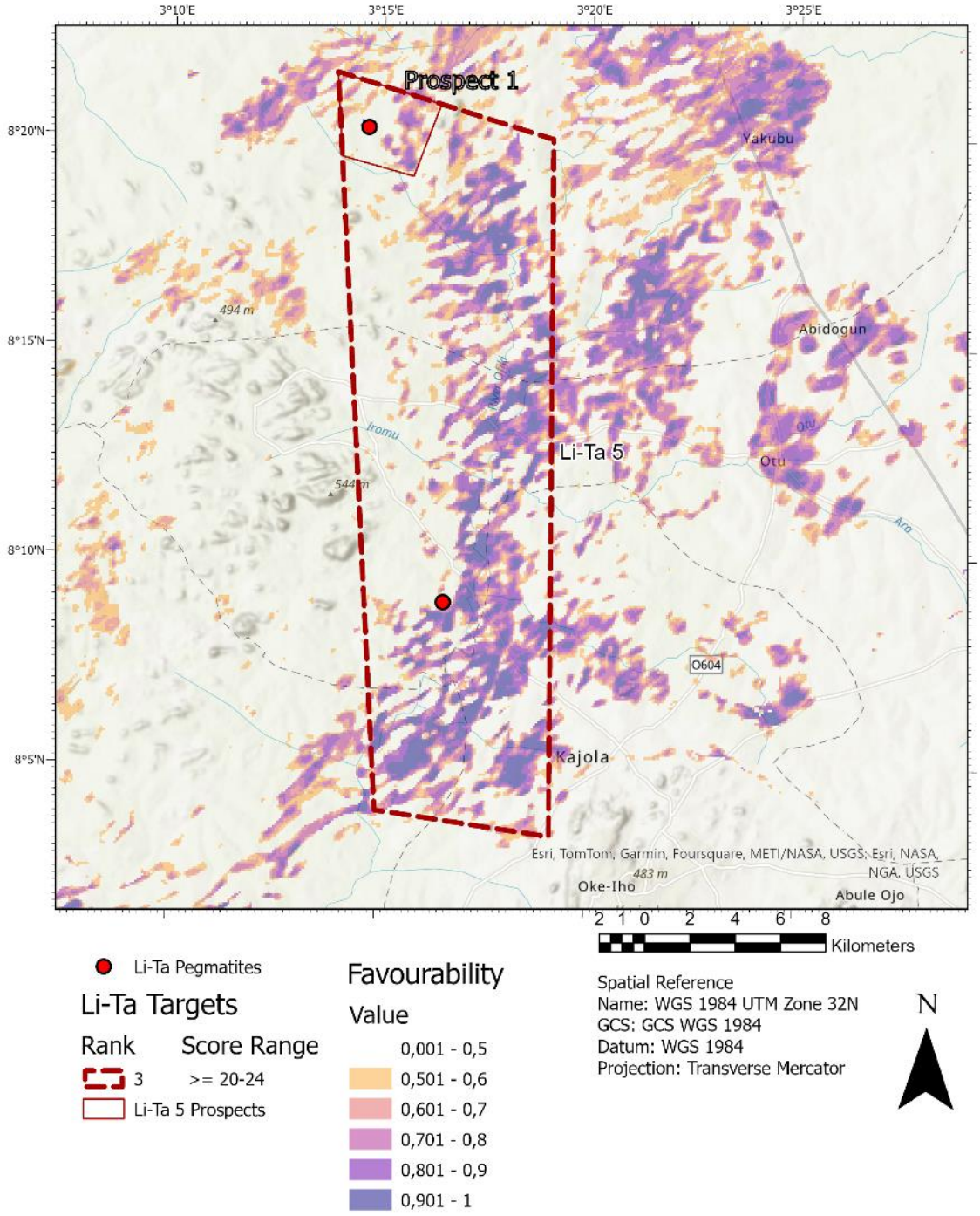


Figure 145: Favourability map for target Li-Ta 5.

7.3.2.6 Target Pegmatite 6

7.3.2.6.1 Summary

The target area situated around Dami Dami town, Niger State, containing no known mineralized pegmatitic veins but a few considerable mining activities related to gold and linked with pegmatites exist. Hoisting rocks are gneisses and volcano-sedimentary greenschist to amphibolite facies sequences. The magnetic anomaly suggests there are structural controls on the area. Currently, there are exploration and mining leases for gold in the area. Favourability map has a diffuse elongated shape with values over 0.8.

7.3.2.6.2 Characterization of the target

7.3.2.6.2.1 Favourability

The shape of the favourability map indicates two main continuous diffused shapes, separating the north and south in two interpreted provinces. Approximately 40% of the target selected is covered by values over 0.6 (Figure 147). The total area of this target is 315.67 km^2.

7.3.2.6.2.2 History

Although somewhat unclear, the satellite imagery suggests that the area had already been active by 2013 with minor shafts and placer pits related to gold mining. By 2019, the activities had moved slightly to the north, but remained artisanal with some evidence of hard-rock workings. One year later (2020), mining had expanded dramatically in all directions and at least 3 pits of around 50m average length appeared. In 2024, all areas seemed to remain active with two more new main sites, one showing workings on hard rock with an artisanal pit of 120m length while the second showing an industrial capacity with several trucks and machinery on a 250m length pit.

7.3.2.6.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) and undifferentiated banded felsic gneisses,

subordinate leucogneiss layers, mafic gneisses and paragneisses (Pbg), within the Western Basement Complex. Several early shear zones run NE-SW and separate greenschist to amphibolite facies sequences (Ns) in the area.

7.3.2.6.2.4 Mineralization

No known mineralized pegmatites are documented in the area, but mineralization from existing gold mining can be interpreted either as pegmatitic veins intruding into older rocks or a stockwork system. The stream network and the DEM suggest that the source of Caesium and Tantalum anomalies is nearby. Through the magnetic signal (RTP 2VD) the shear zones/faults are evident and indicate one major NNE-SSW structure to which the favourability correlates well, and suggest influence from the intruding Older Granite in the vicinity.

- Caesium and Tantalum stream sediment anomalies,
- Au mineralized areas that may be linked to pegmatites within a 5,5km^2 area (Figure 146),
- No values of production reported in the area.

7.3.2.6.3 Suggested prospect areas

The prospect area of 33,45km^2 contains the following characteristics:

- Length of the main structure: 250m (interpreted)
- Average width: 50m (interpreted)
- Number of occurrences: none
- Type of mining: artisanal
- Status: active

Figure 146: Possible pegmatites in the area following a N-S trend and found throughout the area (10°02'07"N 6°39'25"E). Image taken from Google Earth.

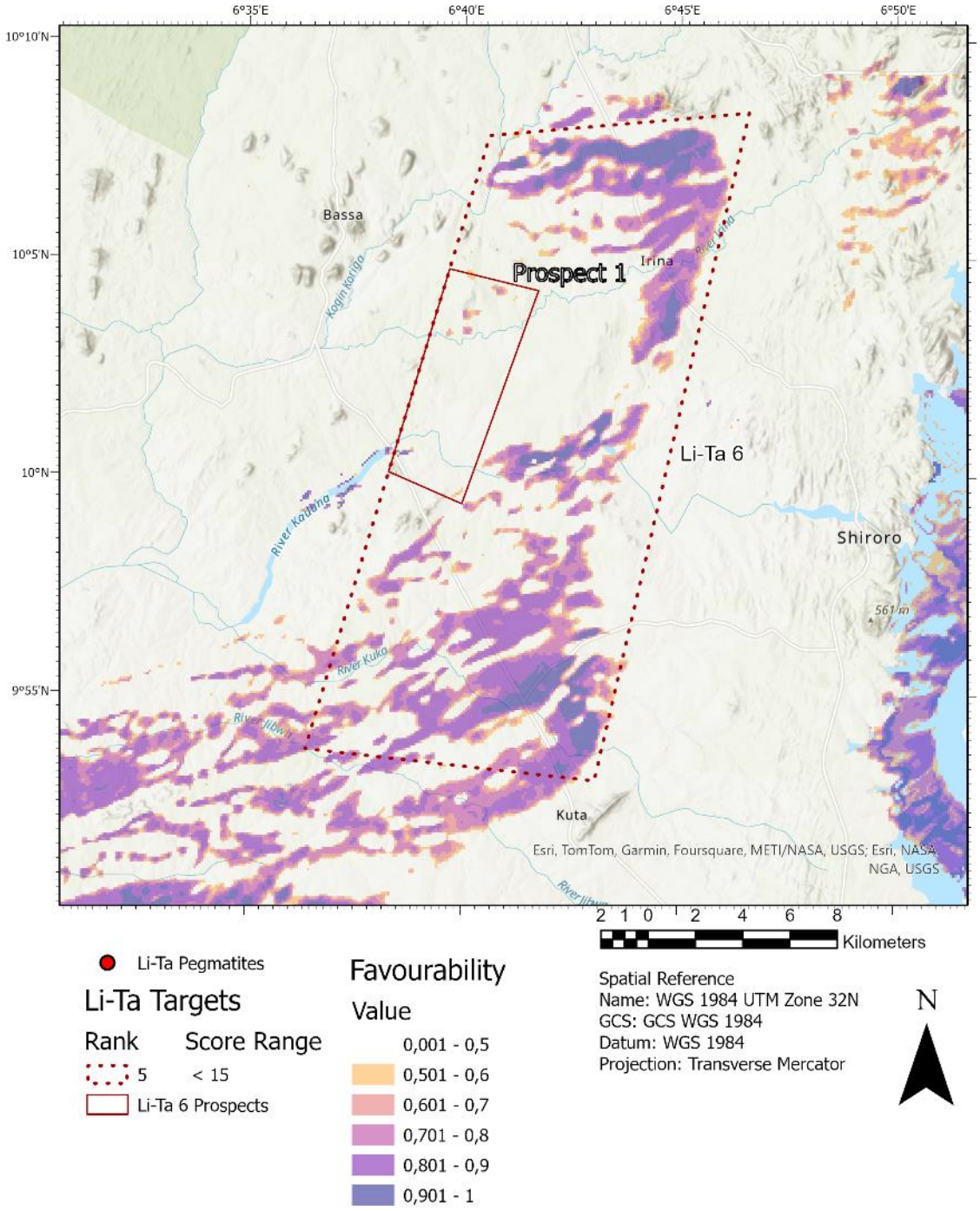


Figure 147: Favourability map for target Li-Ta 6.

7.3.2.7 Target Pegmatite 7

7.3.2.7.1 Summary

The target area situated around Beni Hill, Niger State, contains no known mineralized pegmatitic veins but has recent artisanal activities in an interpreted 2km body within gneisses. The magnetic anomaly suggests mineralization is probably structurally controlled. Currently, no mining license covers the suggested prospect, but several exploration licenses are in the vicinity. Favourability map has a diffuse elongated shape with values over 0.8. The total area of this target is 863.77 km^2.

7.3.2.7.2 Characterization of the target

7.3.2.7.2.1 Favourability

The shape of the favourability map is very diffuse but indicates two main elongated trends that follow the mapped shear zones and can be interpreted regionally as a general continuous shape covering all the selected target (Figure 149). Values above 0.6 approximately cover 40% of the total selected region.

7.3.2.7.2.2 History

The start of the activities in the area can be interpreted not to be so far from the beginning of 2019 since a few mine shafts can be identified in the area. From that date onwards, the activities increased dramatically showing several pits but remained in an artisanal level. Further expansion of the activities continued into the 2022 remaining the main mine site of all the target.

7.3.2.7.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) and undifferentiated banded felsic gneisses, subordinate leucogneiss layers, mafic gneisses and paragneisses (Pbg), within the Western Basement Complex and bordering the Transitional Zone. One Neoproterozoic to Cambrian

syn-tectonic granitic pluton/batholitic body has been interpreted to have intruded the area (Nog). At least 2 main early shear zones run N-S.

7.3.2.7.2.4 Mineralization

No known lithium-tantalum mineralized pegmatites are documented in the area. The identified mineralization in the area is pegmatitic veins intruding into older rocks. The magnetic signal (RTP 2VD) clearly indicates that the area is strongly structurally controlled with two continuous bodies interpreted to follow an N-S trend and defining the shape/location of the highest favourability values.

- Caesium, Lithium and Tantalum stream sediment anomalies,
- Artisanal workings in the area have been identified with favourability values of 1.0 in a total area of at least 5,34km^2 (Figure 148),
- 25t of lithium per annum have been produced in the past by a company.

7.3.2.7.3 Suggested prospect areas

The prospect area of 3,56km^2 contains the following characteristics:

- Length of the main structure: 2.090m (interpreted)
- Average width: 300m (interpreted)
- Number of occurrences: none recorded
- Type of mining: artisanal
- Status: active

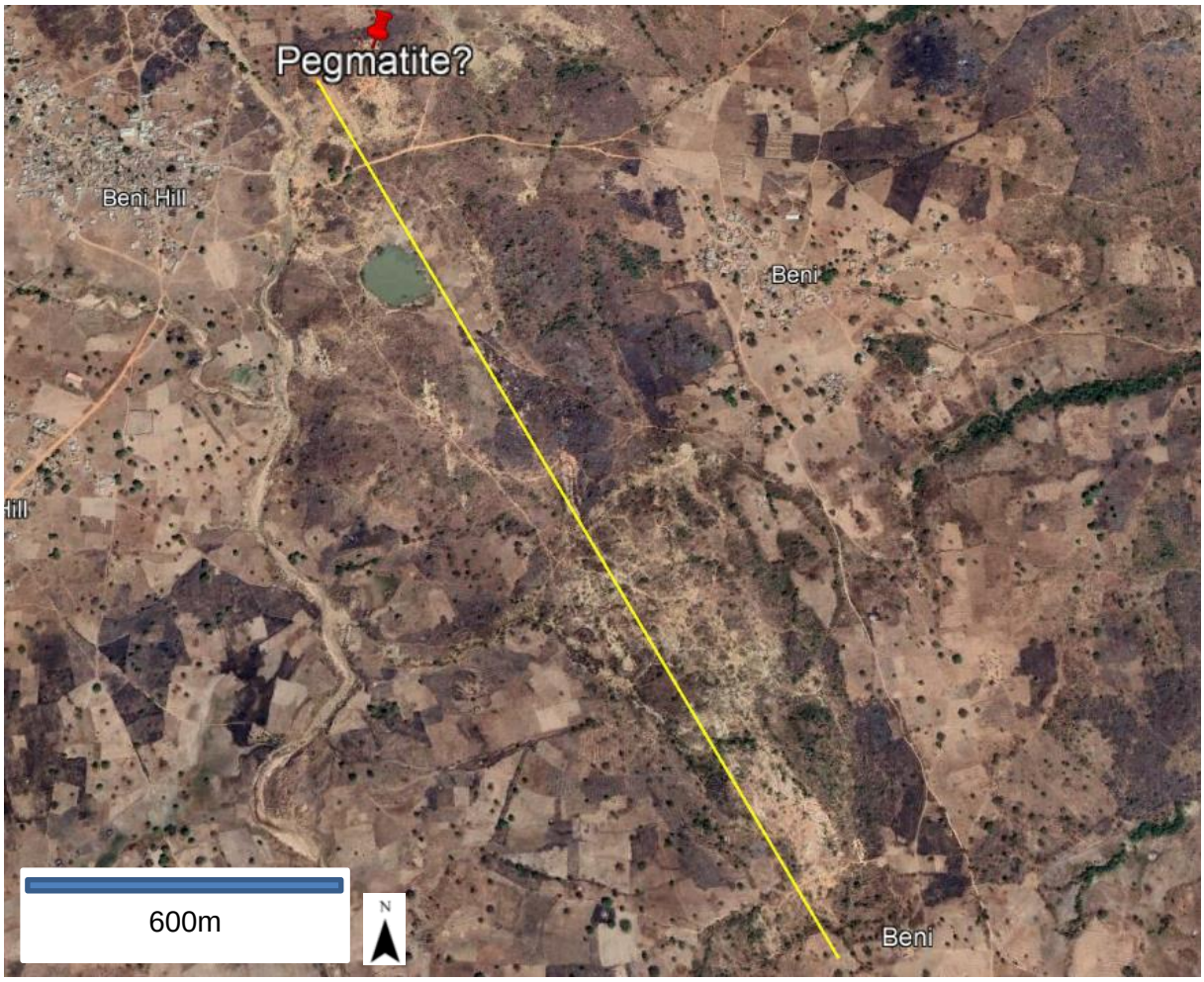


Figure 148: Pegmatite site (9°39'12"N 7°11'40"E). Image taken from Google Earth.

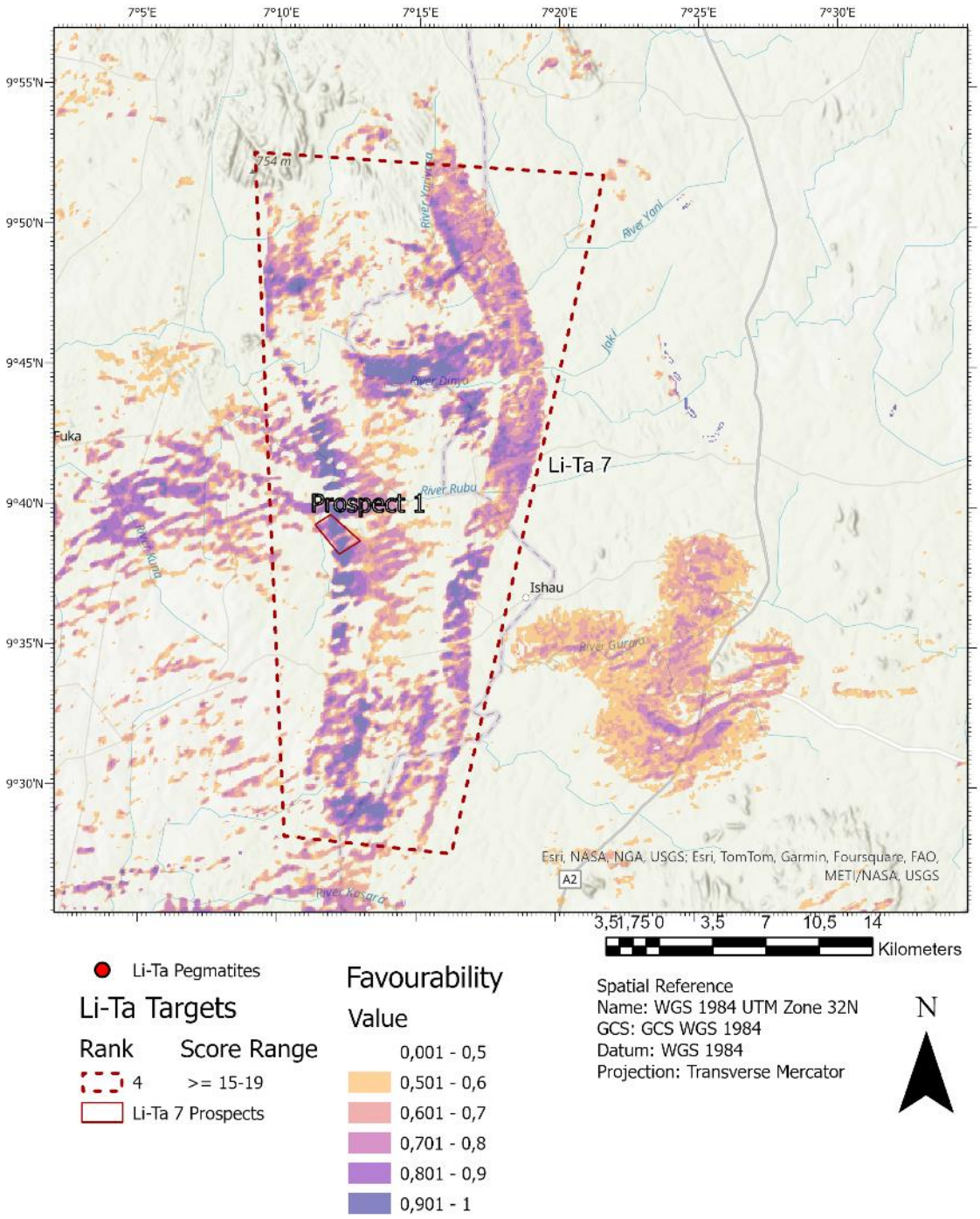


Figure 149: Favourability map for target Li-Ta 7.

7.3.2.8 Target Pegmatite 8

7.3.2.8.1 Summary

The target area situated around Ijero area, Ekiti State, containing 13 known mineralized pegmatitic veins with proven thicknesses of 50m and hosted by gneisses closely related to the local batholitic body. The magnetic anomaly suggests mineralization is probably structurally controlled. Mining in the region is solely artisanal and extends for several kilometres. Currently, there area is partially covered by one mining lease. Favourability map has very compact elongated shape with values over 0.9. The total area of this target is 261.78 km^2.

7.3.2.8.2 Characterization of the target

7.3.2.8.2.1 Favourability

The favourability map contains one very compact elongated shape with a minor secondary compact region to the north east (Figure 151). Values above 0.8 approximately cover 70% of the total selected region and correlate well with the documented pegmatitic mineral occurrences.

7.3.2.8.2.2 History

The start of the activities in the area can be interpreted not to be so far from the beginning of 2019 since a few mine shafts can be identified in the area. From that date onwards, the activities increased dramatically showing several pits but remained in an artisanal level. Further expansion of the activities continued into the 2022 remaining the main mine site of all the target.

7.3.2.8.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) within the Western Basement Complex. One syn-tectonic granitic pluton/batholitic body (Nog) and one late-tectonic granitoid (Nlg) both of Neoproterozoic to Cambrian age are interpreted to have intruded the area. At least one main

early shear zone, divided into two branches, runs N-S just left of the Ifewara – Birnin Gwari Shear Zone.

7.3.2.8.2.4 Mineralization

13 identified locations of deposits are identified in the area with all of them currently active. The main interpreted pegmatite body has a length of approximately 5km. The magnetic signal (tilt derivative) suggests an N-S controlling structure. The identified bodies can be traced for a long distance and the cluster of known mineralized pegmatites is about 73.77 km^2.

- NIMEP project identified:
  - body thickness of 50m (drilling - Figure 150),
  - Li2O values up to 1%, Sn values reaching 3780ppm and up to 3180ppm Ta,
- Caesium, Lithium and Tantalum stream sediment anomalies,
- 2129t of lithium per annum are reported to be produced.

7.3.2.8.3 Suggested prospect areas

The prospect area of 18,40km^2 contains the following characteristics:

- Length of the main structure: 3.500m (interpreted)
- Average width: 400m (interpreted)
- Number of occurrences: 9
- Type of mining: artisanal
- Status: active

Figure 150: Ijero pegmatite body with more than 50 meters thickness currently being mined (7°49'39"N 5°04'14"E). Image taken from Google Earth.

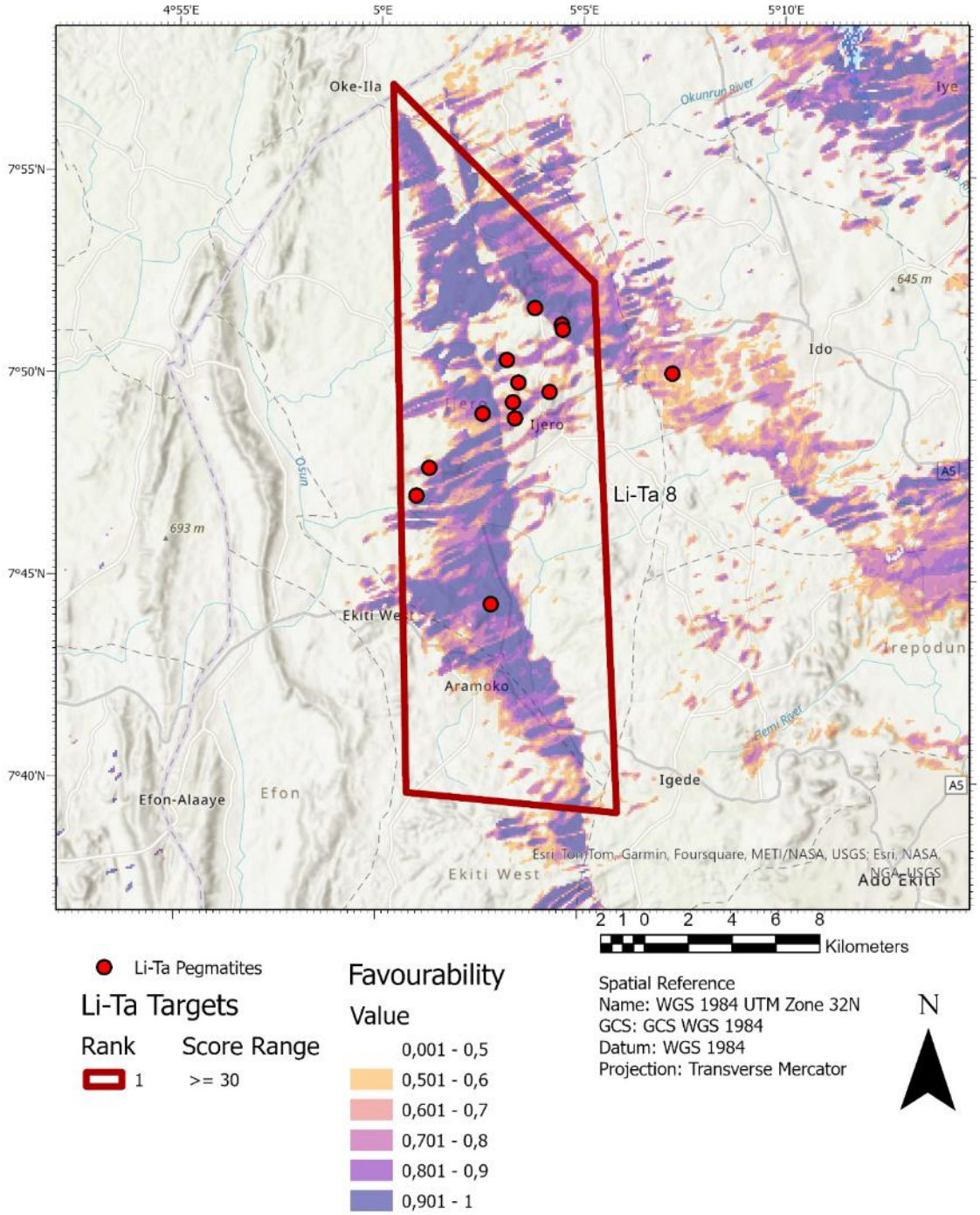


Figure 151: Favourability map for target Li-Ta 8.

7.3.2.9 Target Pegmatite 9

7.3.2.9.1 Summary

The target area situated around Danba Lema, Kwara State, containing 11 known mineralized pegmatitic veins with proven thicknesses of 40m hosted by gneisses and batholith bodies. The magnetic anomaly suggests mineralization is probably structurally controlled. Mining in the region is solely artisanal and extends for several kilometres. Currently, there area is partially covered by one exploration license. Favourability map has two compact rounded shapes with values over 0.8. The total area of this target is 345.75 km^2.

7.3.2.9.2 Characterization of the target

7.3.2.9.2.1 Favourability

The favourability map shows two very compact and rounded shapes suggesting two independent favourable areas (Figure 153). The western favourable area seems to continue further towards the NW. Values above 0.8 approximately cover 50% of the total selected region and correlate well with the documented pegmatitic mineral occurrences.

7.3.2.9.2.2 History

By 2008, the Danba Lema area was already a known extraction site for artisanal miners with two separate active areas separated by a few hundred meters. Barely two years later had the expansion of the activities considerably changed, suggesting the action of excavator machinery for the generation of not-so-shallow pits adding a third mining site. By 2021, this further continued to the south. Additional sites appeared by this time to the north-west of the target as artisanal sites with shafts.

7.3.2.9.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) within the Western Basement Complex. One syn-tectonic granitic pluton/batholitic body (Nog) of Neoproterozoic to Cambrian age are

interpreted to have intruded the area. At least one main late and one early shears zones are identified and run NE-SW just left of the Ifewara – Birnin Gwari Shear Zone.

7.3.2.9.2.4 Mineralization

At least 11 pegmatite deposits are documented in this area with the majority being currently active. There are two main pegmatite bodies currently mined, one with an approximate visible length of 1.2 km, a second pegmatite with around 800 m length. Magnetic signal of the area suggests a considerable high magnitude anomaly around the deposits to the East, whereas a low magnitude one (demagnetization?) towards the ones to the west.

- NIMEP project identified:
  - body thickness of 40m (drilling - Figure 152),
  - Li2O values up to 1.39% and up to 1005ppm Ta,
- All mining activities are artisanal
- No production values are available from this location.

7.3.2.9.3 Prospect areas

The prospect area of 2,34km^2 contains the following characteristics:

- Length of the main structure: 1.000m (interpreted)
- Average width: 200m (interpreted)
- Number of occurrences: 5
- Type of mining: artisanal
- Status: active

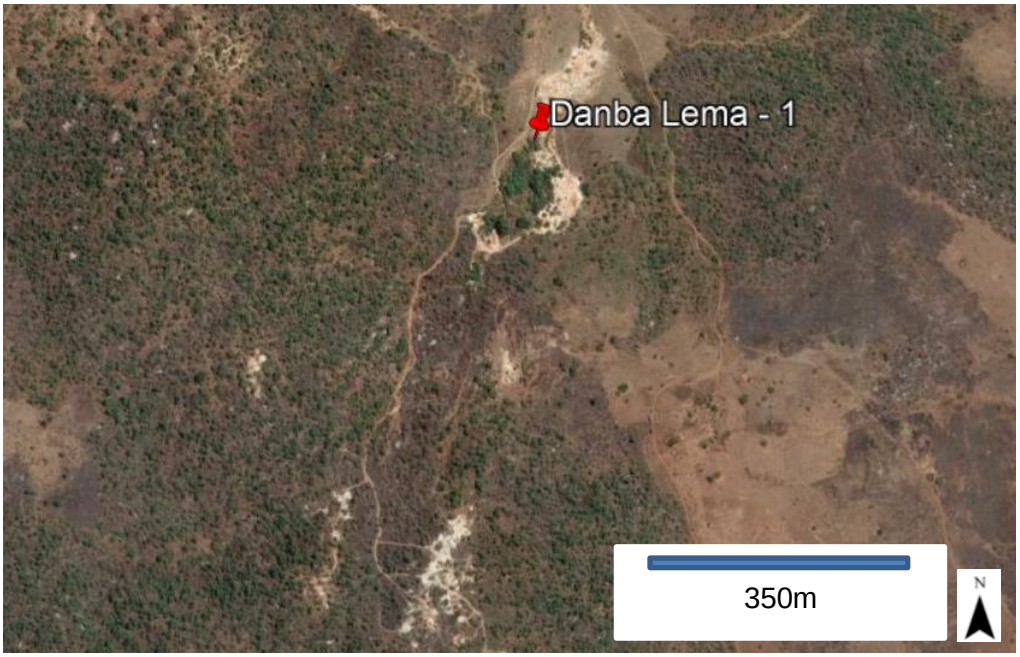


Figure 152: Active pegmatite mine site with MPM values above 0.7 and with an approximate length of 1.2 km (8°40'40"N 5°14'36"E). Image taken from Google Earth.

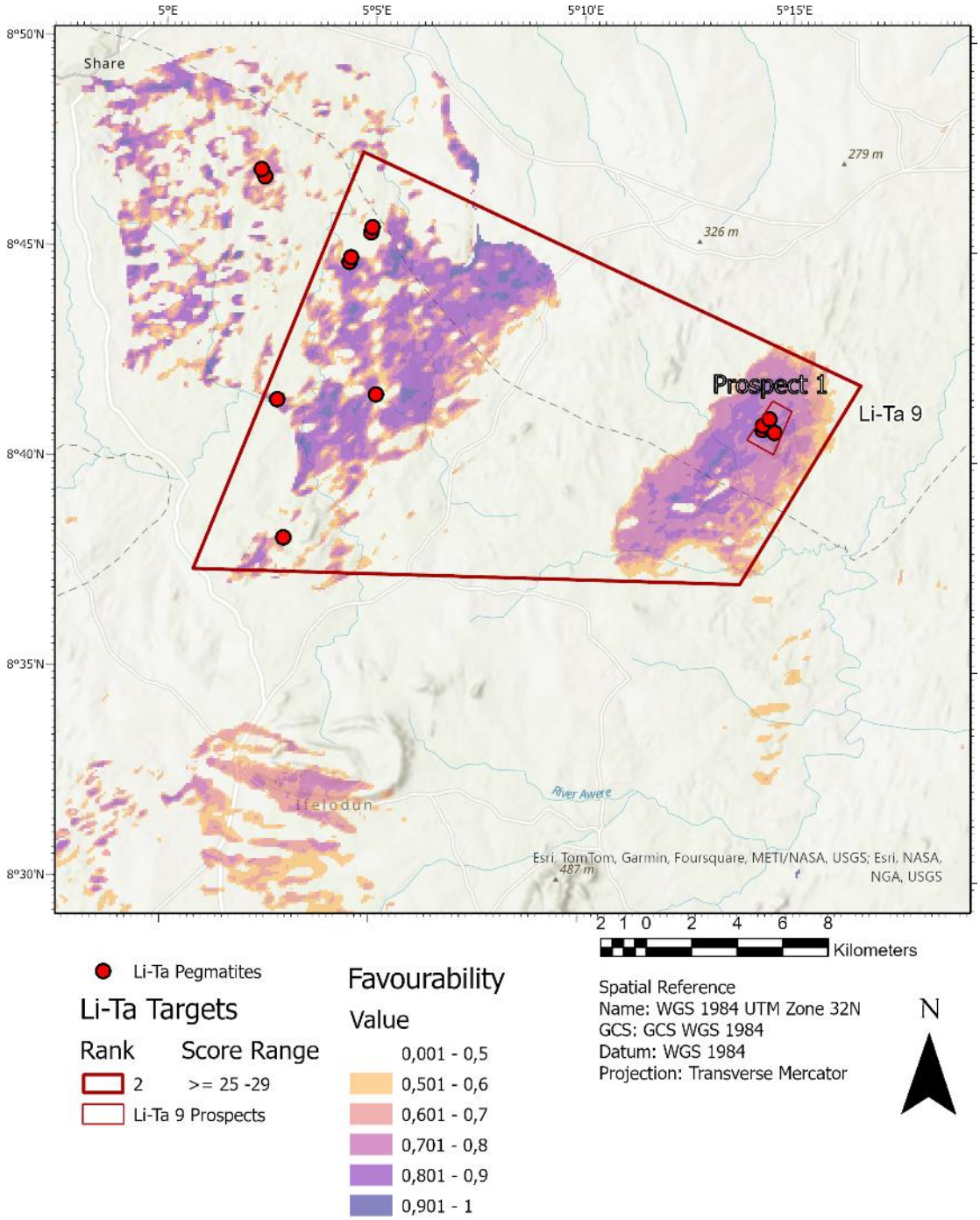


Figure 153: Favourability map for target Li-Ta 9.

7.3.2.10 Target Pegmatite 10

7.3.2.10.1 Summary

The target area situated around Ila-Orangun, Kwara State, containing 3 known mineralized pegmatitic veins, of which two are recent and active, one is abandoned, all hosted by gneisses. The magnetic anomaly suggests mineralization is probably structurally controlled within gneisses. Mining in the region is solely artisanal. Currently, there area has no claimed license. Favourability map has one compact elongated shape with values over 0.8. The total area of this target is 240.72 km^2.

7.3.2.10.2 Characterization of the target

7.3.2.10.2.1 Favourability

The favourability map shows one elongated NE-SW trending compact shape (Figure 155). Values above 0.8 approximately cover 80% of the total selected region and correlate well with the documented pegmatitic mineral occurrences.

7.3.2.10.2.2 History

Mining activities in the area only started around 2013 with one open pit mine with around 100m length. The structure and thickness of this site suggests machinery was probably used. However, two years later (2015) it seems to have been abandoned and giving way at the end of 2016 to a newer open pit mine some tens of meters to the south-east (NR-Mine 2). The latter mine seems to have been also abandoned by 2018, and only until 2022 did two new shallow workings appeared to the south-west (NR-Mine 3 and NR-Mine 4).

7.3.2.10.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) and undifferentiated banded felsic gneisses, subordinate leucogneiss layers, mafic gneisses and paragneisses (Pbg), within the Western

Basement Complex. One main early extensional shear zone runs NE-SW through the middle of the target.

7.3.2.10.2.4 Mineralization

This target contains at least three mine workings with only two remaining active sites. The abandoned site is seen filled with water and has a deep pit. Magnetic anomalies trending SW-NE correlate with the mineral occurrences. On inspection of the satellite imagery of the area, further artisanal activities are spotted to the south of the target.

- Activities are artisanal and shallow, except for the abandoned site (Figure 154),
- Pegmatites seem to have a NE-SW trend,
- No production values are available from this location.

7.3.2.10.3 Prospect areas

The prospect area of 1,52km^2 contains the following characteristics:

- Length of the main structure: 1.400m (interpreted)
- Average width: 40m (interpreted)
- Number of occurrences: 3
- Type of mining: artisanal
- Status: partially active

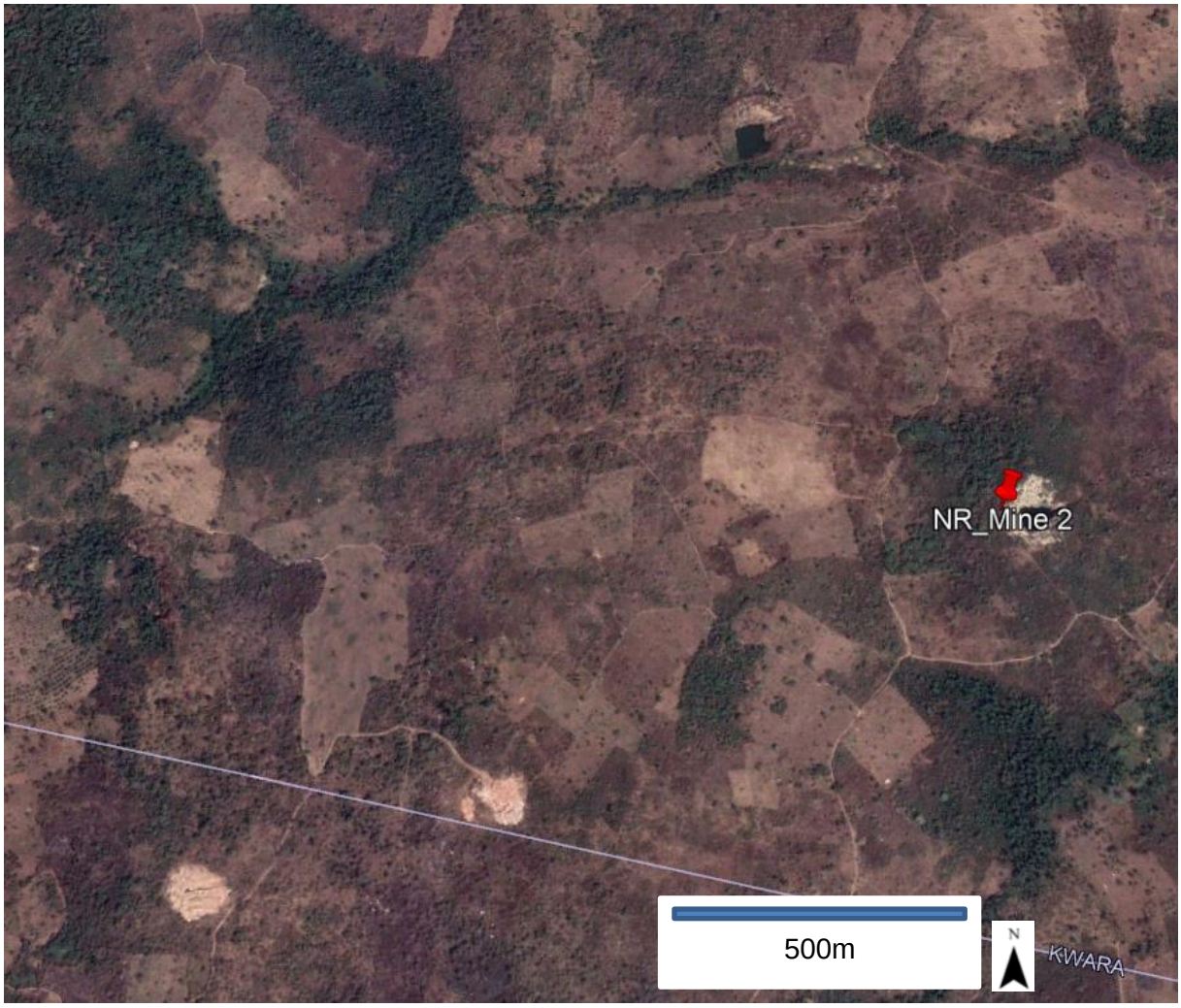


Figure 154: Unregistered mining activities showing workings on a pegmatite with values of 0.82 in the MPM (8°05'32"N 4°54'38"E). Image taken from Google Earth.

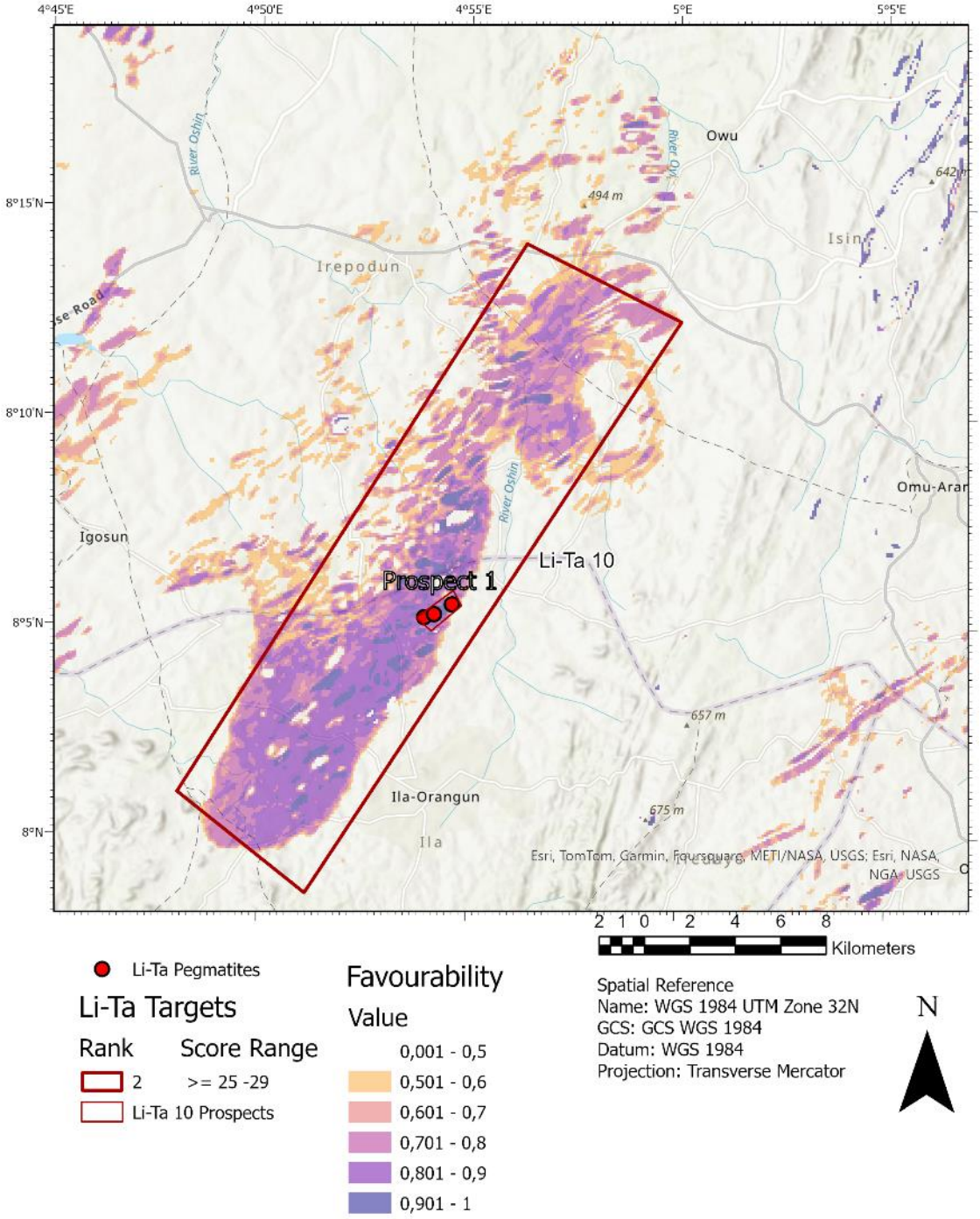


Figure 155: Favourability map for target Li-Ta 10.

7.3.2.11 Target Pegmatite 11

7.3.2.11.1 Summary

The target area situated around Sepeteri Area, Oyo State, containing 12 known mineralized pegmatitic veins hosted in gneisses, are all active and being exploited by artisanal miners. The magnetic anomaly suggests mineralization is probably structurally controlled. Currently, there area is covered by several mining leases. Favourability map has one oval diffused shape with values reaching 0.8. The total area of this target is 245.14 km^2.

7.3.2.11.2 Characterization of the target

7.3.2.11.2.1 Favourability

The favourability map shows a very diffuse oval shape with the longest axis oriented N-S trend (Figure 157). The western favourable area seems to continue further towards the NW. Values above 0.6 approximately cover 40% of the total selected region, and correlation with the mineral occurrences is very low but interpreted to be a missing part of the overall regional shape probably cut out by the presence of a national park.

7.3.2.11.2.2 History

By 2008, the Danba Lema area was already a known extraction site for artisanal miners with two separate active areas separated by a few hundred meters. Barely two years later had the expansion of the activities considerably changed, suggesting the action of excavator machinery for the generation of not-so-shallow pits adding a third mining site. By 2021, this further continued to the south. Additional sites appeared by this time to the north-west of the target as artisanal sites with shafts.

7.3.2.11.2.3 Geological Setting

The rocks are composed of a mixture of Archean to Paleoproterozoic migmatitic gneisses with relict mafic to felsic gneiss enclaves (Pmg) within the Western Basement Complex. At least one main early shear zone runs throughout just right of the Anka Shear Zone.

7.3.2.11.2.4 Mineralization

Within this target and with values above 0.8, a cluster of known mineralized pegmatites (12 entries) concentrate in around 30 km^2. All points are active operations. As seen in Figure 156, mining in the area is extensive and probably expands further around. The magnetic signal in the area suggests that a SE-NW tending anomaly may be correlated with the existing deposits and suggests that the deposits to the NW can be linked with the ones in the SE.

- All mining activities are artisanal,
- No production values are available from this location.

7.3.2.11.3 Suggested prospect areas

The prospect area of contains the following characteristics:

- Length of the main structure: 1.8780m (interpreted)
- Average width: 700m (interpreted)
- Number of occurrences: 6
- Type of mining: artisanal
- Status: active

Figure 156: Massive mining site in the Sepeteri area known for tantalite pegmatites and with MPM values above 0.7 (8°31'15"N 3°40'15"E). Image taken from Google Earth.

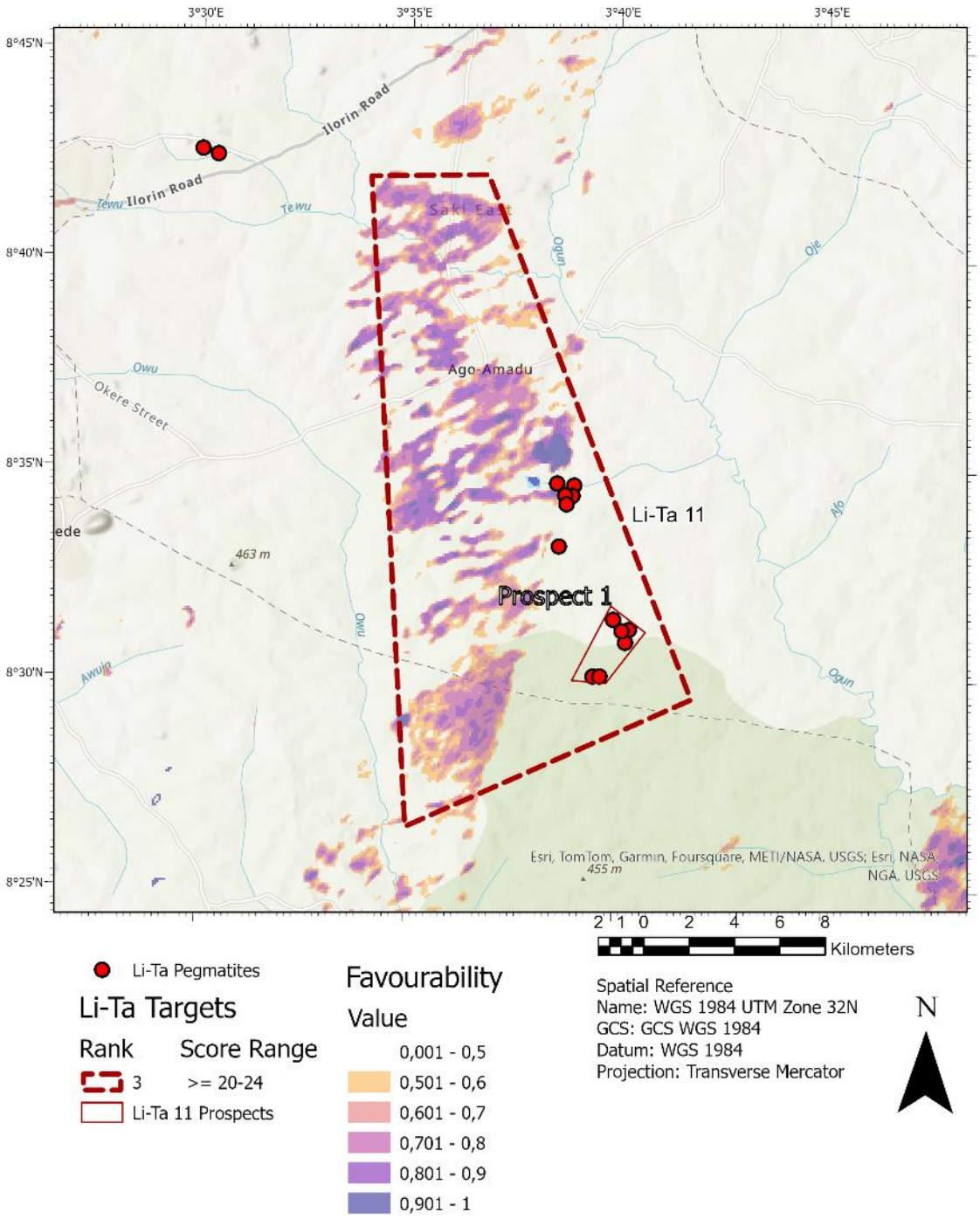


Figure 157: Favourability map for target Li-Ta 11.

7.4 Lead (Pb) – Zinc (Zn) Targets

7.4.1 Ranking and Location

7.4.1.1 Criteria Catalogue

From the general Pb-Zn Favourability Map (Figure 80), a selection of single targets was selected and recommended for further evaluation. This selection represents, to the current knowledge and understanding of the Consultant, the most prospective sites along with a set of typical cases within the target areas.

The selected target areas were ranked using the following catalogue of criteria:

- MPM pattern and favourability value intensity:

MPM pattern and favourability value (FV)	Score
Compact pattern and FV > 0.9	5
Compact pattern and FV > 0.8	4
Compact pattern and FV > 0.7	3
Diffuse pattern and FV > 0.9	2
Diffuse pattern and FV > 0.8	1

- Within visible anticlinal structure:

Within anticlinal structure	Score
Yes	5
No	1

- Proximity to volcanic rocks:

Proximity to volcanic rocks	Score
Yes	5
No	1

- Pb-Zn occurrences known:

Pb-Zn. Occurrences known	Score
Yes	5
No	1

- Number of veins/pits:

Number of veins/pits	Score
More than > 15	5
Between 15 and 10	4
Between 10 and 6	3
Between 6 and 3	2
Less than 3	1

- Pb-Zn active open pit:

Pb-Zn active open pit	Score
Yes	5
No	1

- Length of the existing pits (m):

Length of existing pits (m)	Score
More than > 2000	5
Between 2000 and 1400	4
Between 1400 and 1000	3
Between 1000 and 500	2
Less than 500	1

- NIMEP exploration in the area:

NIMEP exploration in the area	Score
Yes	1
No	5

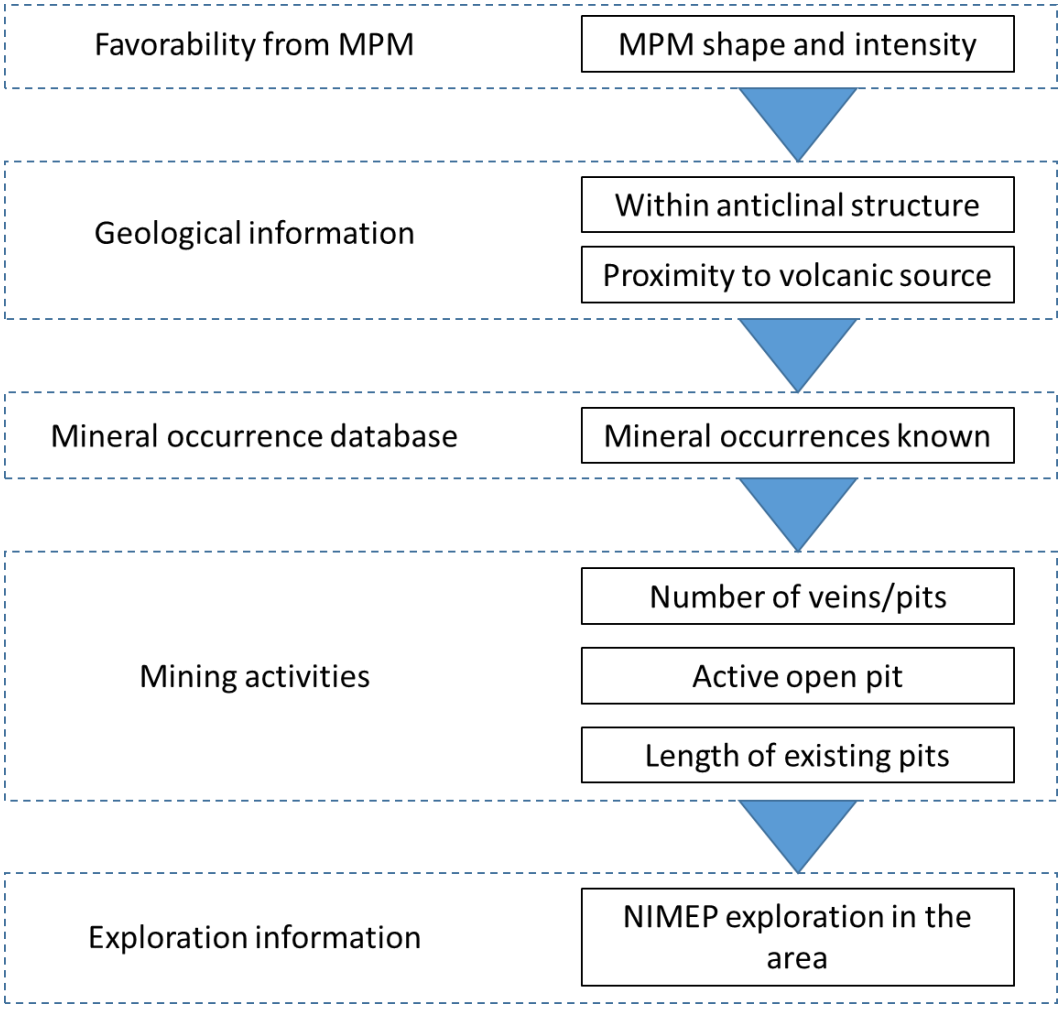


Figure 158: Criteria for the ranking of Pb-Zn Targets.

7.4.1.2 Ranking and location of targets

The identified targets are located in different positions throughout the Benue Trough. Their ranking against the described criteria is shown in Table 13 and their spatial location is shown in Figure 159.

Table 13: The ranking of the Pb-Zn targets

Criteria	Points per Criterium	Pb-Zn Targets and their scoring per criterium								
		Pb Zn 1	Pb Zn 2	Pb Zn 3	Pb Zn 4	Pb Zn 5	Pb Zn 6	Pb Zn 7	Pb Zn 8	Pb Zn 9
MPM favourability map pattern										
Compact pattern above 0.9	5	5		5	5				5	
Compact pattern and above 0.8	4						4	4		
Compact pattern and above 0.7	3		3							
Diffuse pattern and above 0.9	2					2				2
Diffuse pattern and above 0.8	1									
Within visible anticlinal structure? (see Tilt of the RTP and lithostructural map)										
Yes	5	5	5	5	5	5	5		5	
No	1							1		1
Proximity to volcanic rocks (indicated by the 1st Vertical Derivative of RTP magnetic signal)										
Yes	5		5	5		5				5
No	1	1			1		1	1	1	
Pb-Zn occurrences known?										
Yes	5	5	5	5	5	5	5	5		5
No	1								1	
Number of veins/pits										
>15	5					5		5		
15-10	4	4								
10-6	3		3							3
6-3	2			2	2		2			
<3	1								1	
Pb-Zn active open pit?										
Yes, big pit	5	5		5		5	5	5		
Yes, small pit	3		3							3
No mining	1				1				1	
Length of the existing pits (m)										
>2000	5	5				5				
2000-1400	4			4				4		
1400-1000	3						3			
1000-500	2		2							2
<500	1				1				1	
NIMEP exploration in the area?										
Yes	5		5	5	5		5			5
No	1	1				1		1	1	
Total Score										
Score		31	31	36	25	33	30	26	16	26
Rank										
Rank order		2	2	1	3	2	2	3	5	3

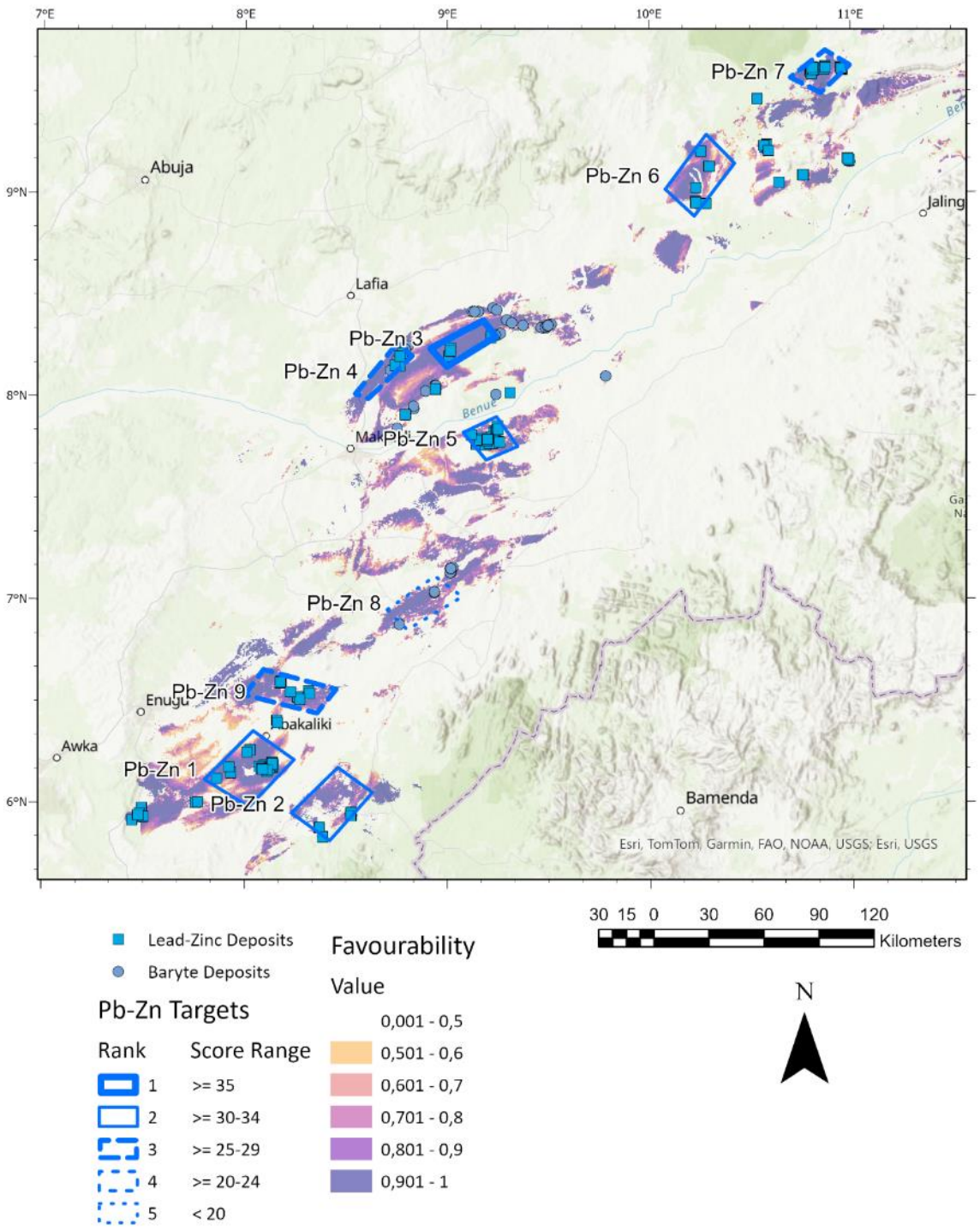


Figure 159: Location and ranking of selected targets for Lead (Pb) and Zinc (Zn).

7.4.2 Description of single targets

7.4.2.1 Target Pb-Zn 1

7.4.2.1.1 Summary

The target within the Lower Benue Trough boasts 15 occurrences of Pb-Zn, two of which are undergoing advanced activities and production, with an output exceeding 50kt of material per year, owned by First Patriot LTD. Extensive N-S trending veins are prevalent, hosted within interbedded argillaceous and sandstone beds. The favourability map reveals a compact shape with values exceeding 0.8. The total area of this target is 999.34 km^2.

7.4.2.1.2 Characterization of the target

7.4.2.1.2.1 Favourability

The favourability map shows a compact shape with values over 0.8 for at least 80% of the target (Figure 162) correlating with the known Pb-Zn occurrences. Holes (values below 0.6) correlate with the hinge of synclines.

7.4.2.1.2.2 History

Activities in the area can be traced back at least to 2007, with an uptake in 2015.

7.4.2.1.2.3 Geological Setting

The regional rocks are identified as early Cretaceous and belong mainly to the Asu River Formation (Car), composed of interbedded argillaceous and sandstone beds, and minimally to the Eze Aku/Yolde Formations (Cey), containing carbonaceous shales, sandstones and limestones.

7.4.2.1.2.4 Mineralization

At least 15 known deposits are located inside this target. The target is located within the Lower Benue Trough and covers two main and several minor anticlines and at least one syncline, all trending SW-NE. The magnetic response in the area shows a high, possibly related to an intrusive body linked with the source of the transported fluids to this area. The area contains only vein occurrences with an interpreted hydrothermal genesis.

- One area has workings panning over 2.000m in length(Figure 160),
- Recent workings (mostly small-scale) on the majority of sites,
- A large active oval open-pit mine with heavy machinery (Figure 161),
- The main orientation of the exploited veins tends N-S,
- Reported mineral production amounts to 50kt of material per year.

7.4.2.1.3 Suggested prospect areas

7.4.2.1.3.1 Prospect 1

The 1.45km^2 defined area contains the following characteristics:

- Length of the main structure: 1.860m
- Average width of pits: 30m
- Number of occurrences: 5
- Status: active

Figure 160: Main vein structure actively being mined (6°09'29"N 8°06'39"E). Image taken from Google Earth.

7.4.2.1.3.2 Prospect 2

The 1.45km^2 defined area contains the following characteristics:

- Length of the main structure: 1.860m
- Average width of pits: 30m
- Number of occurrences: 5
- Status: active

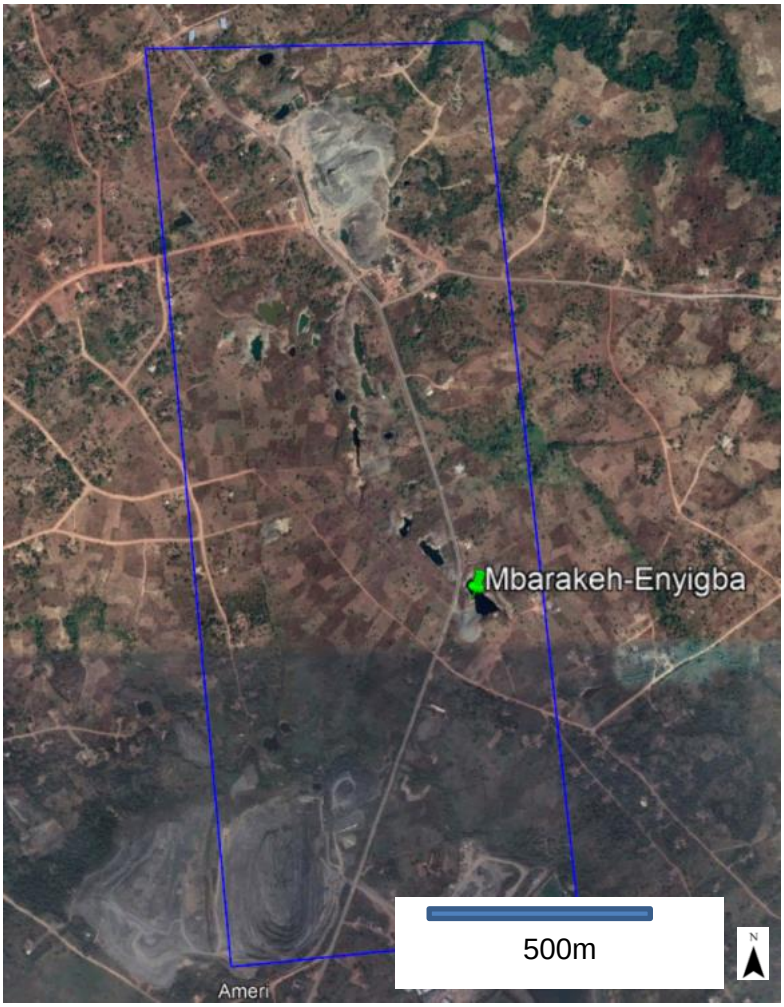


Figure 161: Main vein structure actively being mined (6°11'05"N 8°08'32"E). Image taken from Google Earth.

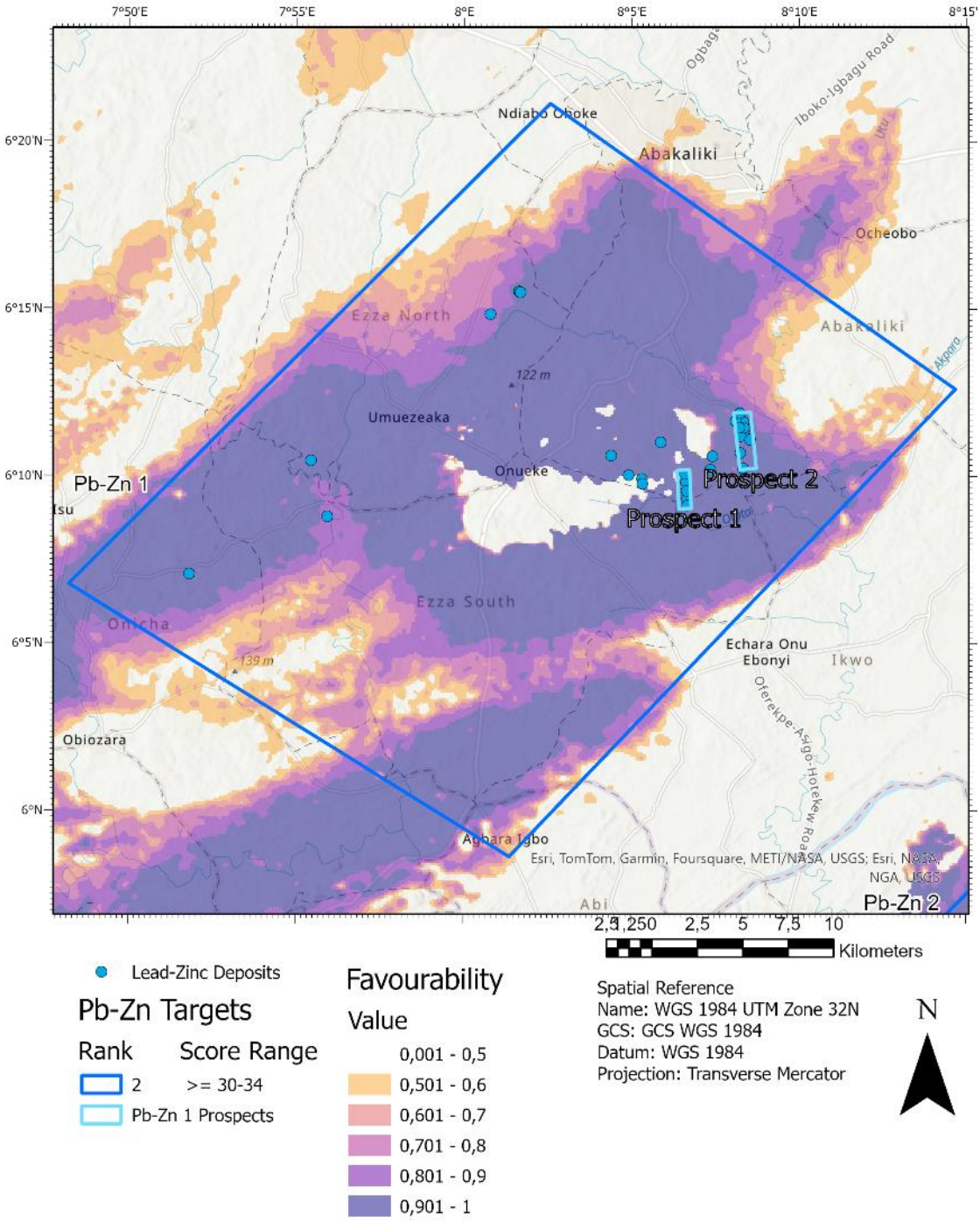


Figure 162: Favourability map for target Pb-Zn 1.

7.4.2.2 Target Pb-Zn 2

7.4.2.2.1 Summary

The target within the Lower Benue Trough comprises 13 occurrences of Pb-Zn, with recent activities observed, including one extending over 700 meters. The general vein trend follows an NW-SE orientation and is hosted within early Cretaceous interbedded argillaceous and sandstone beds. The favourability map indicates a diffuse shape with values over 0.8. The total area of this target is 855.02 km^2.

7.4.2.2.2 Characterization of the target

7.4.2.2.2.1 Favourability

The favourability map shows a diffused favourability with values over 0.8 covering around 50% of the area. Correlation with Pb-Zn occurrences on the southern section following a continuous shape along the mapped regional fault (Figure 163).

7.4.2.2.2.2 History

Activities in the area started around 2015 with recent (2022) extension towards the southern border of the target.

7.4.2.2.2.3 Geological Setting

The regional rocks are identified as early Cretaceous as an intercalation of the Asu River Formation (Car), composed of interbedded argillaceous and sandstone beds, and the Eze Aku/Yolde Formations (Cey), containing carbonaceous shales, sandstones and limestones. A volcanic source (1VD) is spotted and the mapped fault structures on the Oban Massif can be interpreted to continue northwards towards the location (or close by) to the known deposits.

7.4.2.2.2.4 Mineralization

At least 13 known deposits are located inside this target, all of which are located towards the SE border of the target. The target is located within the Lower Benue Trough and encompasses what is interpreted as a series of anticlines and synclines trending SW-NE. The area contains only vein occurrences with an interpreted hydrothermal genesis and solely located within the Car formation.

- The longest structure mined goes for at least 700m (Figure 160),
- No heavy machinery or infrastructure is identified,
- Barite production on the south of the target is reported with 1.170 t per year,
- The main orientation of the exploited veins tends NW-SE.

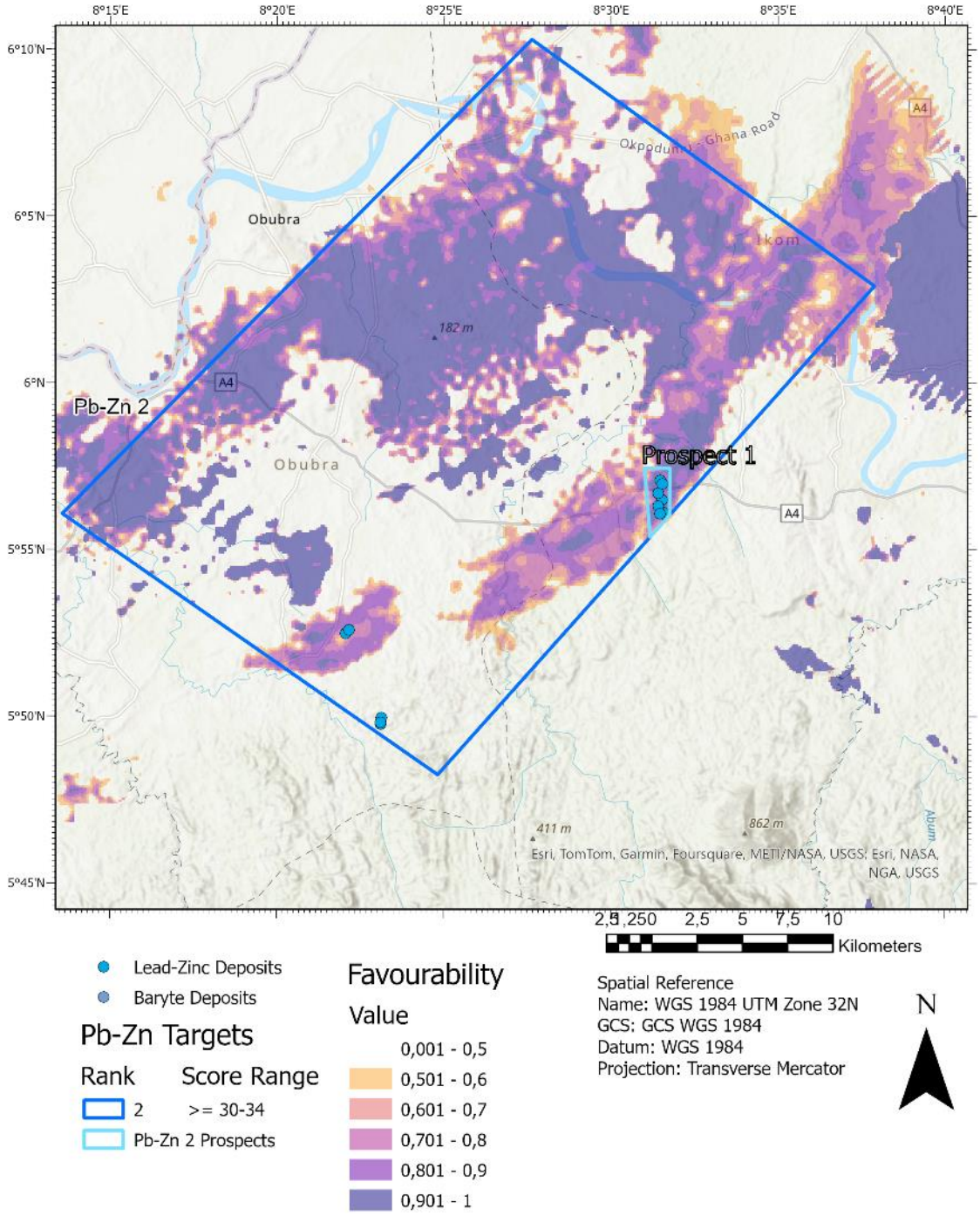


Figure 163: Favourability map for target Pb-Zn 2.

7.4.2.3 Target Pb-Zn 3

7.4.2.3.1 Summary

The target within the Middle Benue Trough encompasses 10 occurrences of Pb-Zn, including one site with active underground mining operations and a substantial processing complex, processing over 20kt of material per year, under the ownership of Synee Alumony Mining Limited. Extensive N-S trending veins, some spanning over 2 kilometers, are prevalent, accompanied by minor E-W trending bodies. These veins are hosted within late Cretaceous syn-rift sandstones interbedded with limestones along the core of the Keana anticline. The favorability map depicts a compact shape with values exceeding 0.9. The total area of this target is 303.60 km^2.

7.4.2.3.2 Characterization of the target

7.4.2.3.2.1 Favourability

The favourability map shows a compact shape following the length of the target and covering around 90% of the selected area (Figure 168). Values over 0.9 correlate with the known Pb-Zn occurrences and some barite occurrences.

7.4.2.3.2.2 History

Activities in the area can be traced back at least to 2010 with two main districts. An industrial complex has been constructed (around 2019) next to one deposit revitalizing the mining activities, including trucks, processing machinery, tailings and, possibly, subterranean workings.

7.4.2.3.2.3 Geological Setting

The regional rocks are identified as Late Cretaceous and syn-rift as Keana/Awe Formations, composed of sandstones, shales and siltstones (Cka1) in the centre of the anticline followed by cross-bedded fine- to very-coarse sandstones interbedded with limestones (Cka2) towards the sides of the fold.

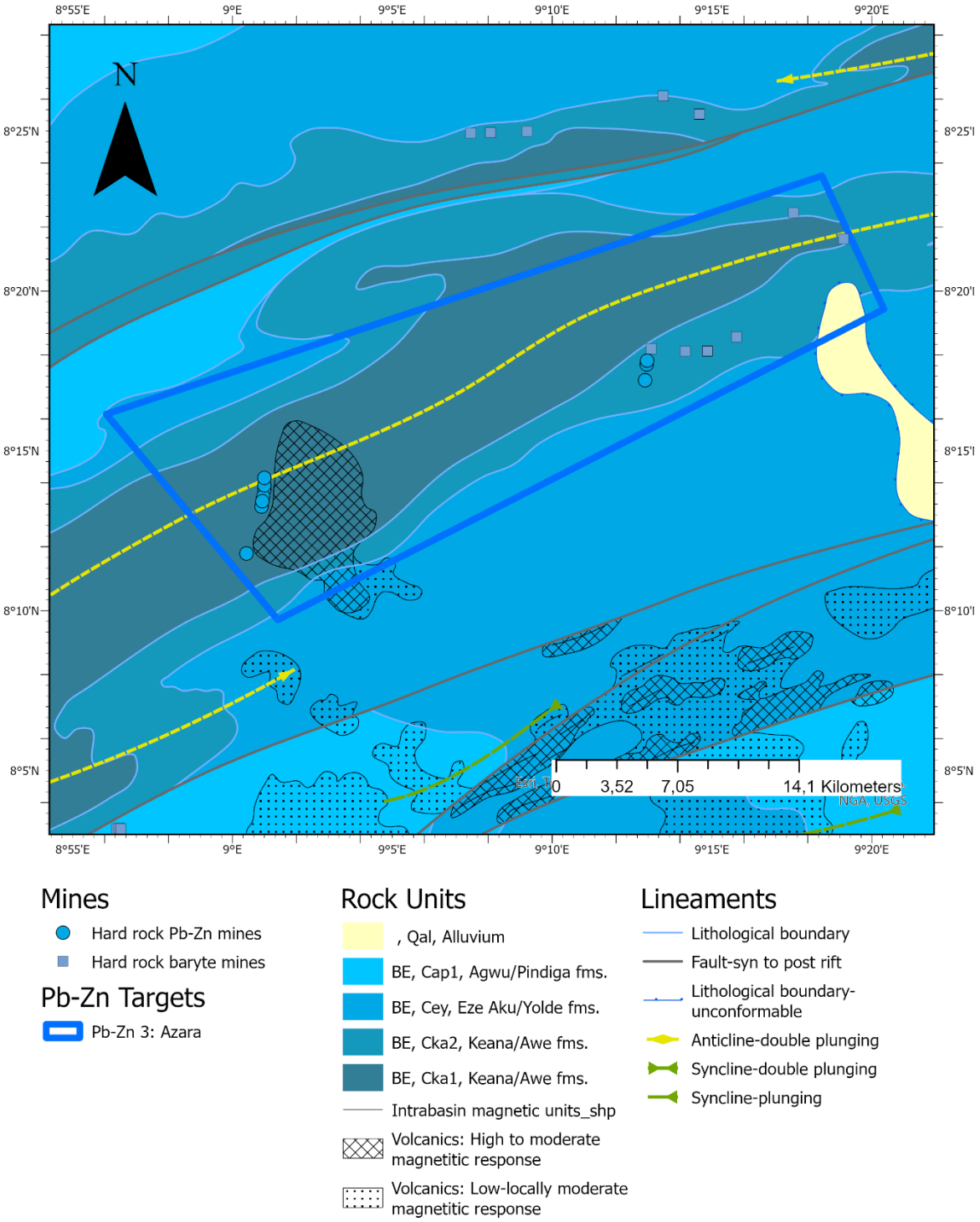


Figure 164: Geology for Pb-Zn Target 3 (Pb-Zn 3: Azara).

7.4.2.3.2.4 Mineralization

At least 10 known deposits of Lead-Zinc and 6 of Barite are located inside this target. The target is located within the Middle Benue Trough. The area lies exactly on the core of the Keana anticline, a major SW-NE trending fold structure. The magnetic response suggests an intrusive body (interpreted as sills) that may be linked with the source of the transported fluids to this area. Type of mineral genesis is interpreted as hydrothermal and occurs as vein-like deposits.

- One area has workings panning over 2.000m in length,
- A large open-pit mine with apparent sub-surface workings, including heavy machinery (Figure 166).
- The main orientation of the exploited veins tends N-S, with minor E-W bodies.
- Reported mineral production amounts to 20kt of material per year.

7.4.2.3.2.5 Distribution of Mineral Tenements (MCO, 11.2023)

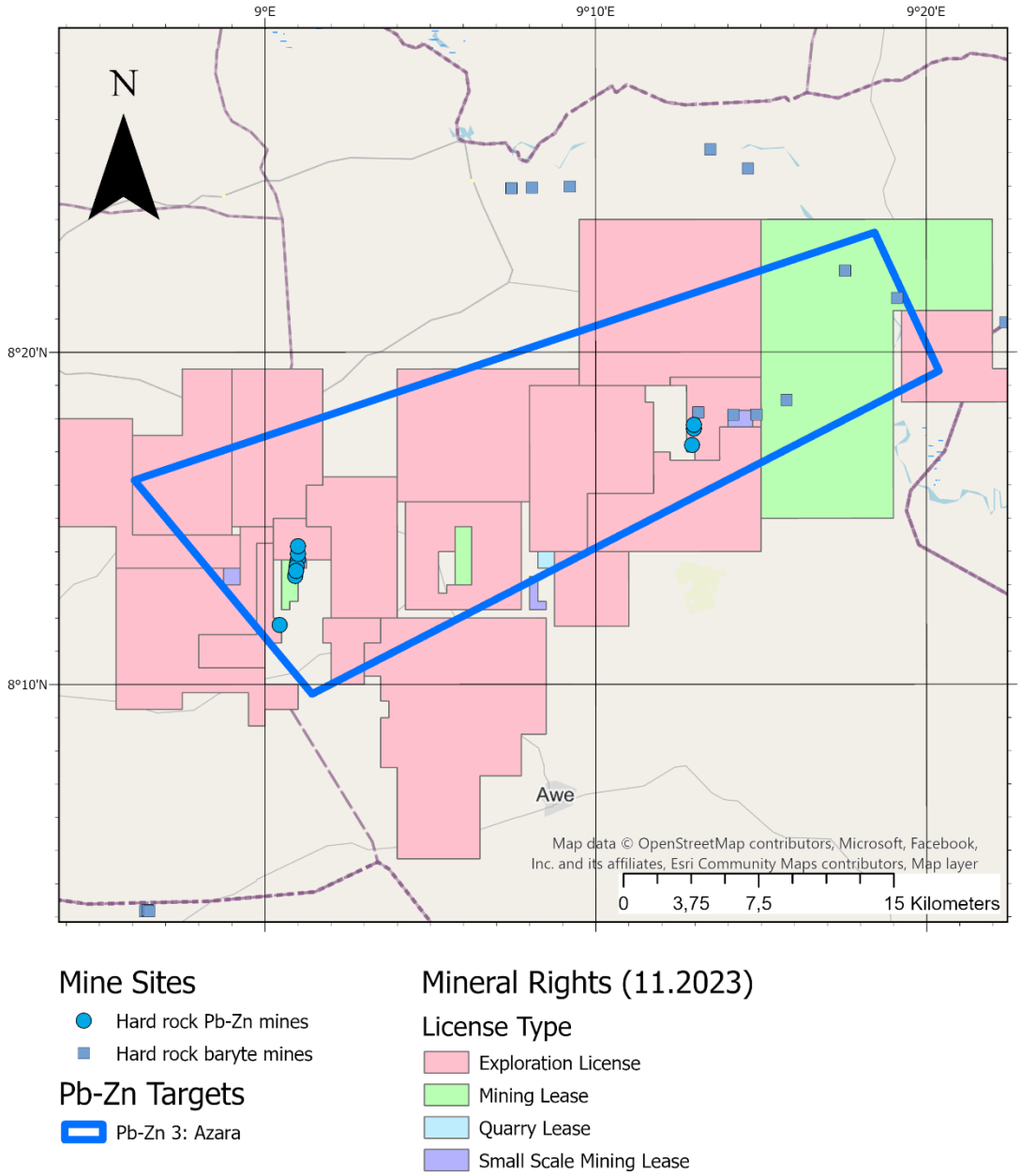


Figure 165: Distribution of Mineral Licenses in Pb-Zn Target 3 (Pb-Zn 3: Azara).

7.4.2.3.3 Suggested prospect areas

7.4.2.3.3.1 Prospect 1

The 1.74km^2 defined area contains the following characteristics:

- Length of the main structure: 2.010m
- Average width of pits: 10m
- Number of occurrences: 6
- Status: active

The current mining license in the area has the following data:

	SSML-024774	ML-027260	EL-036716
Company Name (after MCO)	Nadabo Leand And Zinc Mining Company	Synee Alumony Mining Limited	Centuple Ridge Int. Nigeria Ltd.
Type of License	SSML	Mining Lease	Exploration L.
Commodities	Lead, Zinc	Lead, Zinc	Copper, Fluorspar, Lead, Zinc

Figure 166: Main vein system being exploited (8°13'33"N 9°00'57"E). Image taken from Google Earth.

7.4.2.3.3.2 Prospect 2

The 13.47km^2 defined area contains the following characteristics:

- Length of the main structure: 2.080m (interpreted)
- Average width of pits: 30m
- Number of occurrences: 3
- Status: inactive

The current mining license in the area has the following data:

	SSML-015229 – 1
Company Name (after MCO)	Harrick Global Investment Nig Ltd
Type of License	Exploration
Commodities	Copper, Lead, Lithium Zinc

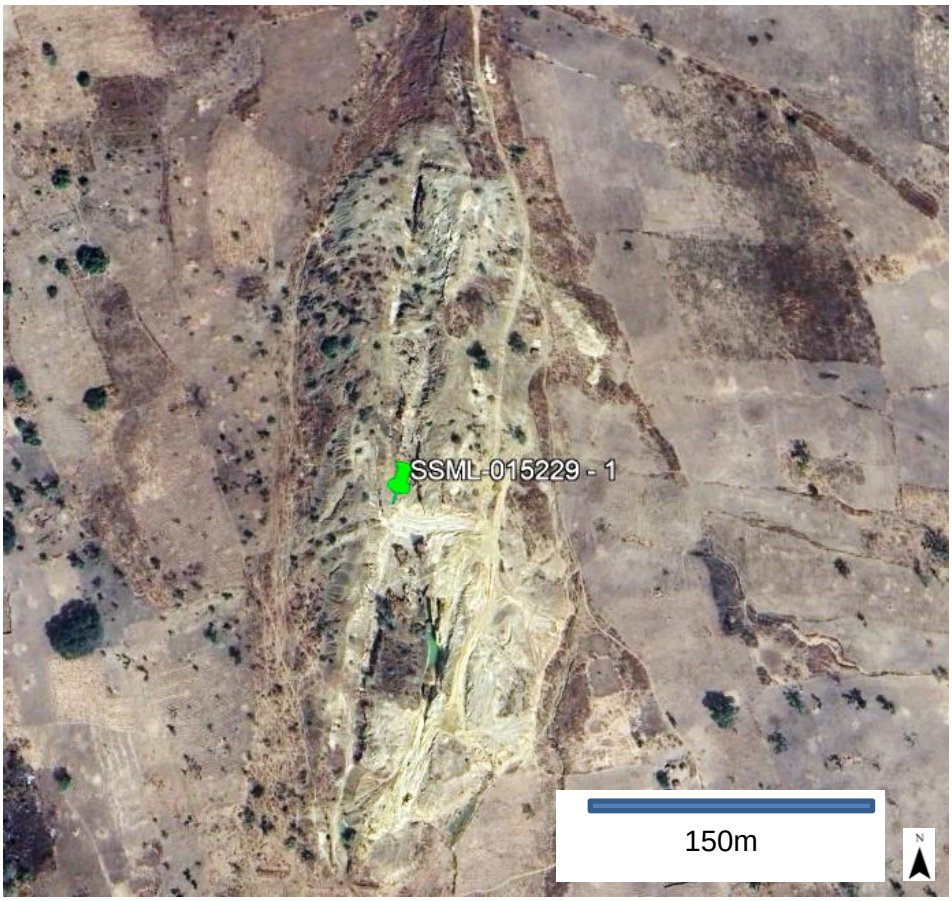


Figure 167: Main vein system being exploited (8°16'07"N 9°14'51"E). Image taken from Google Earth.

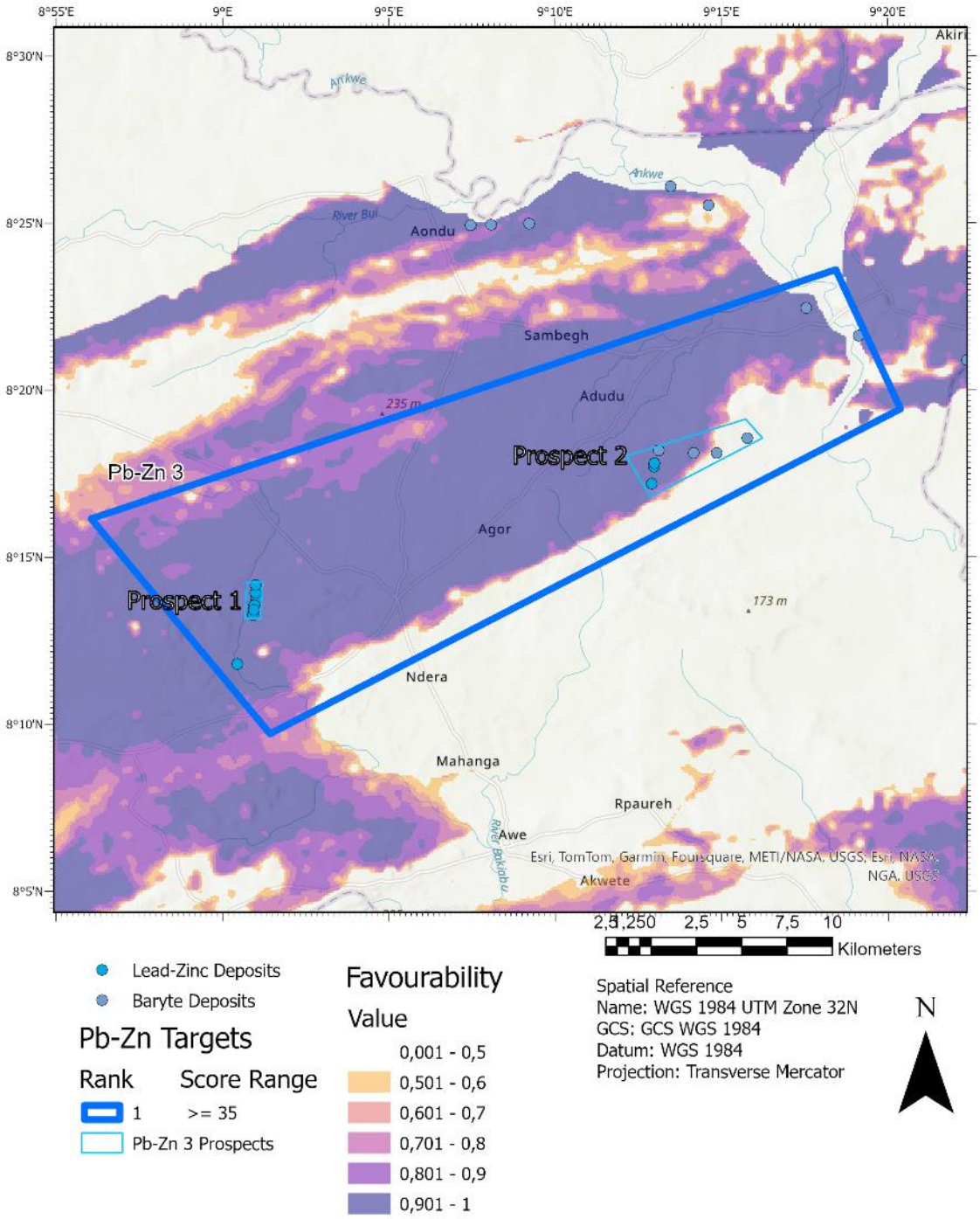


Figure 168: Favourability map for target Pb-Zn 3.

7.4.2.4 Target Pb-Zn 4

7.4.2.4.1 Summary

The target within the Middle Benue Trough comprises 10 occurrences of Pb-Zn, among which one site is actively engaged in underground mining operations, featuring a large processing complex processing over 20kt of material annually, under the ownership of Synee Alumony Mining Limited. Extensive N-S trending veins, some stretching beyond 2 kilometres, are prevalent, along with minor E-W trending bodies. These veins are hosted within late Cretaceous syn-rift sandstones interbedded with limestones along the core of the Keana anticline. The favourability map indicates a compact shape with values exceeding 0.9. The total area of this target is 381.45 km2.

7.4.2.4.2 Characterization of the target

7.4.2.4.2.1 Favourability

The favourability map shows a compact shape following the length of the target and covering more than 90% of the selected area (Figure 170). Values over 0.9 correlate with the known Pb-Zn occurrences and some barite occurrences.

7.4.2.4.2.2 History

Mining activities in the area can be traced back at least to 2010 with some abandoned pits. Sometime around 2018, several mines picked up renewed activities in very small scale, with just one particular site showing continuous activities to date. No industrial machinery is seen in the area.

7.4.2.4.2.3 Geological Setting

The regional rocks are identified as Late Cretaceous made up of syn-rift as Keana/Awe Formations, composed of cross-bedded fine- to very-coarse sandstones interbedded with limestones (Cka2), and the Eze Aku/Yolde Formations, composed of carbonaceous shales, limestones and fine to medium grained sandstone (Cey).

7.4.2.4.2.4 Mineralization

At least 5 known deposits of Lead-Zinc and 2 of Barite are located inside this target. The target is located within the Middle Benue Trough. The area lies on the core of an anticline separated to the north of the Keana anticline by a regional fault, possibly generated during rifting. The trend of the veins go either SW-NE or NW-SE, indicating a relationship with SW-NE trending anomalies. Type of mineral genesis is interpreted as hydrothermal and occurs as vein-like deposits.

- The only active mine spans for a length of 180 m (Figure 169),
- Other sites have been abandoned at least by 2018,
- The main orientation of the exploited veins tends SW-NE and SW-NE,
- No production in the area has been reported.

7.4.2.4.3 Suggested prospect area

The prospective area with size of 1,62km^2 has the following characteristics:

- Length of the main structure: 800m
- Average width of pits: 10m
- Number of occurrences: 1
- Status: active
- There is no current mining license in the prospect.

Figure 169: Main mining site in the selected target area (8°08'58"N 8°45'56"E). Image taken from Google Earth.

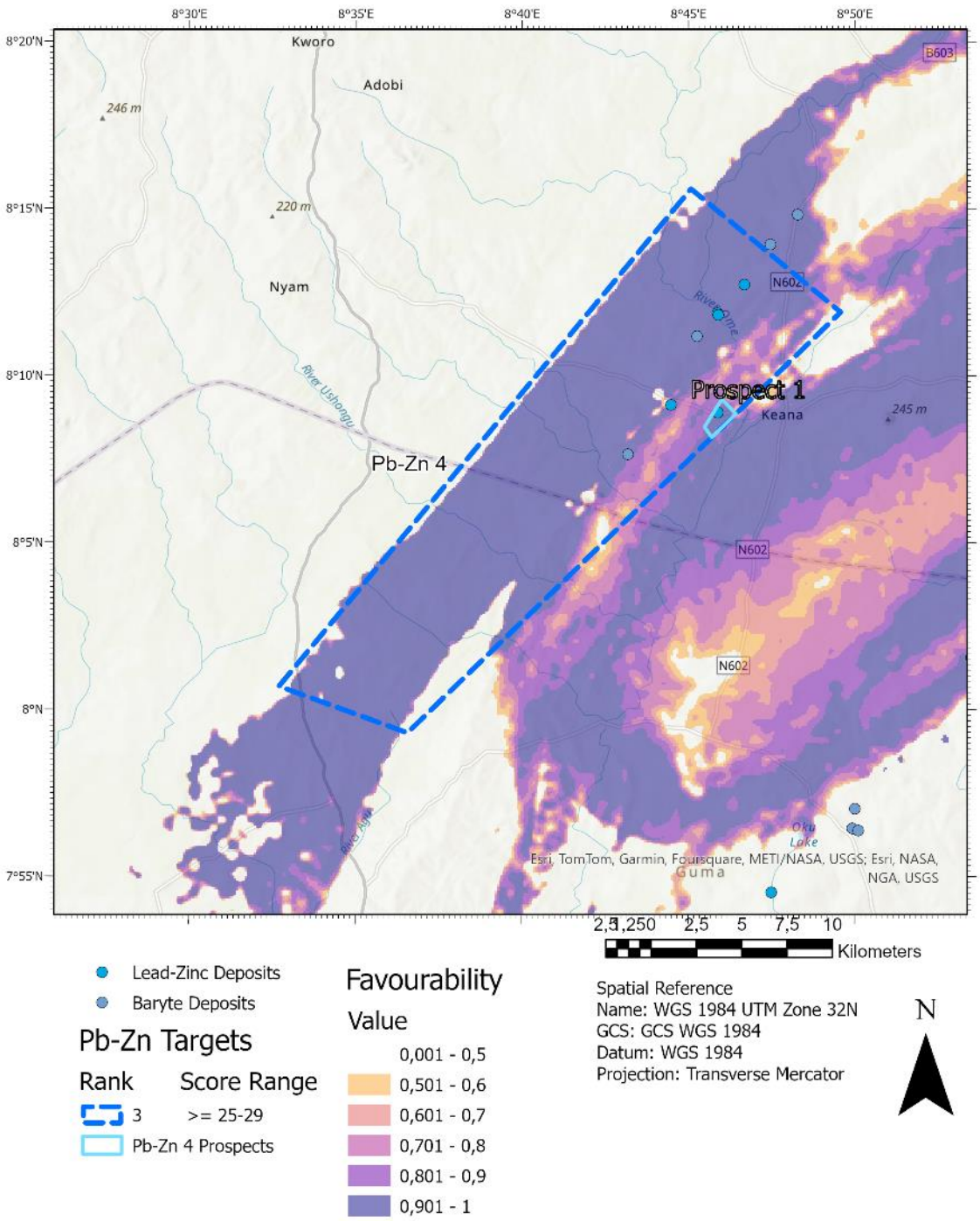


Figure 170: Favourability map for target Pb-Zn 4.

7.4.2.5 Target Pb-Zn 5

7.4.2.5.1 Summary

The target within the Middle Benue Trough boasts 30 occurrences of Pb-Zn, with three primary structures currently being exploited by artisanal miners. The license holder for this area is H & H Mines Ltd. The predominant trend of the mineralized bodies extends E-W for over 1.5 kilometres, with additional minor bodies trending N-S. These occurrences are hosted within late Cretaceous syn-rift carbonaceous shales, mudstones, shaly limestones, and coal seams. The favourability map reveals a continuous, relatively diffuse shape with values exceeding 0.9. The total area of this target is 371.48 km^2.

7.4.2.5.2 Characterization of the target

7.4.2.5.2.1 Favourability

The favourability map shows a continuous shape between compact and diffuse filling more than 60% of the target (Figure 175). Values over 0.9 correlate with the known Pb-Zn occurrences.

7.4.2.5.2.2 History

Mining in the area had started at least by 2014, with the main uptake in mineral extraction around 2021. At least 3 main sites are being exploited on a considerable scale, however no evidence of machinery or industrial processes is seen on satellite imagery. Several other mineral occurrences and sites are either inactive or abandoned.

7.4.2.5.2.3 Geological Setting

The regional rocks are identified as Late Cretaceous and syn-rift as Awgu/Pindiga Formations, composed of carbonaceous shales, mudstones, shaly limestones and coal seams (Cap1).

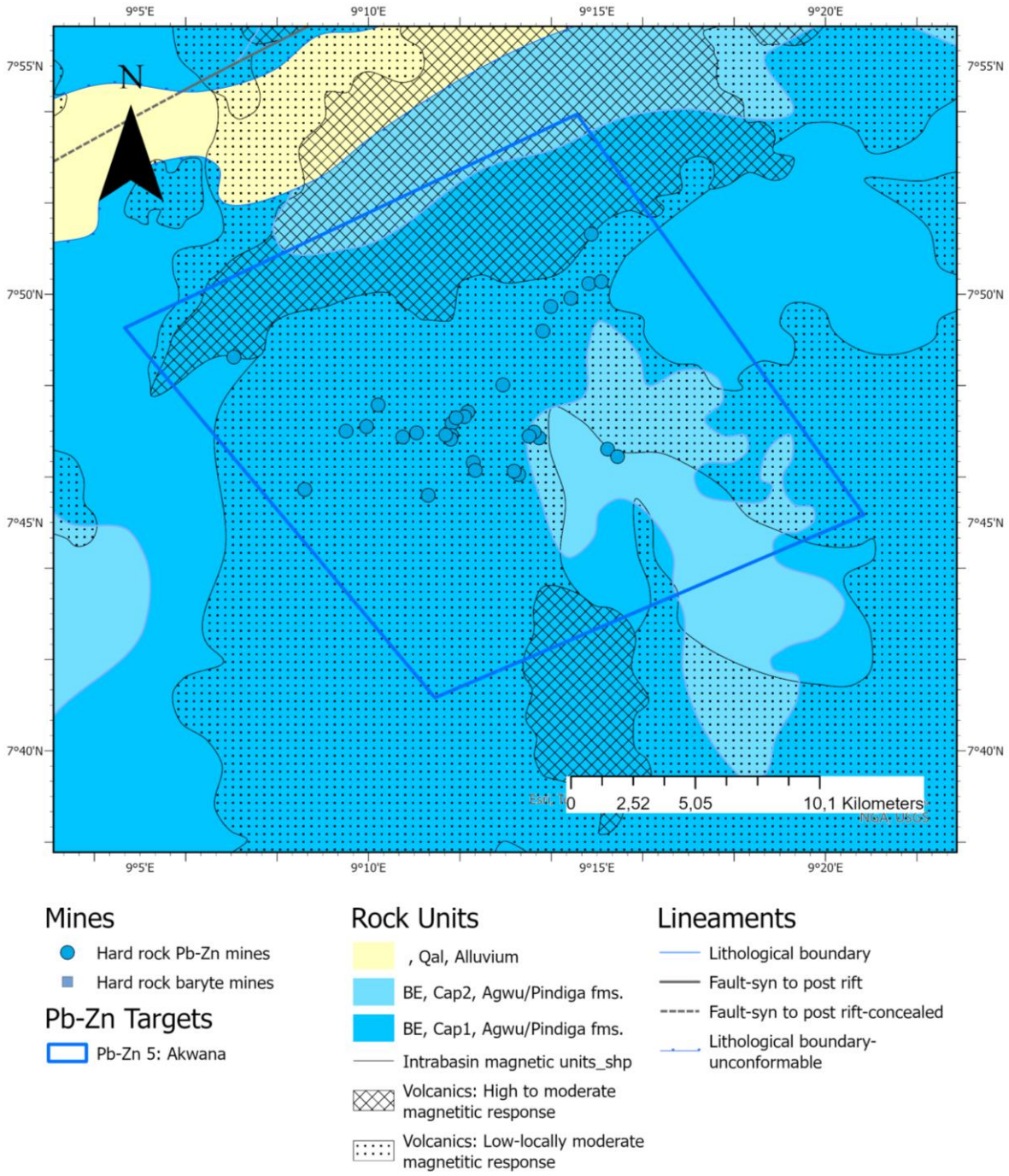


Figure 171: Geology for Pb-Zn Target 5 (Pb-Zn 5: Akwana).

7.4.2.5.2.4 Mineralization

At least 30 known occurrences of Lead-Zinc inside this target. The target is located within the Middle Benue Trough. The combination of the DEM, potassium radiometric signal and the magnetic signal suggest an intrusive body of great magnitude, suggesting a possible fluid source for the mineralization and the existing mineral occurrences. Tilt derivative of the magnetic signal indicates an anticline. Type of mineral genesis is interpreted as hydrothermal and occurs as vein-like deposits. NIMEP exploration campaign has galena occurring within siderite.

- Three main pits with lengths of at least 1.000m with one reaching up to 3.000m (Figure 173),
- Recent industrial workings on major sites on an apparent artisanal level,
- The main orientation of the exploited veins is E-W, minor pits suggest a conjugate N-S trend,
- Reported fluorite mining production of 500t.

7.4.2.5.2.5 Distribution of Mineral Tenements (MCO, 11.2023)

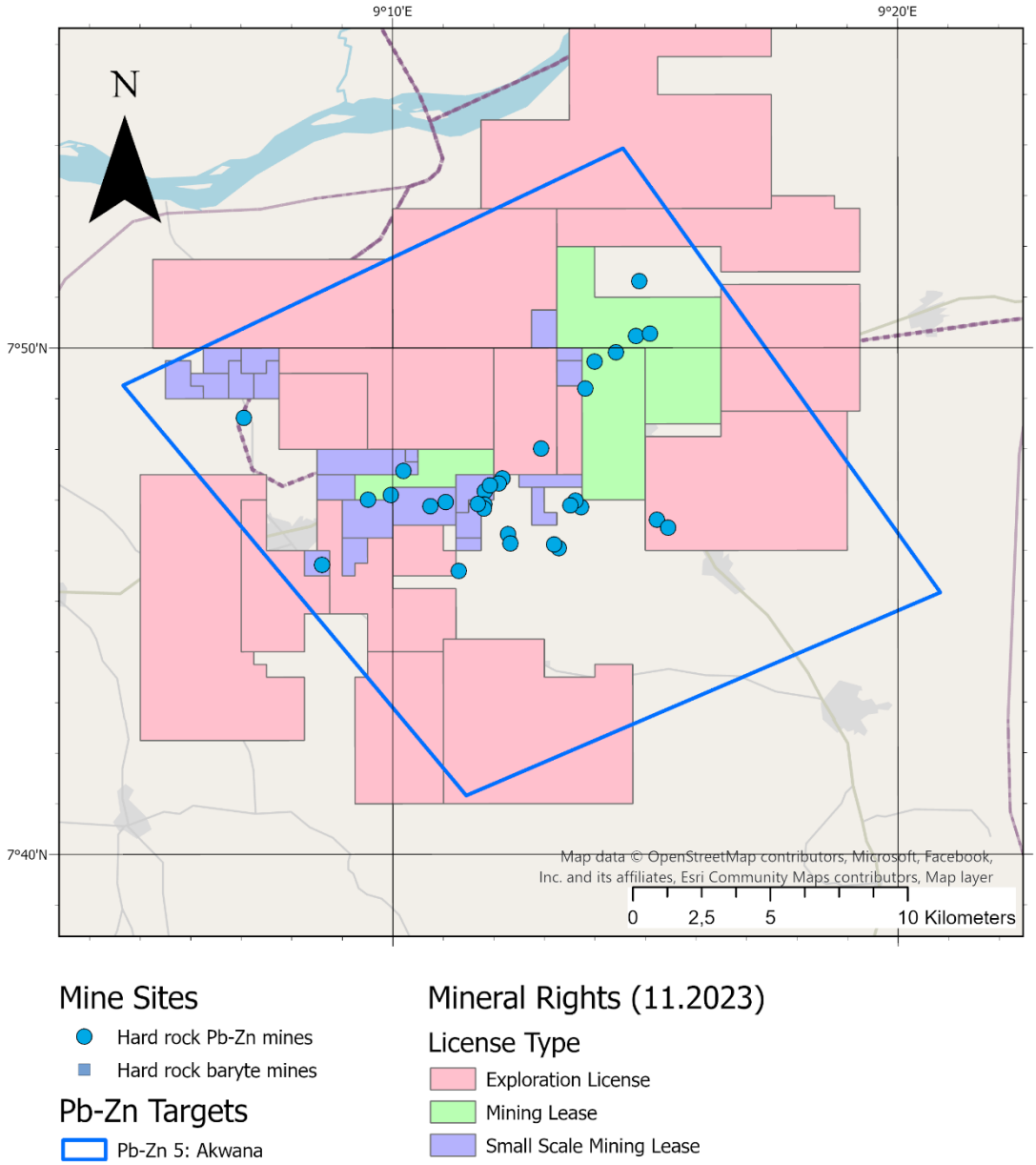


Figure 172: Distribution of Mineral Licenses in Pb-Zn Target 5 (Pb-Zn 5: Akwana).

7.4.2.5.3 Suggested prospect areas

7.4.2.5.3.1 Prospect 1

The 3.15km^2 defined area contains the following characteristics:

- Length of the main structure: 1.600m
- Average width of pits: 12m
- Number of occurrences: 4
- Status: active

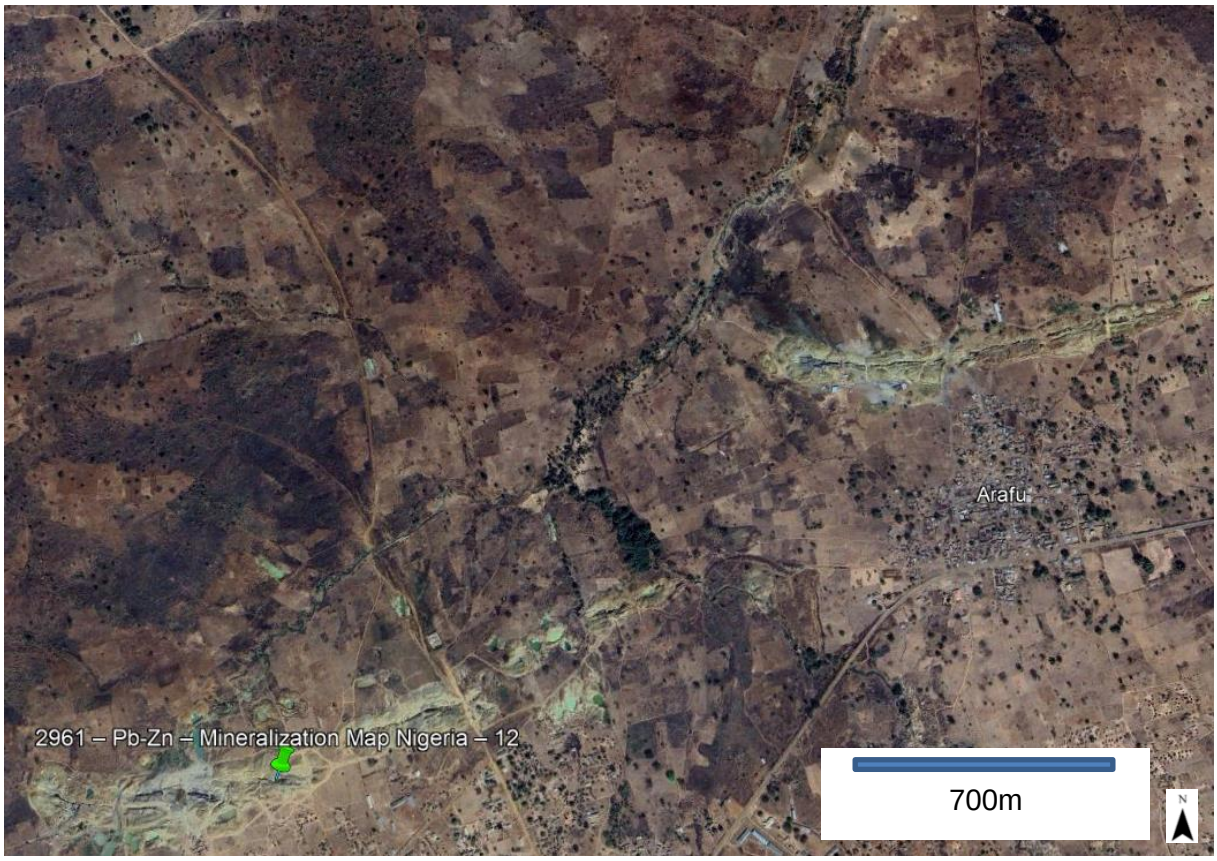


Figure 173: Central vein system currently mined (7°49'45"N 9°14'03"E). Image taken from Google Earth.

7.4.2.5.3.2 Prospect 2

The 3.65km^2 defined area contains the following characteristics:

- Length of the main structure: 995m
- Average width of pits: 20m
- Number of occurrences: 4
- Status: active

The current mining license in the area has the following data:

	SSML-022657	ML-033678	SSML-015481
Company Name (after MCO)	Izabella Nigeria Ltd	Xiang Hui Intl. Mining Nig. Co. Ltd	S.B. Olatunji Global Nigeria Ltd
Type of License	Small Scale Mining Lease	Mining Lease	Small Scale Mining Lease
Commodities	Lead, Zinc	Gold	Lead, Zinc

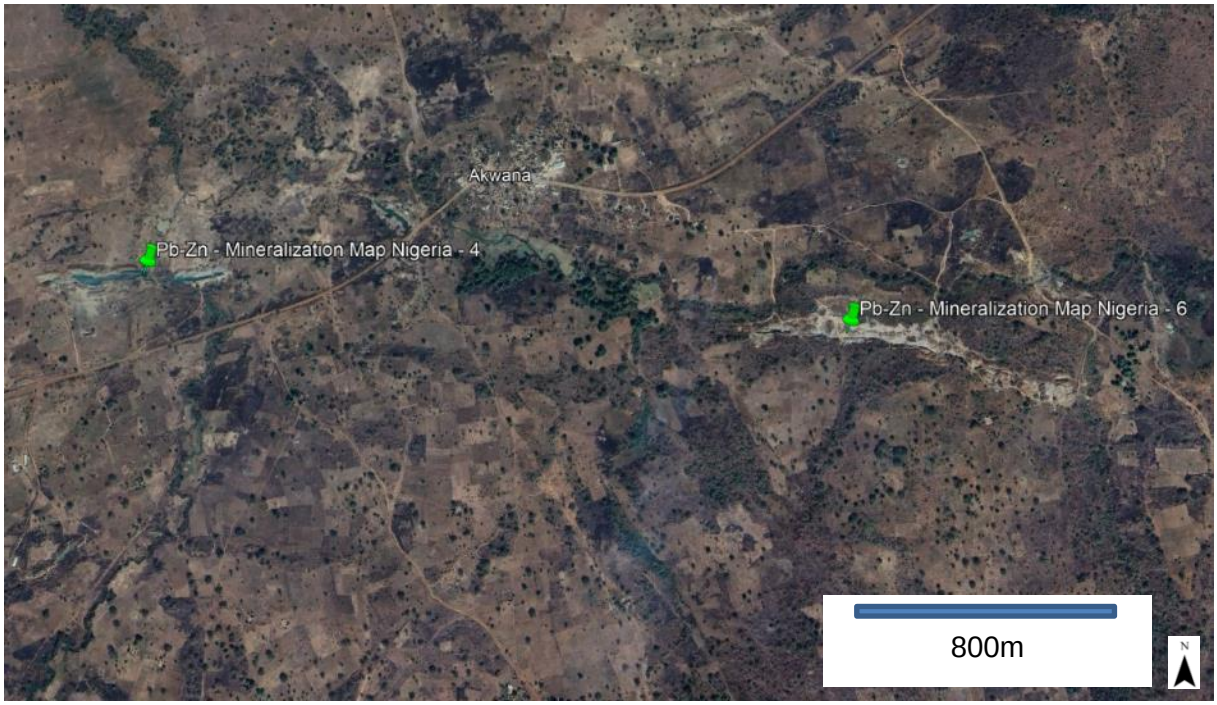


Figure 174: Central vein system currently mined (7°46'53"N 9°10'42"E). Image taken from Google Earth.

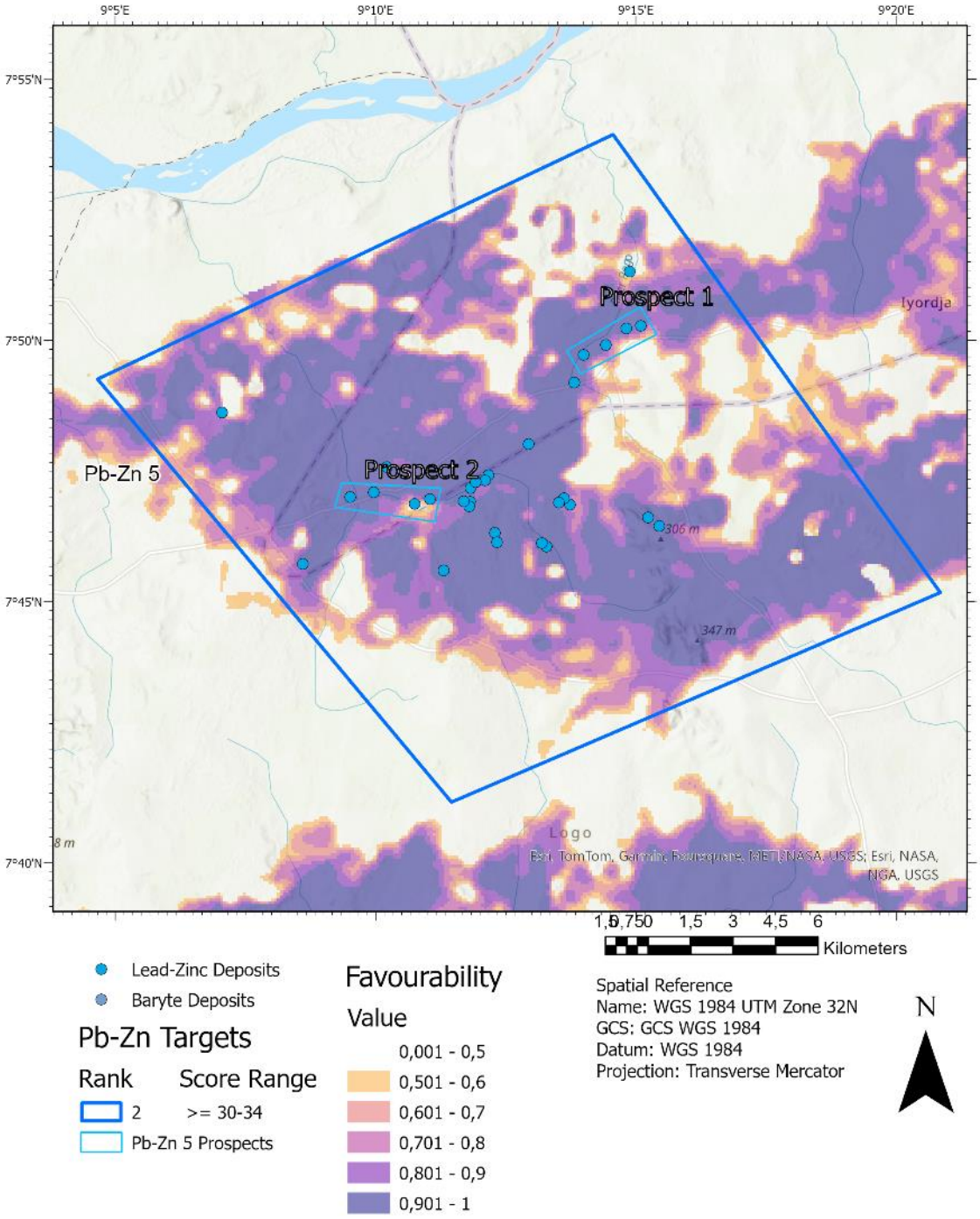


Figure 175: Favourability map for target Pb-Zn 5.

7.4.2.6 Target Pb-Zn 6

7.4.2.6.1 Summary

The target within the Upper Benue Trough comprises 5 occurrences of Pb-Zn, with one site featuring recent small-scale mining operations, currently under the ownership of Geolank Exploration Concepts Ltd, reporting an annual production of 741 metric tons of Pb-Zn. The mineralized veins exhibit a predominant N-S trend, with the main body extending over 1.7 kilometres. These veins are hosted within late Cretaceous syn-rift sediments composed of sandstones, limestones, and other carbonaceous rocks. The favourability map illustrates a compact shape with values exceeding 0.9. The total area of this target is 792.12 km^2.

7.4.2.6.2 Characterization of the target

7.4.2.6.2.1 Favourability

The favourability map shows a continuous compact shape (sole for a hole in the middle) filling more than 75% of the target (Figure 177). Values over 0.9 correlate with the known Pb-Zn occurrences.

7.4.2.6.2.2 History

Mining activities can be traced back to 1985 possibly linked with British activities during the colonial times. One main site showed considerable activity between 2012 and 2019, after which no detectable changes to pit size or depth are identifiable. No evidence of machinery or industrial processes is seen on satellite imagery, but a number of structures were built in the area. Other mineral occurrences and sites are either inactive or abandoned.

- One main pit with length of at least 1.720m (Figure 173),
- All identified pits are either abandoned or inactive,
- The main orientation of the exploited veins is N-S.
- Reported Lead-Zinc mining production of 741t and 1750t for different sites.

7.4.2.6.2.3 Geological Setting

The regional rocks are identified as Late Cretaceous made up of syn-rift as Keana/Awe Formations, composed of cross-bedded fine- to very-coarse sandstones interbedded with limestones (Cka2), the Eze Aku/Yolde Formations, composed of carbonaceous shales, limestones and fine to medium grained sandstone (Cey), and the Awgu/Pindinga Formations, composed of carbonaceous shales, mudstones, shaly limestones and coal seams (Cap1, Cap2 and Cap3).

7.4.2.6.2.4 Mineralization

At least 5 known occurrences of Lead-Zinc inside this target. The area lies on the northern core of a double-plunging syncline and crosscut SSW-NNE by a double regional fault, possibly generated during rifting. The Tilt derivative of the magnetic signal suggests that the limbs of the fold are SE-NW trending. The trend of the veins is N-S with the type of mineral genesis interpreted as hydrothermal. NIMEP exploration in the largest structure indicate a steep/vertical dipping structure with grades up to 19.5 % Zn and 1.6% Pb.

7.4.2.6.3 Suggested prospect areas

The active area of 1,89km^2 contains the following characteristics:

- Length of the main structure: 1.720m
- Average width of pits: 70m
- Number of occurrences: 2
- Status: active/inactive?

Figure 176: Key mine currently active with at least 1400m length (8°57'07"N 10°13'47"E). Image taken from Google Earth.

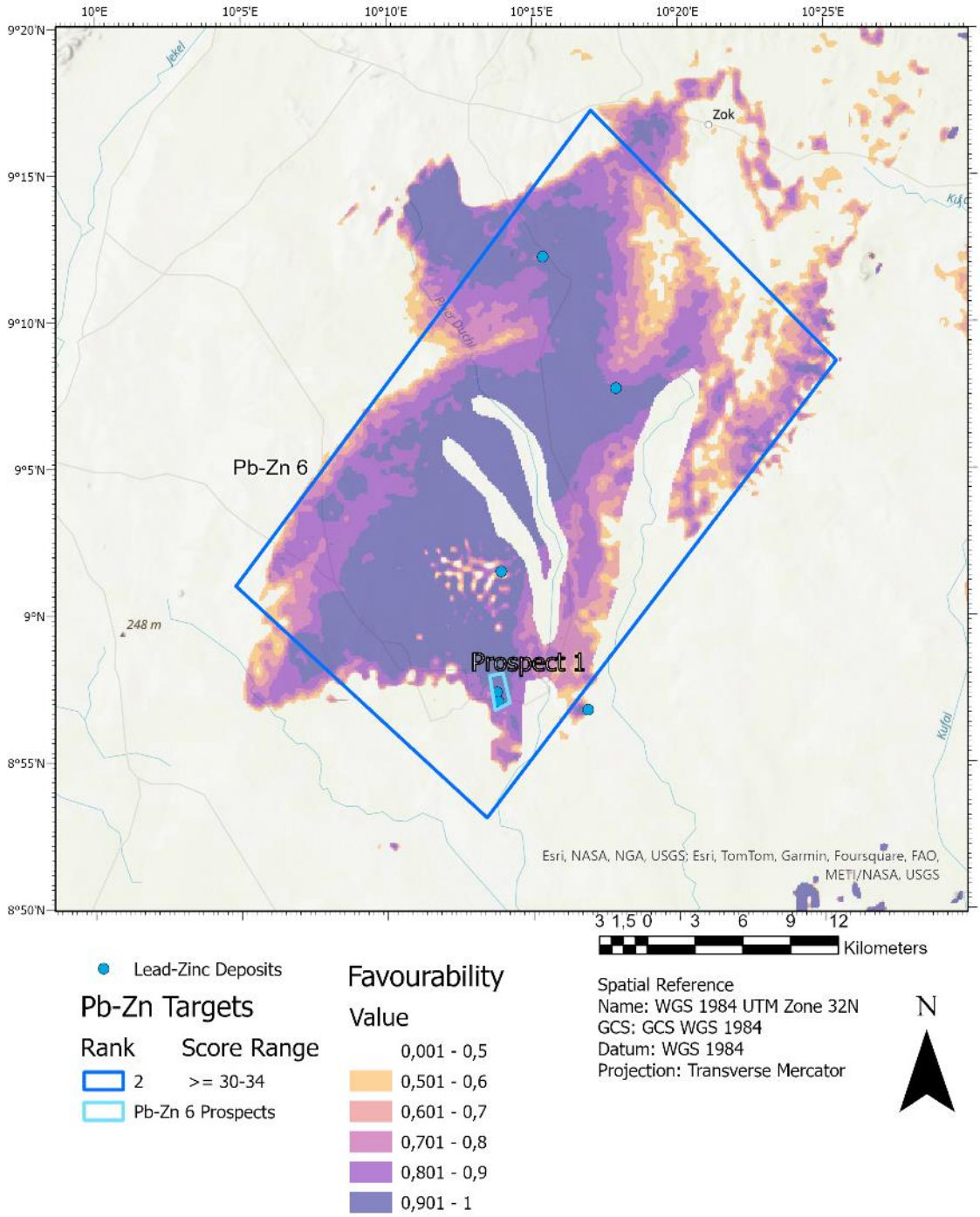


Figure 177: Favourability map for target Pb-Zn 6.

7.4.2.7 Target Pb-Zn 7

7.4.2.7.1 Summary

The target within the Upper Benue Trough boasts 47 occurrences of Pb-Zn, with one site currently undergoing recent industrial-scale mining operations and owned by Imperial JV Limited, a joint venture company. Lead production in the target area has been reported to reach 30 tons per annum by Aby Diamond Company. The mineralized veins exhibit a predominant NNW-SSE trend, with the main body extending over 1.9 kilometres. These veins are hosted within early and late Cretaceous syn-rift sediments comprised of sandstones and siltstones. The favourability map depicts a compact shape with values exceeding 0.9. The total area of this target is 365.37 km^2.

7.4.2.7.2 Characterization of the target

7.4.2.7.2.1 Favourability

The favourability map shows a continuous compact shape with some diffusing towards the edges but filling more than 60% of the target (Figure 181: Favourability map for target Pb-Zn 8.Figure 181). Values over 0.9 correlate with most of the known Pb-Zn occurrences.

7.4.2.7.2.2 History

Mining activities can be traced back to at least 2003. One main site showed considerable activity starting 2019 by showing a well-defined open-pit, along industrial heavy-duty machinery allowing a constant extraction of ore. Big tailing mounds are spotted but no clear evidence of a processing plant. Other mineral occurrences only show recent artisanal workings, however satellite imagery only goes until 2020. The identified occurrences form a 41 km^2 cluster area.

7.4.2.7.2.3 Geological Setting

The regional rocks on the rims of the anticline are identified as Late Cretaceous made up of syn-rift as Keana/Awe Formations, composed of sandstones interbedded with siltstones

(Cka1), and, exposed on the core of the anticline, older Early Cretaceous syn-rift Bima SS, composed of coarse-grained sandstone (Cbs2) and sandstones with volcanogenic epiclastic sediment.

7.4.2.7.2.4 Mineralization

At least 47 known occurrences of Lead-Zinc are reported inside this target. The area lies on the Upper Benue Trough and includes a severely faulted anticline (SW-NE) run through by SW-NE regional faults. The magnetic signal suggests some anomalies from magnetic bodies (intrusives?) that can be roughly correlated with the existing mineral occurrences. The trend of the veins is NNW-SSE (conjugate to the regional faults?) with the type of mineral genesis interpreted as hydrothermal.

- One main pit with length of at least 1.950m (Figure 178),
- All identified pits seem to be active,
- The main orientation of the exploited veins is NNW-SSE,
- Reported Lead-Zinc mining production of 741t and 1750t for different sites.

7.4.2.7.3 Suggested prospect areas

The active area of 8,30km^2 contains the following characteristics:

- Length of the main structure: 1.950m
- Average width of pits: 100m
- Number of occurrences: 10
- Status: active

Figure 178: Main mine actively exploited in the target area (9°35'25"N 10°48'18"E). Image taken from Google Earth.

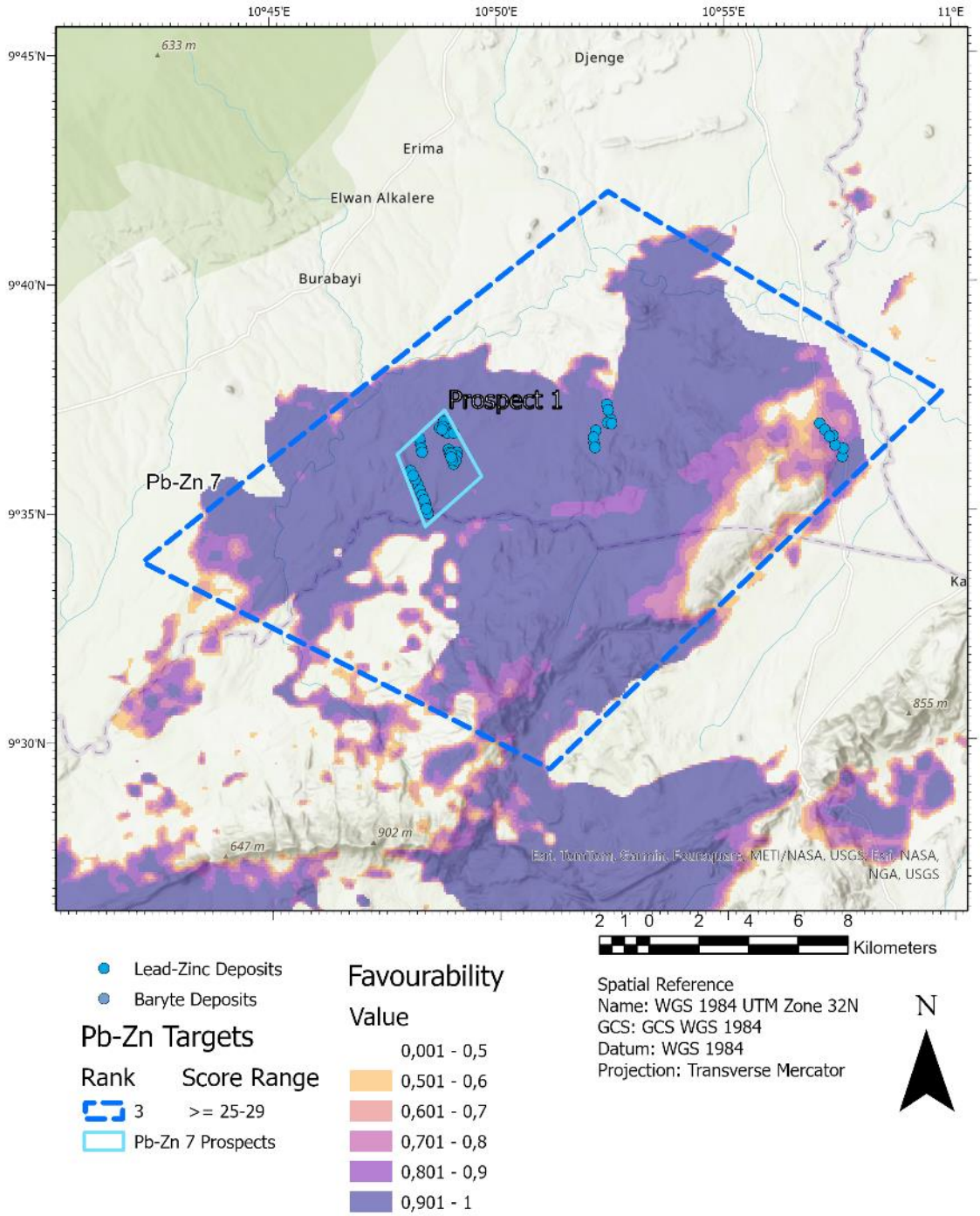


Figure 179: Favourability map for target Pb-Zn 7.

7.4.2.8 Target Pb-Zn 8

7.4.2.8.1 Summary

The target within the Lower Benue Trough features no reported occurrences of Pb-Zn but is abundant in barite deposits. Mining operations within the area are entirely artisanal, with no industrial equipment in use. Interestingly, the primary active mining zone currently lacks any license claimant and remains open for exploitation. The mineralized veins predominantly trend NE-SW, although the main mined body, approximately 350 meters in length, follows a conjugate NW-SE direction. These occurrences are hosted within late Cretaceous syn-rift sediments composed of sandstones and siltstones. The favourability map depicts a semi-compact shape with values exceeding 0.9.

7.4.2.8.2 Characterization of the target

7.4.2.8.2.1 Favourability

The favourability map shows a continuous semi-compact shape filling more than 70% of the target (Figure 181) and trending obliquely. Values over 0.9 correlate are common and correlate with known barite mineral locations. The total area of this target is 542.28 km^2.

7.4.2.8.2.2 History

Mining activities can be traced back to at least 2010 where several pits are visible. One site, although known for several years before, only presented considerable activities starting 2021. The lack of evidence of machinery, infrastructure or tailing accumulations suggest activities remain artisanal.

7.4.2.8.2.3 Geological Setting

The regional rocks on the rims of the anticline are solely identified as Late Cretaceous made up of syn-rift as Keana/Awe Formations, composed of sandstones interbedded with siltstones (Cka1).

7.4.2.8.2.4 Mineralization

No known Lead-Zinc occurrences are reported, nonetheless, at least 6 barite mines exist inside this target. The area lies on the Lower Benue Trough and covers the north-eastern section of a NE-SW trending anticline. The magnetic signal suggests magnetic anomalies that may be linked with untapped discoveries of Pb-Zn mineral occurrences. The trend of the mineralized bodies is interpreted as NE-SW, however, recent workings suggest a conjugate direction (NW-SE) also exists. The type of mineral genesis interpreted as hydrothermal. Remarks on the identified pits:

- One main pit with length of at least 350m (Figure 178),
- All identified pits seem to be active,
- The main orientation of the exploited veins is NE-SW, however some conjugate structures have been recently discovered,
- No production values are reported.

7.4.2.8.3 Prospect area:

The active area of 6,83km^2 contains the following characteristics on estimations (Figure 180):

- Length of the main structure: 350m
- Average width of pits: 30m
- Number of occurrences: none yet documented
- Status: active

No current/active mining license has claimed the area.

Figure 180: Newly discovered mine within the target area (6°53'23"N 8°46'50"). Image taken from Google Earth.

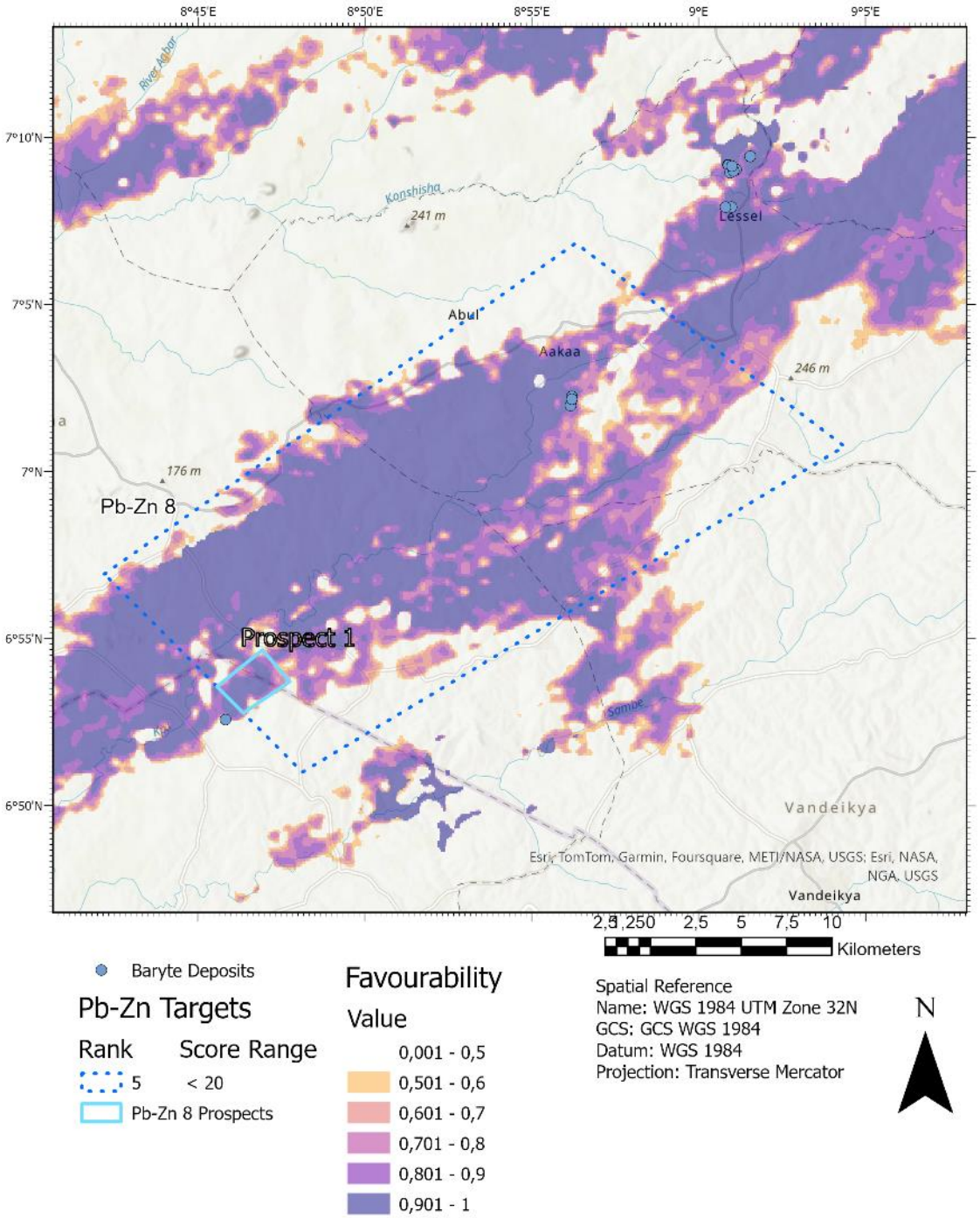


Figure 181: Favourability map for target Pb-Zn 8.

7.4.2.9 Target Pb-Zn 9

7.4.2.9.1 Summary

The target within the Upper Benue Trough boasts 47 occurrences of Pb-Zn, with one site currently undergoing recent industrial-scale mining operations, owned by Imperial JV Limited, a joint venture company. Lead production in the target area has been reported at 30 tons per annum by Aby Diamond Company. The mineralized veins predominantly trend NNW-SSE, with the main body extending over 1.9 kilometres. These veins are hosted within early and late Cretaceous syn-rift sediments composed of sandstones and siltstones. The favourability map depicts a compact shape with values exceeding 0.9. The total area of this target is 636.14 km^2.

7.4.2.9.2 Characterization of the target

7.4.2.9.2.1 Favourability

The favourability map shows a continuous diffused shape filling more than 50% of the target Figure 181: Favourability map for target Pb-Zn 8.(Figure 183). Values over 0.9 correlate with the known Pb-Zn occurrences.

7.4.2.9.2.2 History

Mining activities can be traced back to at least 1985 possibly dating back to the colonial mining era. One main site showed considerable activity starting 2016 by showing a well-defined open-pit, but seems currently inactive. Big tailing mounds are spotted but no clear evidence of a processing plant or machinery (all licences in the area are artisanal or small-scale). Another main pit reactivated around 2021 with water removal and sporadic activities. All other pits show a certain degree of abandonment.

7.4.2.9.2.3 Geological Setting

The regional rocks are identified as Late Cretaceous made up of syn-rift as Keana/Awe Formations, composed of sandstones interbedded with siltstones (Cka1).

7.4.2.9.2.4 Mineralization

At least 8 known occurrences of Lead-Zinc are reported inside this target. The area lies on the Lower Benue Trough and includes at least 2 anticlines running NE-SW. The magnetic signal in the area (1VD and Tilt) suggest that identifiable NW-SE trending features may control the mineralization. The trend of the veins is NNW-SSE (conjugate to the regional faults?) with the type of mineral genesis interpreted as hydrothermal.

- One main abandoned pit with length of at least 400m (Figure 161),
- All identified pits seem to be inactive/abandoned,
- The main orientation of the exploited veins is NW-SE,
- Reported Lead-Zinc mining production is unclear.

7.4.2.9.3 Prospect area:

The active area of 12,03km^2 contains the following characteristics:

- Length of the main structure: 400m
- Average width of pits: 50m
- Number of occurrences: 2
- Status: active

Figure 182: Reactivated mine site (6°30'29"N 8°16'17"E). Image taken from Google Earth.

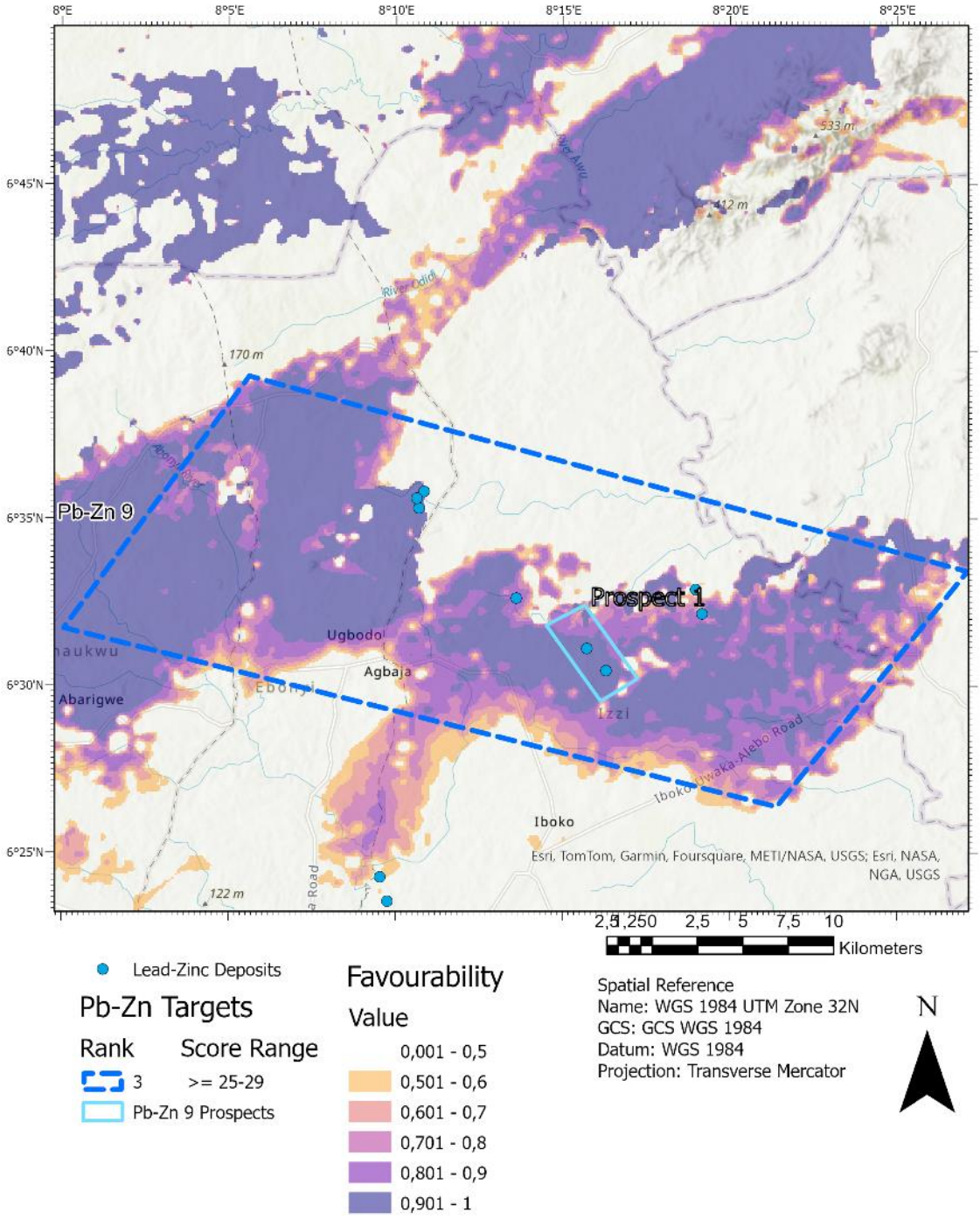


Figure 183: Favourability map for target Pb-Zn 9.

7.5 Uranium (U) Targets

7.5.1 Identification and Location

7.5.1.1 Criteria Catalogue

Due to the scarcity of mineral occurrences, a Uranium MPM was not created. However, due to its relevance and current market value (see chapter 3.4), an analysis of available data is possible to select targets.

In Nigeria, the following genetic types of U-occurrences are possible:

- Granite related Uranium, either in hydrothermal veins in or around the intrusives or as disseminated U in the granites
- Sandstone hosted Uranium
- Uranium related to phosphorites
- Uranium in accessory minerals in various granitoid and alkaline rocks /(pyrochlore, monazite, xenotime, and similar minerals.

Generally, because of the presence of suitable geological environments, the discovery of big deposits seems to be possible. At this moment, no ranking is possible as the knowledge about the mineral potential of the different genetic types of U occurrences is scarce. The following criteria for selection of areas was used:

- eU/eTh values high:

eU/eTh values high
More than > 1.0
Between 1.0 and 0.6
Between 0.6 and 0.4
Between 0.4 and 0.2
Less than 0.2

- eUranium values high:

eUranium content high	Score
Yes	5
No	1

- Uranium occurrences known:

Uranium occurrences known	Score
Yes	5
No	1

- Sedimentary clastic rocks with organic material (coal, bitumen or similar):

Sedimentary rocks	Score
Yes	5
No	1

- Phosphorite occurrences known:

Coal Phosphorite occurrences	Score
Yes	5
No	1

7.5.1.2 Location of targets

The identified targets are located in different positions throughout the Benue Trough. Their spatial location is shown in Figure 184.

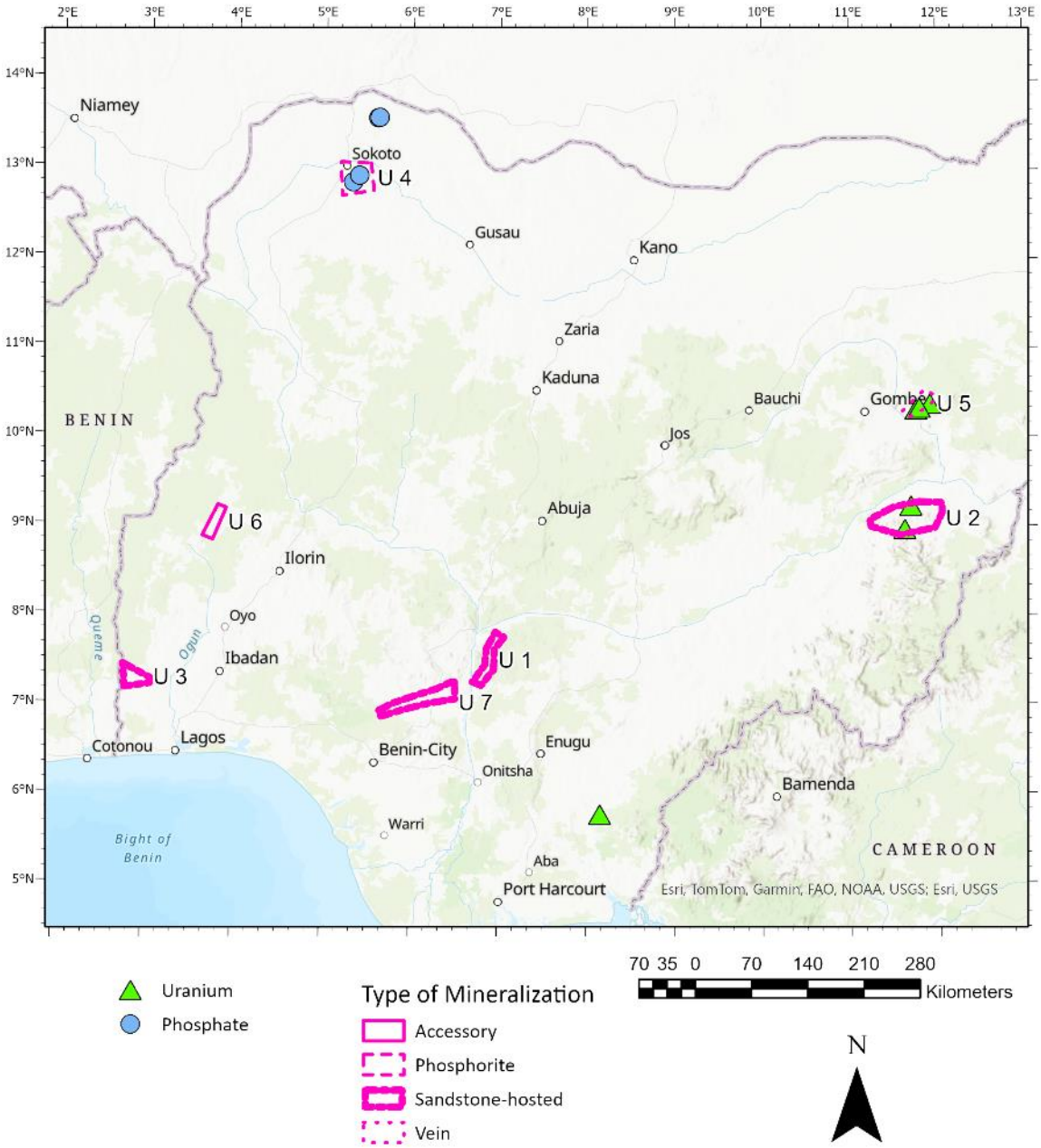


Figure 184: Location and ranking of selected targets for Uranium (U).

7.5.2 Description of targets

7.5.2.1 Target Uranium 1

Location: Lower Benue Trough, Benue State.

Geology: Sandstones, shales, mudstones and coal (Cnl and Cms – Late Cretaceous post-rift).

Mining activities: At least three important coal deposits are being mined along the same sedimentary layers further to the East of the identified area (Figure 185).

Additional information: high values of eUranium are detected in the area and correlated with points of high value of the ratio of eU/eTh (Figure 186). It is recommend to investigate the ash of the coal for its U content, and searching for U in the sandstones accompanying the coal seams.

Total area: 769.18 km^2.

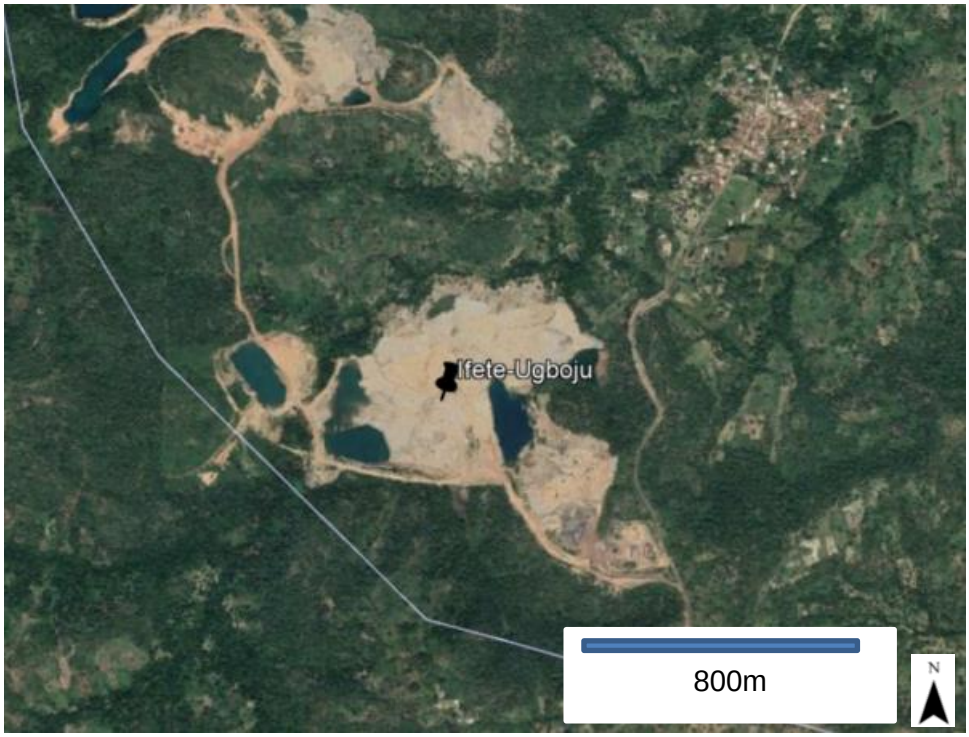


Figure 185: Coal mine in the selected target suggesting Uranium concentration potential (7°25'33"N 7°46'35"E). Image taken from Google Earth.

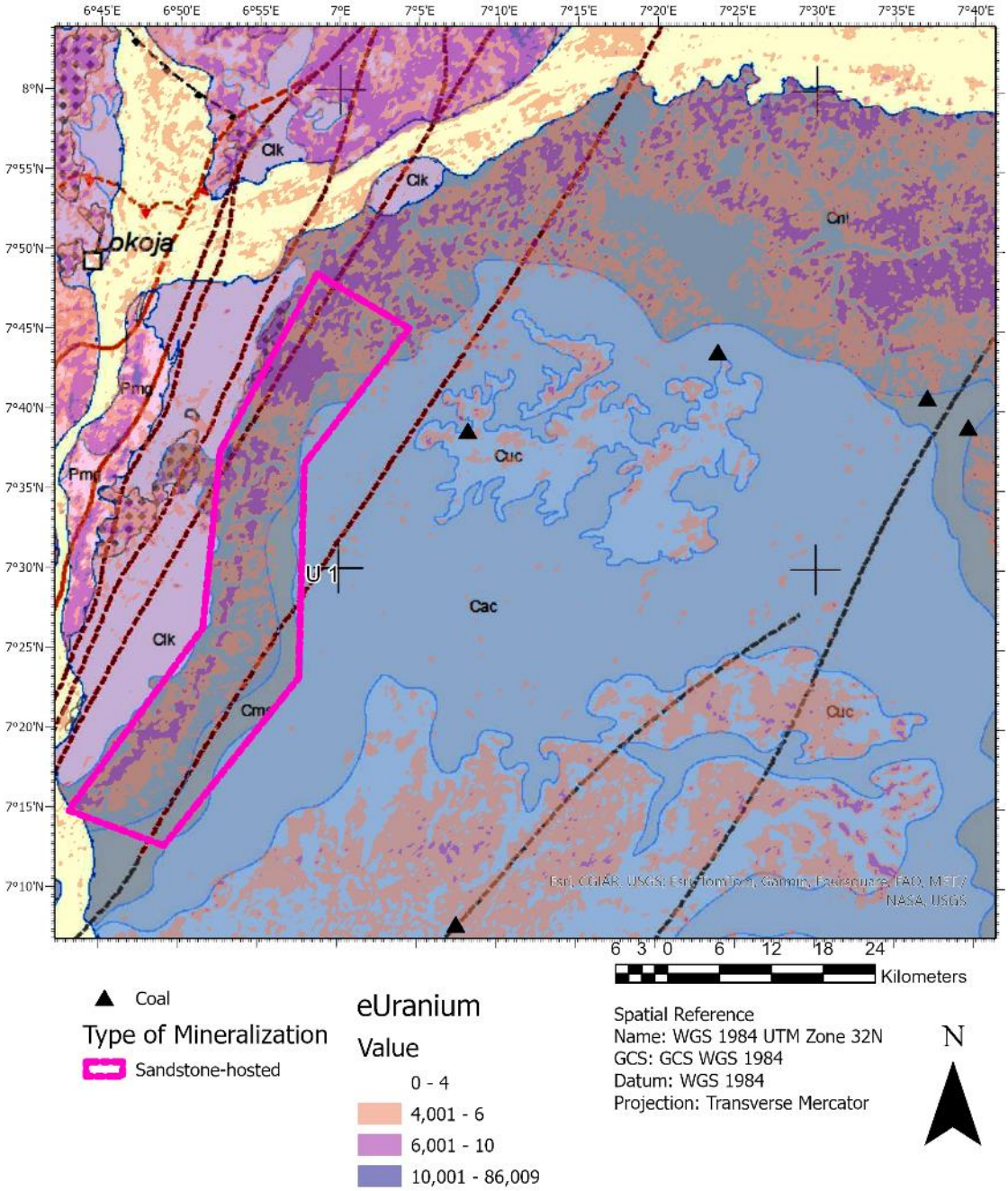


Figure 186: eUranium superimposed on the Litho-structural map for target U 1.

7.5.2.2 Target Uranium 2

Location: Eastern Basement Complex and Upper Benue Trough, Taraba State.

Geology: Mainly sandstones (Cbs1 and Cbs2 – Early Cretaceous syn-rift) delimited to the north by a main fault structure and separating younger sediments (Cka1 – Late Cretaceous syn-rift). A main syn-tectonic granite (Nog – Neoproterozoic to Cambrian) is located south of the target area.

Mining activities: No mining activity is seen in the area, however two known occurrences have been identified in the area:

- Mayo Lope prospect (northern area of the target): with detected concentrations of 0.18% and 0.25% U in sandstones (Olade M. , 2020).
- Mika prospect (southern area of the target): veins and disseminations of Uranium in a brecciated granite with grades of 0.63% U (Karniliyus & Akedegwa, 2018).

Additional information: high values of eUranium are linked to the intruding granite that has probably been weathered, with fluids carrying the Uranium downslope and depositing in the sandstones as an infiltration mechanism.

Total area: 2,601.98 km^2 (Figure 187).

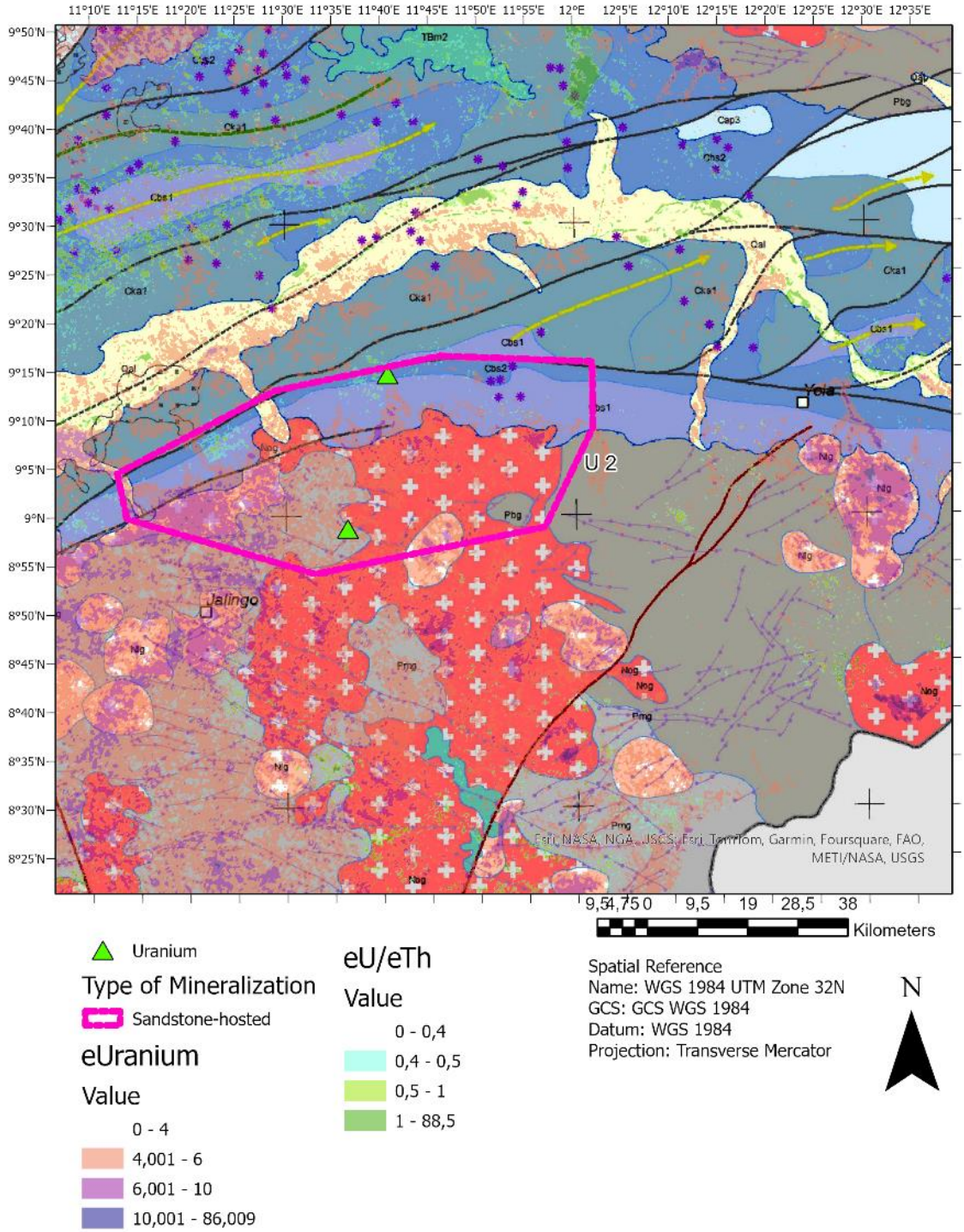


Figure 187: eUranium superimposed on the Litho-structural map for target U 2.

7.5.2.3 Target Uranium 3

Location: south-western corner of Nigeria, Ogun State.

Geology: Late cretaceous sandstones, shales, mudstones and coal.

Mining activities: Several mine sites exist in the area for commodities unrelated to Uranium.

Additional information: high values of eUranium are detected in the area and correlated with ratios of eU/eTh (Figure 188). The shape is very compact indicating that the concentrations of Uranium are extensive and follow the bedding regionally and discarding the possibility of river accumulation.

Total area: 577.09 km^2.

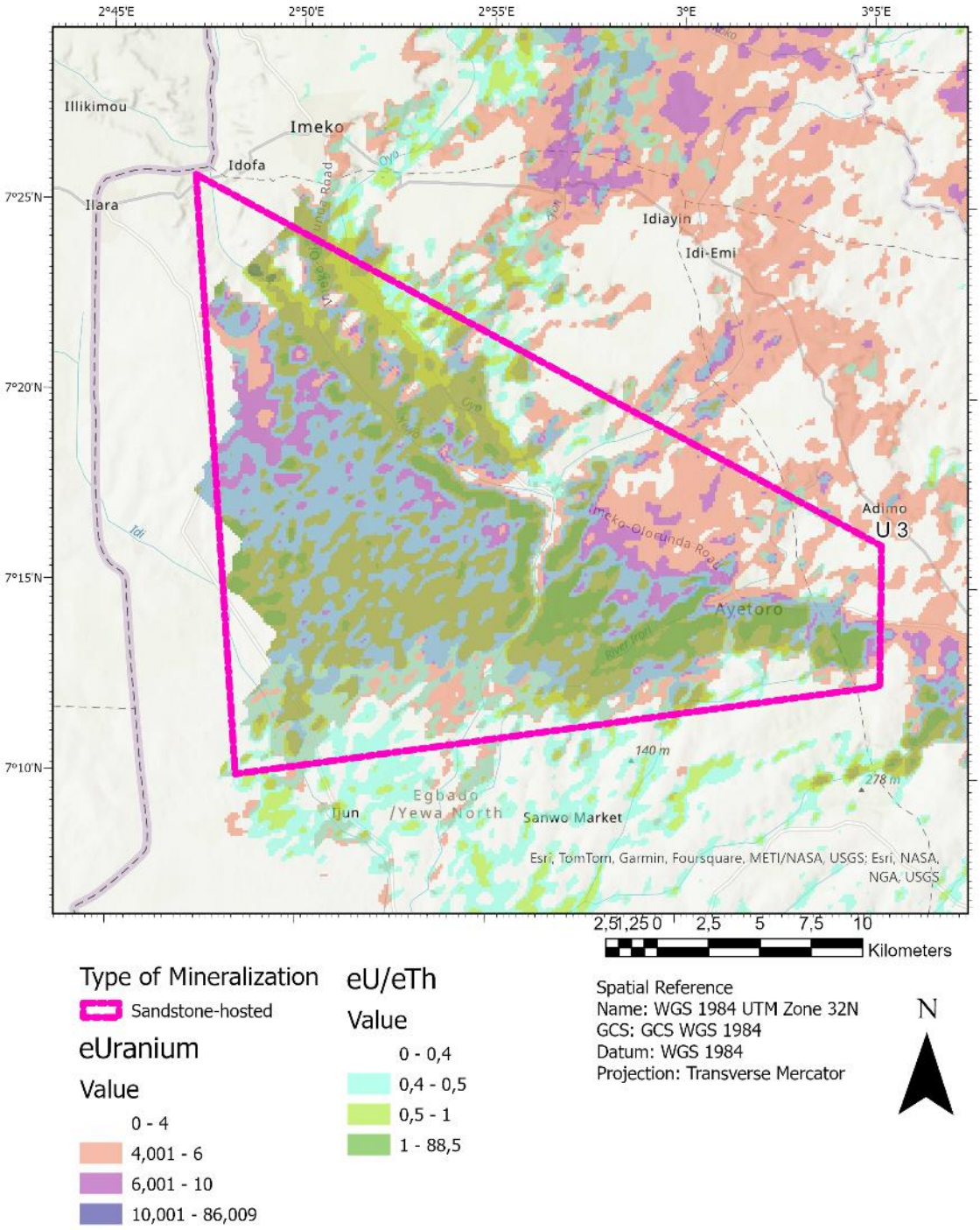


Figure 188: eUranium and eU/eTh ratio map for target U 3.

7.5.2.4 Target Uranium 4

Location: north-western corner of Nigeria, Sokoto State.

Geology: Paleogene to Neogene laterites sandstones and clays (Tgw2) on top of late cretaceous undifferentiated sandstone, shale, siltstone and claystone (Cwt2).

Mining activities: Phosphate mine sites are documented in the area (Figure 189). The known U grade in the phosphorites reach up to 29-65 ppm (Ogunleye P. O., 2002)-(Mustapha, 2022) .

Additional information: As U may enrich in lateritic formations as well, it is recommended to verify serval points with pits and measure the U grades in situ using pXRF devices. The total area interpreted to hold this mineralization is estimated to have a total size of 8,196 km^2.

Total area: 1,458.93 km^2.

Figure 189: Phosphate mining site with eU/eTh value of 1.0 (12°55'30"N 5°21'47"E). Image taken from Google Earth.

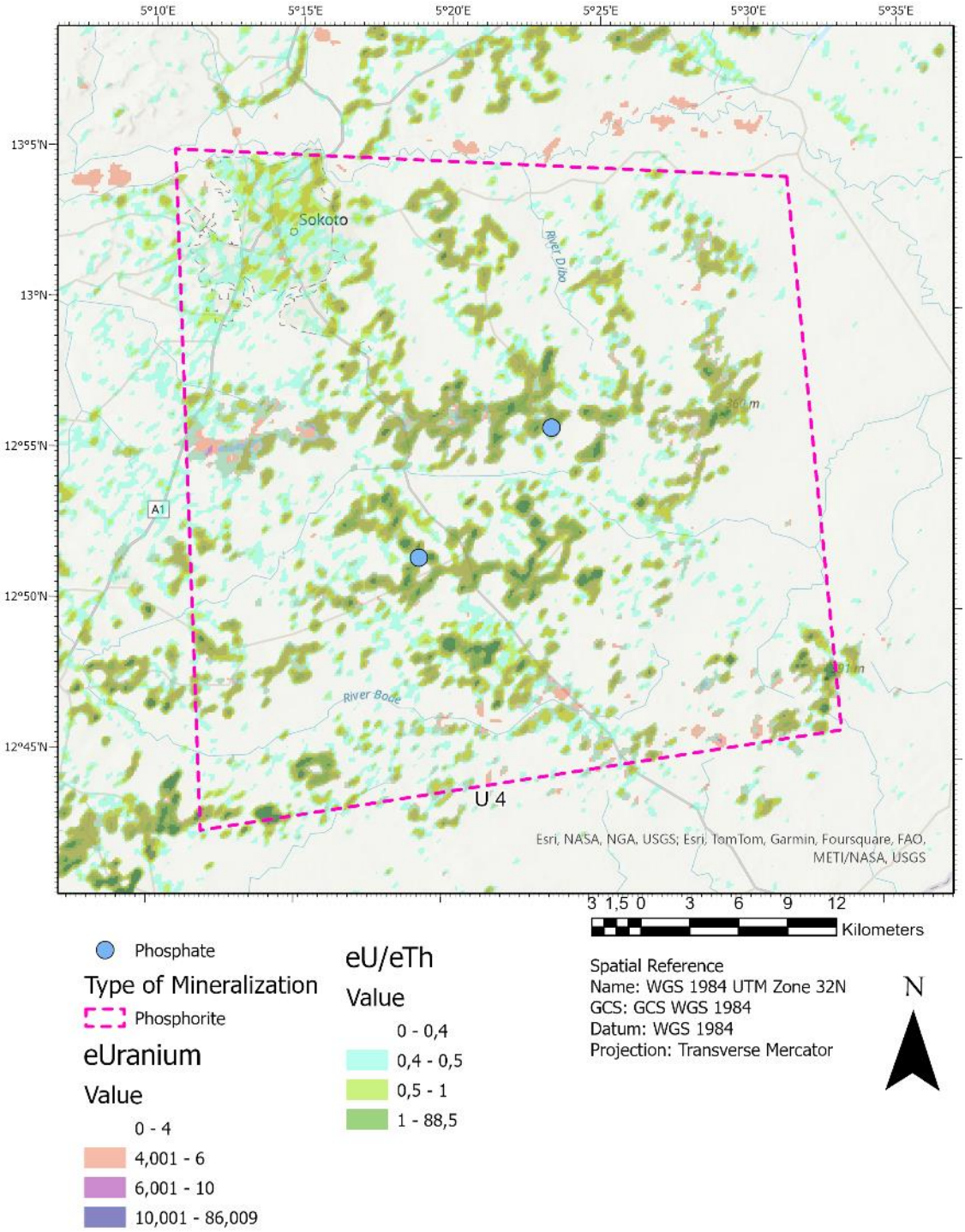


Figure 190: eUranium and eU/eTh ratio map for target U 4.

7.5.2.5 Target Uranium 5

Location: Upper Benue Trough, Borno State.

Geology: Migmatitic gneisses with some interpreted volcanic dykes trending SW-NE.

Mining activities: No known mining area or activity has been registered within the target area. At least three locations of Uranium occurrences have been reported in the area and seen to correlate very well with a linear magnetic anomaly suggesting a tectonically controlled (vein type?) deposit (Figure 191**Fehler! Verweisquelle konnte nicht gefunden werden.**):

- Gubrunde: no documented information on U concentrations.
- Kanawa: average U concentrations are 0.1wt. % (Bute, Yang, Yang, Kayode, & Lu, 2022)
- Zona Propsect: average concentrations are around 650 ppm.

Additional information: high values of eUranium in a very compact shape are detected in the area. However, very high values of eTh are also detected.

Total area: 657.40 km^2 (Figure 191).

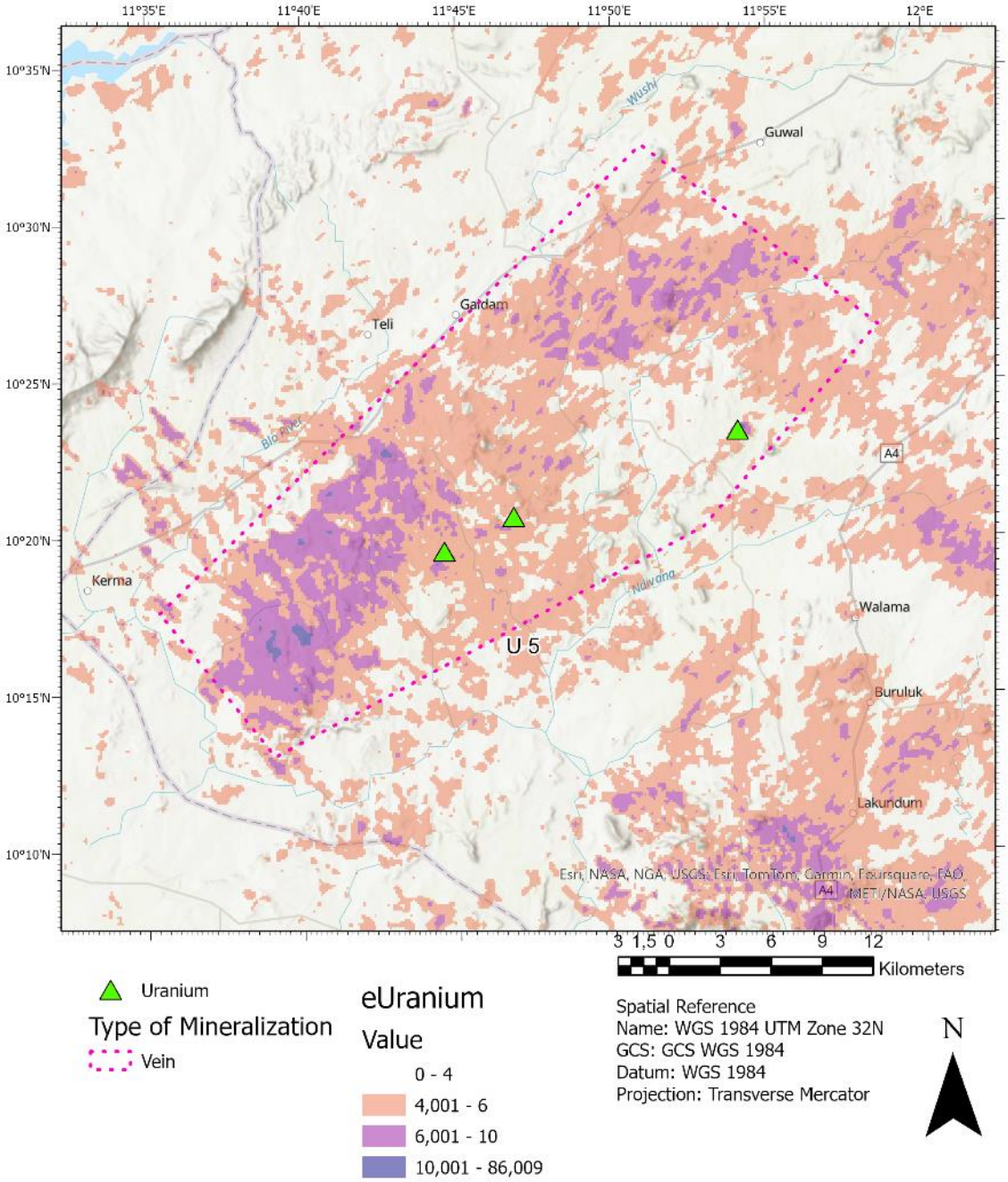


Figure 191: eUranium and eU/eTh ratio map for target U 5.

7.5.2.6 Target Uranium 6

Location: around Kisi town, Oyo State.

Geology: according to the 2M geology, the rocks in the area are banded gneisses along with late syn-tectonic Older Granites. However, the radiometric response indicates mainly an intrusive body with a very elongate shape.

Mining activities: No known mining area or activity has been registered within the target area.

Additional information: the target contains the highest eUranium values of Nigeria in a very well defined shape. However, very high values of eTh are also detected. Nonetheless, nowhere else in Nigeria such structure exists. The Potassium radiometric signal suggests an intrusive body that has disseminated Uranium, and the RTP 1VD signal indicates a prominent fault cross-cutting the body. Studies on accessory minerals in granites have indicated that uraniferous pyrochlore can occur with concentrations of up to 3.5 wt. % UO2 and up to 4.3 wt. % ThO2 (Beer, 1952).

Total area: 538.56 km^2 (Figure 192).

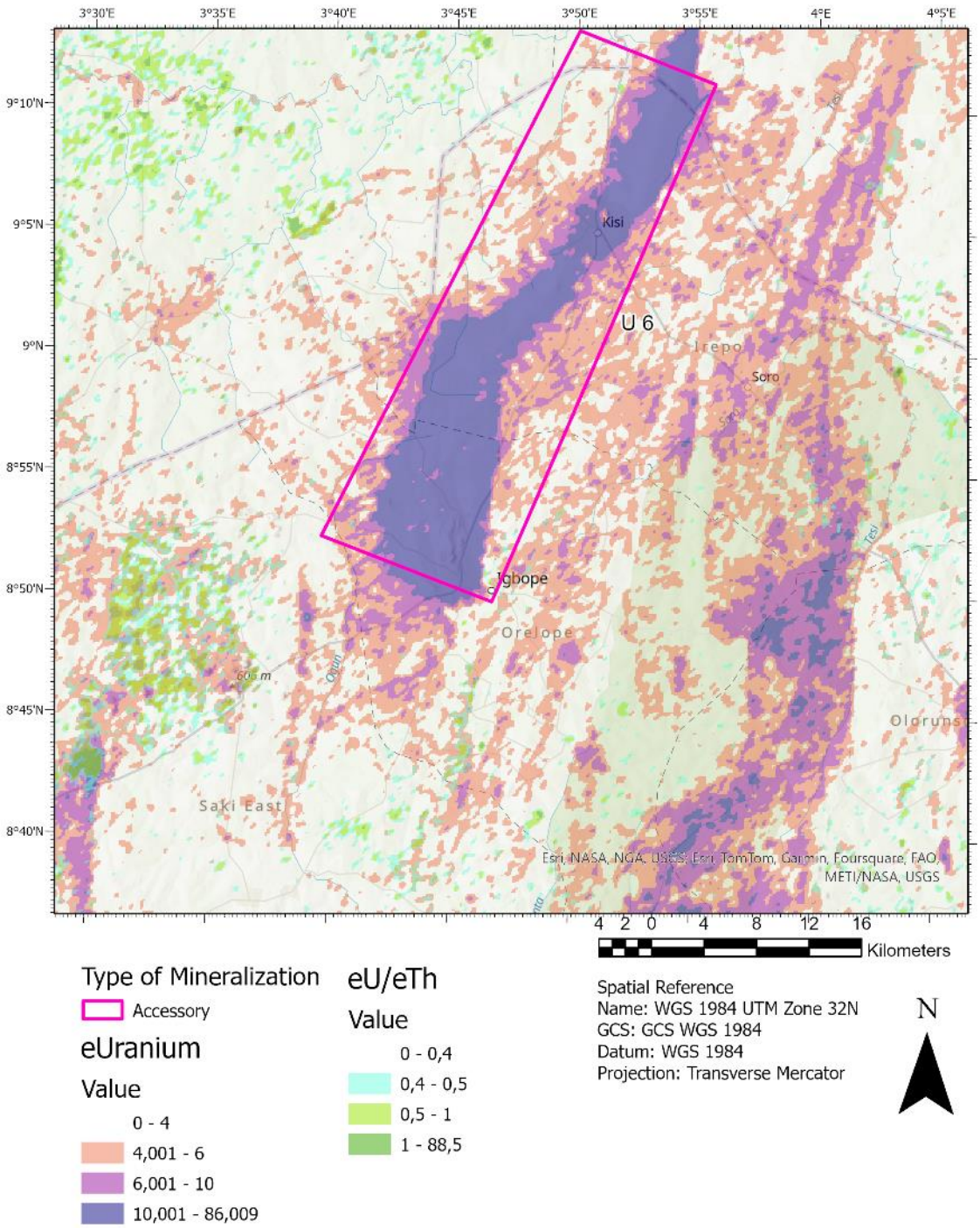


Figure 192: eUranium and eU/eTh ratio map for target U 6.

7.5.2.7 Target Uranium 7

Location: Lower Benue Trough, Benue State.

Geology: Sandstones, shales, mudstones and coal.

Mining activities: No documented occurrences or mining activities are documented in the area.

Additional information: high values of eUranium are detected in the area and correlated with points of high value of the ratio of eU/eTh (Figure 193). The values follow the geology mapped in the area suggesting an accumulation of uranium as infiltration and not as lateritic enrichment. Intrusives in the basement complex with high eU values suggest a possible U source for the formation of sandstone hosted Uranium. Documented coal occurrences also indicated favourability for Uranium in the area (please check 7.5.2.1)

Total area: 1,342.89 km^2.

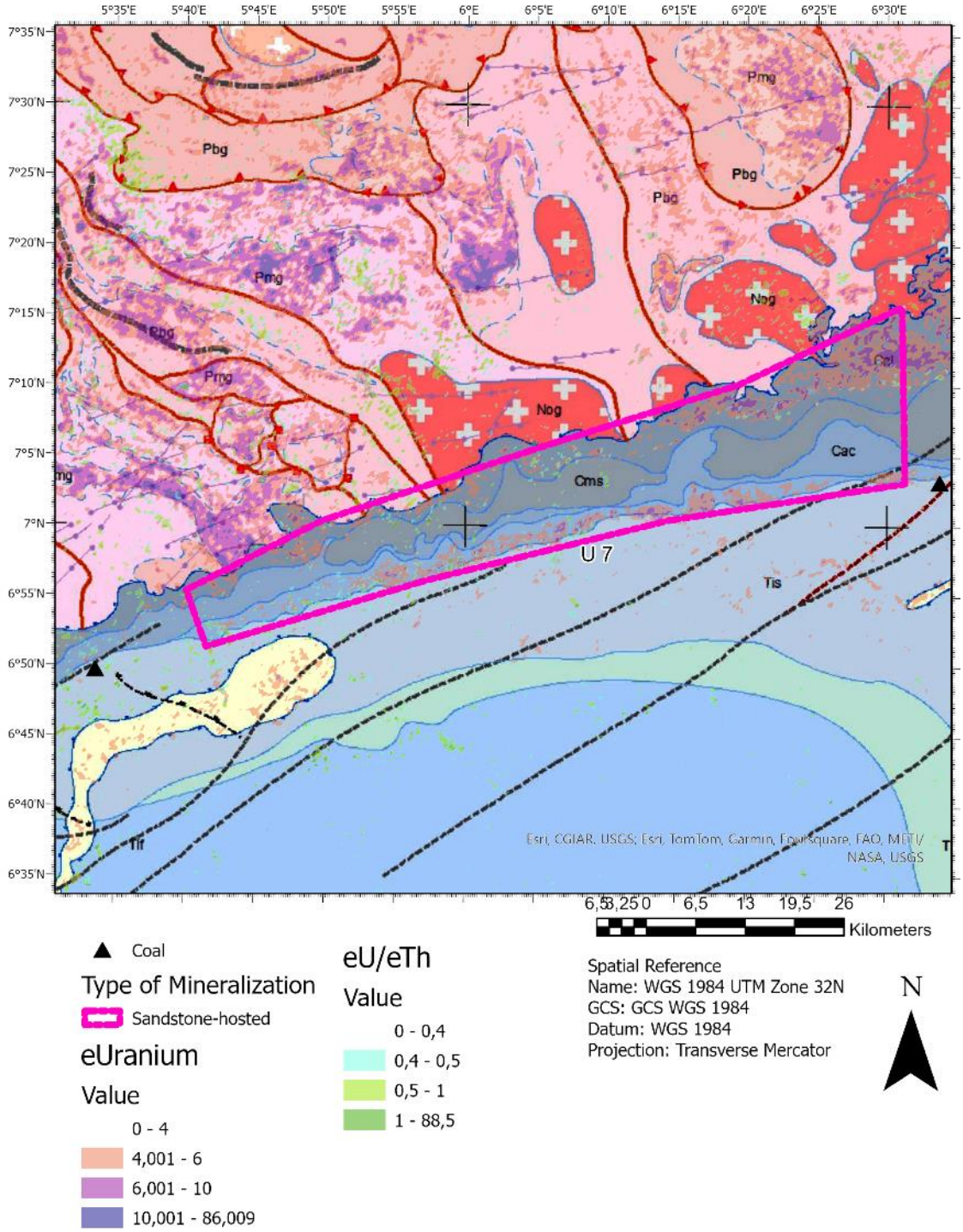


Figure 193: eUranium and eU/eTh ratio map for target U 7.

8. Recommendations

8.1 Further Strategies

National and regional activities:

- Further develop predictive maps with the following considerations:
  - Integrate the new geophysical airborne data,
  - Incorporate the new geochemical data,
  - Add mine production as available.
- Release of new maps (through the DSS) through press releases (plus similar marketing strategies).

Thematic Commodity Activities:

- Clarify the prospectivity by reconnaissance studies, while identifying the mineralization type (sandstones, phosphorites?)
- Determine further the prospectivity of pegmatites with reconnaissance studies (identify industrial pegmatites)
- Understand the metallogeny of the alkaline complexes directed to Niobium, Tantalum, Lithium, Rare-earth elements and, possibly, carbonatites.
- Clarify further potential commodities (Cu, Ni, Cr.

Local activities

- Block prospective tenements free of licenses (focus on areas with known mineral occurrences),
- Focus on relevant/future metals: Au, U, Li, Nb, Ta and Sn,
- geochemical campaigns on identified prospective areas (targets) for targeted exploration and identify key objectives,
- Execute a drilling campaign on the detected objectives.

8.2 Further Improvements

To continue improving the existing system, the following activities shall be made critical in subsequent implementations:

- Direct link to the mining cadastral data to keep the information up-to-date in the DSS,
- Direct link to the Geodata Centre information stored in the NGSA premises,
- Implement a data release functionality for data to be monetized (e.g., sales portal),
- Classify the existing data from the Ministry and NGSA into confidential and public (free or on sale) for organization and transparency,
- Perform data improvement activities by the back-end users (the agencies):
    - Addition of new data (e.g., exploration reports),
    - Improve data (e.g. mineral occurrence data, new geological maps)
    - Integrate the NMRDSS backend into the business processes at NGSA, ASM, IPMT, etc.
- Analyze the business processes and identify the interaction with the system (e.g., annual reporting about buying centers),
- Integrate with other relevant ministries and keep track of relevant updates from their data (e.g., national planning, infrastructure, agriculture)
- Execute extensive training activities for the following aspects:
    - IT services: hardware and IT-infrastructure, database and GIS web services.
    - Geological aspects: economic geology, predictive mapping, commodities.
    - Mining aspects: locations, activities, production, operators.

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10. Project Risks and Mitigations

The Consultant has currently identified the challenges shown in Table 14 along with mitigation possibilities. Note that some entries are still marked as open and must be resolved as soon as possible.

Table 14: Identified risks (until now) of the project along with proposed mitigations

ID	Risk Category	Risk Name	Overall Risk Rating	Risk Resp.	Mitigation Action	Status
1	Quality	Geochemical Data is not available	High	Avoid	Will not be considered, may be used at end for verification.	Closed
2	Quality	No additional data delivered	High	Avoid	Base analysis on existing data with a bigger uncertainty with loss of quality	Closed
3	Budget	No support from the Client for Consultant to participate in relevant Events	Medium	Control	Redirect efforts in supporting the Client in planning for events only	Closed
4	Quality	Missed input of relevant stakeholders	Medium	Control	Revision of other sources	Closed

Annex 1: List of DST Meetings

	Action items	Responsibility	Date
1	M&E to share past geologist's report on proof-of-concept applicants with Beak	Seyi Olawale	22nd February 2024
2	Finalize discussion on proof-of-concept and additional areas PGW will visit for groundtruthing	Dr. Abba Usman /Warwick Crowe/Luis Pizano	23rd February 2023
3	Follow up with MinDiver admin to send invitation letter for visa application to Beak and Emma	Seyi Olawale	23rd February 2024
4	PIU to send letter to the Ministry to facilitate information request from MI	Engr. Abdullahi Also	28th February 2024
5	Finalize PIU approval of training content	Dr. Abba Usman	29th February 2024
6	Send list of selected target areas to MI to get info on commodities in these areas	Luis Pizano	29th February 2024
7	Contact PIU for feedback on bidding criteria and process for calling for bidding requests from local investors	Emmanuel Etuk	1st March 2024
8	Follow up with MI for required data and ensure they are shared with the project delivery team	Engr. Abdullahi Also	5th March 2024
9	MI to identify companies in selected target areas and select commodities project team would concentrate on	Mr. Ime Ekirpkpo	4th March 2024
10	PIU to share list of possible international investors with project team so Mining Guide can be forwarded to them	Luis Pizano, John Eyre, Dr. Abba Usman	10th March 2024
	Comments		
	Trainings • Technical training and Investment facilitation training have been rescheduled to 18th March. • Project team is still waiting for approval of the training curriculum.		

Data

- Discussion with PGW ongoing on ground-truthing data to be provided from analyses from Airborne Geophysical Survey. PGW has shared their groundtruthing program for selected sites scheduled for the 2nd week of March.
- The first batch of the geochemical mapping data has been shared for use by the MIF team.
- Data on selected areas and commodities are still pending from the MI department.

Mining Conferences

- Preparation for attendance and presentation at the PDAC conference (Canada) happening in March.

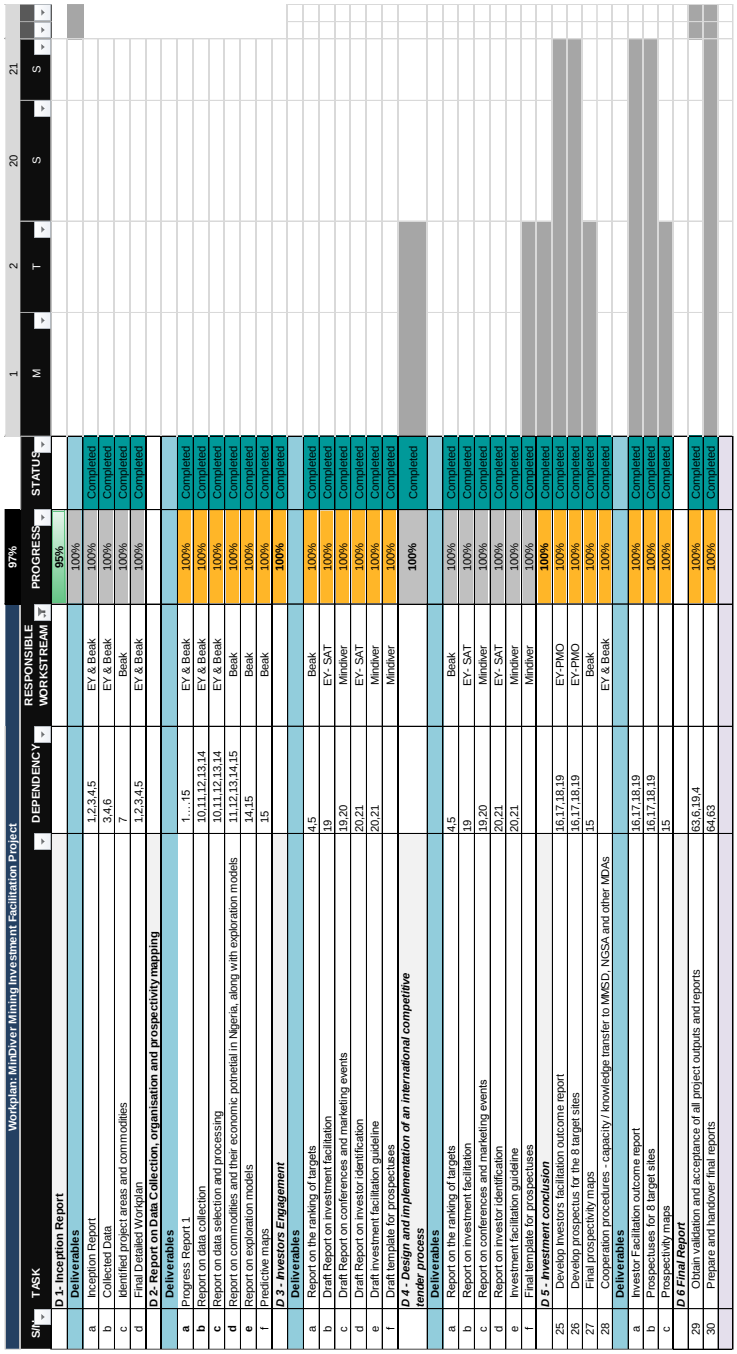
Stakeholder Engagements and Investment Facilitation

- There are ongoing engagements with mining exploration companies to understand their current state, technology in place for mining in the country.
- Engagements with MDAs are ongoing for data required by the technical team to continue their study, however, responses from the MDAs have been slow, affecting the timely completion of deliverables.
- There is scheduled engagement with IPMT and PIU to understand the investment facilitation context for Nigeria and investors' expectations. The goal of this is plan a fit-for-purpose training curriculum on investment facilitation.

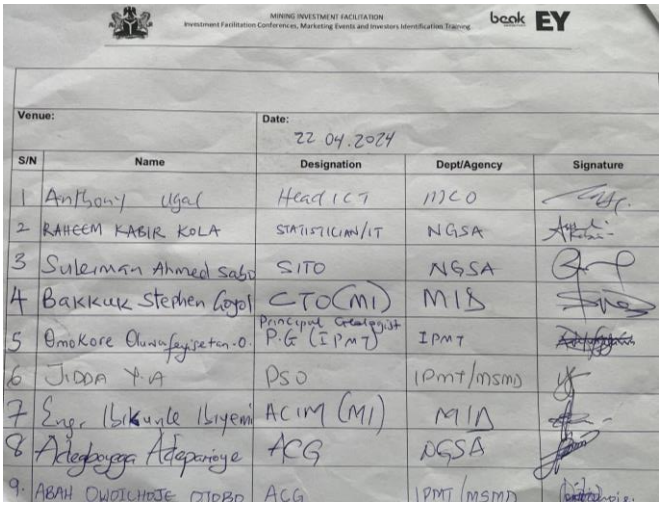
Annex 2: The Detailed Workplan

Workplan: MinDiver Mining Investment Facilitation Project

S/N	TASK	DEPENDENCY	RESPONSIBLE WORKSTREAM	PROGRESS	STATUS
				97%	
				95%	
	D 1- Inception Report			100%	
	Deliverables			100%	
a	Inception Report	1,2,3,4,5	EY & Beak	100%	Completed
b	Collected Data	3,4,6	EY & Beak	100%	Completed
c	Identified project areas and commodities	7	Beak	100%	Completed
d	Final Detailed Workplan	1,2,3,4,5	EY & Beak	100%	Completed
	D 2- Report on Data Collection, organisation and prospectivity mapping				
	Deliverables				
a	Progress Report 1	1…15	EY & Beak	100%	Completed
b	Report on data collection	10,11,12,13,14	EY & Beak	100%	Completed
c	Report on data selection and processing	10,11,12,13,14	EY & Beak	100%	Completed
d	Report on commodities and their economic potnetial in Nigeria, along with exploration models	11,12,13,14,15	Beak	100%	Completed
e	Report on exploration models	14,15	Beak	100%	Completed
f	Predictive maps	15	Beak	100%	Completed
	D 3 - Investors Engagement			**100%**	Completed
	Deliverables				
a	Report on the ranking of targets	4,5	Beak	100%	Completed
b	Draft Report on investment facilitation	19	EY- SAT	100%	Completed
c	Draft Report on conferences and marketing events	19,20	Mindiver	100%	Completed
d	Draft Report on investor identification	20,21	EY- SAT	100%	Completed
e	Draft investment facilitation guideline	20,21	Mindiver	100%	Completed
f	Draft template for prospectuses	20,21	Mindiver	100%	Completed
	D 4 - Design and implementation of an international competitive tender process		Mindiver	**100%**	Completed
	Deliverables				
a	Report on the ranking of targets	4,5	Beak	100%	Completed
b	Report on investment facilitation	19	EY- SAT	100%	Completed
c	Report on conferences and marketing events	19,20	Mindiver	100%	Completed
d	Report on investor identification	20,21	EY- SAT	100%	Completed
e	Investment facilitation guideline	20,21	Mindiver	100%	Completed
f	Final template for prospectuses		Mindiver	100%	Completed
	D 5 - Investment conclusion			**100%**	Completed
25	Develop Investors facilitation outcome report	16,17,18,19	EY-PMO	100%	Completed
26	Develop prospectus for the 8 target sites	16,17,18,19	EY-PMO	100%	Completed
27	Final prospectivity maps	15	Beak	100%	Completed
28	Cooperation procedures - capacity / knowledge transfer to MMSD, NGSA and other MDAs		EY & Beak	100%	Completed
	Deliverables				
a	Investor Facilitation outcome report	16,17,18,19		100%	Completed
b	Prospectuses for 8 target sites	16,17,18,19		100%	Completed
c	Prospectivity maps	15		100%	Completed
	D 6 Final Report				
29	Obtain validation and acceptance of all project outputs and reports	63,6,19,4		100%	Completed
30	Prepare and handover final reports	64,63		100%	Completed



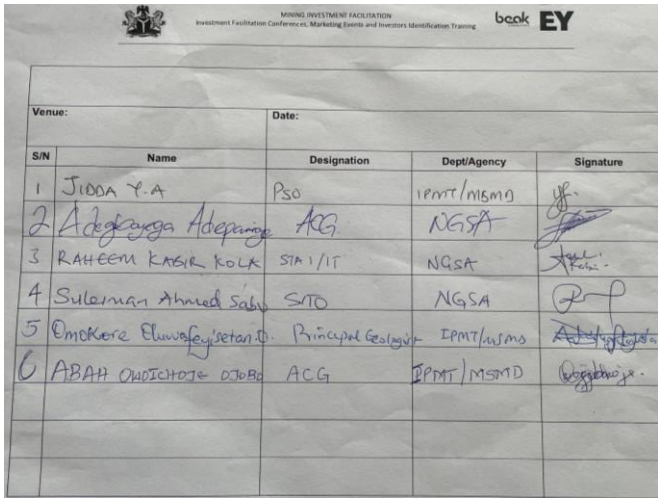
Annex 3: Attendance Lists Training (22-23-24.04.2024)



MINING INVESTMENT FACILITATION
Investment Facilitation Conferences, Marketing Events and Investors Identification Training

Venue: | Date: 22 04.2024

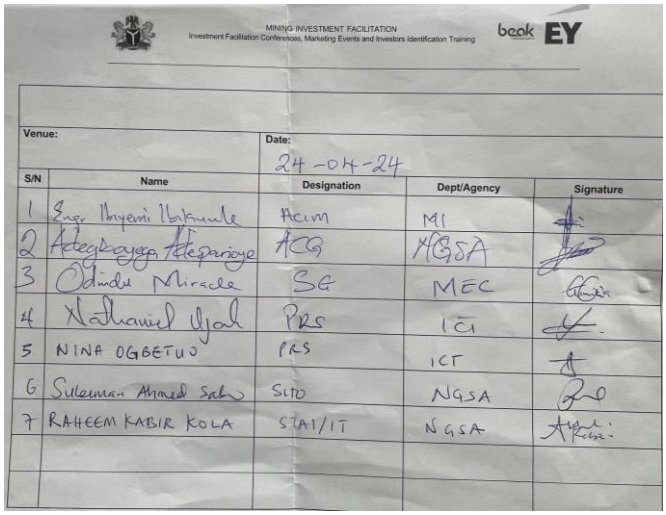
S/N	Name	Designation	Dept/Agency	Signature
1	Anthony Ugal	Head ICT	MCO	
2	RAHEEM KABIR KOLA	STATISTICIAN/IT	NGSA	
3	Suleiman Ahmed Sabo	SITO	NGSA	
4	Bakkuk Stephen Gojol	CTO(MI)	MID	
5	Omokore Oluwafeyisetan.O.	Principal Geologist P.G (IPMT)	IPMT	
6	JIDDA Y.A	PSO	IPMT/MSMD	
7	Engr. Ibikunle Ibiyemi	ACIM (MI)	MID	
8	Adegbayega Adeparoye	ACG	NGSA	
9.	ABAH OWOICHOJE OJOBO	ACG	IPMT (MSMD)	



MINING INVESTMENT FACILITATION
Investment Facilitation Conferences, Marketing Events and Investors Identification Training

Venue: | Date:

S/N	Name	Designation	Dept/Agency	Signature
1	JIDDA Y.A	PSO	IPMT/MSMD	
2	Adegbayega Adeparoye	ACG	NGSA	
3	RAHEEM KABIR KOLA	STAI/IT	NGSA	
4	Suleiman Ahmed Sabo	SITO	NGSA	
5	Omokore Oluwafeyisetan.O.	Principal Geologist	IPMT/MSMD	
6	ABAH OWOICHOJE OJOBO	ACG	IPMT/MSMD	



MINING INVESTMENT FACILITATION
Investment Facilitation Conferences, Marketing Events and Investors Identification Training

Venue: | Date: 24-04-24

S/N	Name	Designation	Dept/Agency	Signature
1	Engr. Ibiyemi Ibikunle	ACIM	MI	
2	Adegbayega Adeparoye	ACG	NGSA	
3	Odinda Miracle	SE	MEC	
4	Nathaniel Ugal	PRS	ICT	
5	NINA OGBETUO	PRS	ICT	
6	Suleiman Ahmed Sabo	SITO	NGSA	
7	RAHEEM KABIR KOLA	STAI/IT	NGSA	

Annex 4: Report on Investment Facilitation

Annex 5: Report on Conferences and Marketing Events

Annex 6: Report on Investor Identification

Annex 7: Investment Facilitation Guideline

Annex 8: Prospectus_Au_1_Ife-Ilesha

Annex 9: Prospectus_Au_2_Kimu

Annex 10: Prospectus_Au_8_Pategi

Annex 11: Prospectus_Sn-Nb_2_Barakin

Annex 12: Prospectus_Sn-Nb_5_Yalwar

Annex 13: Prospectus_Li-Ta_1_Ogapa

Annex 14: Prospectus_Li-Ta_2_Keffi

Annex 15: Prospectus_Pb-Zn_3_Azara

Annex 16: Prospectus_Pb-Zn_5_Akwana

Annex 17: Investor Facilitation Outcome Report

Map 1: Map of Metallic Minerals and Metallogeny of Nigeria 1:2M

Map 2: Predictive Map of Granite related Gold

Map 3: Predictive Map of Gold related to Metamorphic Belts

Map 4: Predictive Map of Gold Placers

Map 5: Predictive Map of Tin Placers

Map 6: Predictive Map of Tin and Niobium in Young Alkaline Complexes

Map 7: Predictive Map of Tantalum-Lithium Pegmatites

Map 8: Predictive Map of Lead and Zinc in Benue Trough

Map 9: Location and Ranking of Exploration Targets