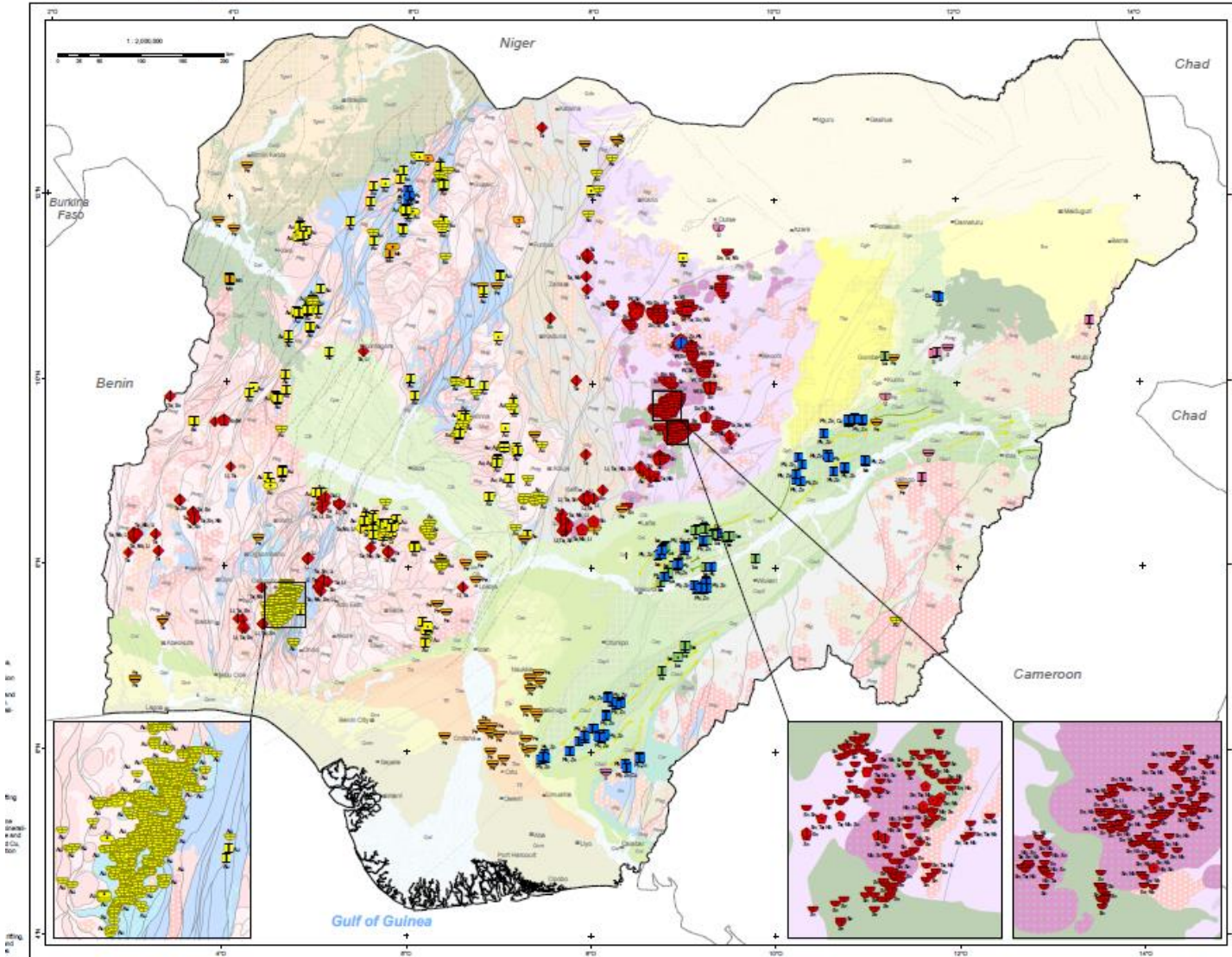




Map of Metallic Minerals and Metallogeny of Nigeria

1 : 2,000,000



**Andreas Barth, Luis Pizano**

**Beak Consultants GmbH,  
Germany**

**Abuja, May, 14<sup>th</sup> 2024**

# The Project Workflow and Strategy

Focus on commodities with considerable value and growth potential

Understand the mineral potential of Nigeria

Create and implement the communication strategy:

The NMRDSS as the most important instrument

Identify relevant commodities

Create mineral potential maps

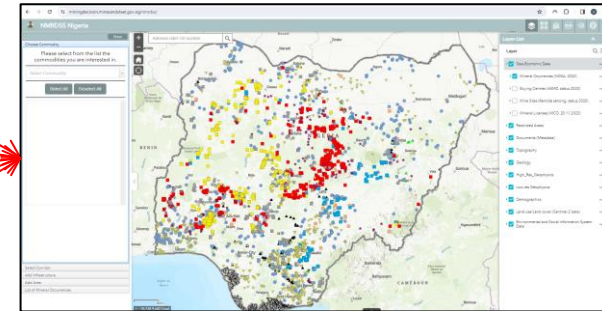
Identify target areas

Rank the target areas

Create passports

Market the targets

Publication of data and derived information



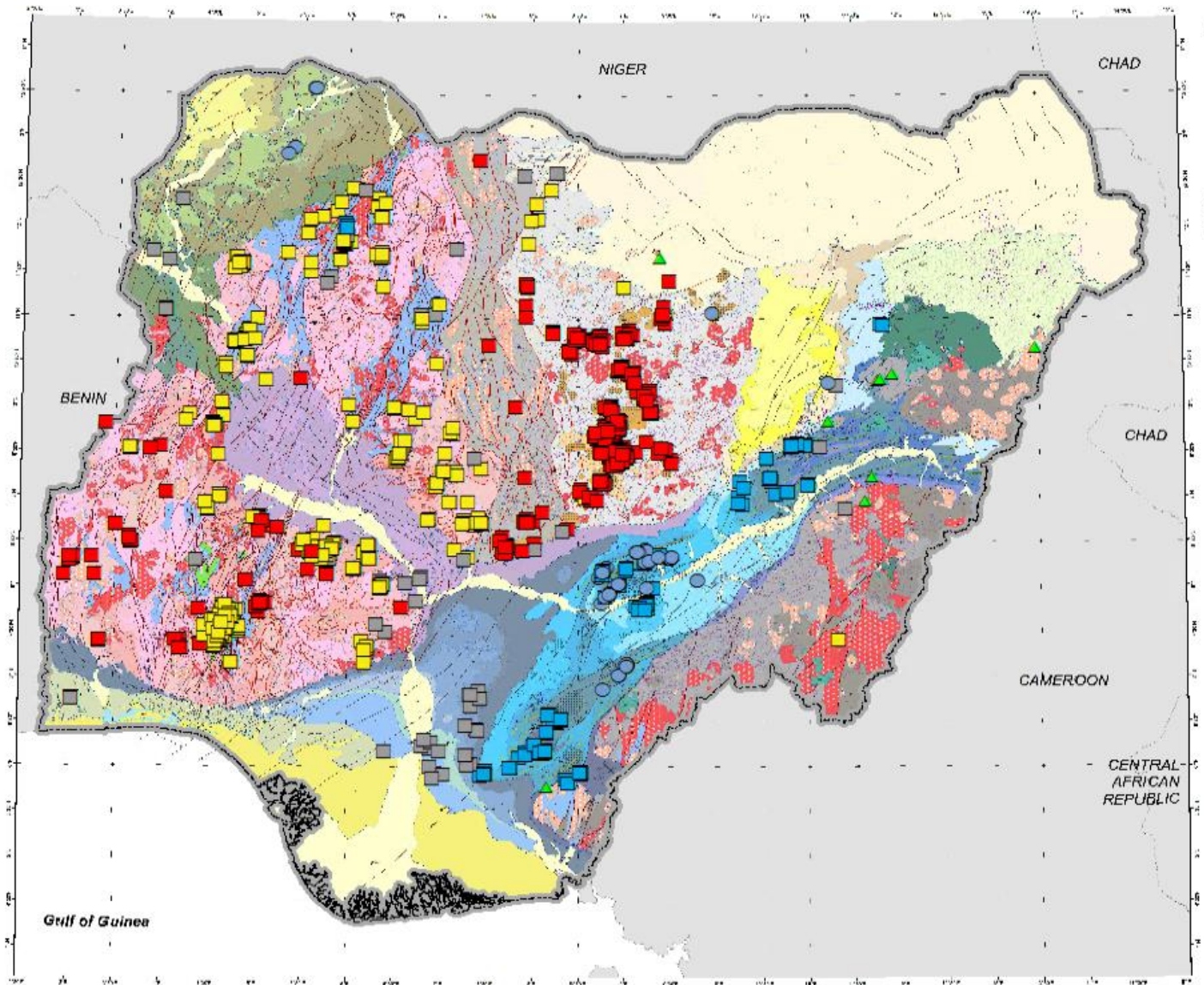
- The NMRDSS
- Dedicated events
- Public conferences
- ...

- Topography
- Geology
- Minerals
- Geophysics
- Tectonics
- Mining
- ....

Mineral licenses



# Identification of economically important Commodities



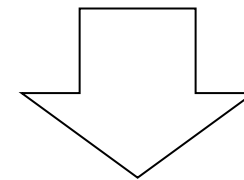
Map of Metallic Minerals and Metallogeny of Nigeria

1 : 2,000,000

Shows the dependencies between the minerals and space and time

The metallic minerals of Nigeria:  
Locations of >2000 mineral occurrences  
**verified:** Sn, Nb, Li, Ta, Au, Pb, Zn, U

Critical minerals lists EU and USA considered



The project commodities are: **Sn, Nb, Li, Ta, Au, Pb, Zn, U** + considerations for REE, PGE, Ni, Cr

# The backend database – developed since 2019

The screenshot displays the user interface of the Nigerian Mineral Resources Decision Support System (NMRDSS). The window title is "MIS - Nigeria" and the menu bar includes "File", "Administration", "Modules", and "Help". The main content area features a header with the text "a customized **advangeo**® product, designed and developed by **beak** CONSULTANTS" and the version "Version: 1.0.8717 (13.11.2023)". The interface is organized into several functional categories, each with a list of menu items:

- Geology**
  - Geological Map 1:2M
- Economic Geology**
  - Mineral Occurrences
  - Mining Cadastre
- Documents**
  - Published Documents
  - Unpublished Documents
  - Spatial Data
- ASM Data**
  - Buying Centres
  - Cooperatives
  - Mine Site Monitoring
  - Potential Mine Sites
- Geophysics / Geochemistry**
  - Geophysical Datasets
  - Geochemical Datasets
- ASM Field Work Data**
  - Mine Sites
  - Observation Points
  - Hard Material Samples
  - Analytical Certificates
  - Analytical Results
- System Administration**
  - Change Password
  - Lookup Tables
  - User Administration
- GIS**
  - Start ArcGIS

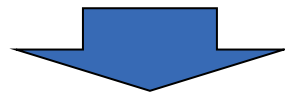


# From Data to Mineral Potential Maps

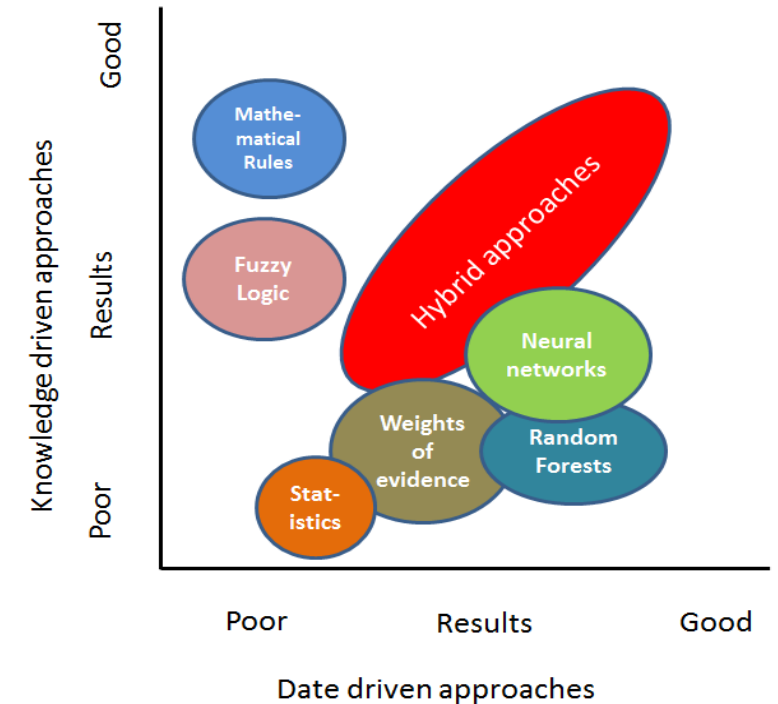
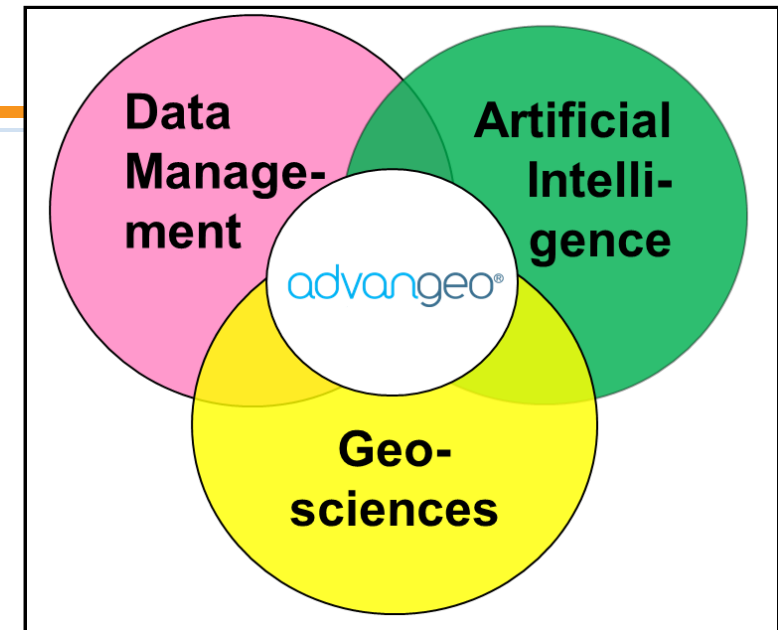
Using **Artificial Intelligence (AI)** for data analysis.

Preconditions for AI application are diverse and accurate data

Deep understanding of the Metallogeny:  
What Mineral is Where and Why?



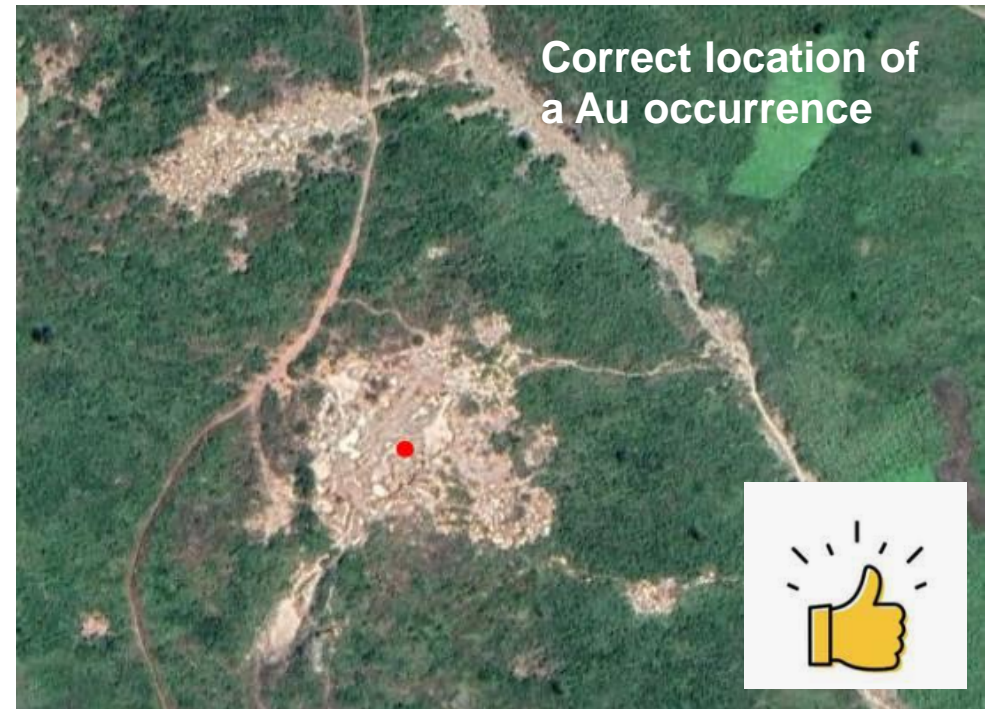
The algorithms have to consider knowledge.



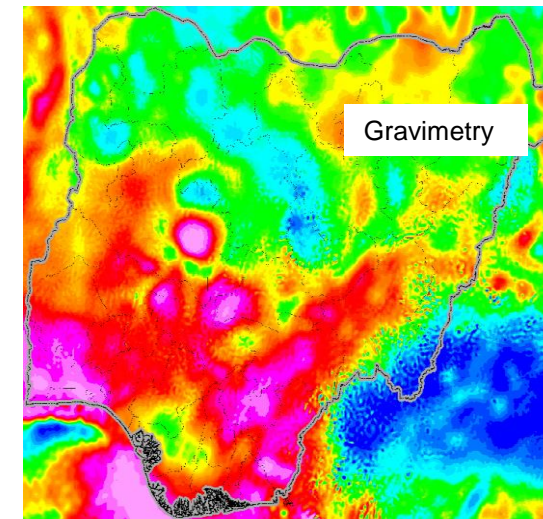
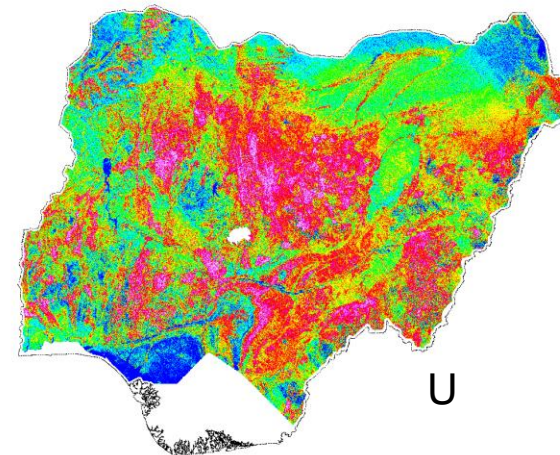
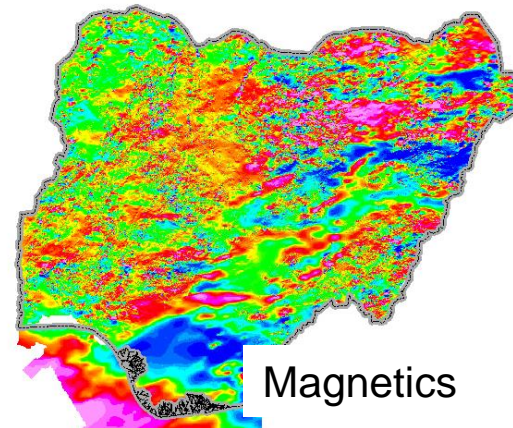
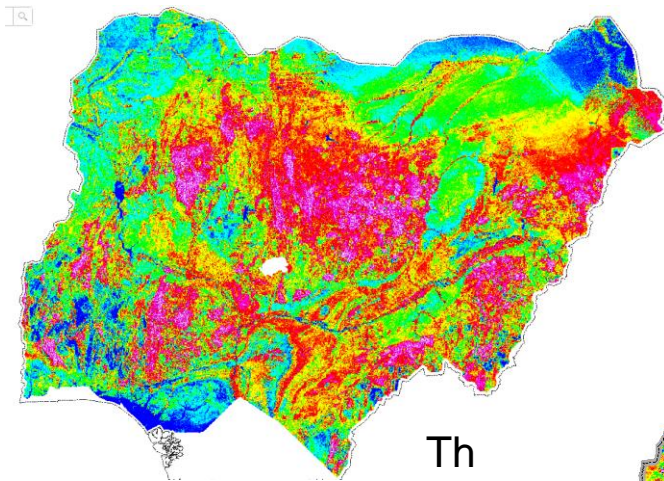
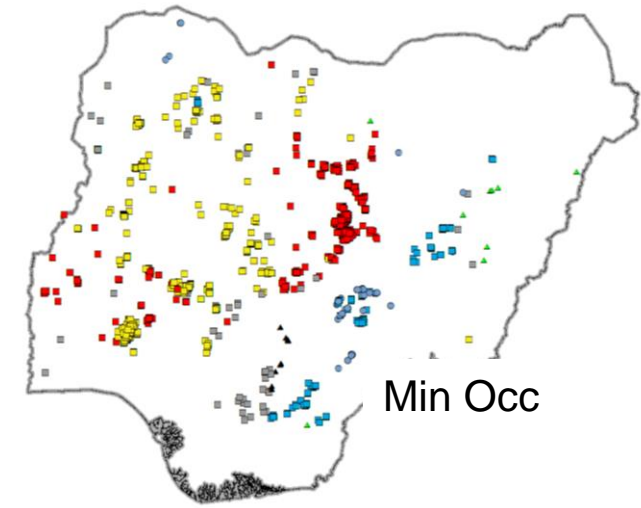
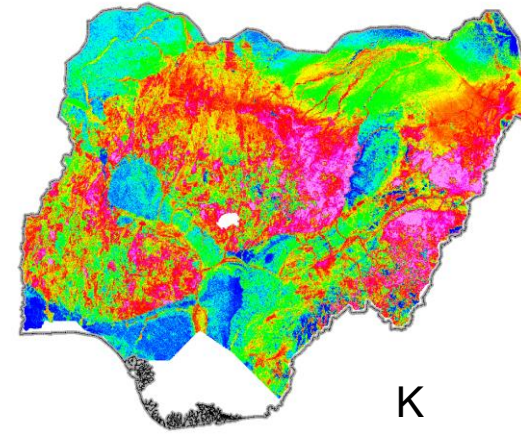
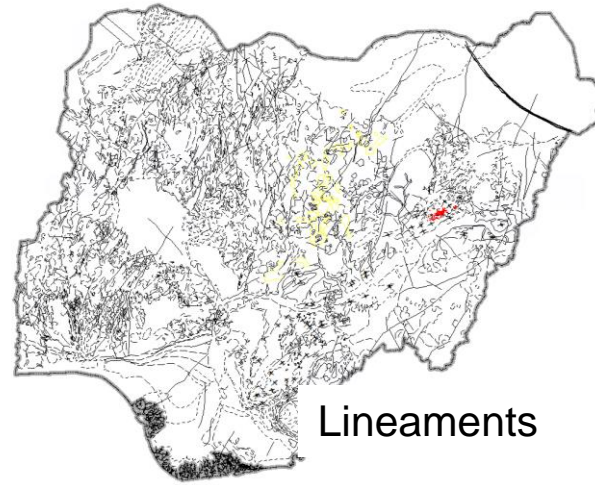
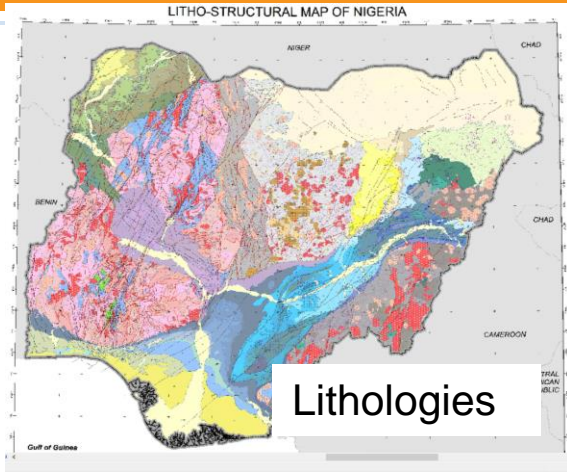
# Verification of mineral occurrence data

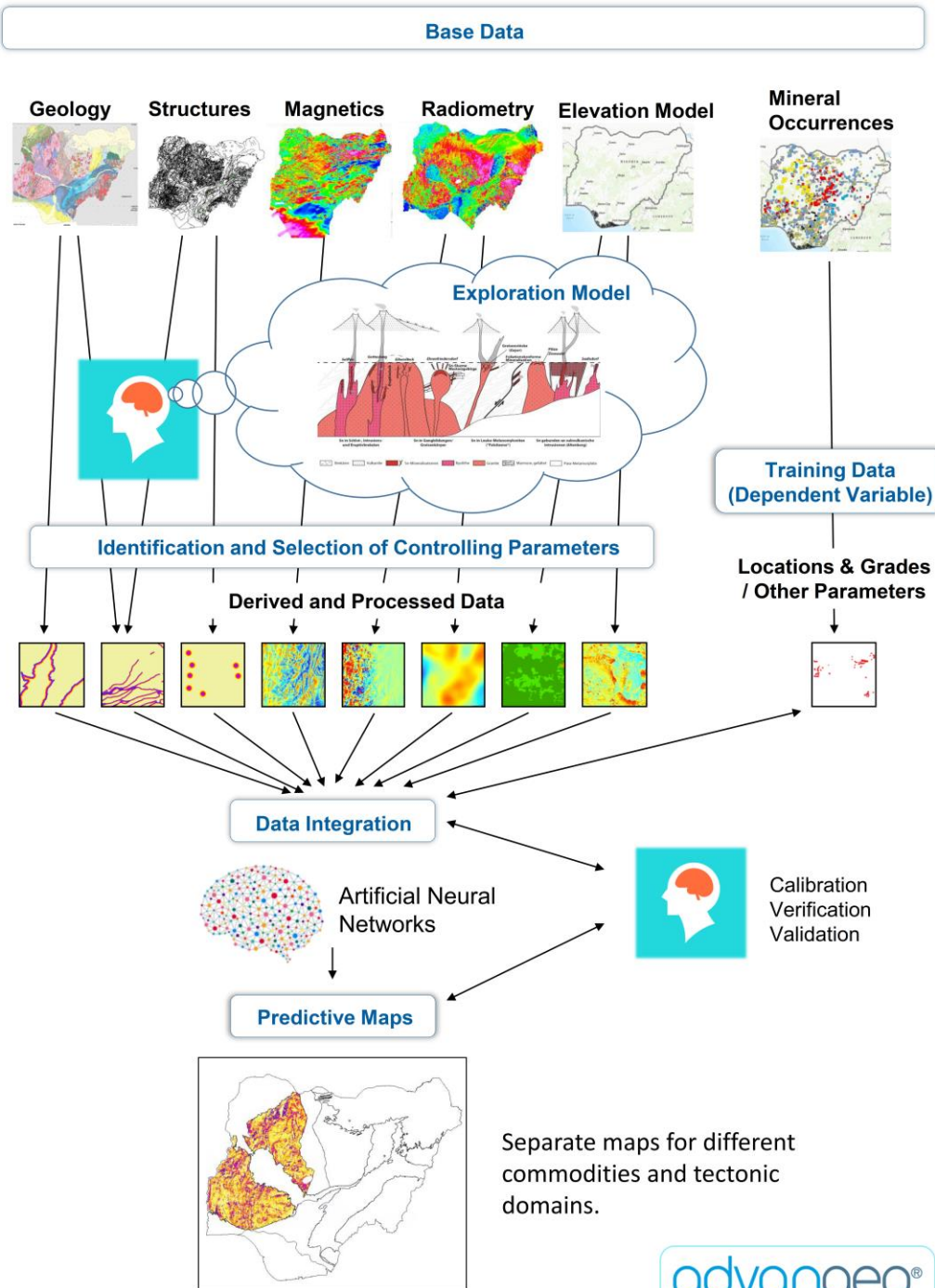
**Artificial Intelligence (AI)** analyses the location of the mineral occurrences in relation to (potentially) controlling parameters:

- Accurate locations are crucial
- Wrong locations lead to wrong “AI - knowledge” and wrong interpretation results



# Available Spatial Datasets





# The AI application workflow

Artificial Neural Networks implemented in Beak's advanced prediction software.

Consideration of knowledge using spatial dependencies:

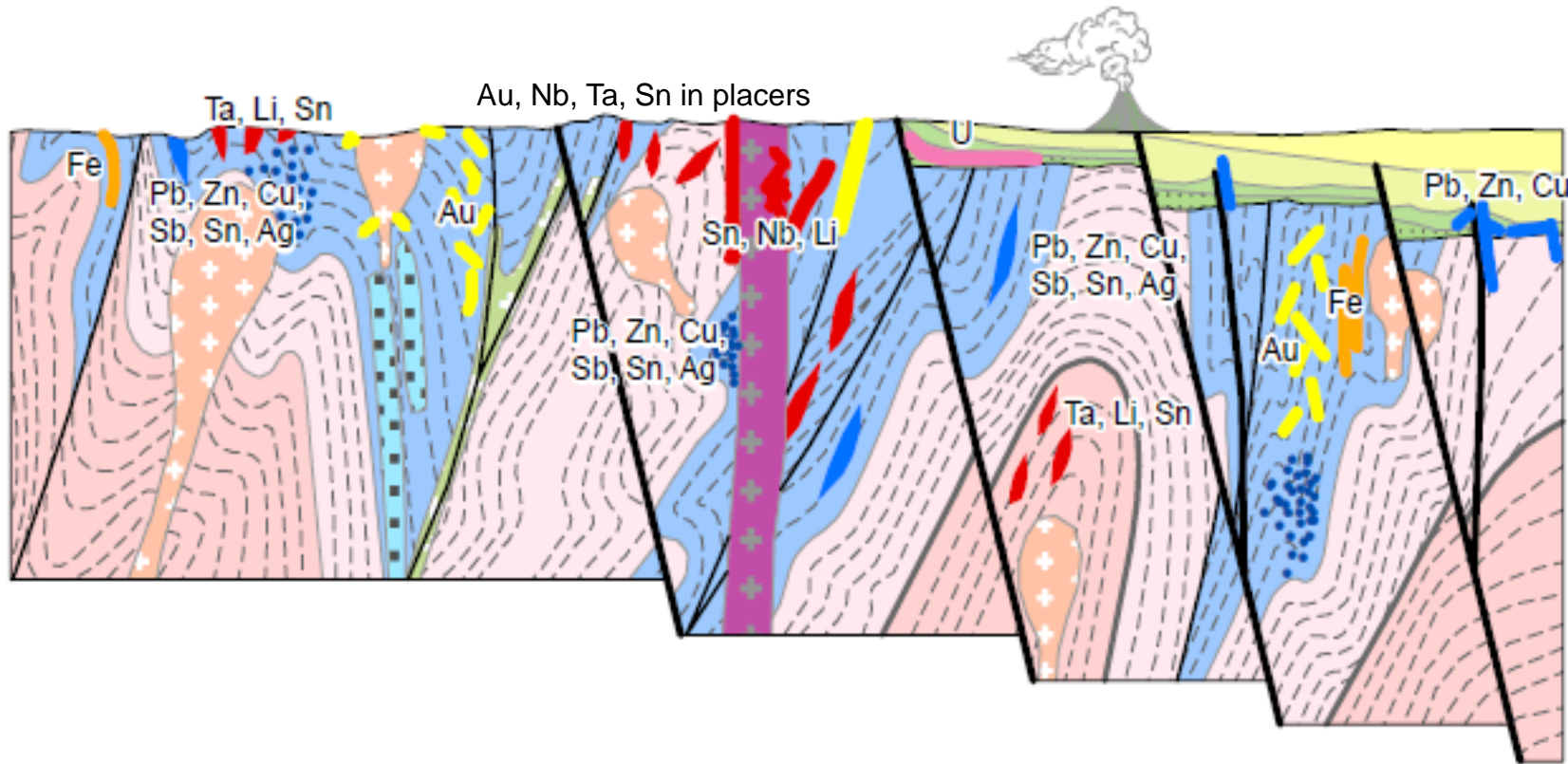
- Distances from/ to faults
- Distances from/ to intrusives
- Host rock lithology





# The Metallogenic History

## Cenozoic



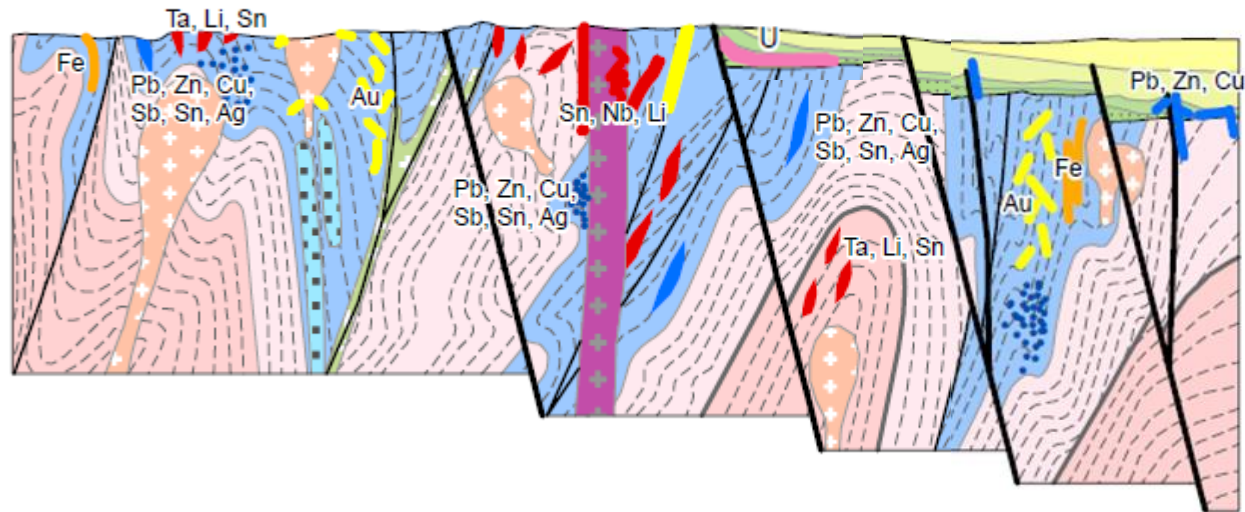
Further block tectonics, basaltic vulcanism, lateritization and erosion

Formation of terrace and recent alluvial placers, and of residual mineralization in laterites  
Formation of U infiltration mineralization.

What we see today has a long history.

- > 3,000 My of history
- Divers and multi-stadial
- Commodities have been re-distributed several times

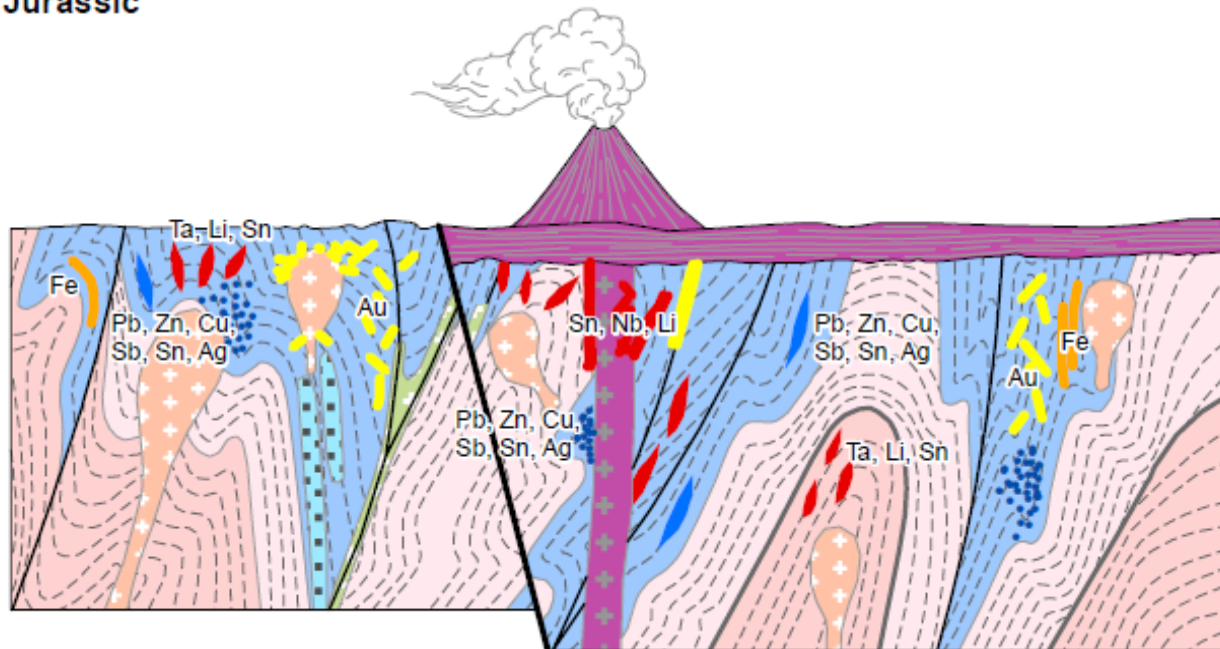
## Cretaceous



Erosion and further rifting

Formation of sandstone hosted U infiltration mineralization and of structure and carbonate rock hosted Cu, Pb, Zn, ba mineralization

## Jurassic



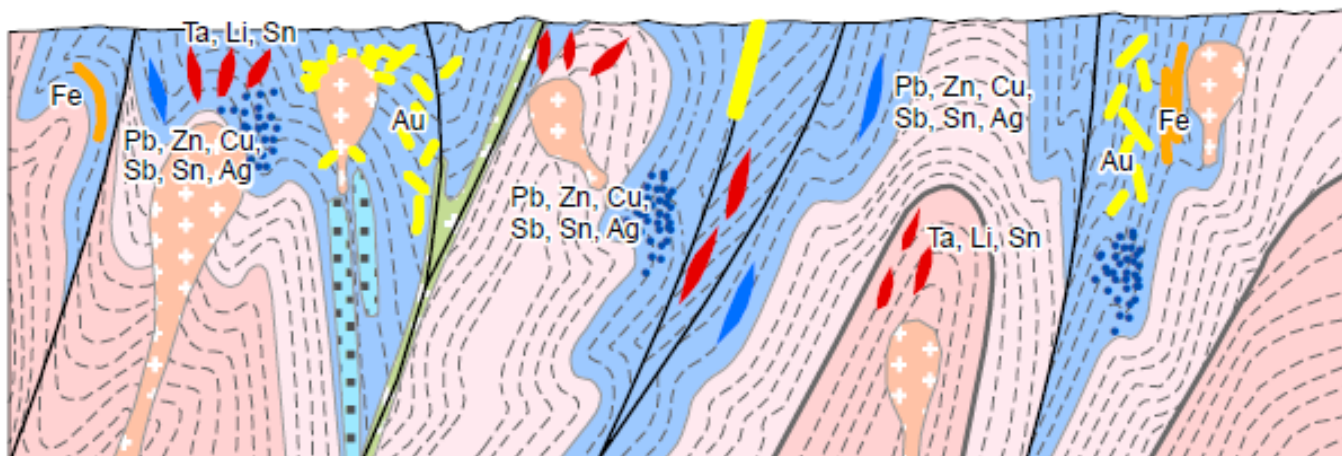
Block tectonics, initial rifting, formation of alkaline and granitic ring complexes

Re-distribution of pre-existing mineralisations: Pb, Zn, Cu, Ag, Sb, Sn, Au, Li, Sn, Nb, Ta Formation of alkaline complex related mineralisations: Li, Sn, Ta, W, REE

# The Metallogenic History

# The Metallogenic History

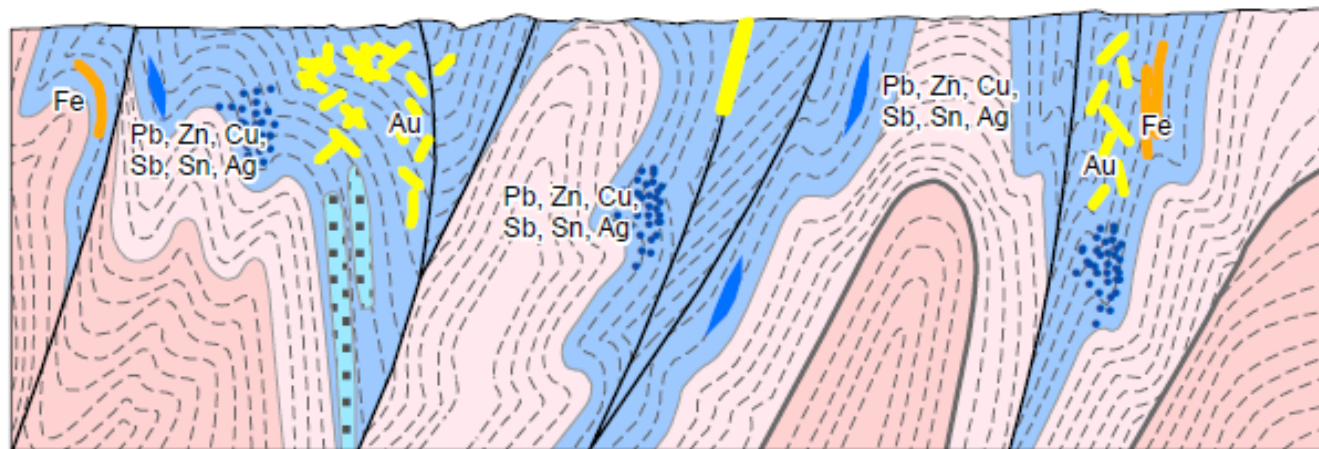
## Lower Paleozoic - Neoproterozoic



Syn-tectonic and posttectonic granitic intrusives and pegmatites

Re-distribution of pre-existing mineralizations: Pb, Zn, Cu, Ag, Sb, Sn, Au  
Formation of granite and pegmatite hosted mineralizations: Li, Sn, Ta, W

## Pre-Panafrican reworked basement

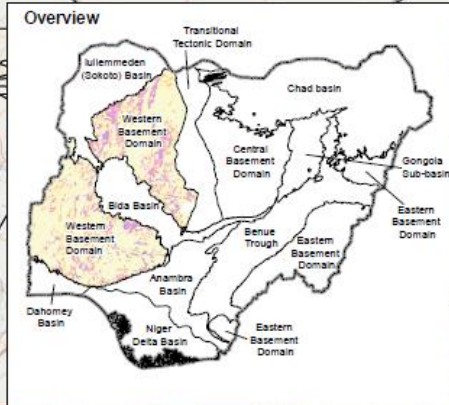
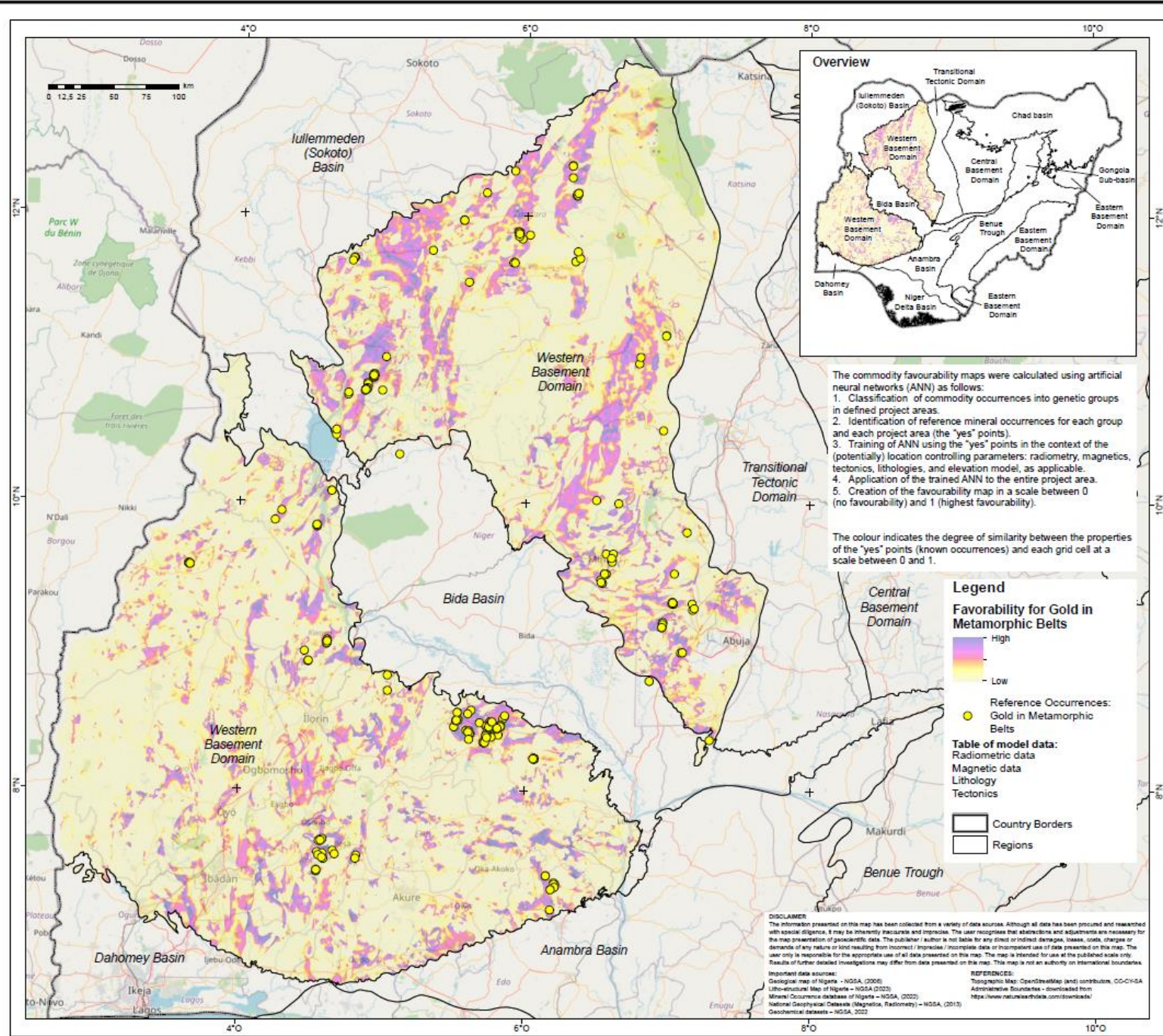


Greenstone belts and migmatite-gneiss complex

Mafic and ultramafic intrusives, orthogneisses

Structure related, stratiform, disseminated and stockwork type sulfides and native gold: Pb, Zn, Cu, Ag, Sb, Sn, Au





The commodity favourability maps were calculated using artificial neural networks (ANN) as follows:

1. Classification of commodity occurrences into genetic groups in defined project areas.
2. Identification of reference mineral occurrences for each group and each project area (the "yes" points).
3. Training of ANN using the "yes" points in the context of the (potentially) location controlling parameters: radiometry, magnetics, tectonics, lithologies, and elevation model, as applicable.
4. Application of the trained ANN to the entire project area.
5. Creation of the favourability map in a scale between 0 (no favourability) and 1 (highest favourability).

The colour indicates the degree of similarity between the properties of the "yes" points (known occurrences) and each grid cell at a scale between 0 and 1.

**Legend**

**Favourability for Gold in Metamorphic Belts**

High (Purple)

Low (Yellow)

Reference Occurrences:

- Gold in Metamorphic Belts (Yellow circle)

**Table of model data:**

- Radiometric data
- Magnetic data
- Lithology
- Tectonics

Country Borders (Black line)

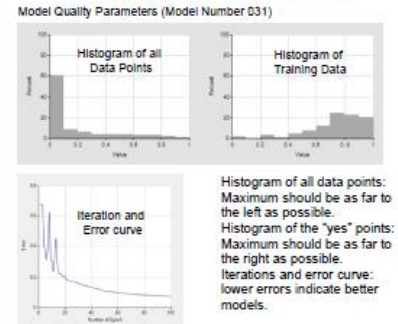
Regions (Grey line)

**DISCLAIMER**  
The information presented on this map has been collected from a variety of data sources. Although all data has been procured and researched with special diligence, it may be inherently inaccurate and imprecise. The user recognizes that alterations and adjustments are necessary for the map presentation of geoscientific data. The publisher/author is not liable for any direct or indirect damages, losses, costs, charges or demands of any nature or kind resulting from incorrect/imprecise/incomplete data or inconsistent use of data presented on this map. The user only is responsible for the appropriate use of all data presented on this map. The map is intended for use at the published scale only. Results of further detailed investigations may differ from data presented on this map. This map is not an authority on international boundaries.

**Important data sources:**  
Geological map of Nigeria - NGSA, (2006)  
Litho-structure Map of Nigeria - NGSA, (2003)  
Mineral Occurrence Database of Nigeria - NGSA, (2002)  
National Geophysical Database (Magnetics, Radiometry) - NGSA, (2013)  
Geoscientific datasets - NGSA, 2022

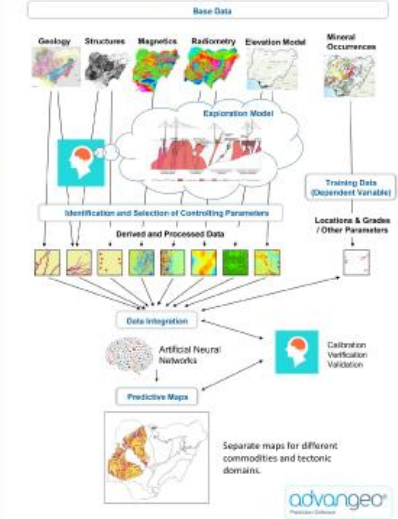
**REFERENCES:**  
Topographic Map OpenStreetMap (and contributors), CC-BY-SA  
Administrative Boundaries - contributed from  
<https://www.naturalearthdata.com/downloads/>

### Favorability for Gold in Metamorphic Belts Western Domain, Nigeria



#### Data processing Scheme

Artificial Neural Networks (ANN) based Mineral Predictive Mapping Workflow



### Favorability for Gold in Metamorphic Belts Western Domain, Nigeria

**Map Compilation**  
Dr. A. Barth (Beak),  
L. A. Pizano Wagner (Beak),  
A. Brosig (Beak)

**Data Capture**  
L. A. Pizano Wagner (Beak), Z. Gartullin (Beak),  
A. Baurista Gascoena (Beak), A. Brosig (Beak),  
A. Barth (Beak), V. Tyum (Beak), P. Cocher (Beak),  
N. Rizaldinova (Beak)

**Cartography & Layout**  
C. Repper (Beak), A. Barth (Beak)

**AI-based Predictive Mapping**  
A. Brosig (Beak), Dr. A. Barth (Beak)

**Information Management & GIS**  
L. A. Pizano Wagner (Beak),  
P. Cocher (Beak),  
C. Repper (Beak)

**Map projection**  
Transverse mercator  
(UTM Zone 32N)

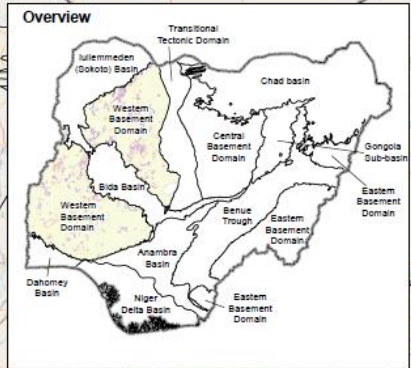
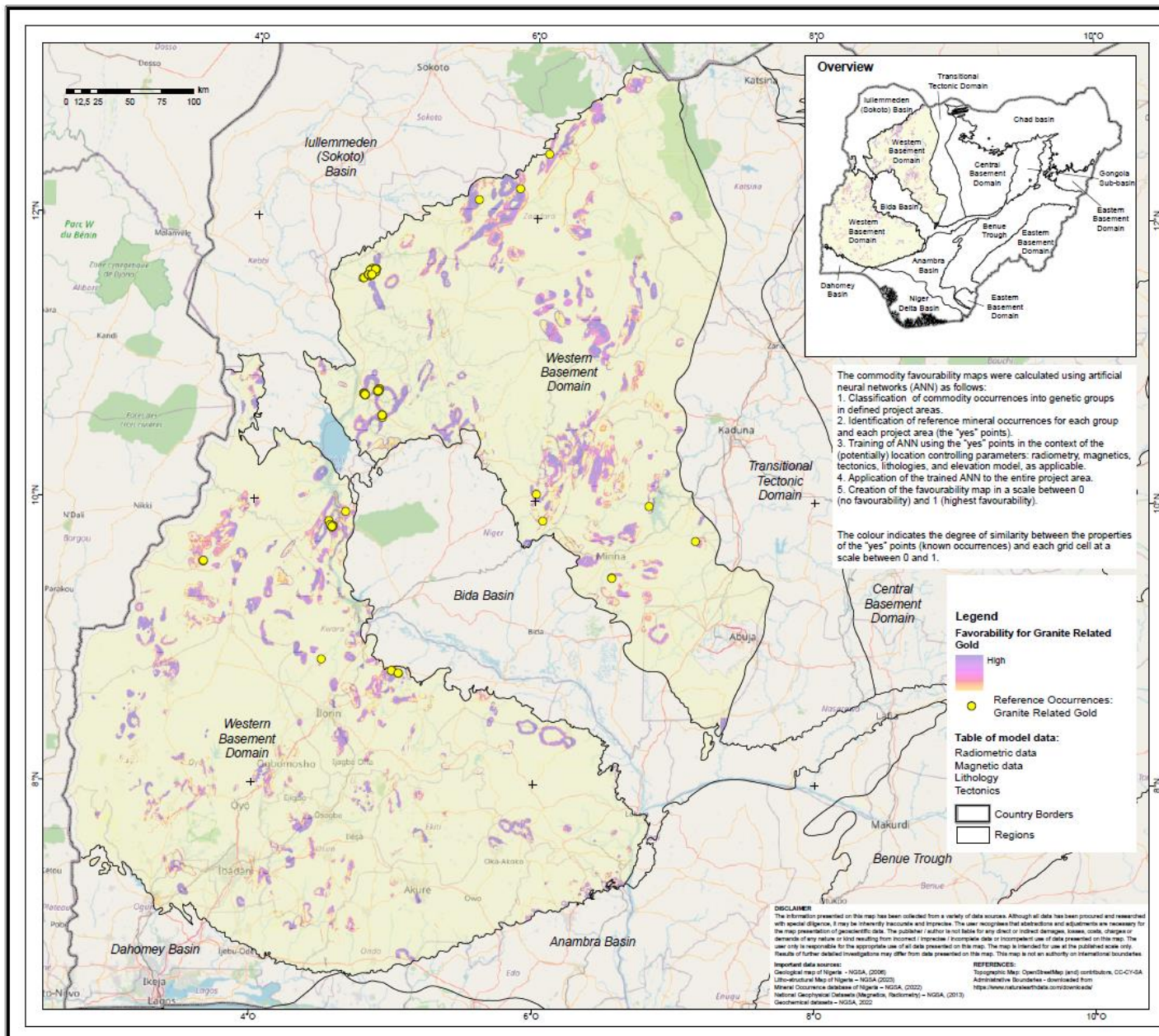
**Reference system**  
Spheroid: WGS\_1984  
Datum: D\_WGS\_1984

**Project Name**  
Mineral Sector Support for Economic Diversification Project (MINDIVER)

**Project Coordinator**  
Dr. Salim Salbam

**Project Financing**  
The World Bank

# The mineral potential maps: Au in metamorphic belts



- The commodity favourability maps were calculated using artificial neural networks (ANN) as follows:
1. Classification of commodity occurrences into genetic groups in defined project areas.
  2. Identification of reference mineral occurrences for each group and each project area (the 'yes' points).
  3. Training of ANN using the 'yes' points in the context of the (potentially) location controlling parameters: radiometry, magnetics, tectonics, lithologies, and elevation model, as applicable.
  4. Application of the trained ANN to the entire project area.
  5. Creation of the favourability map in a scale between 0 (no favourability) and 1 (highest favourability).

The colour indicates the degree of similarity between the properties of the 'yes' points (known occurrences) and each grid cell at a scale between 0 and 1.

**Legend**

**Favourability for Granite Related Gold**

- High (Purple)
- Reference Occurrences: Granite Related Gold (Yellow dots)

**Table of model data:**

- Radiometric data
- Magnetic data
- Lithology
- Tectonics

Country Borders (Black line)

Regions (Grey line)

**DISCLAIMER**  
The information presented on this map has been collected from a variety of data sources. Although all data has been processed and rechecked with several diligences, it may be inherently inaccurate and imprecise. The user recognizes that alterations and adjustments are necessary for the map presentation of geoscientific data. The publisher / author is not liable for any direct or indirect damages, losses, costs, charges or demands of any nature or kind resulting from incorrect, incomplete data or inappropriate use of data presented on this map. The user only is responsible for the appropriate use of all data presented on this map. This map is intended for use at the published scale only. Results of further detailed investigations may differ from data presented on this map. This map is not an authority on international boundaries.

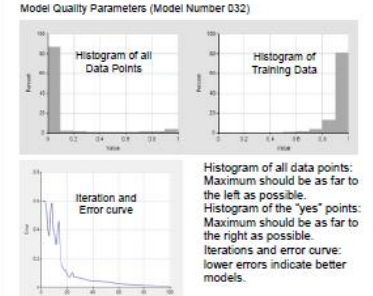
**Important data sources:**

- Geological map of Nigeria - NGSA (2006)
- Litho-structural Map of Nigeria - NGSA (2023)
- Mineral Occurrence Database of Nigeria - NGSA (2022)
- National Geophysical Database (Magnetica, Radiometric) - NGSA (2013)
- Geoscientific Database - NGSA (2022)

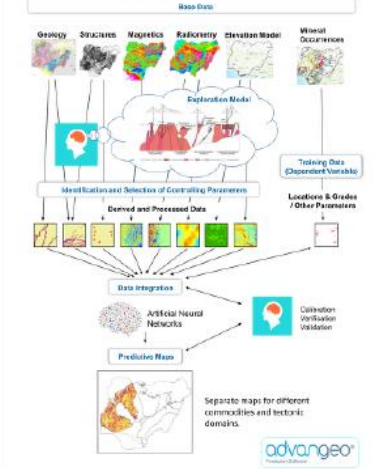
**REFERENCES:**

- Topographic Map: OpenStreetMap (and) contributors, CC-BY-SA
- Administrative Boundaries - downloaded from <https://www.naturalearthdata.com/contributors/>

### Favorability for Granite Related Gold Western Domain, Nigeria



### Data processing Scheme Artificial Neural Networks (ANN) based Mineral Predictive Mapping Workflow



### Favorability for Granite Related Gold Western Domain, Nigeria

**Map Completion**  
Dr. A. Barth (Beak), L. A. Pizano Wagner (Beak), A. Brosig (Beak), C. Repper (Beak), A. Barth (Beak)

**Data Capture**  
L. A. Pizano Wagner (Beak), Z. Garfudin (Beak), A. Baufista Gasconia (Beak), A. Brosig (Beak), A. Barth (Beak), V. Tyurni (Beak), P. Cocher (Beak), N. Rozadnova (Beak)

**Cartography & Layout**  
C. Repper (Beak), A. Barth (Beak)

**Information Management & GIS**  
L. A. Pizano Wagner (Beak), P. Cocher (Beak), C. Repper (Beak)

**Project Name**  
Mineral Sector Support for Economic Diversification Project (MnDiver)

**Project Coordinator**  
Dr. Salim Salami

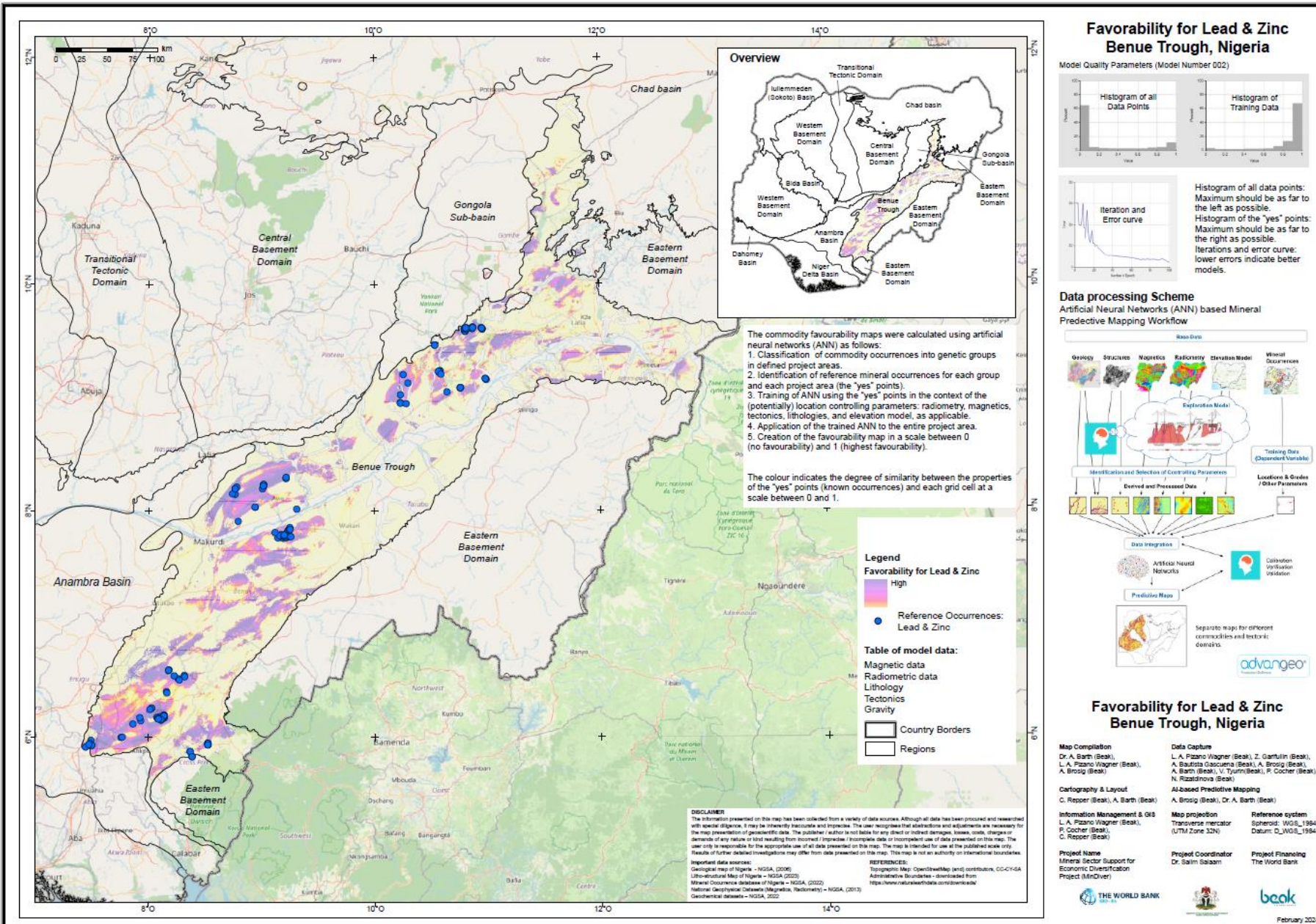
**Project Financing**  
The World Bank

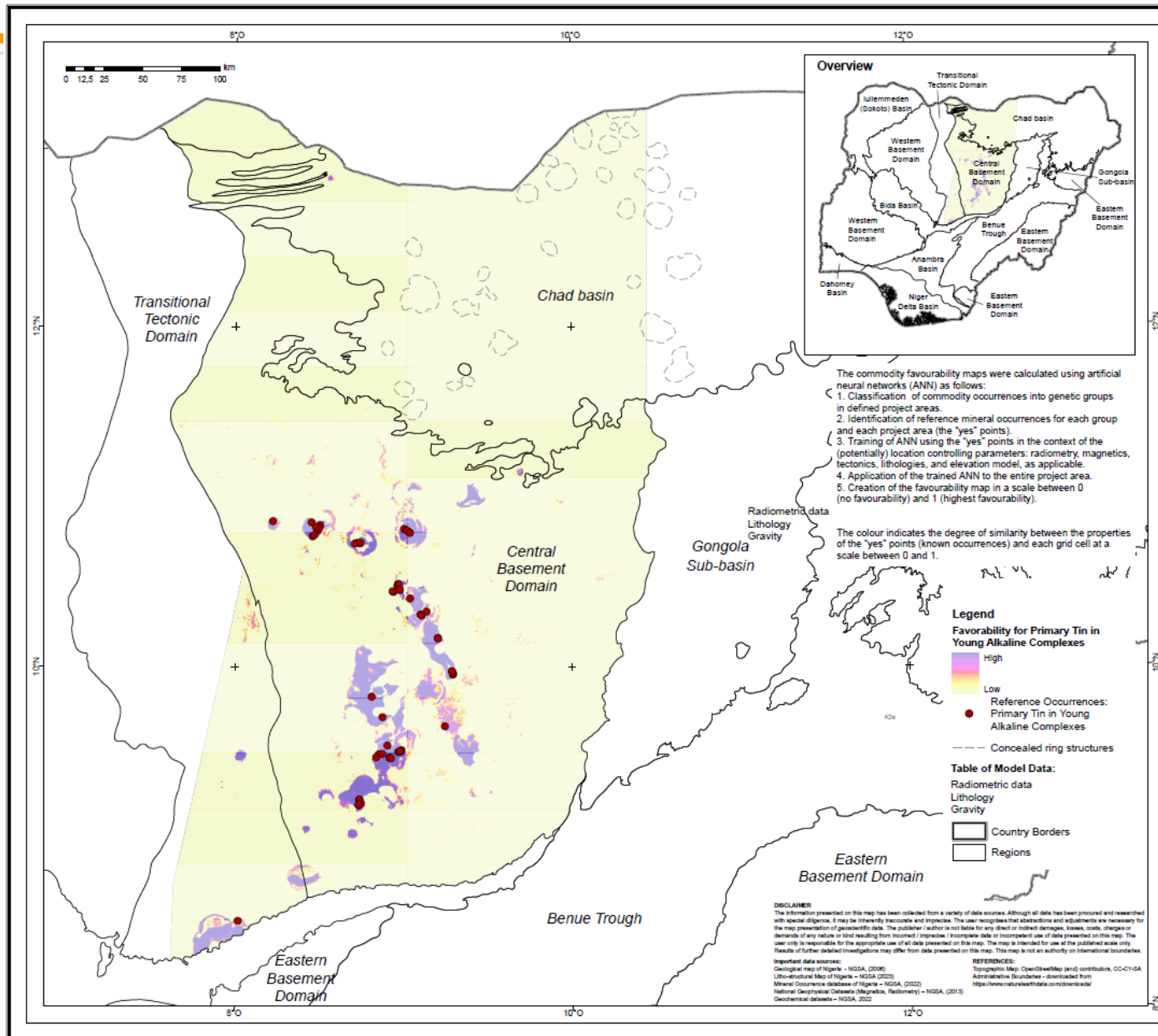
# The mineral potential maps: Granite related Au



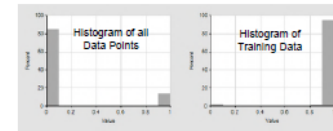
# The mineral potential maps:

# Pb & Zn in the Benue Trough



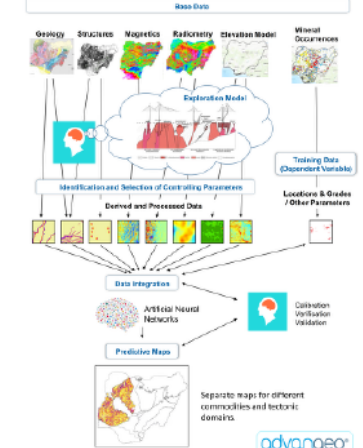


### Favorability Map for Primary Tin in Young Alkaline Complexes Central Basement Domain, Nigeria



Iteration and Error curve  
 Histogram of all data points: Maximum should be as far to the left as possible.  
 Histogram of the "yes" points: Maximum should be as far to the right as possible.  
 Iterations and error curve: lower errors indicate better models.

### Data processing Scheme Artificial Neural Networks (ANN) based Mineral Predictive Mapping Workflow



### Favorability Map for Primary Tin in Young Alkaline Complexes Central Basement Domain, Nigeria

**Map Compilation**  
 Dr. A. Barth (Beak), L. A. Pizano Wagner (Beak), A. Brosig (Beak)

**Data Capture**  
 L. A. Pizano Wagner (Beak), Z. Garfalin (Beak), A. Brosig (Beak), A. Brosig (Beak), A. Barth (Beak), V. Tyurin (Beak), P. Cocher (Beak), N. Rostadnova (Beak)

**Cartography & Layout**  
 C. Resper (Beak), A. Barth (Beak)

**Information Management & GIS**  
 L. A. Pizano Wagner (Beak), P. Cocher (Beak), C. Resper (Beak)

**Map projection**  
 Transverse mercator (UTM Zone 32N)

**Reference system**  
 Spheroid: WGS\_1984  
 Datum: D\_WGS\_1984

**Project Name**  
 Mineral Sector Support for Economic Diversification Project (MnDiver)

**Project Coordinator**  
 Dr. Salim Salamin

**Project Financing**  
 The World Bank

**Logos:** THE WORLD BANK, beak

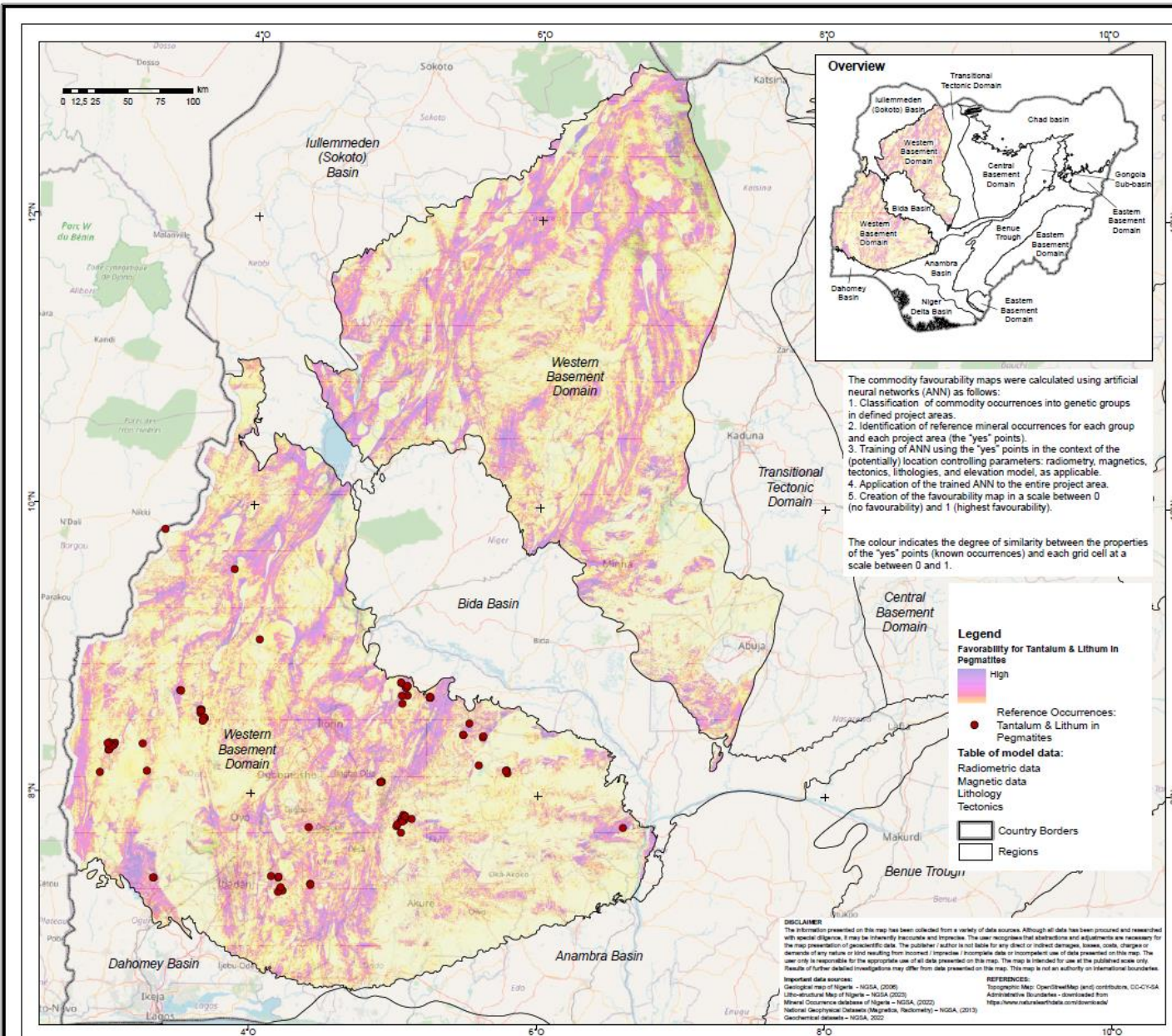
February 2024

# The mineral potential maps: Sn & Nb in Mesozoic alkaline Intrusive Complexes



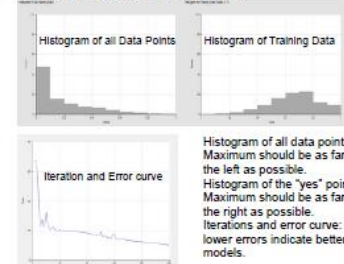
# The mineral potential maps:

# Ta & Li in pegmatites



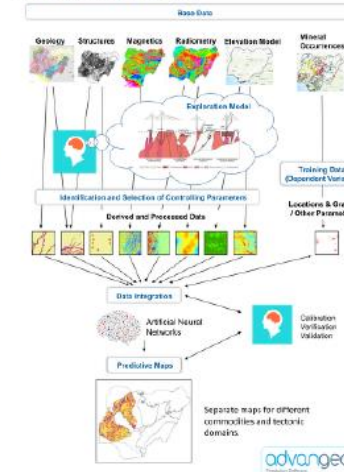
## Favorability Map for Tantalum and Lithium in Pegmatites Western Domain, Nigeria

Model Quality Parameters (Model Number 060)



### Data processing Scheme

Artificial Neural Networks (ANN) based Mineral Predictive Mapping Workflow



## Favorability Map for Tantalum and Lithium in Pegmatites Western Domain, Nigeria

**Map Compilation**  
Dr. A. Barth (Beak),  
L.A. Pizano Wagner (Beak),  
A. Broggi (Beak)

**Cartography & Layout**  
C. Resper (Beak), A. Barth (Beak)

**Information Management & GIS**  
L.A. Pizano Wagner (Beak),  
P. Cocher (Beak),  
C. Resper (Beak)

**Project Name**  
Mineral Sector Support for Economic Diversification Project (MinDiver)

**Data Capture**  
L.A. Pizano Wagner (Beak), Z. Garfulin (Beak),  
A. Badilla Cascoana (Beak), A. Broggi (Beak),  
A. Barth (Beak), V. Tyurin (Beak), F. Cocher (Beak),  
N. Rizaldhova (Beak)

**AI-based Predictive Mapping**  
A. Broggi (Beak), Dr. A. Barth (Beak)

**Map projection**  
Transverse mercator  
(UTM Zone 32N)

**Project Coordinator**  
Dr. Saim Salazar

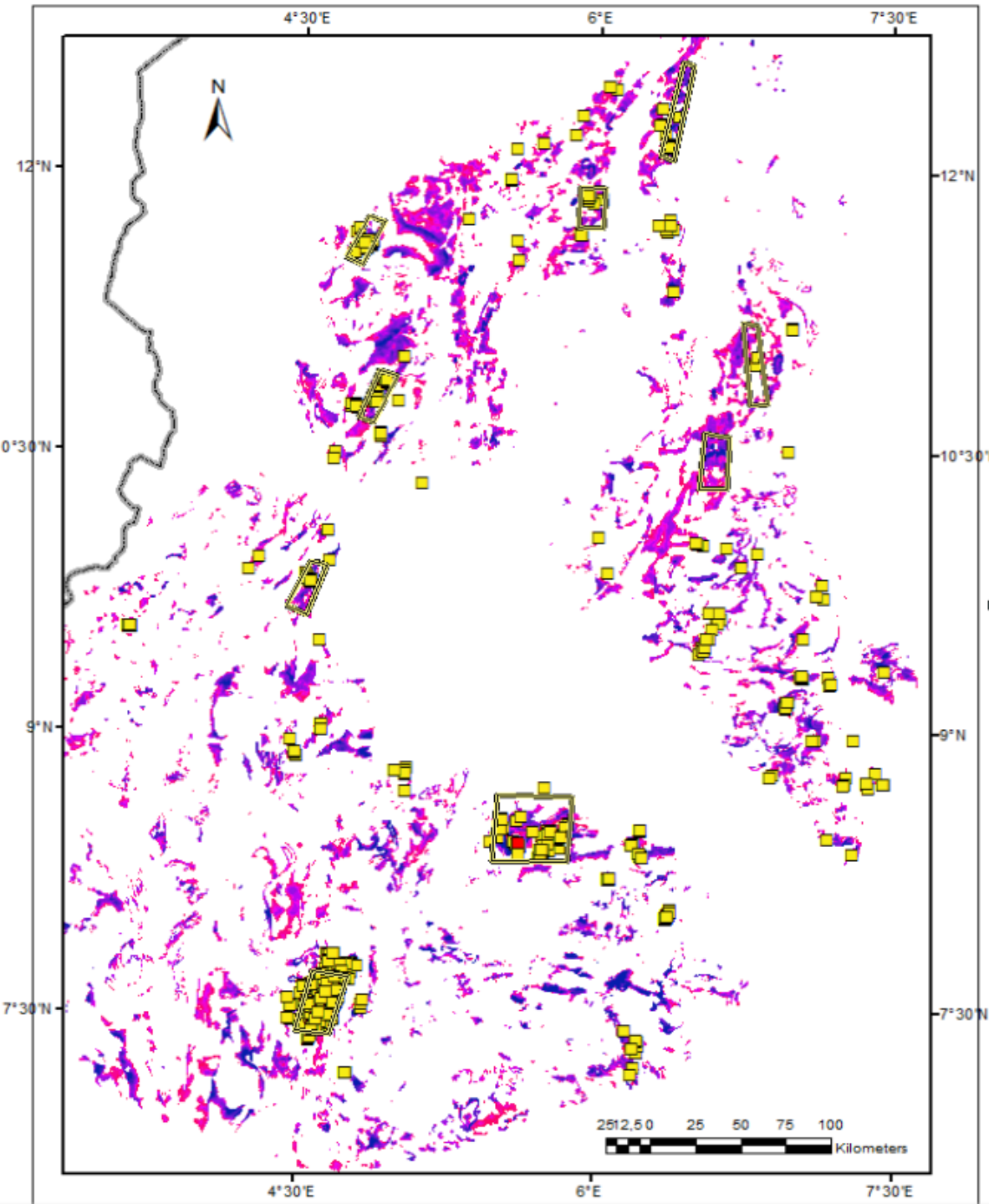
**Project Financing**  
The World Bank



February 2024



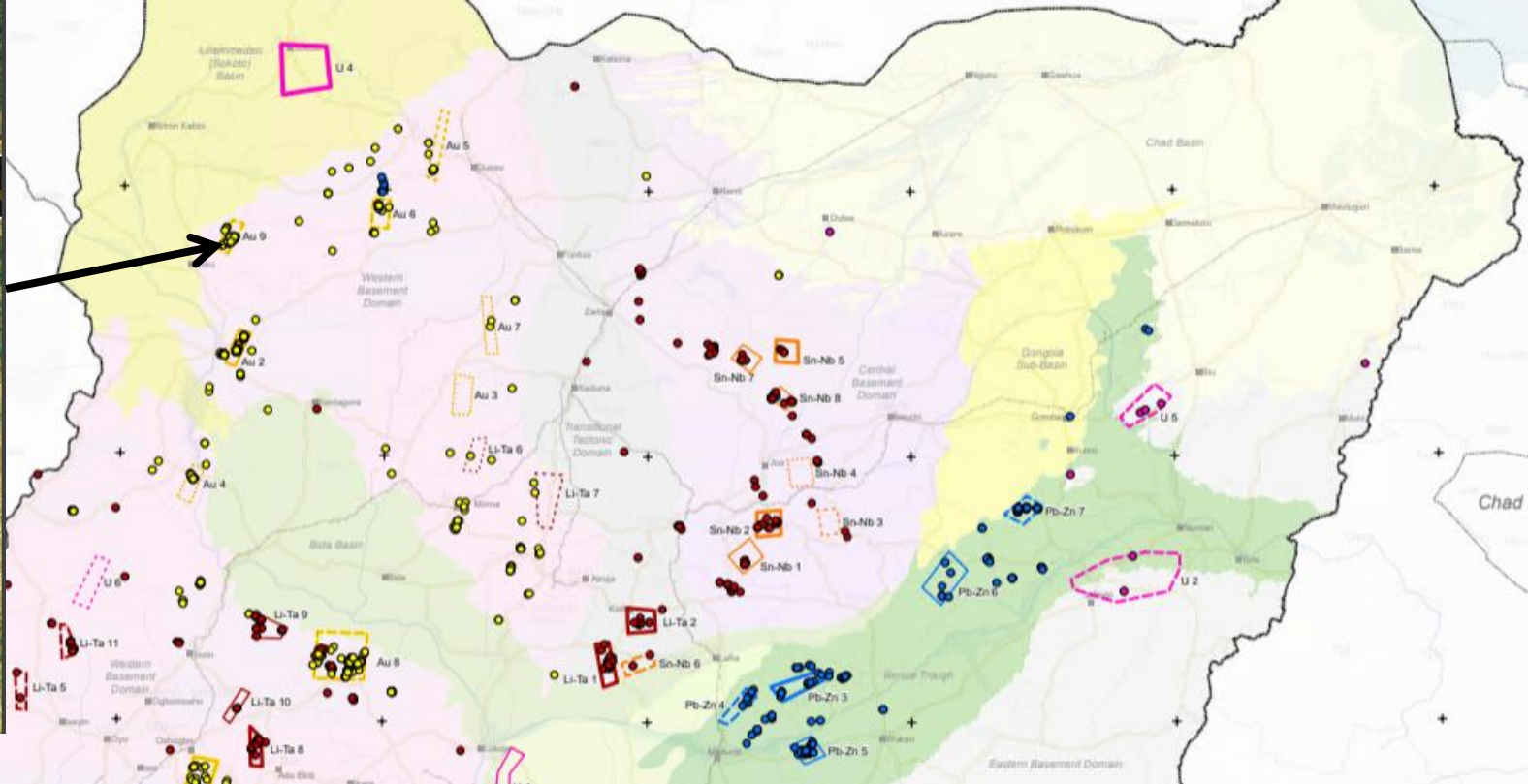
# Target identification/ ranking: Example hard rock Gold



## Identification / evaluation criteria:

Current/ historic mining?

- Number of mines in the cluster?
- Size of mined area?
- High favourability area?
- Shist belt composition?
- Placer mines around?
- Exploration data?



**Legend**

**Mineral Occurences (without Placers)**

- Gold (Au)
- Base Metals (Pb, Zn, ba)
- Rare Metals (Ta, Li, Sn, Nb)
- Nuclear Fuel (U)

**Gold (Au) Targets**

Rank	Score
<span style="border: 2px solid yellow; padding: 2px;"> </span>	≥ 45
<span style="border: 1px solid yellow; padding: 2px;"> </span>	≥ 40-44
<span style="border: 2px dashed yellow; padding: 2px;"> </span>	≥ 35-39
<span style="border: 1px dashed yellow; padding: 2px;"> </span>	≥ 34-30
<span style="border: 1px dotted yellow; padding: 2px;"> </span>	< 30

**Tin (Sn) Targets**

Rank	Score
<span style="border: 2px solid orange; padding: 2px;"> </span>	≥ 31
<span style="border: 1px solid orange; padding: 2px;"> </span>	≥ 25-30
<span style="border: 2px dashed orange; padding: 2px;"> </span>	≥ 20-24
<span style="border: 1px dashed orange; padding: 2px;"> </span>	≥ 15-19
<span style="border: 1px dotted orange; padding: 2px;"> </span>	< 15

**Lithium (Li)-Tantalum (Ta)-Pegmatites Targets**

Rank	Score
<span style="border: 2px solid red; padding: 2px;"> </span>	≥ 30
<span style="border: 1px solid red; padding: 2px;"> </span>	≥ 25 -29
<span style="border: 2px dashed red; padding: 2px;"> </span>	≥ 20-24
<span style="border: 1px dashed red; padding: 2px;"> </span>	≥ 15-19
<span style="border: 1px dotted red; padding: 2px;"> </span>	< 15

**Lead (Pb)-Zinc (Zn) Targets**

Rank	Score
<span style="border: 2px solid blue; padding: 2px;"> </span>	≥ 35
<span style="border: 1px solid blue; padding: 2px;"> </span>	≥ 30-34
<span style="border: 2px dashed blue; padding: 2px;"> </span>	≥ 25-29
<span style="border: 1px dashed blue; padding: 2px;"> </span>	≥ 20-24
<span style="border: 1px dotted blue; padding: 2px;"> </span>	< 20

**Uranium (U) Targets**

Genetic types

<span style="border: 2px solid pink; padding: 2px;"> </span>	1 Sandstone hosted
<span style="border: 1px solid pink; padding: 2px;"> </span>	2 Phosphate related
<span style="border: 2px dashed pink; padding: 2px;"> </span>	3 Granite related/hydrothermal
<span style="border: 1px dotted pink; padding: 2px;"> </span>	4 Accessory minerals



**The Selected Targets**

# Prospectuses

For the high-ranked targets  
Summary of information  
regarding:

- Prospectivity
- Infrastructure
- Labour & supporting industries/ services
- Natural environment
- Land use/ land cover
- Existing tenements

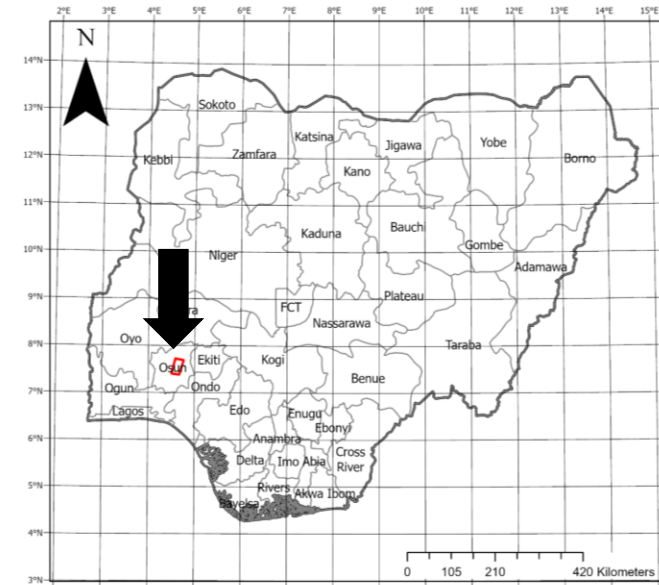


MINISTRY OF SOLID MINERALS DEVELOPMENT  
FEDERAL REPUBLIC OF NIGERIA  
TARGET PASSPORT

Au 1: Ife-Ilesha

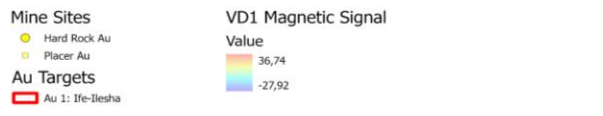
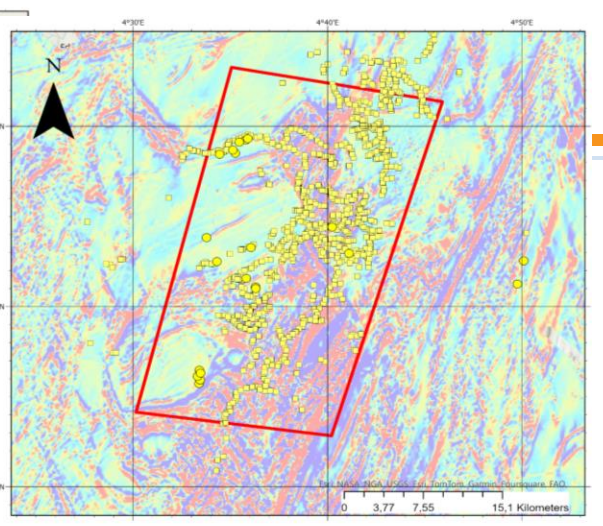
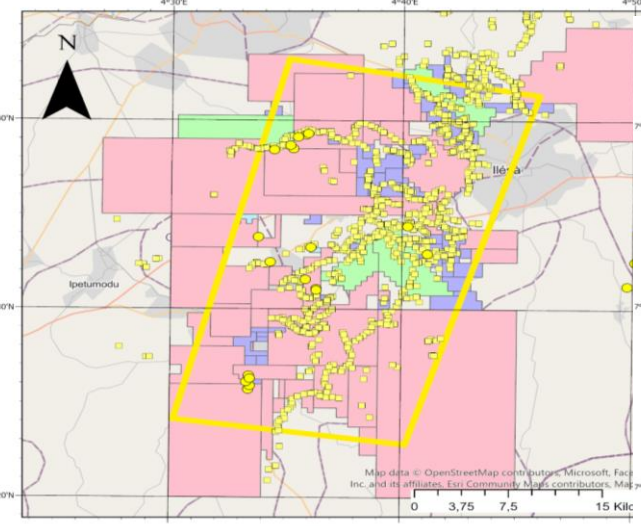
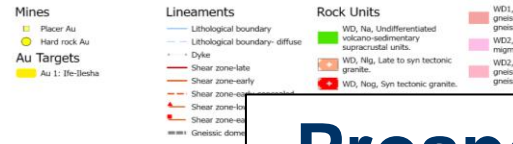
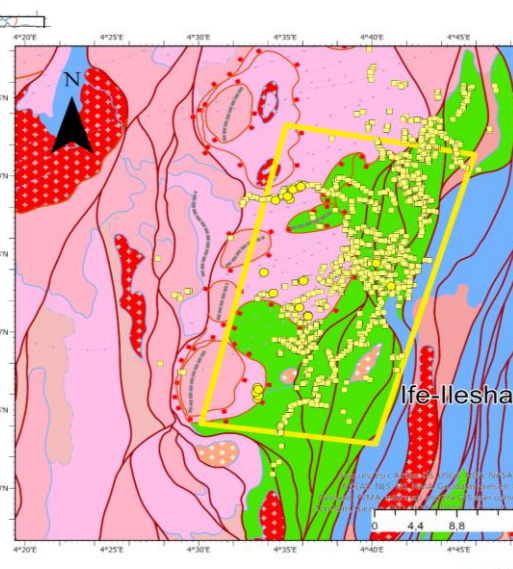
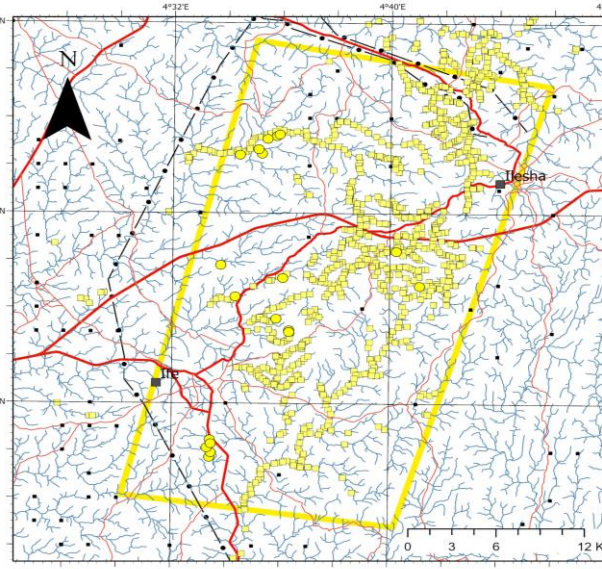
## Summary

*The selection of target is due to the big number of hard rock occurrences, placer mines and prospectivity indicated by the favourability map. It is located between two large towns with very good infrastructure, including highways, airports, and national transmission grid. The area belongs to one of the recent most attractive areas for gold in Nigeria within a very favourable geological setting. Availability of data for the site poses a unique chance for the discovery of vast undercover deposits.*

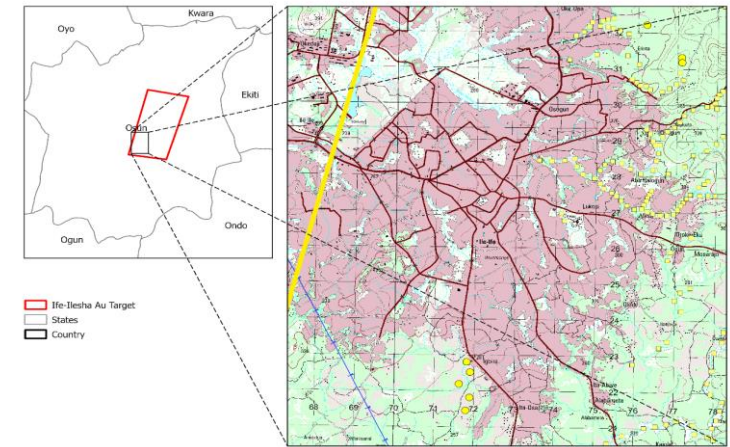
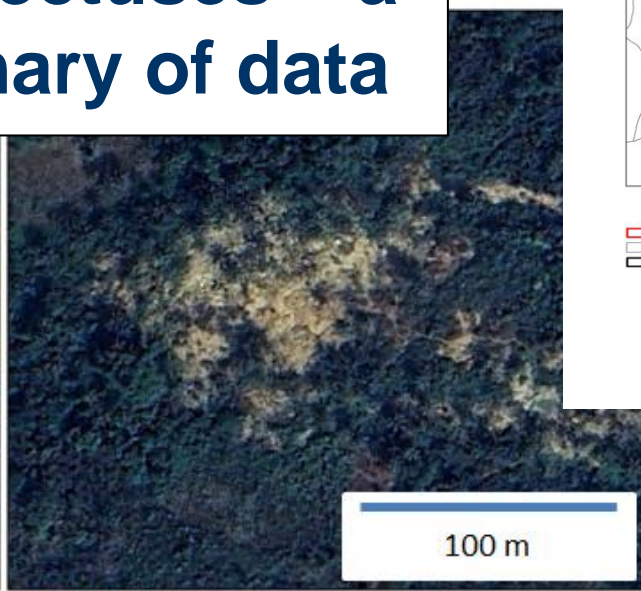
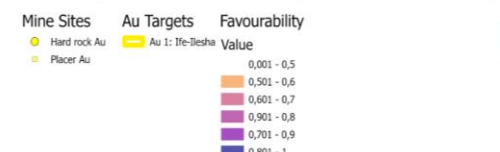
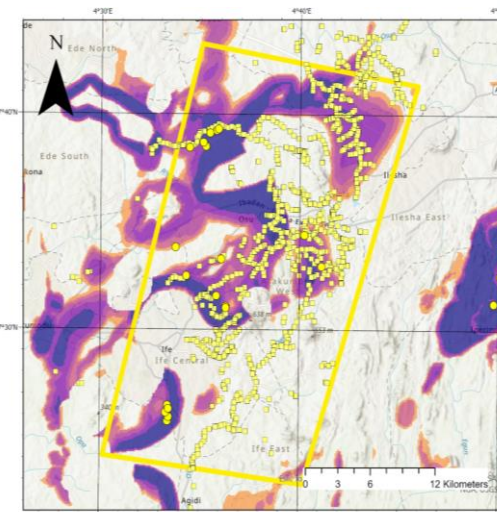


□ Ife-Ilesha Au Target  
□ States  
□ Country





# Prospectuses – a summary of data



# Marketing

- The NMRDSS
- National events
- Existing tenement owners
- International events
- Targeted invitations to selected potential investors



# Thank you for your attention



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**Dr. Andreas Barth,  
Luis Pizano**

**on behalf of a big team.**

