

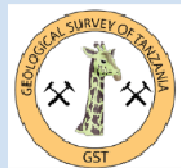
# Data Management and Exploration targeting – case studies from Tanzania and Ghana



Andreas Barth, Andreas Knobloch, Kwame Odame Boamah, John O. Duodu, Abdulkerim Mruma, Yokbeth Myumbilwa

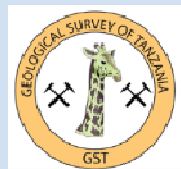
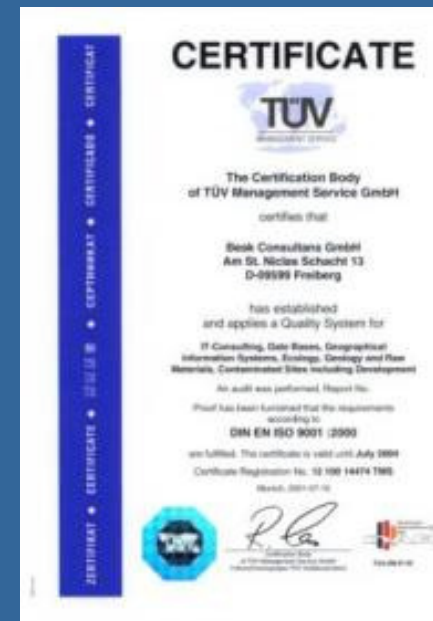
[www.beak.de](http://www.beak.de)

andreas.barth@beak.de



# Beak Consultants GmbH

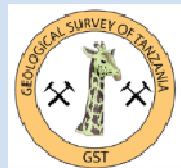
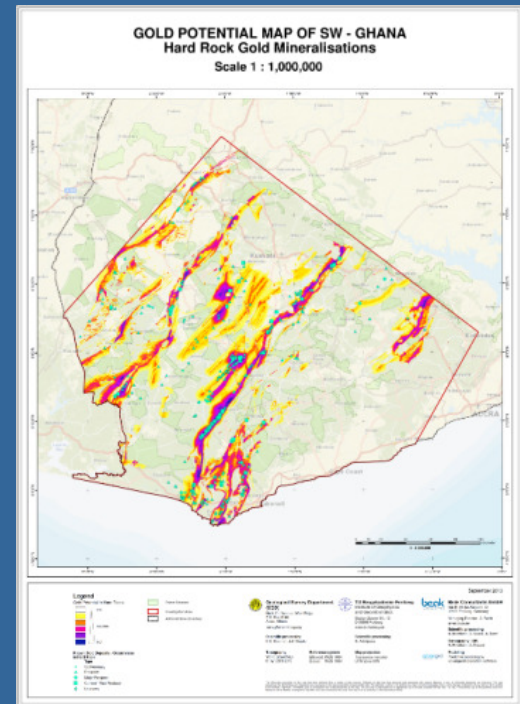
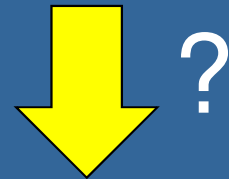
- Fields of business
  - Geology, exploration, environment
  - GIS and cartography
  - Tailor-made software
- ISO 9001:2000 certificate
- 19 years of company experience
- Roots are the
  - East German Geological Survey
  - Canadian Beak Consultants International
- Active in Ghana since 2005:
  - Databases and GIS
  - Mineral exploration targeting
  - Data processing



## How to best structure geological data?

## How to get from databases to mineral potential maps ?

- Approach
- Data integration
- Use cases
- Benefits



# The Tanzania Project: 2013 - 2015

## Provision of Consulting Services for Preparation of Geoscientific Data Information Management System

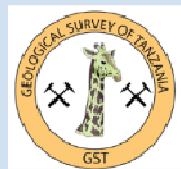
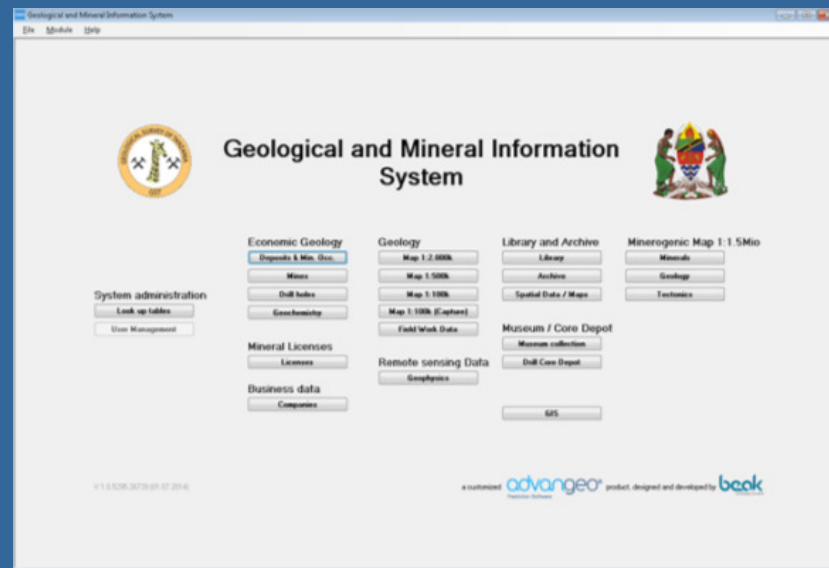
No. ME/008/SMMRP/C/35

Project ID: P096302

2013 - 2015

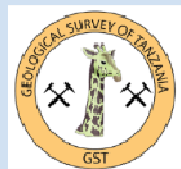
### Important results:

- The IMS
- Corrected/ improved data
- Metallogenic map & models

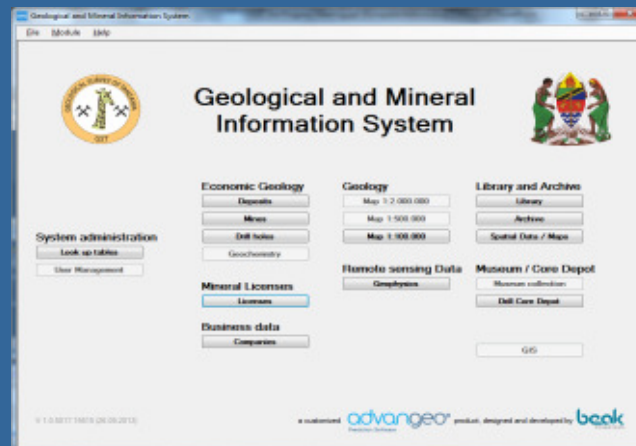
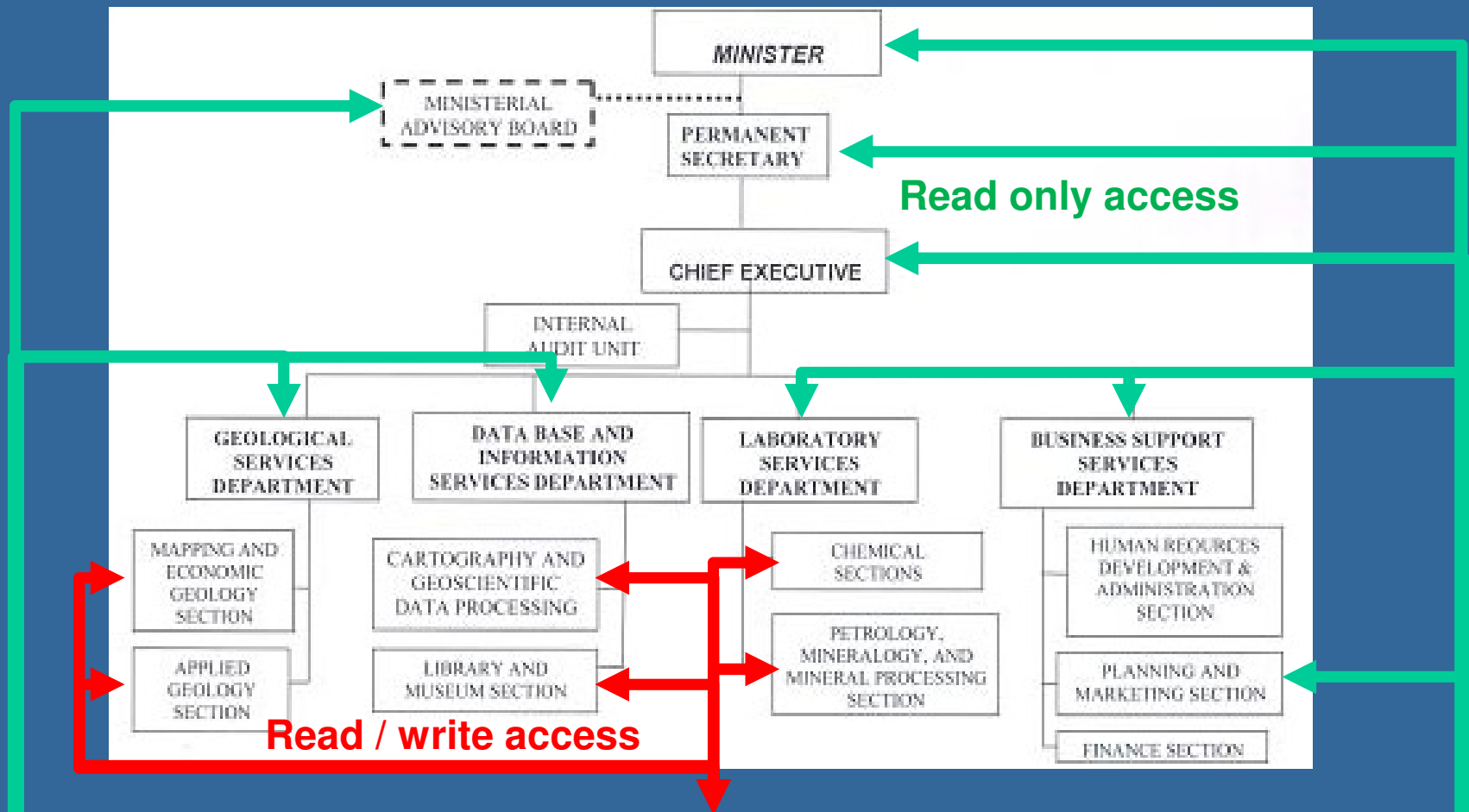


# The aim of the Tanzania Project (taken from the ToR's)

- .....the principle objective of this assignment is to introduce a **modern data management system** into the **daily working process** of the GST in order to enhance its ability to store, manage and **provide data** to the **private and public sector** of the country's economy and society.

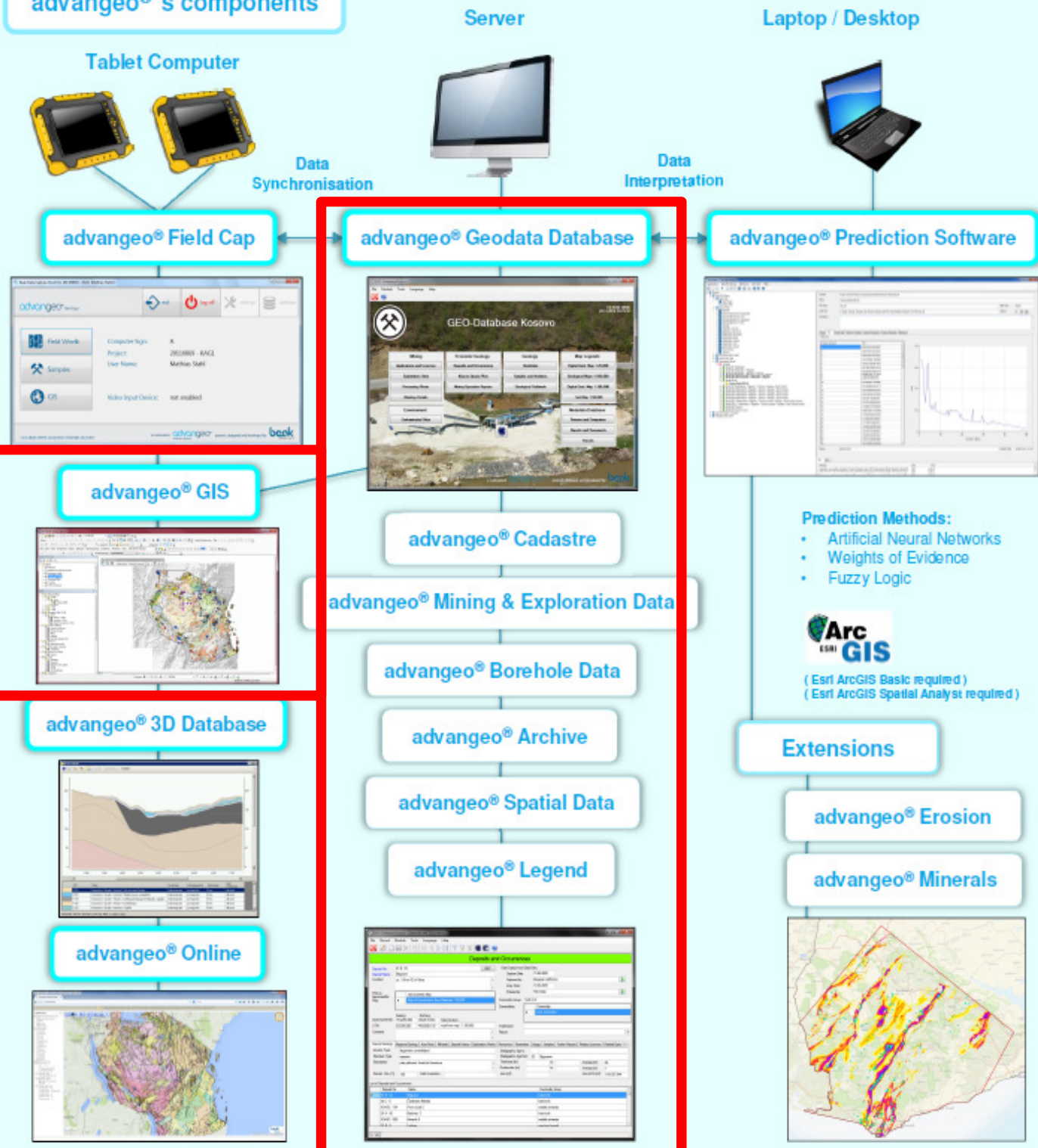


# GMIS Tanzania Interactions





## advangeo®'s components



## advangeo® Software Solutions



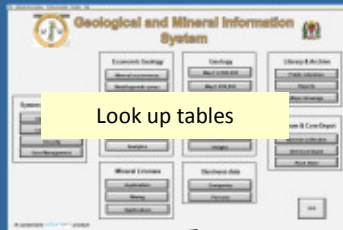
# advangeo®

## Software Products

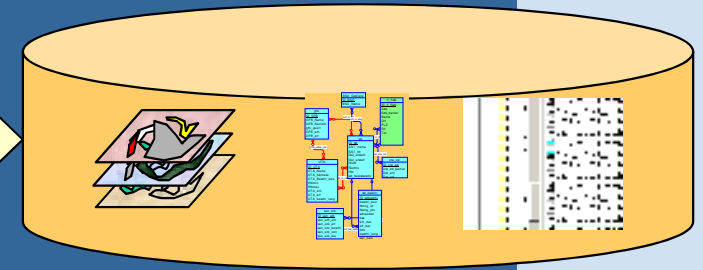
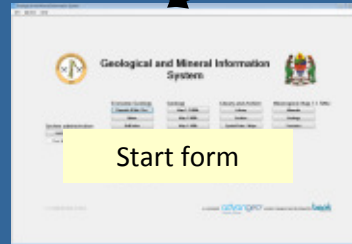
storage of big 3D data volumes in a product neutral database.

- **advangeo® Online** is a web based user interface for both spatial and table data.

# GMIS Tanzania Database Design

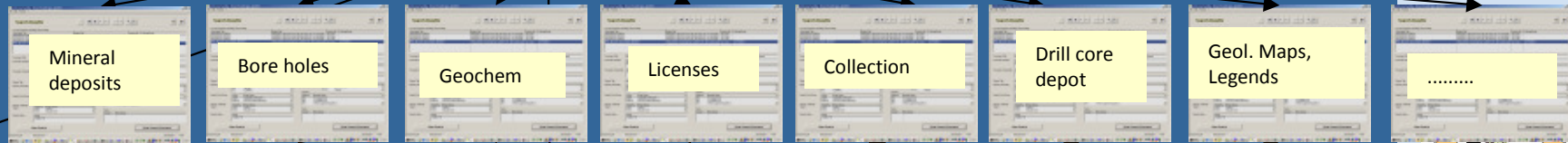


Database Management Modules



Meta data & files

Real data

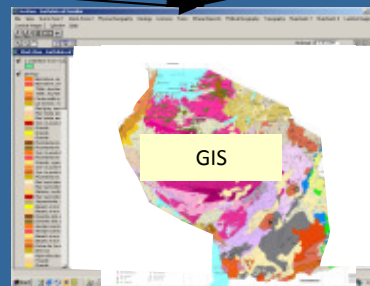


Library

Spatial data, Maps

View Maps in the GIS

View Documents

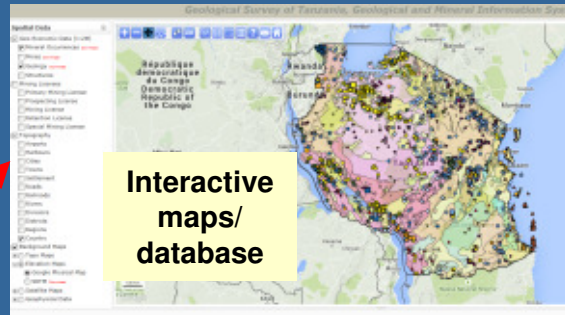


Map printing





# GMIS Tanzania Web Portal



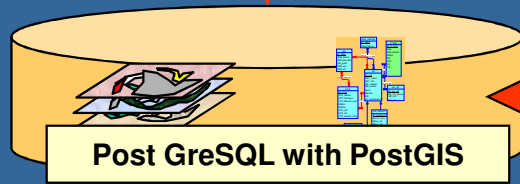
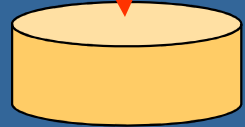
Internet  
Spatial data from  
other sources:

- \* Open Street Map
- \* Google Maps
- \* Virtual Earth
- \* Yahoo Maps...

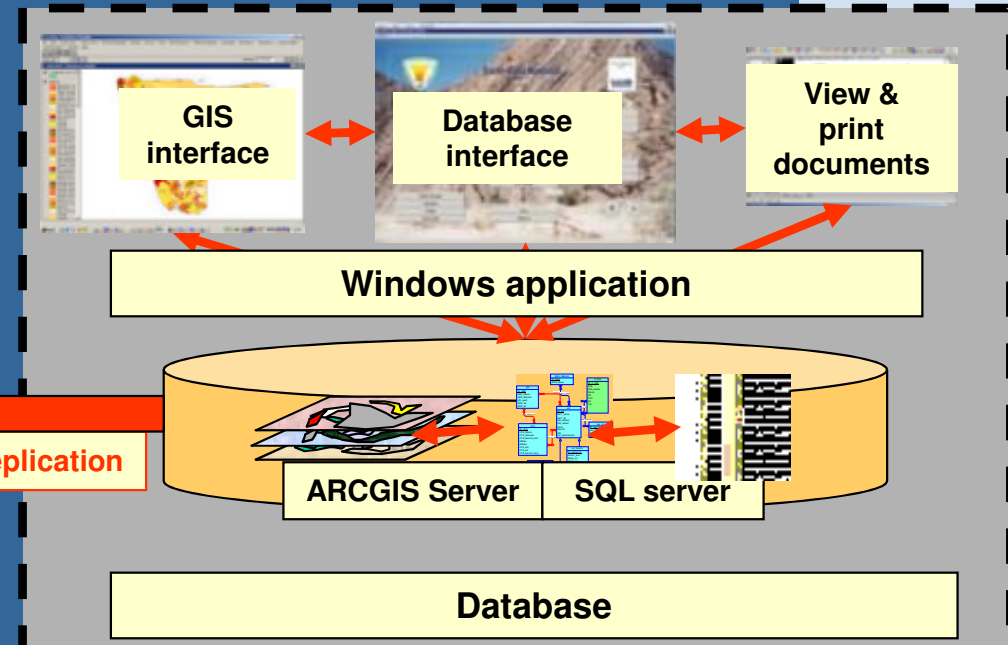


GeoServer

CMS

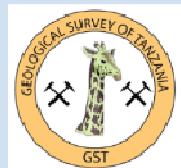
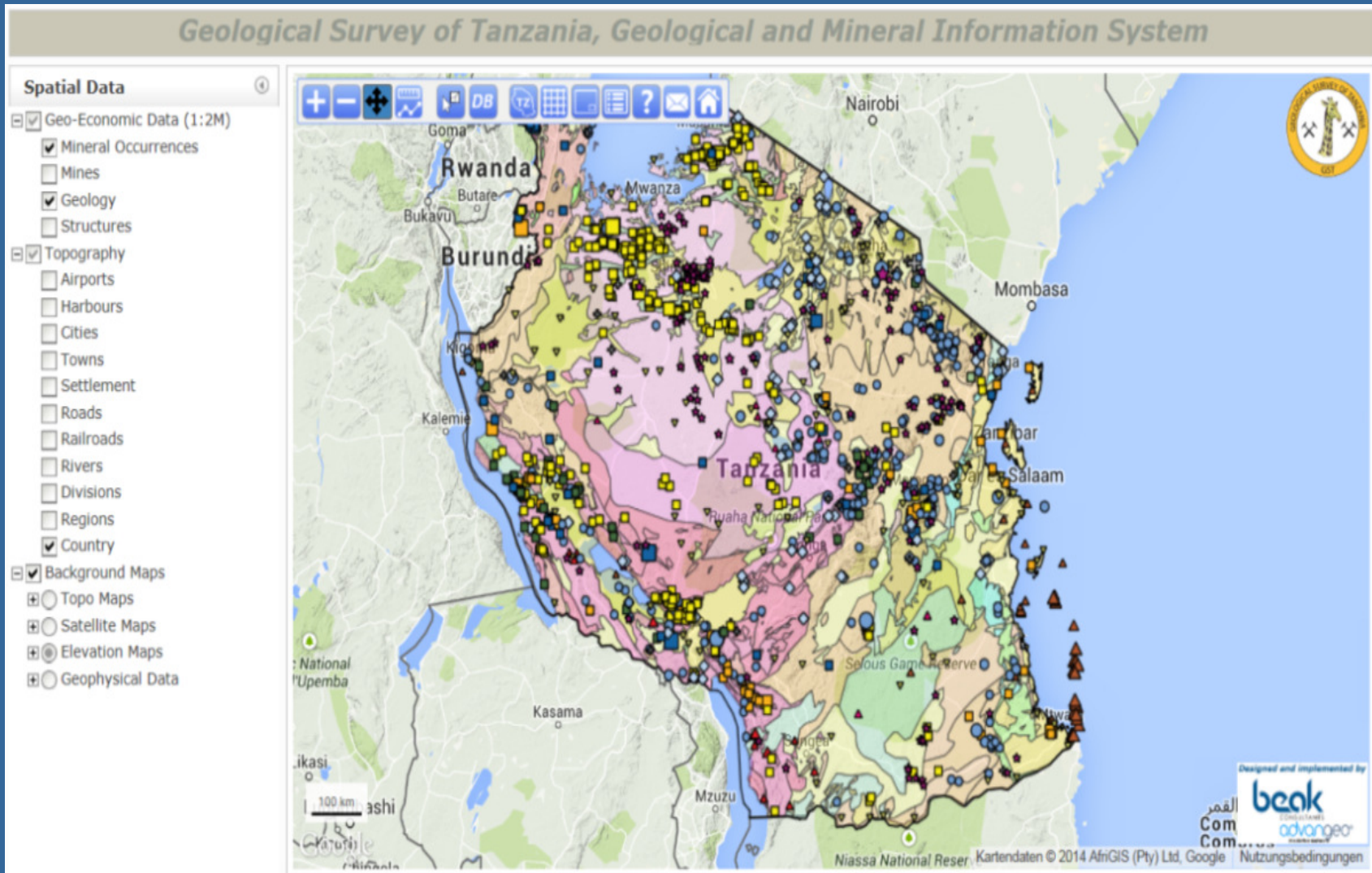


Web Database



# GMS Tanzania Public Web Site

[www.gmis-tanzania.com](http://www.gmis-tanzania.com)



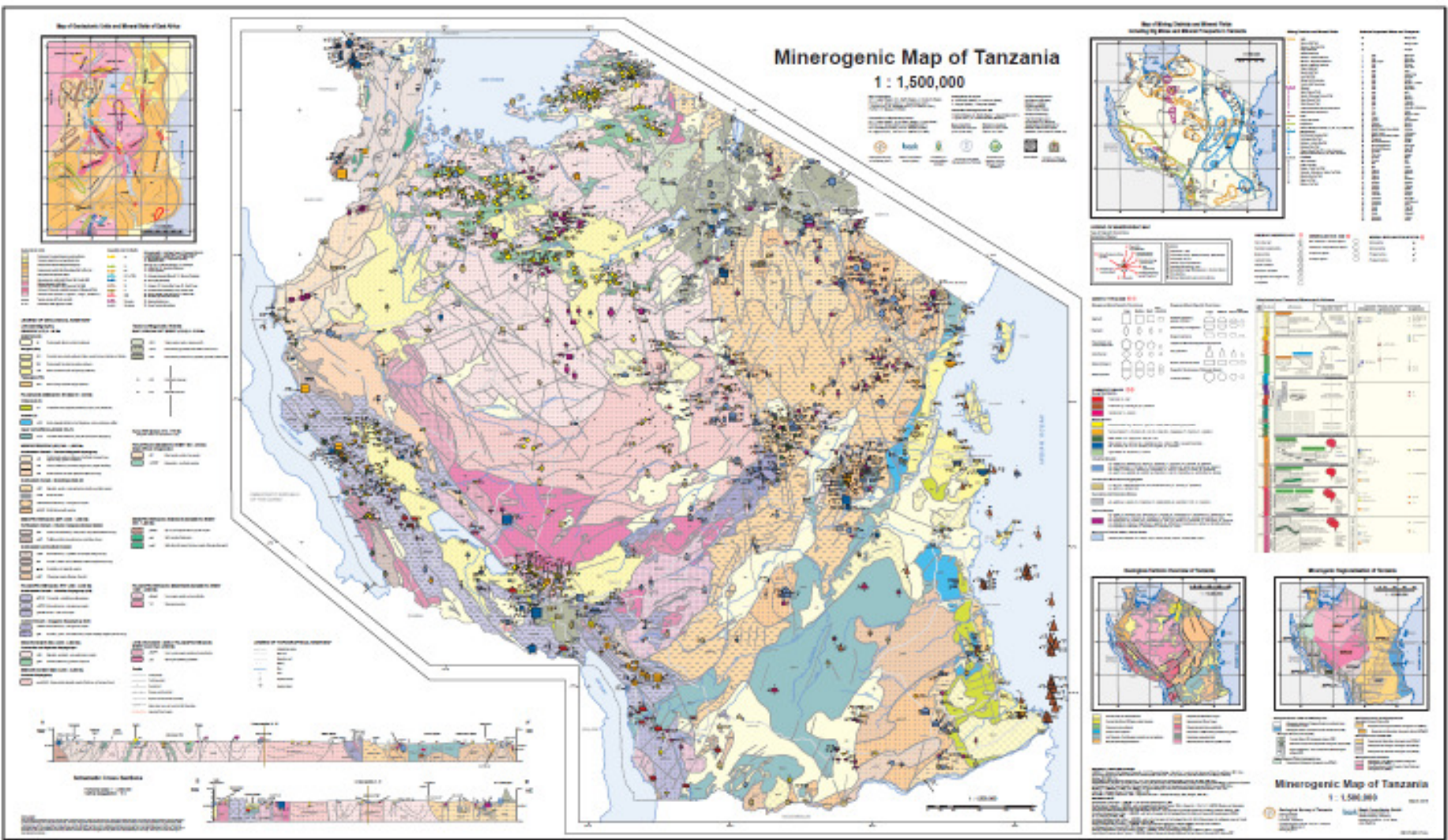
# Field Data Verification

## Verified mineral occurrence data:

- Locations
- Grades
- By-products
- Genetic types
- Mining conditions, Metallurgy
- Tailing description

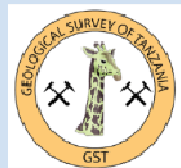
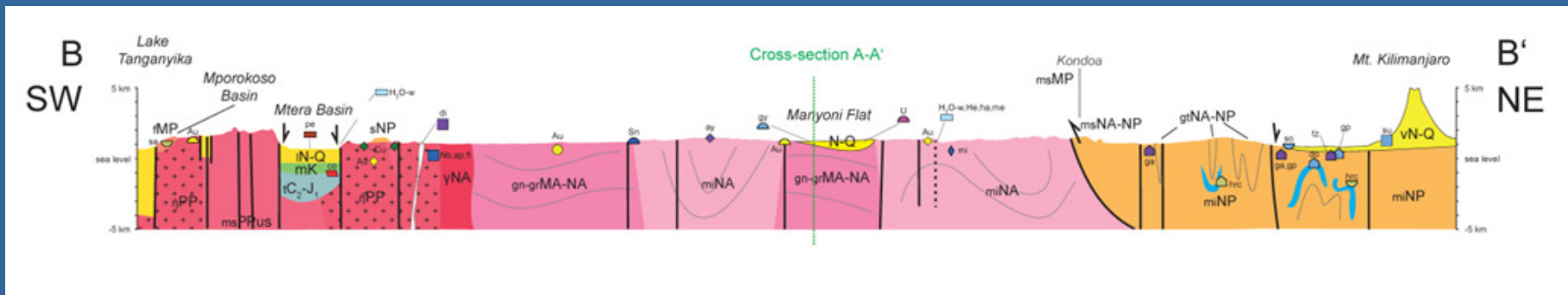
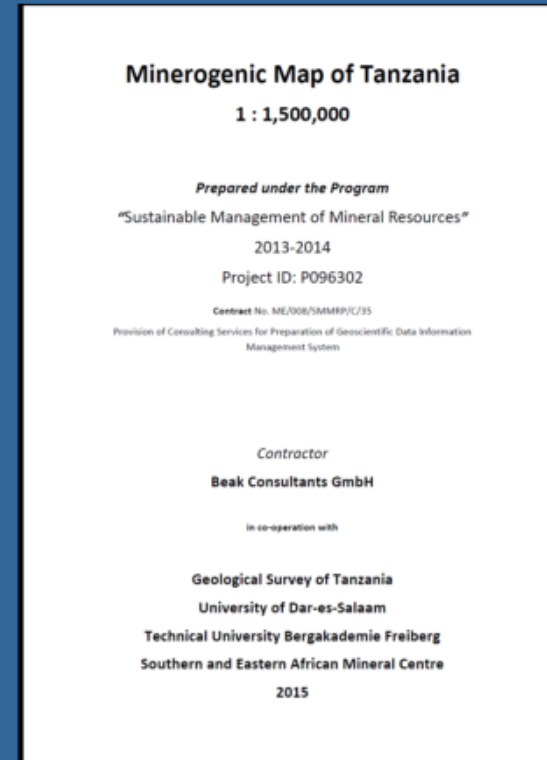
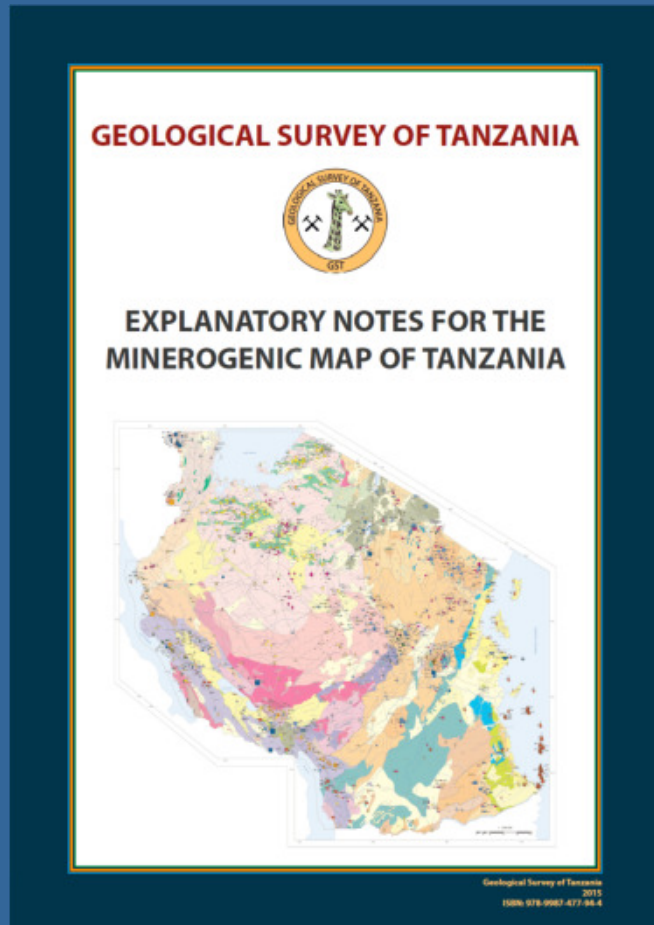


# The Minerogenic Map is a summarizing document

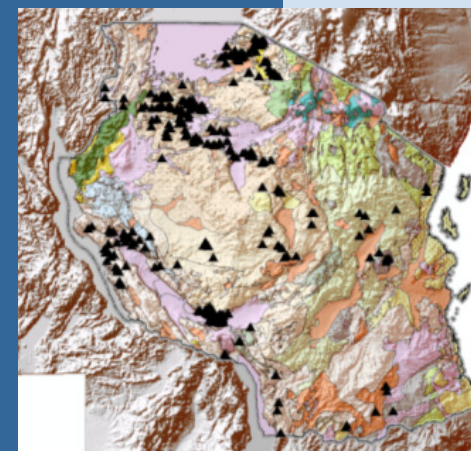
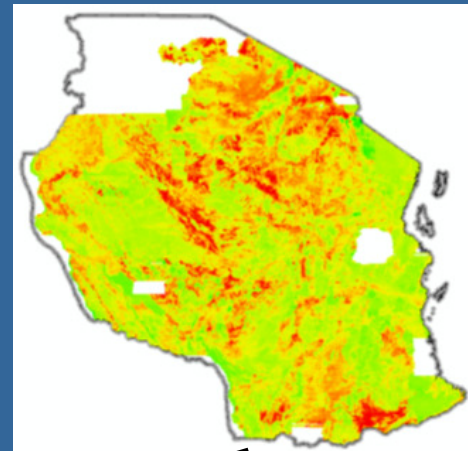
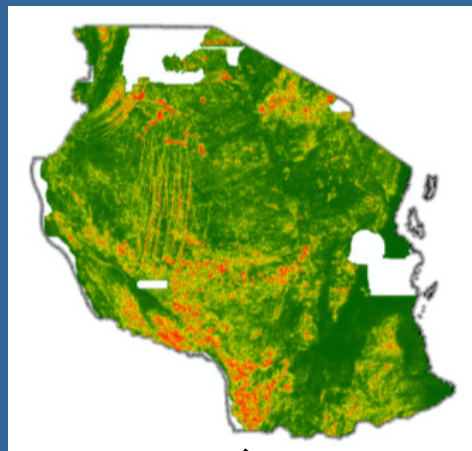
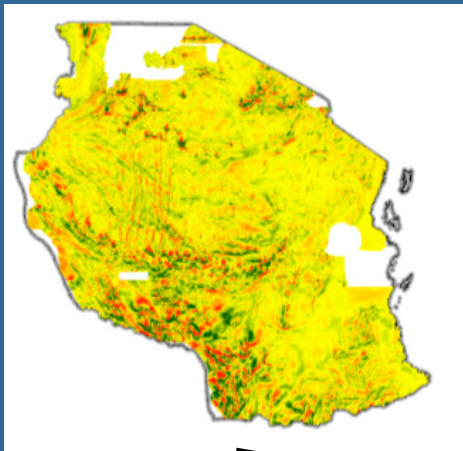


# Minerogenic Map: accurate mineral occurrence locations

Mineral occurrence descriptions, genetic understanding, mineral potential



# Gold in Tanzania



advangeo<sup>®</sup>  
Prediction Software

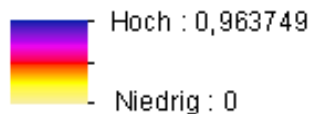
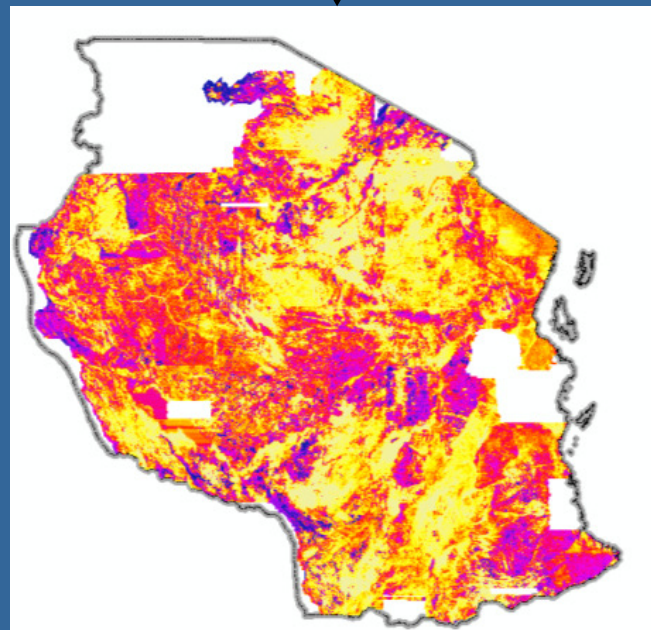
**Training Data:**  
Location of known greenstone hosted gold occurrences

**Training Area:**  
Northern Part of the craton

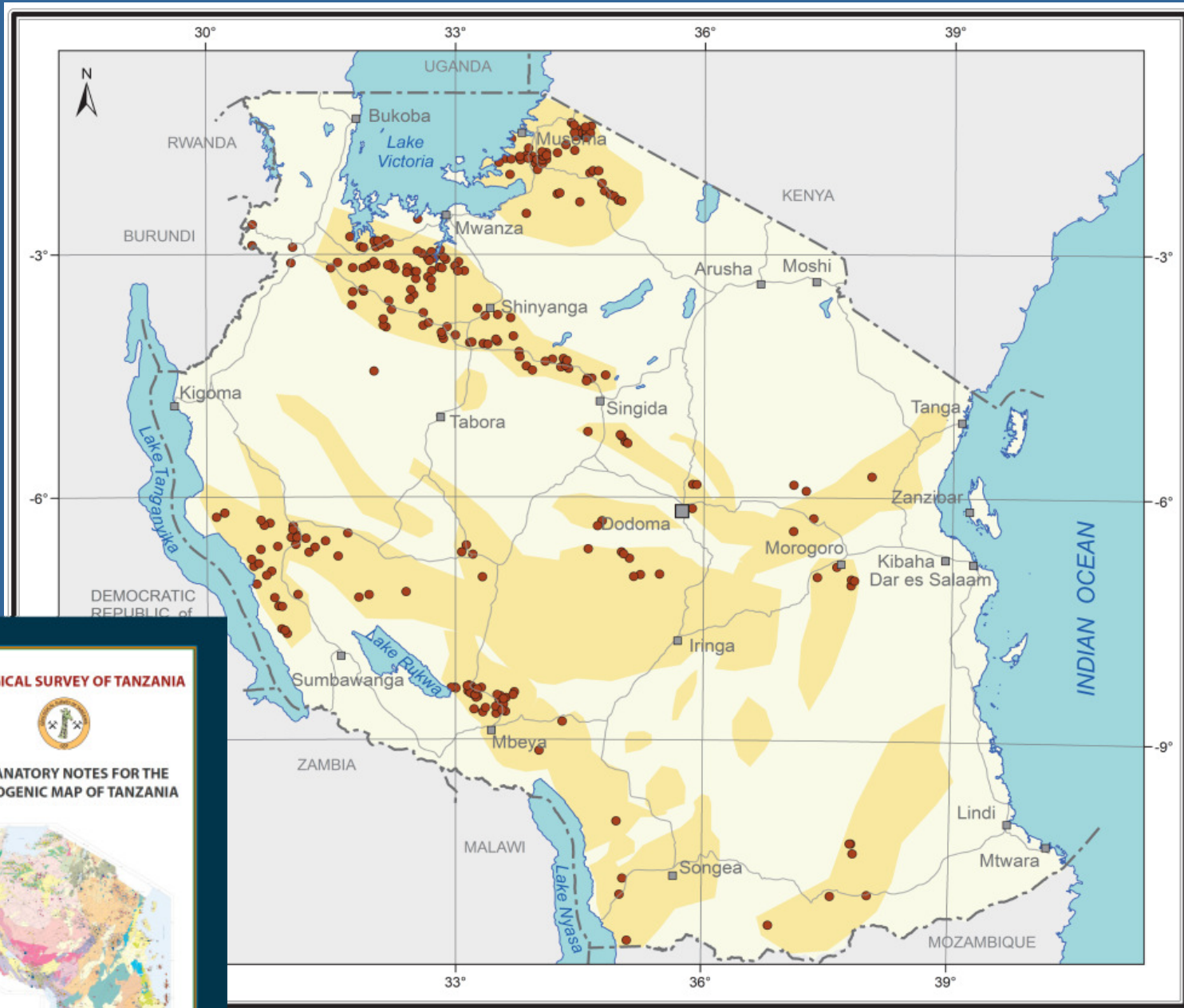
**Model Input Data:**

- Geology
- Tectonics
- Magnetics
- Potassium
- Uranium
- Thorium
- Elevation model

Au  
predictive  
map



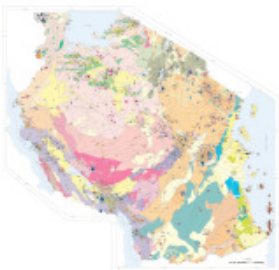
# Tanzania Gold Potential Map



**GEOLOGICAL SURVEY OF TANZANIA**



**EXPLANATORY NOTES FOR THE  
MINEROGENIC MAP OF TANZANIA**

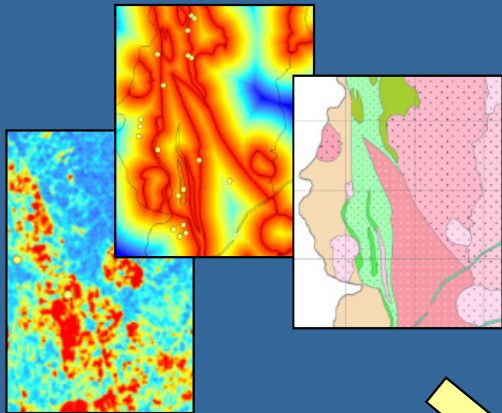


Geological Survey of Tanzania  
P.O. Box 10000, Dar es Salaam  
Tanzania

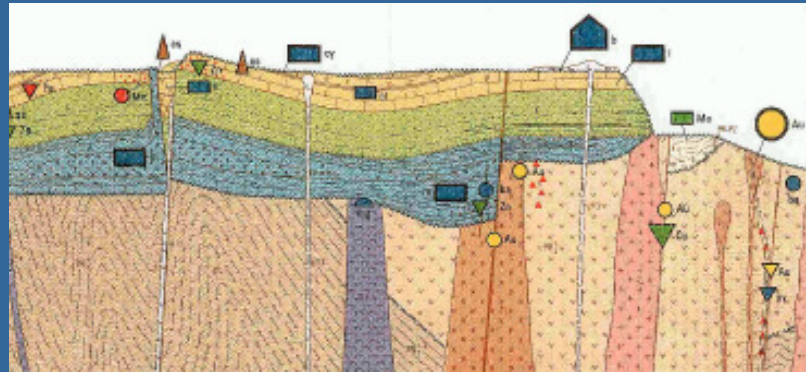


# Mineral Predictive Mapping

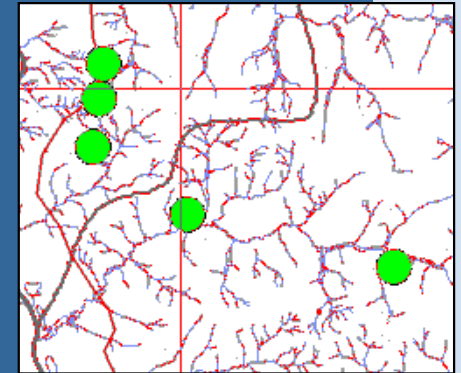
Data sets



Metallogenic Models



Locations =  
Known  
occurrences



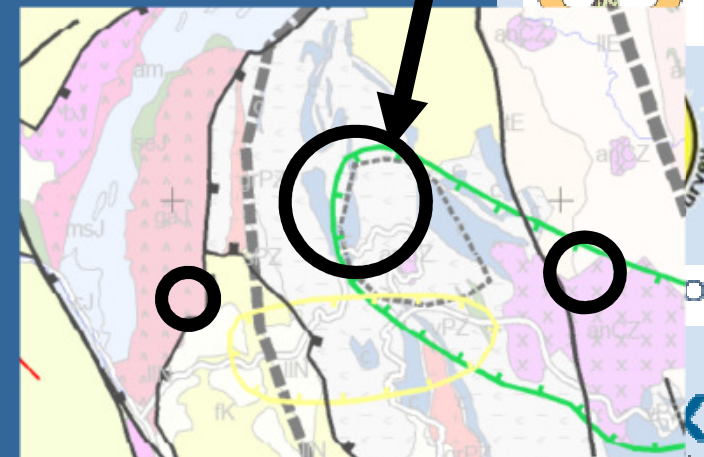
The expert's knowledge  
/experience supported by  
modern information  
technology



Data Analysis and  
Interpretation

Exploration  
target map

Target areas







## advangeo® Software Solutions

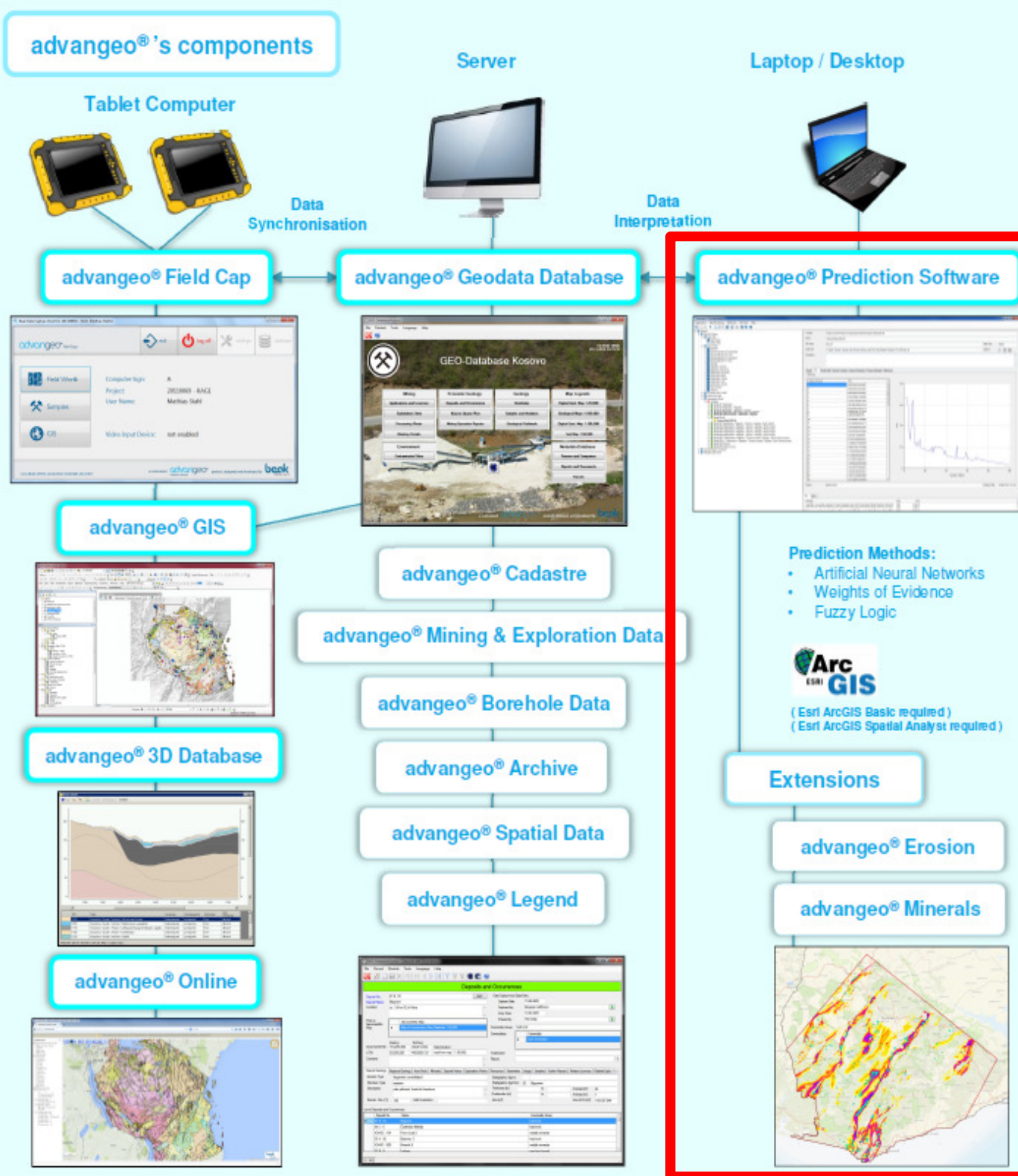
The experience of working with advangeo® is a seamless integration of spatial data.

# advangeo®

## Software Products

storage of big 3D data volumes in a product neutral database.

- advangeo® Online is a web based user interface for both spatial and table data.



- Prediction Methods:**
- Artificial Neural Networks
  - Weights of Evidence
  - Fuzzy Logic

**Arc GIS**  
 ( Esri ArcGIS Basic required )  
 ( Esri ArcGIS Spatial Analyst required )

- Extensions**
- advangeo® Erosion
  - advangeo® Minerals

# Mineral Predictive Mapping Approaches

- Data driven:

- Artificial neural networks

- Random Forests

- Logistic regression

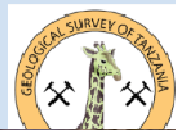
- Weights of evidence

- .....

- Knowledge driven:

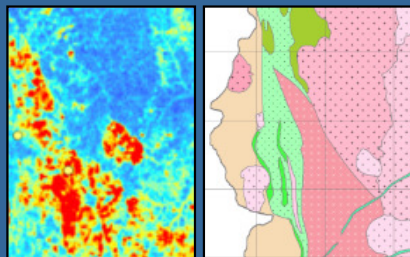
- Fuzzy logic

- Ranking

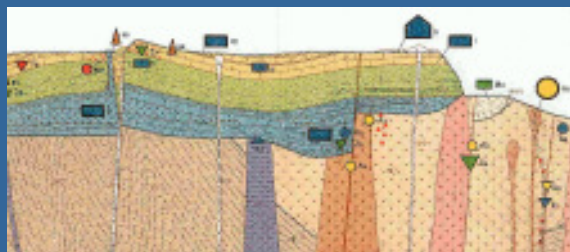


# Predictive Mapping Using Artificial Neural Networks

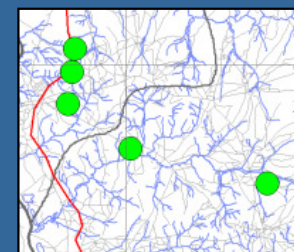
Data sets



Metallogenic Models

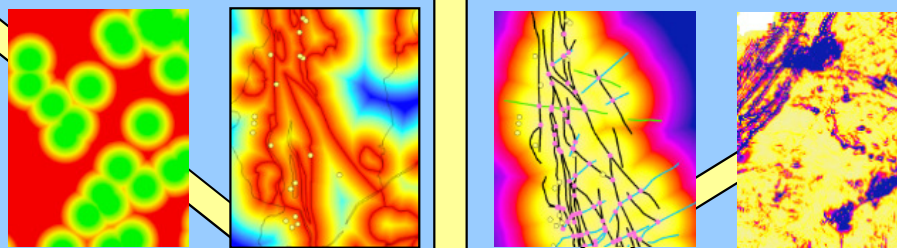


Locations

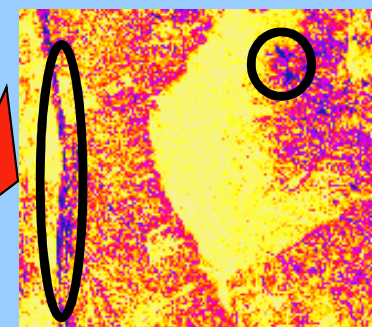
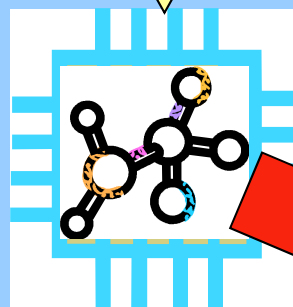


Pre-Processing

Extraction of potentially ore controlling features



The artificial neuronal network "replaces" the experts empirical data analysis

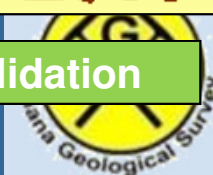


The predictive map = Exploration target map

Validation



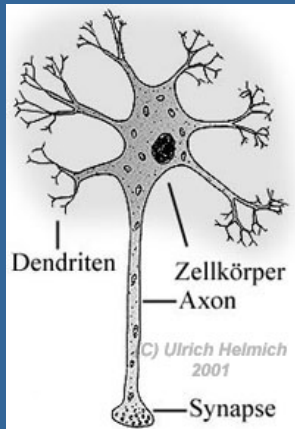
advangeo®  
Prediction Software



advangeo®  
Prediction Software

beak

# Artificial Neural Networks: The Method

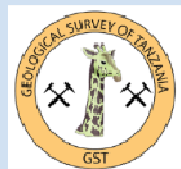
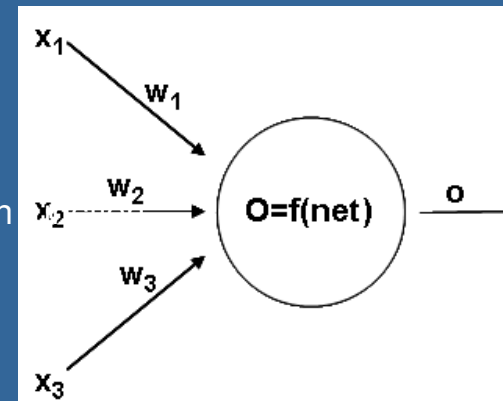


## Model: Neuron Cell

- Functionality as a biological neural system
- Consists of artificial neuron cells
- Simulation of biological processes of neurons by use of suitable mathematical operations
- In most cases layer-like configuration of the neurons

## The Neuron Cell as a Processor

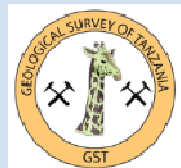
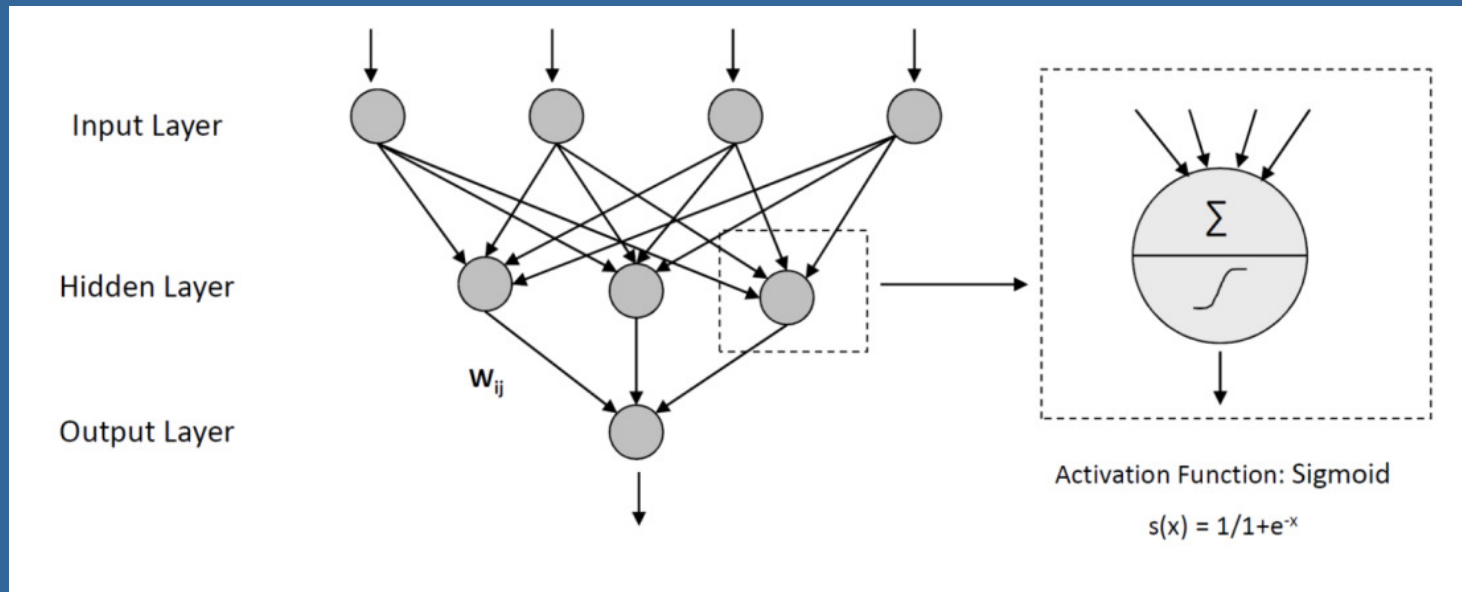
- **Connection between the neurons by weights  $w$** 
  - Enforce or reduce the level of the input information
  - Are directed, can be trained
- **Input signals**
  - Re-computed to a single input information: the propagation
- **Output signals**
  - Activation function computes the output status of a neuron (often used: Sigmoid function)



# Artificial Neural Networks: Principal Setup

## Network Topology: MLP (Multi Layer Perceptron)

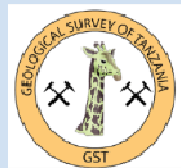
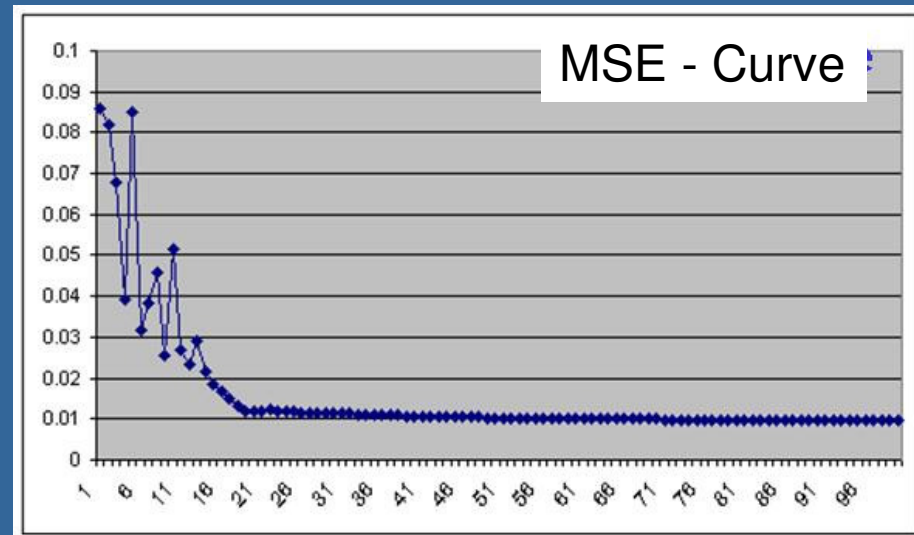
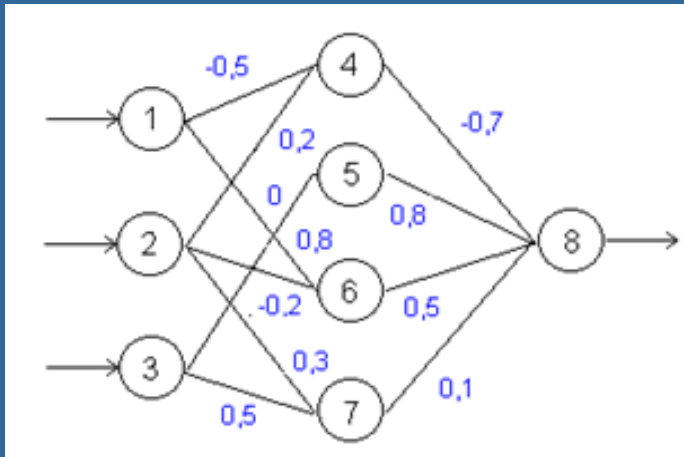
- Set-up of neurons in layers
- Direction and degree of connections
- Amount of hidden layers and neurons



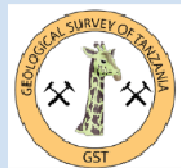
# Artificial Neural Networks: The Training Process

## Learning Algorithm: Back-Propagation

- Repeated input of training data
- Modification of weights  $w$
- Reduces error between expected and actual output of the network



# Gold in South-West Ghana



# How to Build a Predictive Model?

① Definition of Model Accuracy / Resolution and Extent

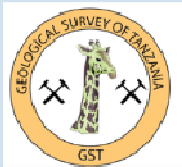
② Selection and Harmonization of Source Data

③ Processing of Source Data

④ Preparation of Model Input Data

⑤ Setting Up and Running of Different Model Scenario

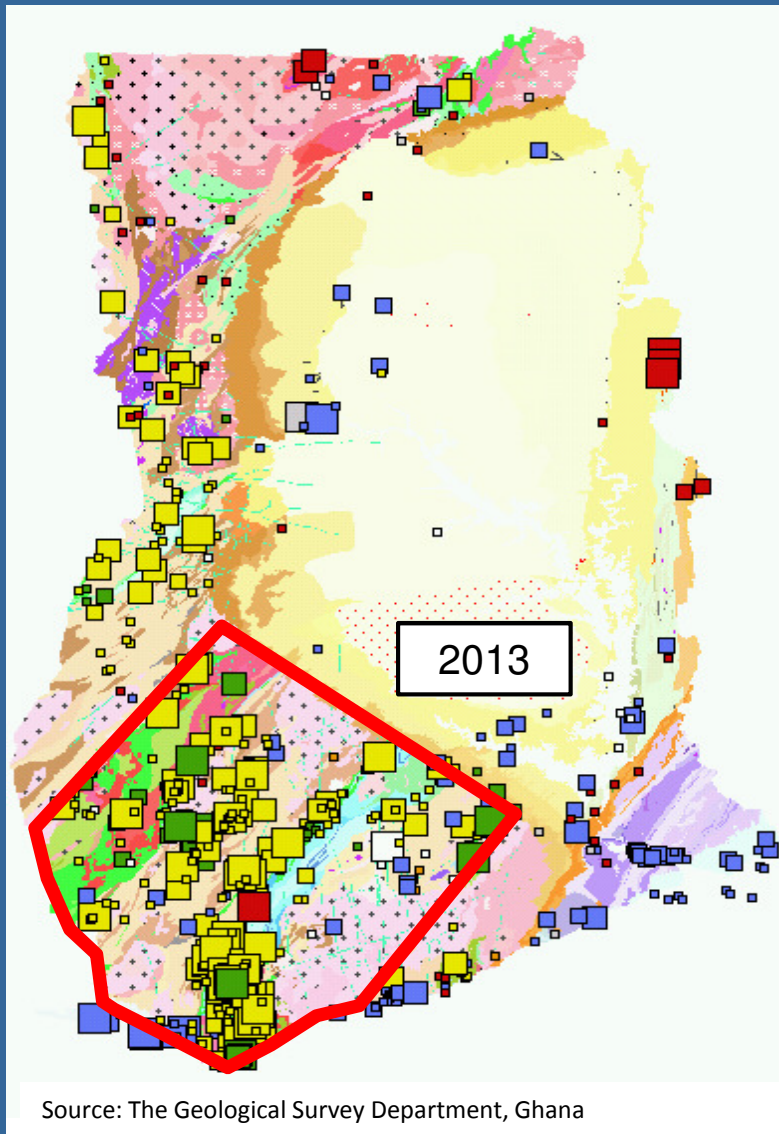
⑥ Presentation of Final Model Scenario Results





# Study Area & Genetic Model

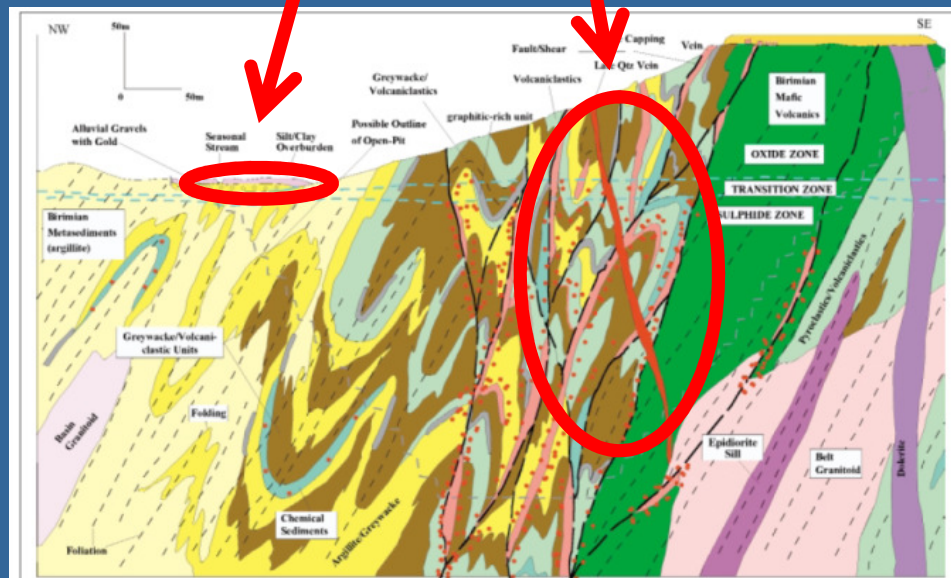
## Investigation Area



## Genetic types of gold deposits

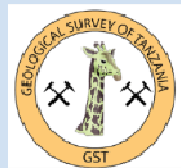
Placers

Hard rock



Source: Gold Deposits of Ghana, Minerals Commission, Ghana, ROBERT J. GRIFFIS, KWASI BARNING, FRANCIS L. AGEZO, FRED K. AKOSAH, 2002

 Gold deposits



# How to Build a Predictive Model?

① Definition of Model Accuracy / Resolution and Extent

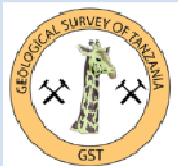
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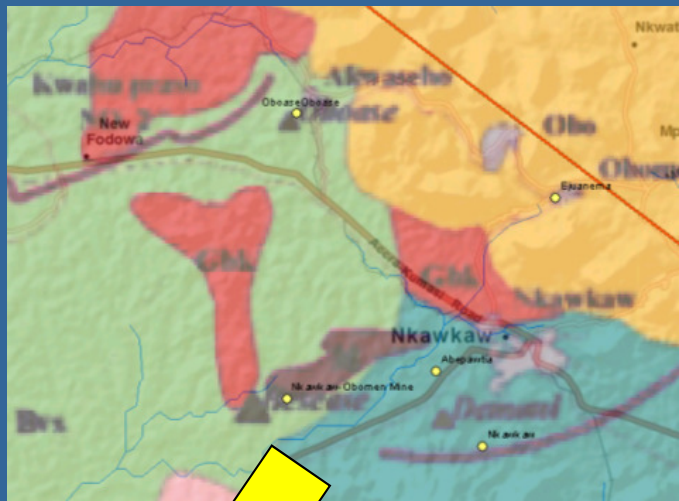
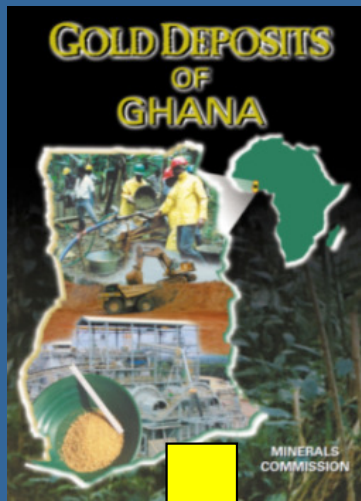
⑥ Presentation of Final Model Scenario Results



# Harmonizing Gold Occurrence Data

**GEODATABASE GHANA**

- Mining**
  - Mineral Licences
  - Mines
  - Monthly Mining Return Reports
  - Quarterly Prospecting Return Reports
- Mineral Trade**
  - Previous Mineral Trade Figures
  - Mineral Trade Permits
- Administration**
  - Integrity Check
  - Lookup Tables
  - Security
- Economic Geology**
  - Mineral Deposits & Occurrences
  - Geochemistry: Sample Locations
  - Geochemistry: Samples & Analytics
- Remote Sensing Data**
  - Geophysics and its metadata
  - Geophysics Datasets
- Business Data**
  - Persons & Companies
  - Annual Mining Return Reports
- Geology**
  - Drill Holes
  - Geological Field Work Data
  - Samples & Analytics
  - Pumping Tests
- Metadata Database**
  - Bibliography & Documents
  - Spatial Data
- Environment**
  - Contaminated Sites
- GIS**
  - GIS Viewer

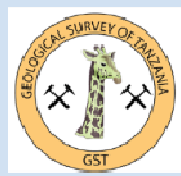


FK	COMMGR	FK SIZE	COMMGR SZ	open ended	hostrock	origin	content	Au bearing	hos	type	Size Buff	Size Value	Size1	A
10	0	0	0	current producer		vein and stockwork system	2.46;28.4(2,17)			4	500	50	4	
10	1	0	0	prospect		vein system	8.1(2,5);3.2(1,48)			2	200	5	2	
10	2	0	0	current producer		vein system	16.0(2,6)			2	500	50	4	
10	1	0	0	current producer	metasediments and volcanoclastics	vein system	15.1(1,52)			2	500	50	4	
10	1	0	0	prospect	metasediments and volcanoclastics	vein system	0.6(4);5.23(4)	sulphide / oxide	arsenopyrit	2	200	5	2	
10	4	104	0	past prospect/producer	metasediments and volcanoclastics	vein system	15(3);5.325(3)	sulphide / oxide		2	500	50	4	
10	4	104	0	past prospect/producer	sediments	vein system	0.46885(8,39);2.168012(7,11);P.24.5	conglomerates		2	500	50	4	19
10	4	0	0	major prospect		vein and stockwork system	9.53(1,8)			4	300	10	3	
10	4	104	0	past prospect	metasediments and volcanoclastics	vein system	0.041(4,4);2.997(4,4);1.41(3,2)			2	500	50	4	

## Project database attributes:

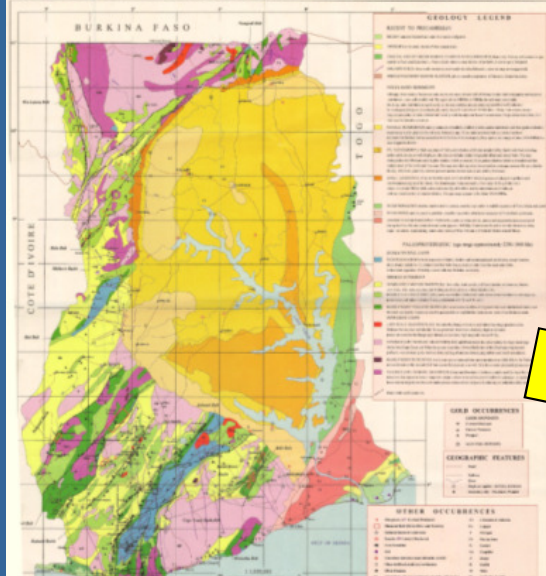
- Exact location
- Genetic type
- Host rocks
- Ressources
- Size
- Producer

- 340 vein/stockwork deposits/occurrences
- 40 placers
- 30 unclear (excluded)

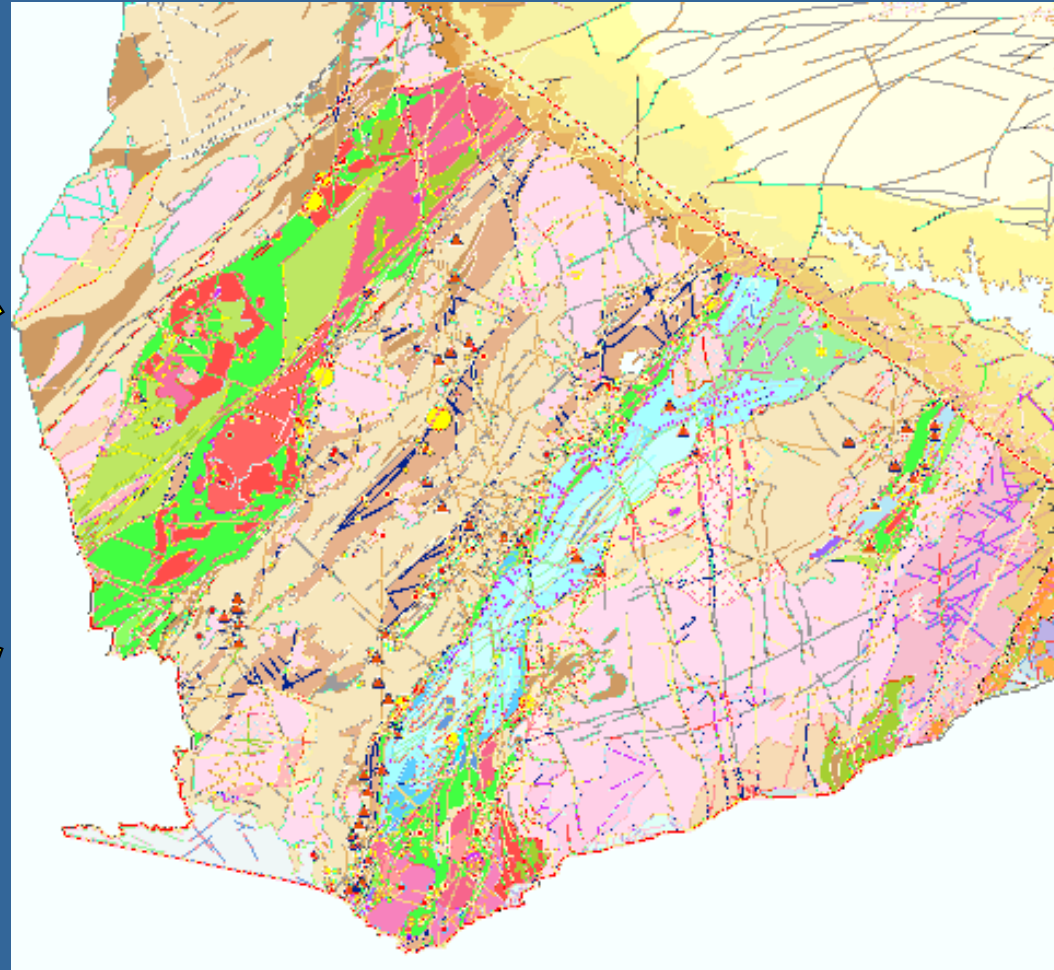
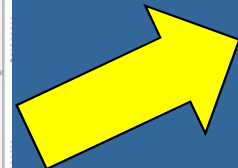
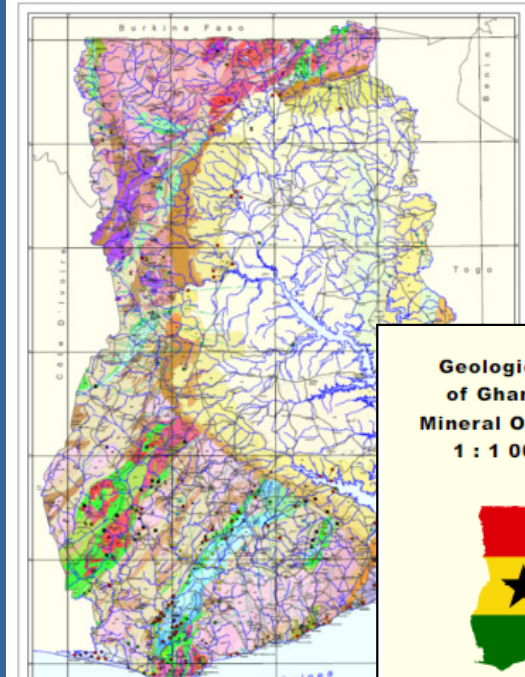
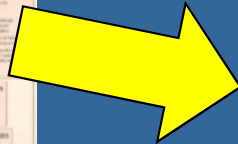


# Harmonizing Geological & Tectonic Data

GEOLOGY AND MINERAL RESOURCES OF GHANA



Minerals Commission, Griffis Consulting, 2002

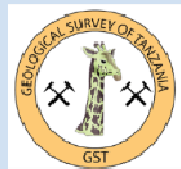


Geological Map of Ghana with Mineral Occurrence  
1 : 1 000 000

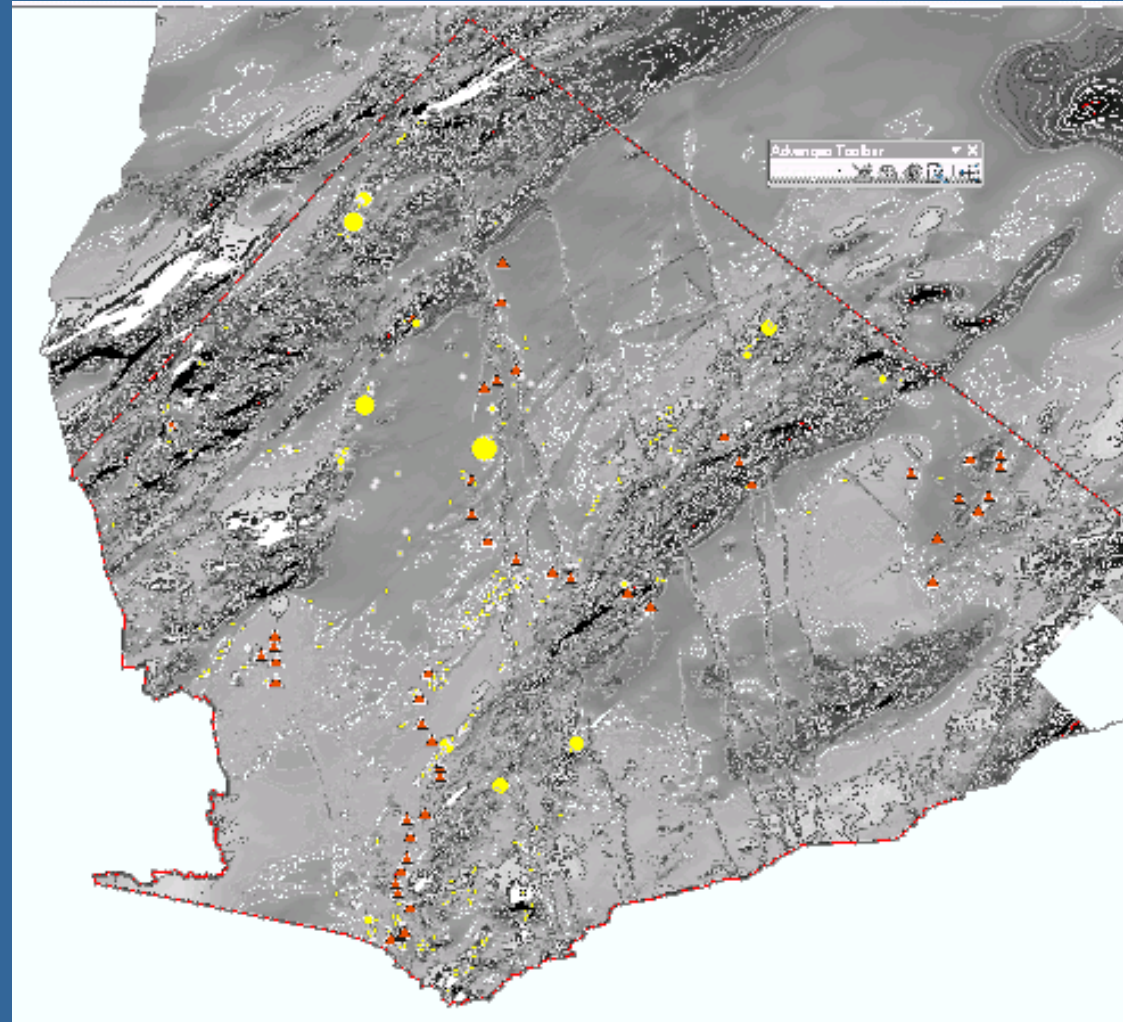
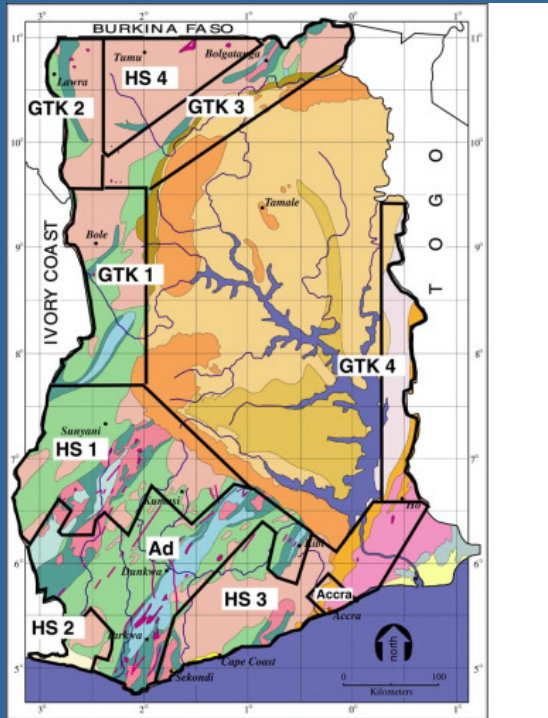


2012

GSD, BGR, 2012



# Processing / Harmonizing Geophysical Data



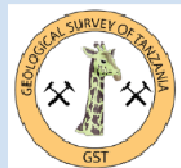
## PROCESSING AND INTERPRETATION OF AIRBORNE GEOPHYSICAL DATA

AIRBORNE SURVEY 1999-2000

Philip Yaw Oduro Amoako  
Samuel Kwabla Amedofu  
Thomas Akamaluk

Geological Survey Department of Ghana

February 2004



# How to Build a Predictive Model?

① Definition of Model Accuracy / Resolution and Extent

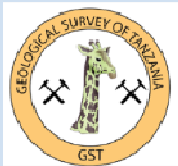
② Selection and Harmonization of Source Data

③ Processing of Source Data

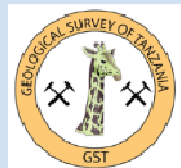
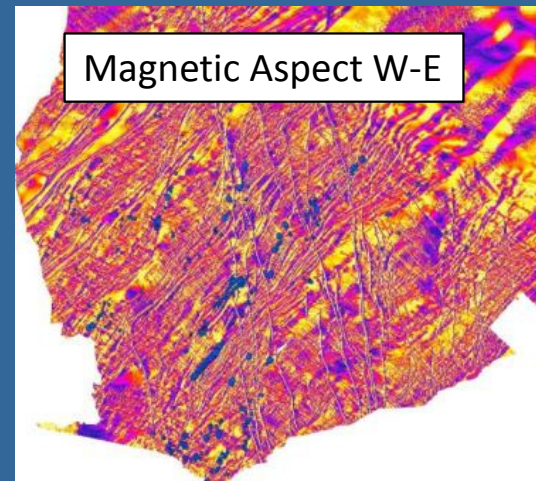
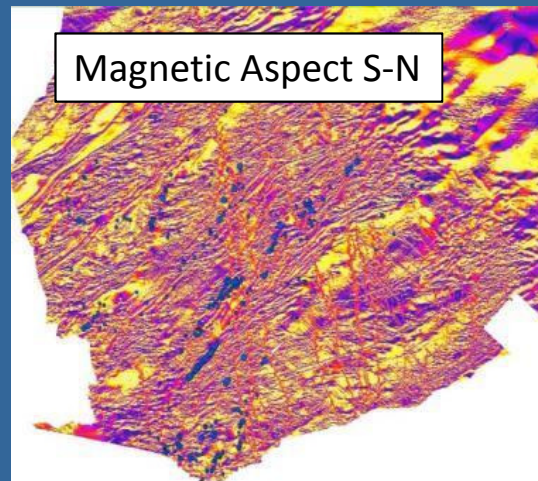
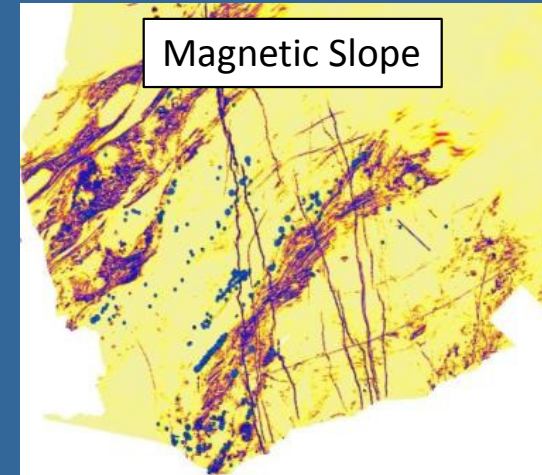
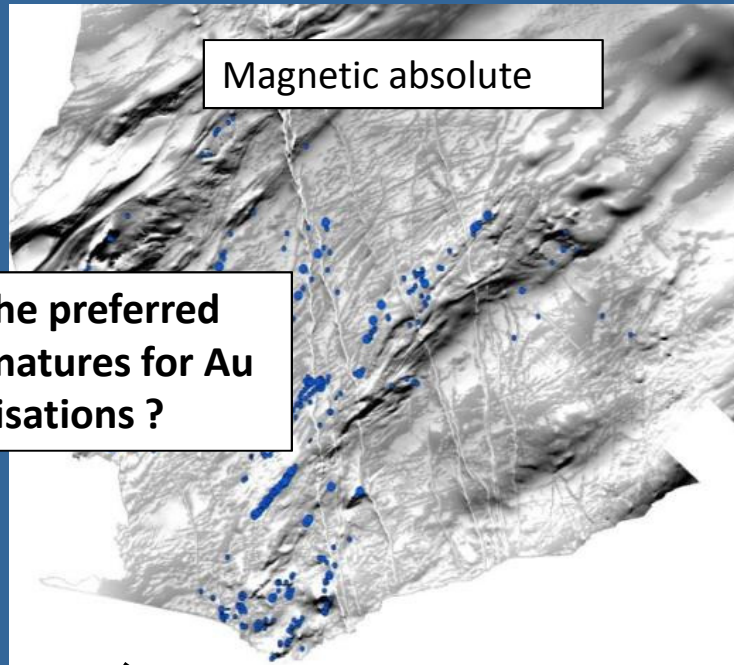
④ Preparation of Model Input Data

⑤ Setting Up and Running of Different Model Scenario

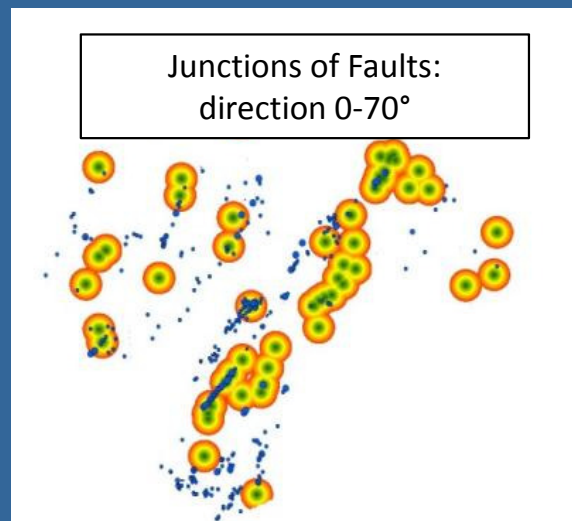
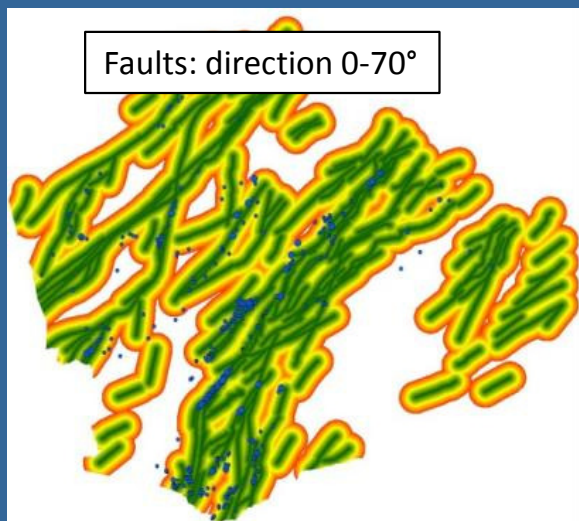
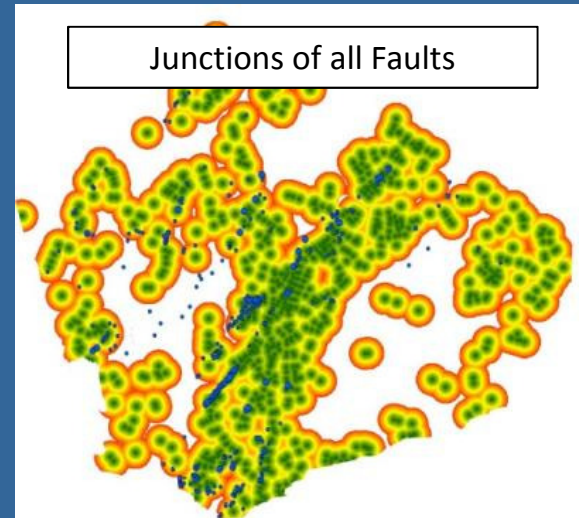
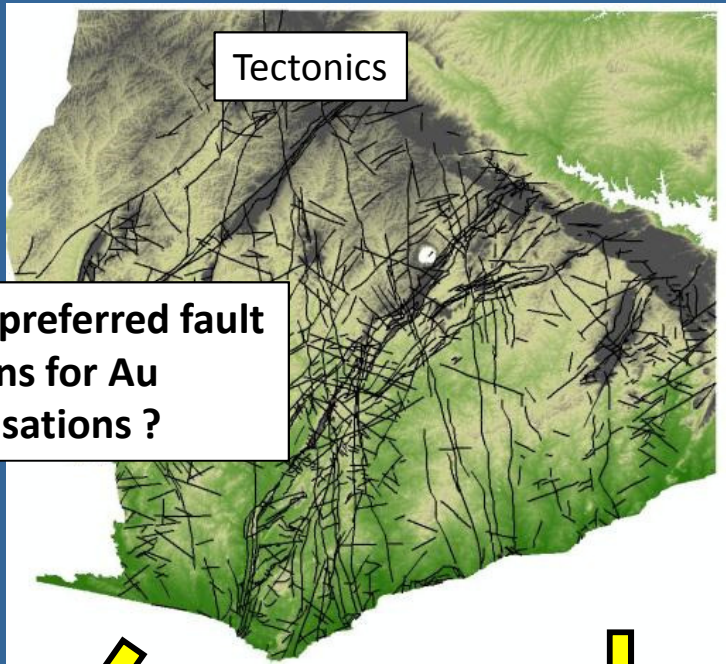
⑥ Presentation of Final Model Scenario Results



# Processing of Magnetic Data: Derivatives



# Processing of Tectonic Data: Direction / Intersections





# Processing of Tectonic Data: Size

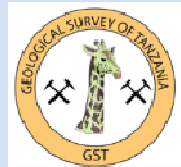
Tectonics

What are the preferred fault sizes for Au mineralisations ?

Faults (big > 36km)

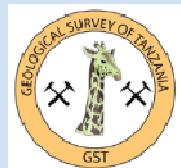
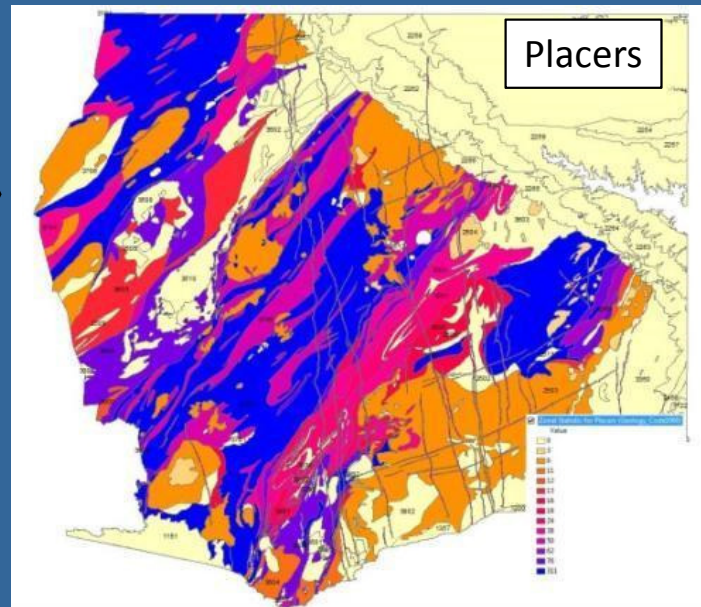
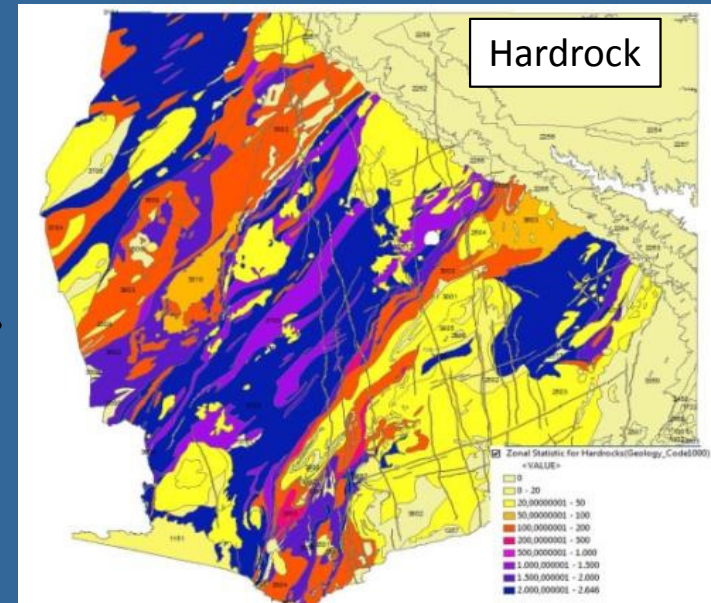
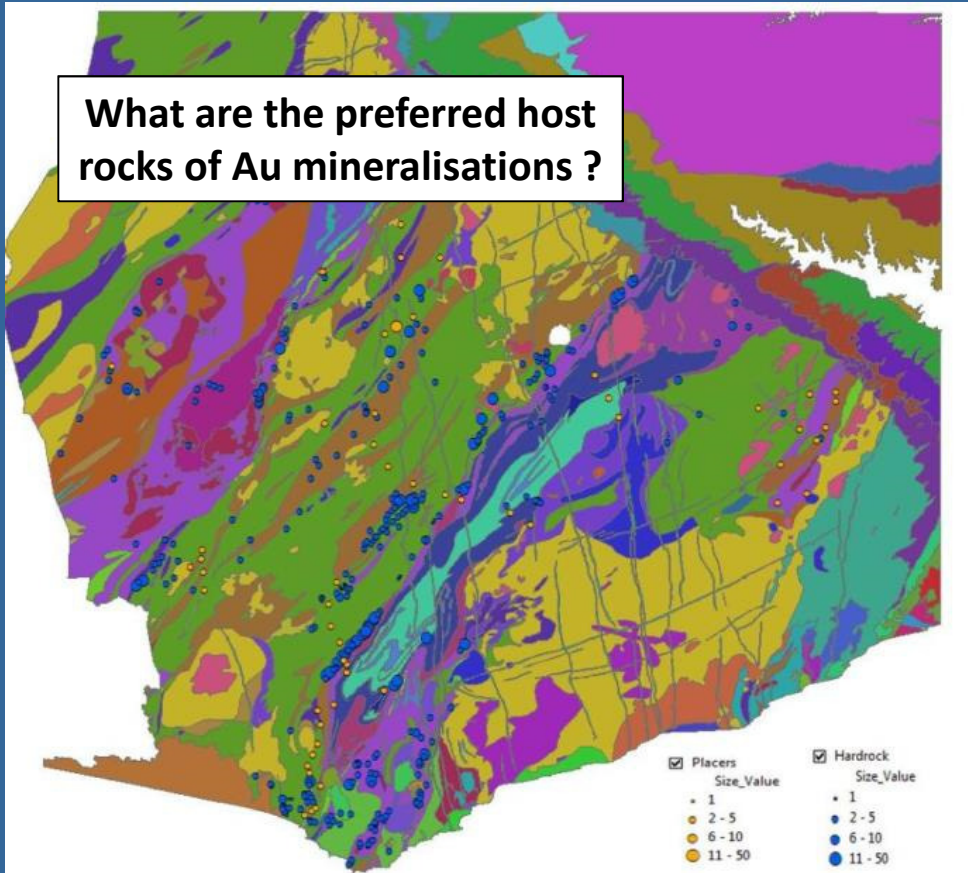
Faults (small < 14km)

Faults (medium 14-36 km)



# Processing of Geological Data: Rock Units

What are the preferred host rocks of Au mineralisations?



# How to Build a Predictive Model?

① Definition of Model Accuracy / Resolution and Extent

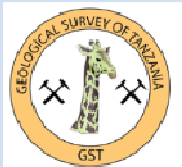
② Selection and Harmonization of Source Data

③ Processing of Source Data

④ Preparation of Model Input Data

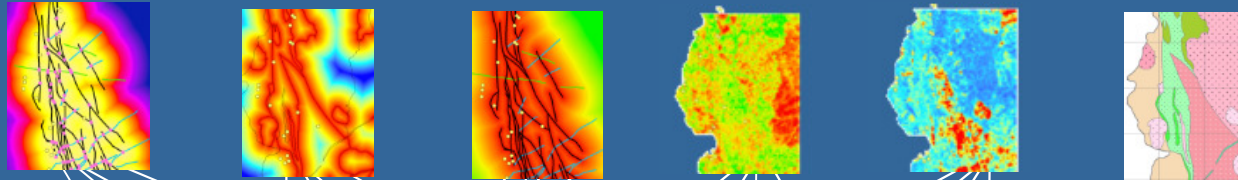
⑤ Setting Up and Running of Different Model Scenario

⑥ Presentation of Final Model Scenario Results



# Qualitative Model: Setup

Input Data / Layers



Weights

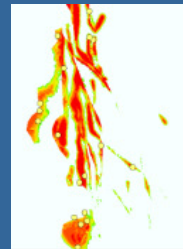
Hidden Layers



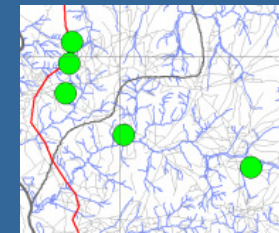
Weights

Output Layer

Result: Probability



Training Data



Known Mineralisations

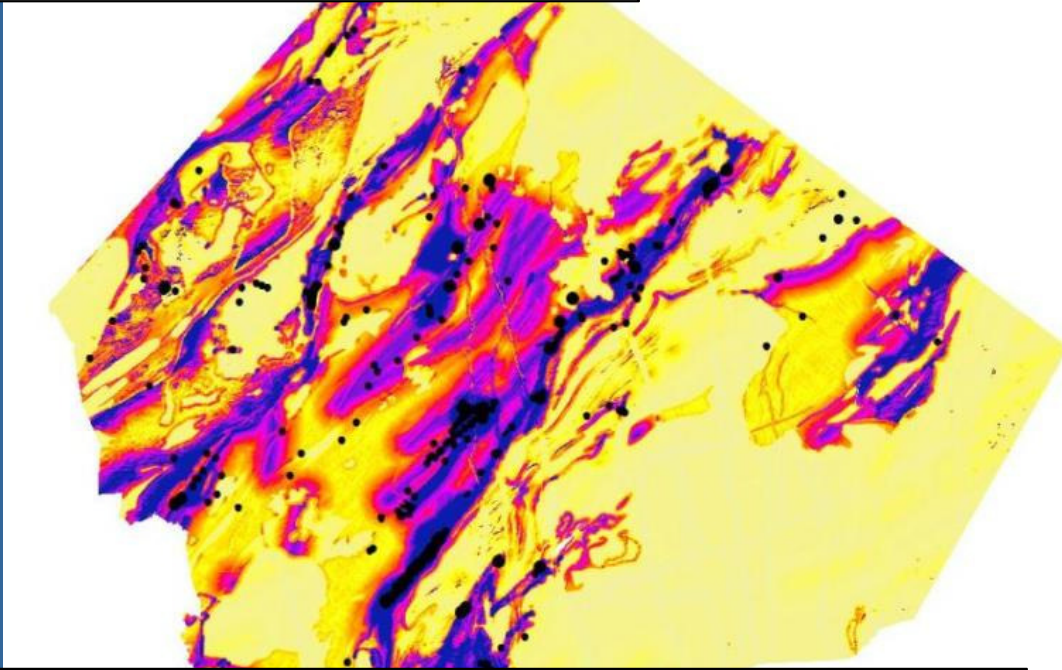
Validation



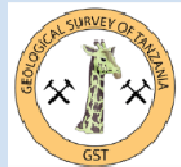
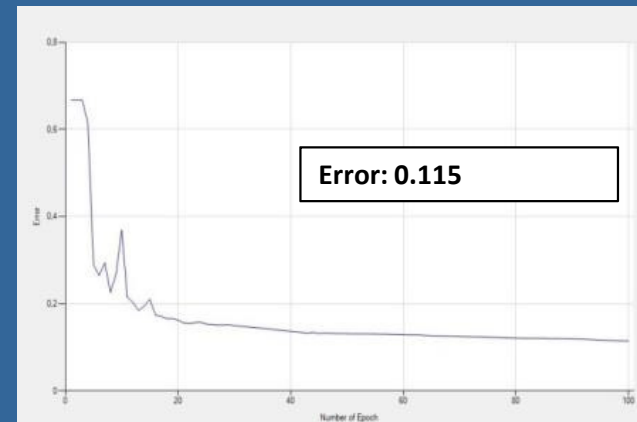
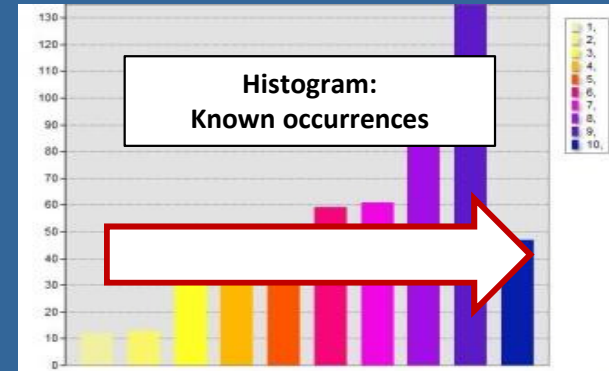
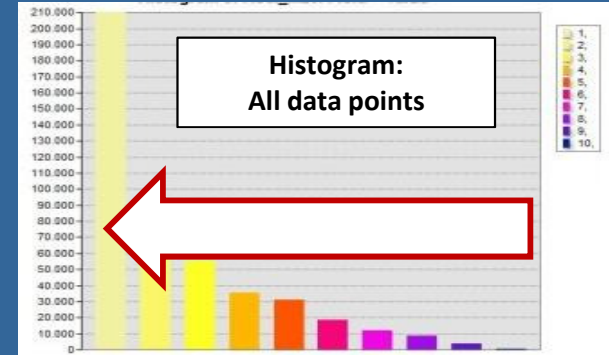
# Qualitative Models: Gold in Hard Rocks

## Input Data

- Large faults
- Striking direction 5 – 75 degrees
- Junctions
- Small faults
- Geology

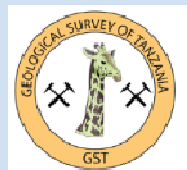
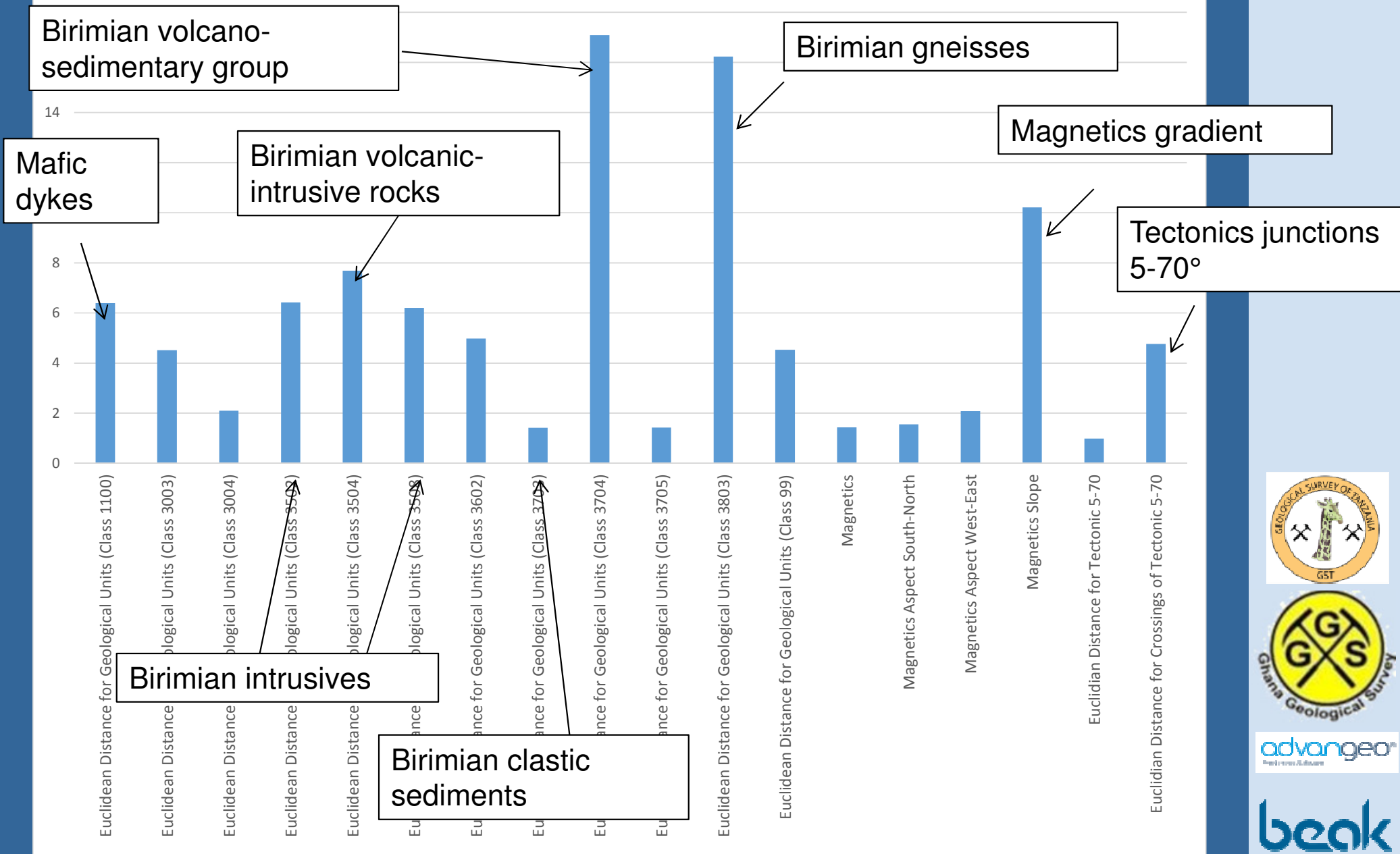


- Very clear spatial pattern
- Prospective zones are small
- Prospective zones are focused
- Most of known occurrences are located in high potential areas
- Low error: approx. 0.115



# Importance / Significance of Input Data Layers

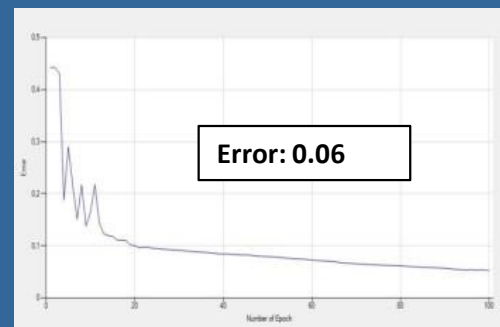
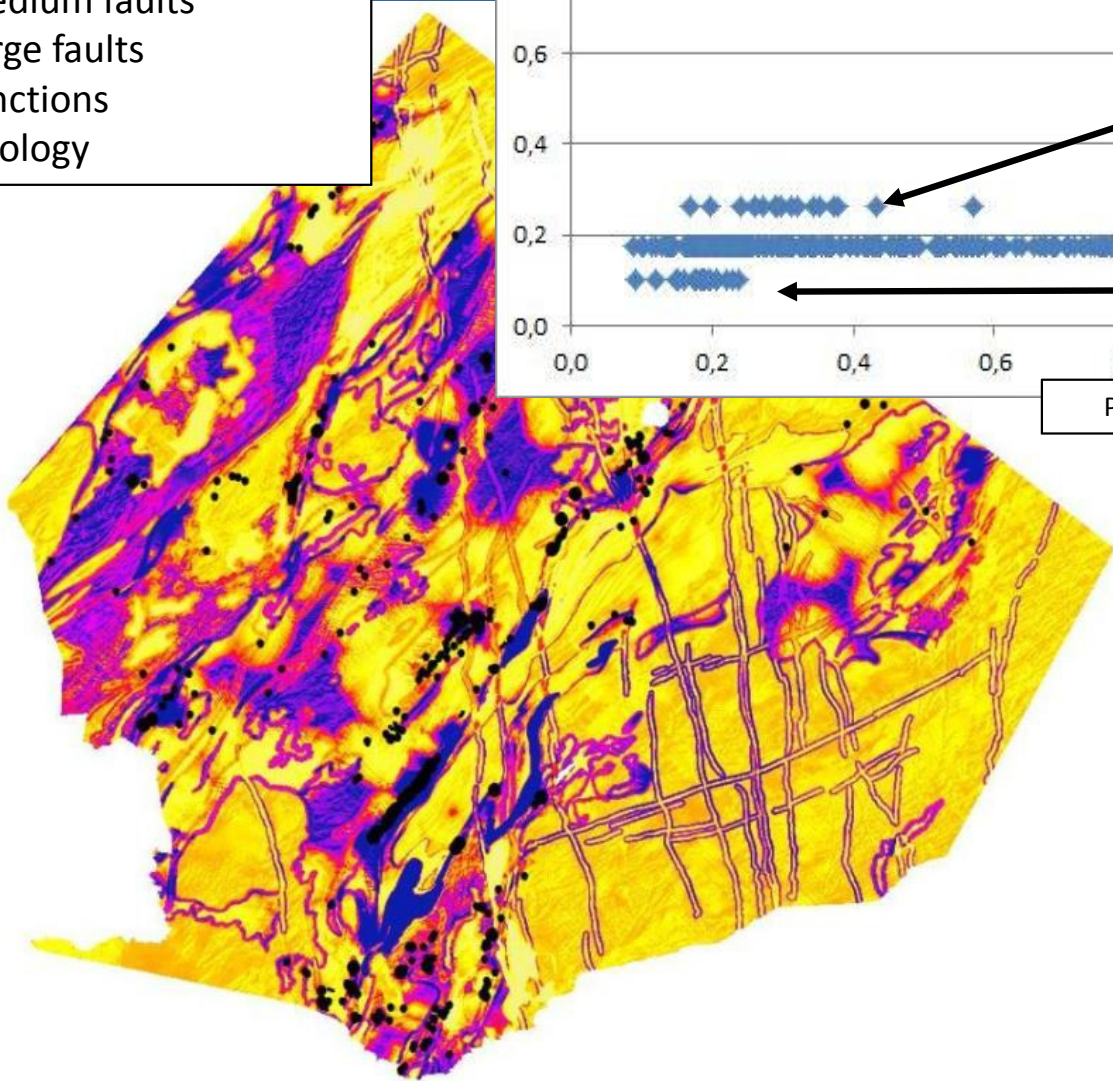
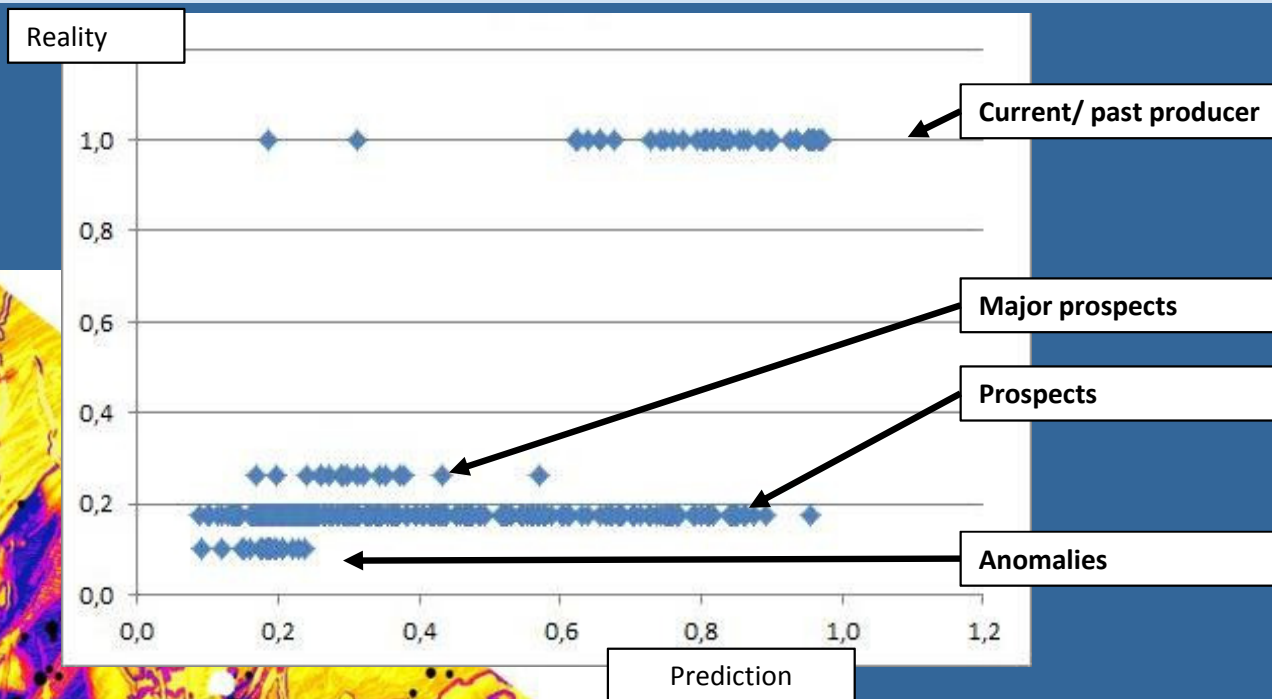
Connection Weights after "Garson's Algorithm"



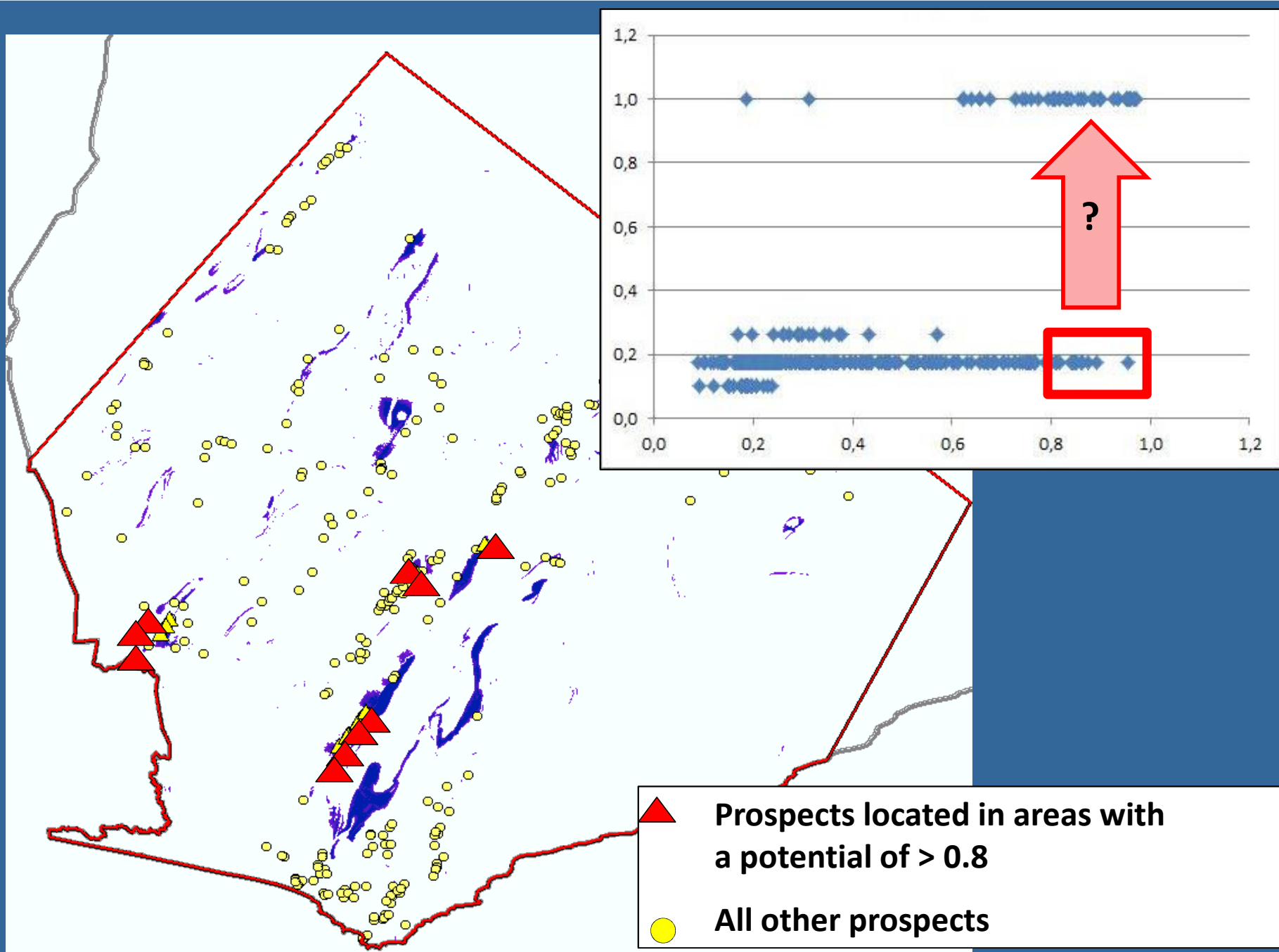
# Quantitative Models: Gold in Hard Rocks

## Input Data

- Magnetics, absolute
- Magnetics, slope
- Magnetics, aspect
- Medium faults
- Large faults
- Junctions
- Geology



# The Most Prospective Targets



- ▲ Prospects located in areas with a potential of  $> 0.8$
- All other prospects





# How to Build a Predictive Model?

① Definition of Model Accuracy / Resolution and Extent

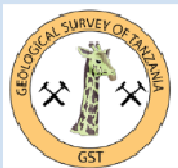
② Selection and Harmonization of Source Data

③ Processing of Source Data

④ Preparation of Model Input Data

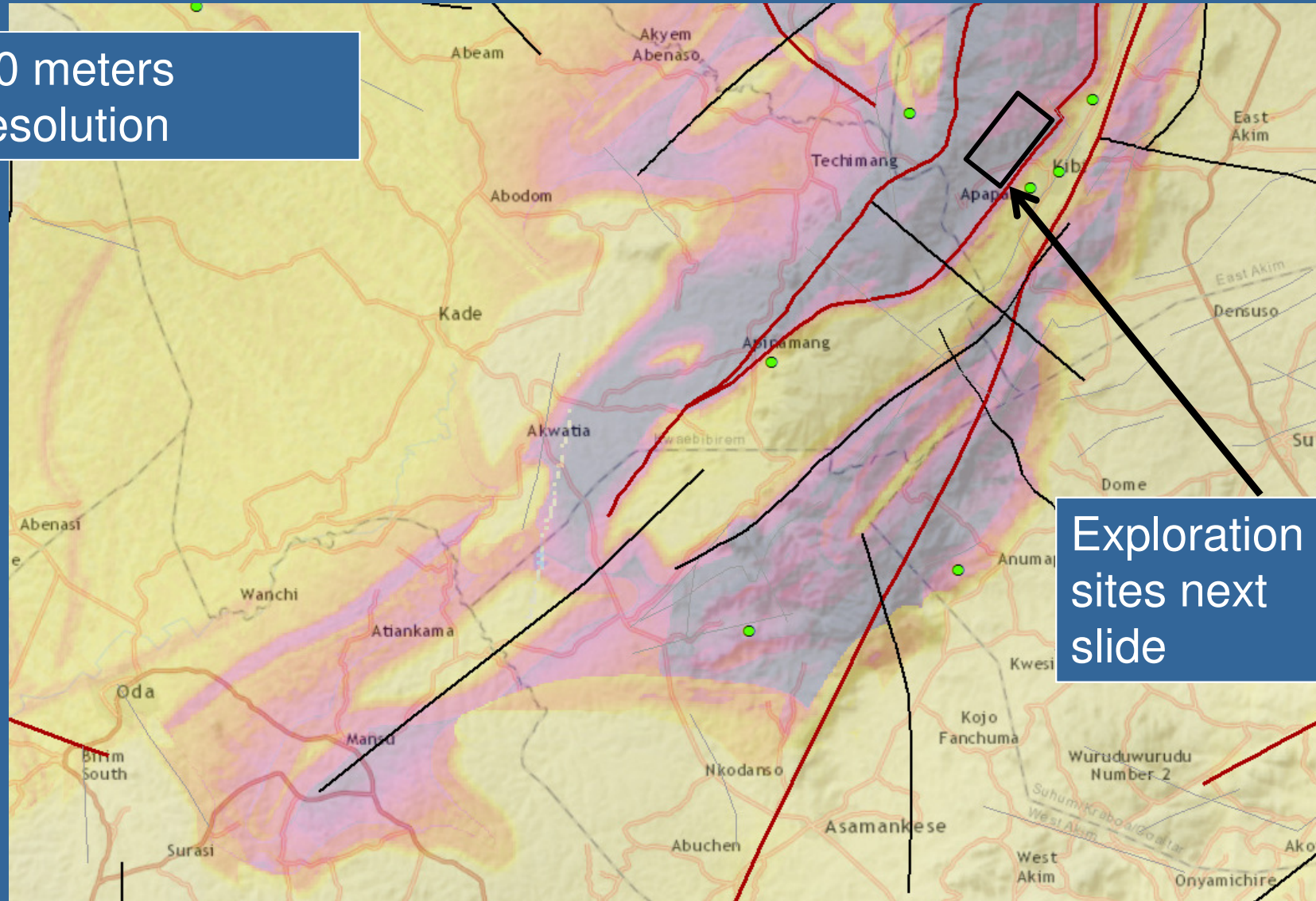
⑤ Setting Up and Running of Different Model Scenario

⑥ Presentation of Final Model Scenario Results

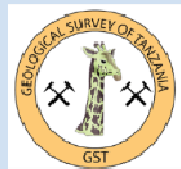


# The Model Accuracy: Kibi Belt

50 meters  
resolution



Exploration  
sites next  
slide

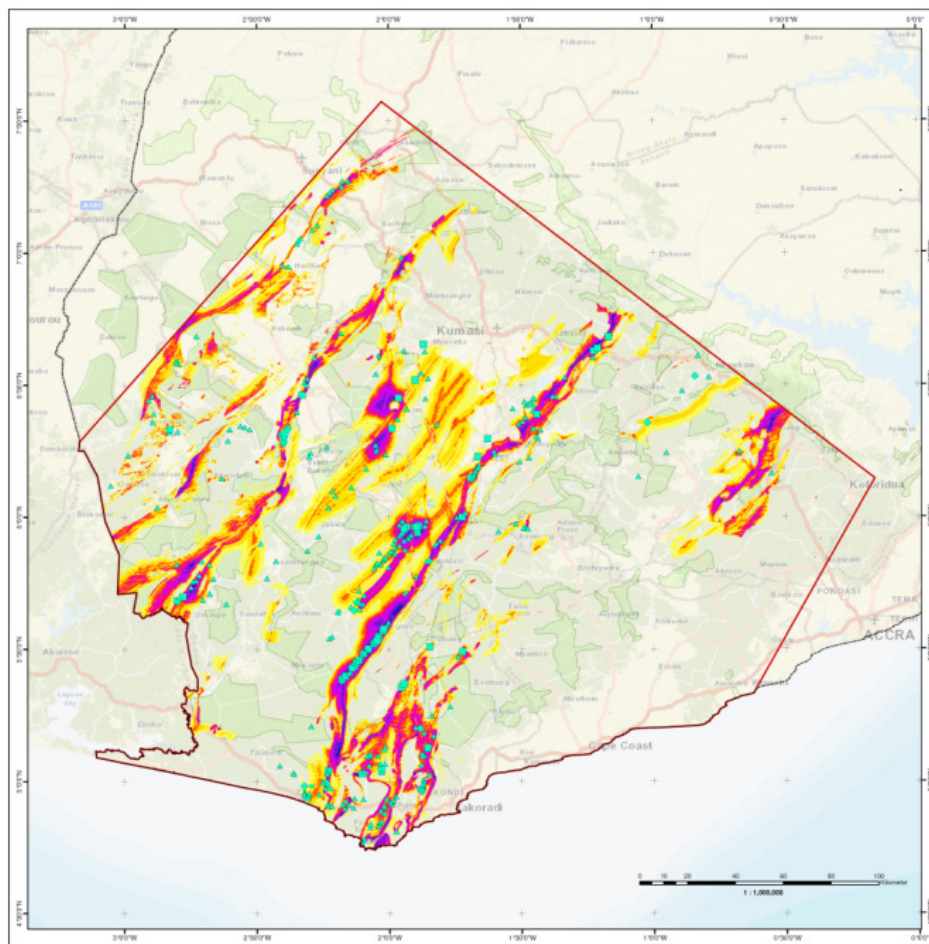


# Exploration Lines Near Kibi



# Final Map Product

## GOLD POTENTIAL MAP OF SW - GHANA Hard Rock Gold Mineralisations Scale 1 : 1,000,000



### Legend

- Gold Potential in Hard Rocks**
- low
  - medium
  - high
- Known Gold Deposits / Occurrences in Hard Rock Type**
- Salt Anomaly
  - ▲ Prospect
  - ▲ Major Prospect
  - Current / Past Producer
  - Unknown

- Forest Reserve
- Investigation Area
- Administrative Boundary



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[www.ghana-mining.org](http://www.ghana-mining.org)

**Scientific processing**  
K.O. Boateng, J.A. Duroto

**Topography**  
World Street Map  
© by ESRI 2011



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**Scientific processing**  
S. Antiquus

**Map projection**  
Transverse mercator  
UTM Zone 30N



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90504 Freiberg, Germany  
Managing Director: A. Barth  
[www.beak.de](http://www.beak.de)

**Scientific processing**  
A. Strüben, S. Neack, A. Barth

**Cartography: GIS**  
A. Strüben, C. Reppert

**Modeling**  
Predictive modelling by  
advangeo® geospatial software

September 2013

The information presented on this map has been collected from a number of data sources. Although all data has been processed and presented in a uniform manner, it may be subject to errors and omissions. The map is provided as a general guide only and should not be used for any specific purpose. The user should consult the relevant authorities for more detailed information. The map is not a liability of the Geological Survey Department.

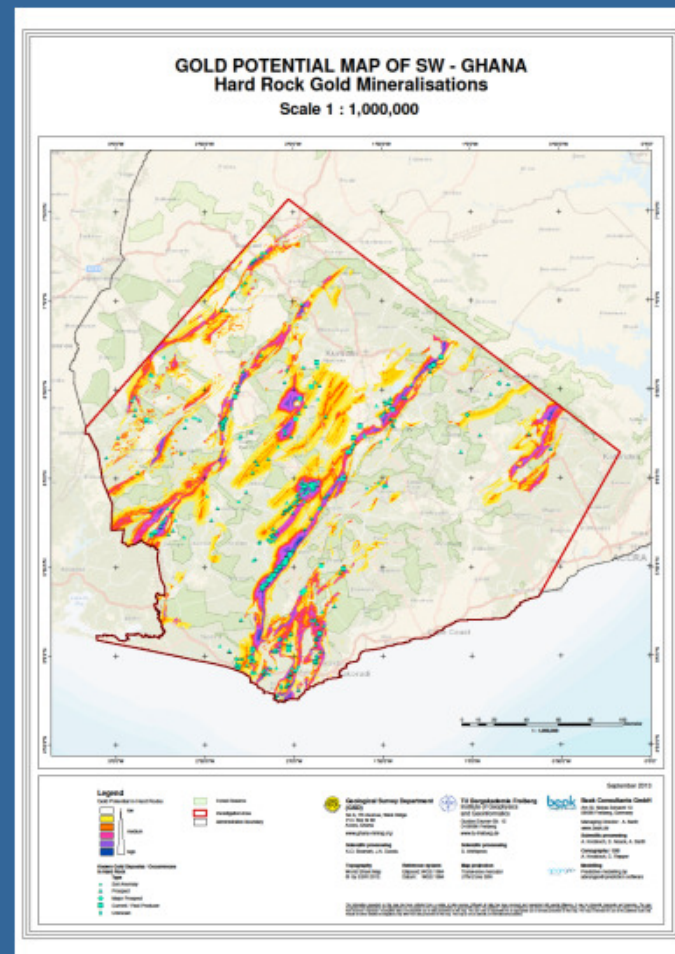


# Conclusions

- Neural network based mineral predictive maps:
  - Are data driven
  - Are not biased
  - Are easy to create



- Organizes any kind of geological data
- Supports neural network based exploration targeting
- Fully ESRI GIS and database integrated



# Thank you for your attention

More information at  
Our booth and our web site  
[www.beak.de](http://www.beak.de)

The SW Ghana Gold low resolution map is available at:

[http://www.beak.de/beak/sites/default/files/content/7\\_News/174\\_23\\_Sep\\_2013/Ghana\\_Au\\_LO\\_W.pdf](http://www.beak.de/beak/sites/default/files/content/7_News/174_23_Sep_2013/Ghana_Au_LO_W.pdf)

The Geological and Mineral Information System of Tanzania is available at:

[www.gmis-tanzania.com](http://www.gmis-tanzania.com)

We wish to thank our clients, partners and supporters for the excellent co-operation.

