

Gold Potential Mapping in South-West Ghana Using Advangeo® Prediction Software: Database, Approach, Results, Benefits

How to find new exploration targets in an old mining area?

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Kwame Odame Boamah, John O. Duodu

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Agenda

- Gold in South-West Ghana
- Database
- Predictive Mapping Technology
- Results
- Application
- Conclusion

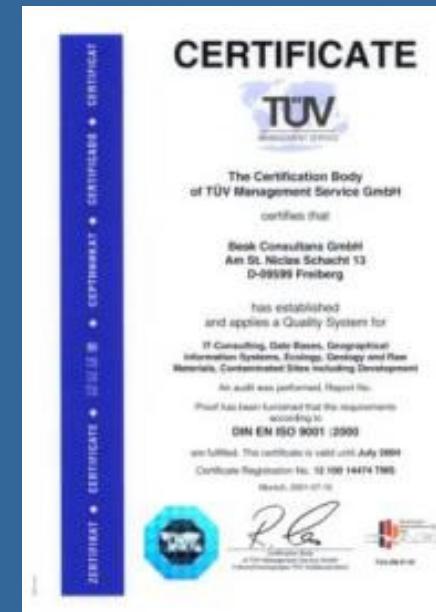


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geospatial solutions

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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



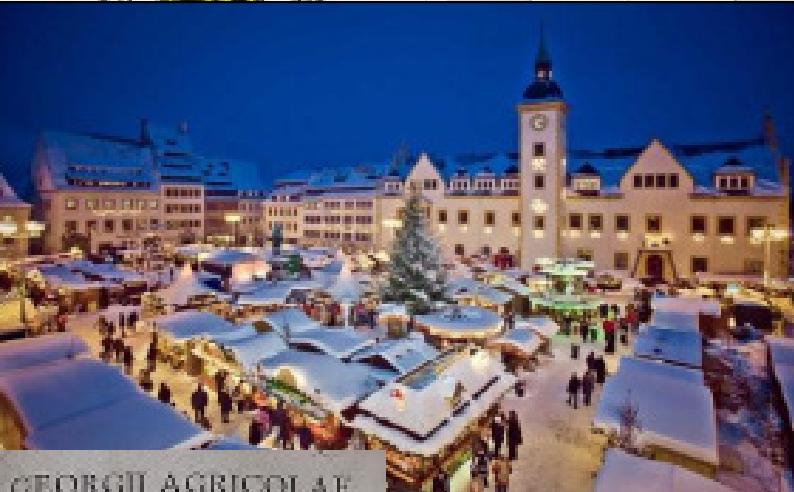
Geological Survey Department of Ghana



- Principle geoscientific governmental body of Ghana
- Hosts the national geoscientific data.
- Cooperation GSD – Beak Consultants since 2005



Mining University Freiberg



- founded in 1765
- the most attractive University with bias in Mining and Geology
- > 1000 Students in Mining and Geosciences
- Cooperating with Beak Consultants since 15 years

Helmholtz-Institut Freiberg für Ressourcentechnologie



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geological survey

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Gold in South-West Ghana

- Prime product of Ghana for thousands of years
- Annual production reaches 134 t (2012)
- Income for millions of people



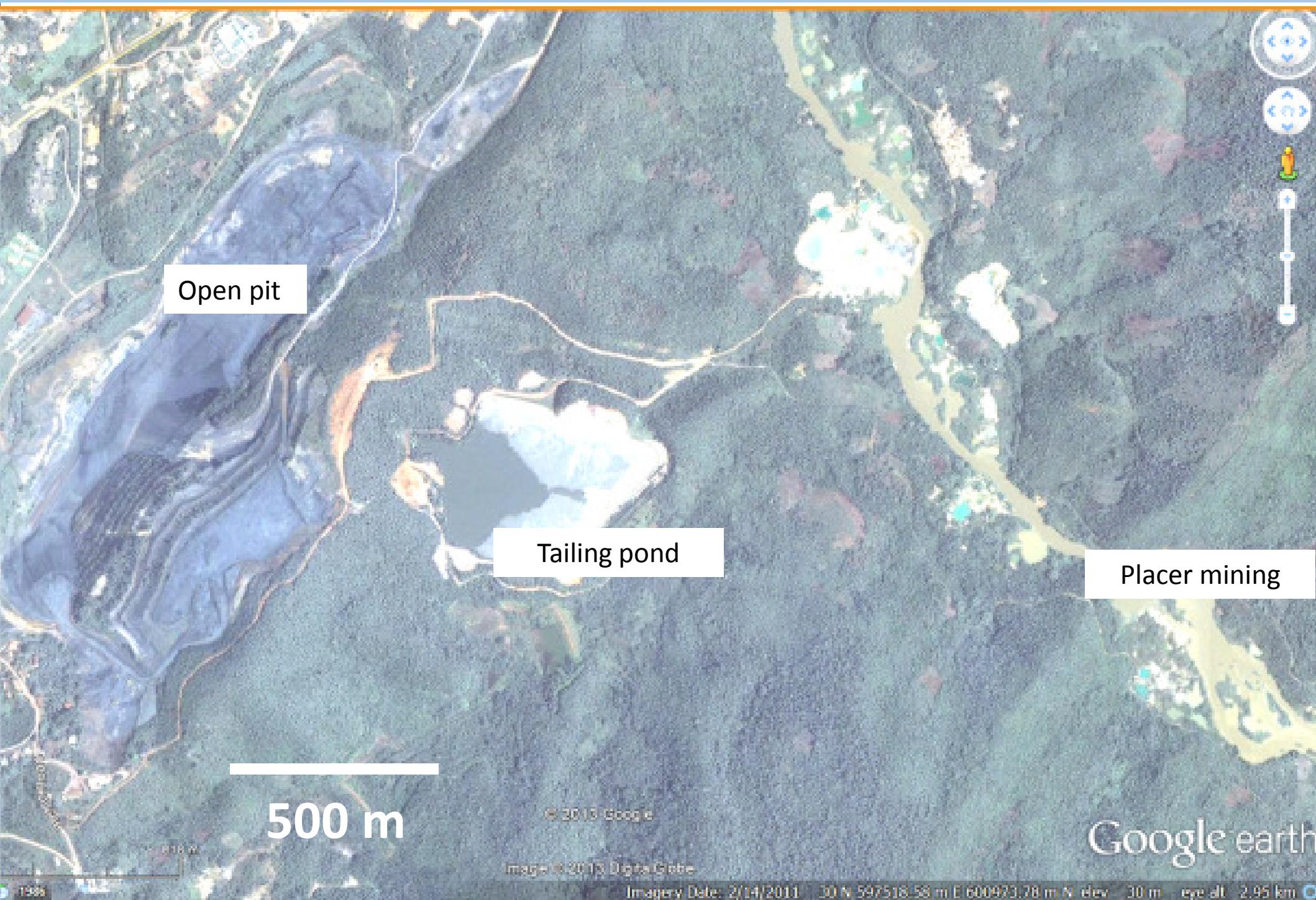
- Destroys landscapes
- Consumes land
- Competes with other land use
- Creates conflicts



advanGeo
Geological Survey

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Gold Mining at Prestea



500 m

© 2013 Google

Image © 2013 DigitalGlobe

Imagery Date: 2/14/2011 30°N 59°25'18.58" E 60°09'17.78" N elev: 30 m eye alt: 2.95 km

Google earth

Small Scale Gold Mining at Dunkwa



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If we knew where the Gold is, we could....

- Safe exploration funds
- Attract more investment
- Guide the industry and ASM
- Foresee and manage land use conflicts
- Protect resources & environment
- Improve infrastructure planning
- do many more important things ...



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Approaches of Predictive Mapping

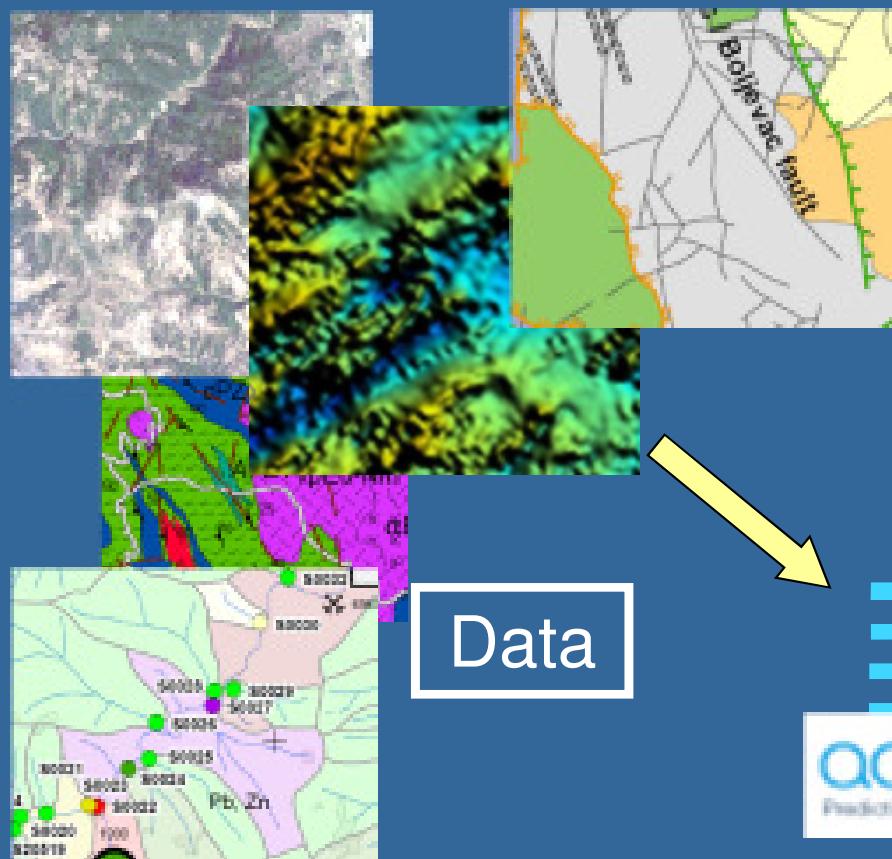
- Data driven:
 - neural networks
 - logistic regression
- Knowledge driven:
 - fuzzy logic
 - weights of evidence
 - simple summarizing of relevant information



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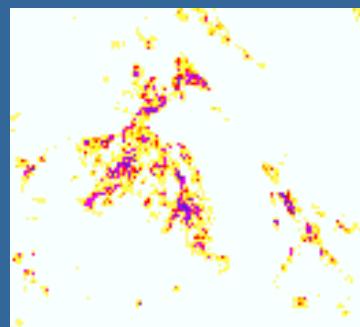
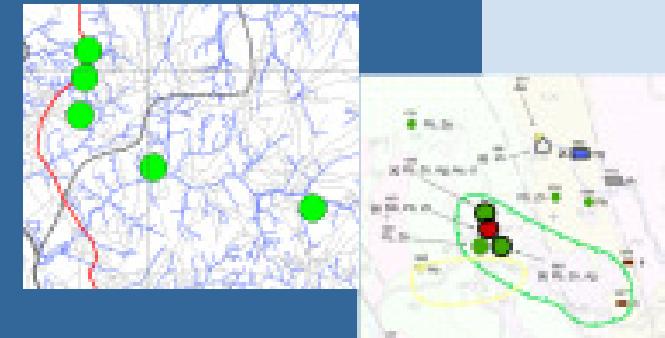
Using artificial neural networks



Data



Locations



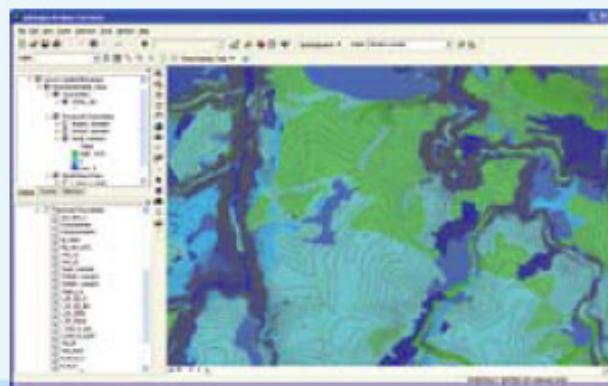
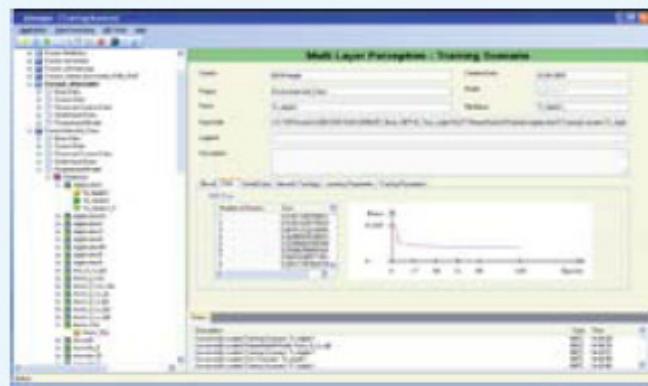
Validation



The predictive maps:

- probabilities
- grades
- resources ...

Advangeo Software Structure



Data and Model Explorer

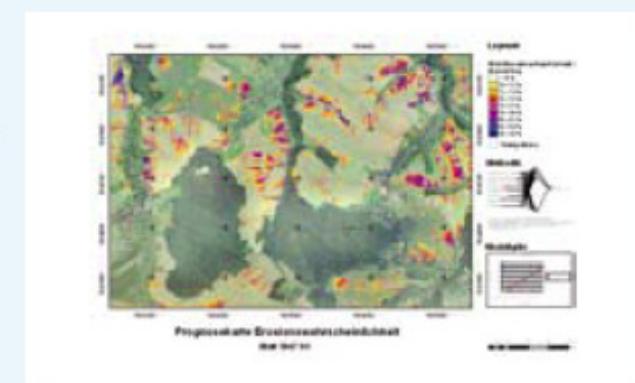
GIS Extension

Metadata

Spatial Data

advangeo's components

Referenced Data Resources



Prediction Presentation



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Prediction Software

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How to build a predictive model with advangeo ?

advangeo - [List Base Data]

Application Data Processing Extensions GIS Tools Help

Projects
Gold SW Ghana - Knobloch
Base Data
Project Area
Model Area
TrainArea
TrainArea2
Source Data
Deposits & Occurrences
Elevation
Geology (SW-Ghana)-1000m Buffer
Geology (SW-Ghana)-1000m Buffer by C
Geophysics - Magnetics 1
Geophysics - Magnetics 2
Stratigraphy (SW-Ghana) - 1000m Buffer
Tectonic (5-70 degrees; medium; big)
Tectonic
Processed Source Data
AlluvialData
Deposits & Occurrences
Elevation
Geology (SW-Ghana)-1000m Buffer
Geology (SW-Ghana)-1000m Buffer by C
Geophysics - Magnetics 1
Geophysics - Magnetics 2
Rock Contact (SW-Ghana) - 5000m Buffer
Stratigraphy (SW-Ghana) - 1000m Buffer
Tectonic (5-70 degrees; medium; big)
Tectonic
Model Input Data
AlluvialData
Deposits & Occurrences
Elevation
Geology (SW-Ghana)-1000m Buffer
Geology (SW-Ghana)-1000m Buffer by C
Geophysics - Magnetics 1
Geophysics - Magnetics 2
Rock Contact (SW-Ghana) - 5000m Buffer
Stratigraphy (SW-Ghana) - 1000m Buffer
Tectonic 5-70
Tectonics - All
Tectonics - Direction
Tectonics - Length
Parameterized Model
Prediction
Model 001
Model 002
Model 003
Model 004
Model BS1_027_1s_magn_abv_slope_a
Model BS1_028_1s_magn_abv_slope_a
Model BS1_029_1s_ZStatMaccM25_1
Model BS1_031_1s_ED_Flonh425gE0
Model BS1_032_1s_M26_251stFlkoch26_ED_FlowLines_FlowAccFromM26
Model BS1_033_1s_M26_251stFlkoch26clipped_ED_FlowLines_FlowAccFromM26
Model BS2_4_005_BY (magn_abv)
Model BS2_4_006_magn_abv_slope
Model BS2_4_007_magn_abv_slope_aspect

Project\Gold SW Ghana - Knobloch\Base Data

Name	File Name	Creation Date
TrainArea2	TrainArea2.hrp	16.08.2013 08:40:04

Step 1: Setting model accuracy and area

Step 2: Selecting / harmonizing source data

Step 3: Processing source data

- Selecting attributes
- Creating data layers

Step 4: Preparing model input data

- Mapping source data to base grid
- Leveling data values

Step 4: Building the models

Info Error

Message Type

Project 'Gold SW Ghana - Knobloch' already loaded: Z:\Bearbeitung\advangeo\Ghana_01\Ghana_01.adv... WARNING



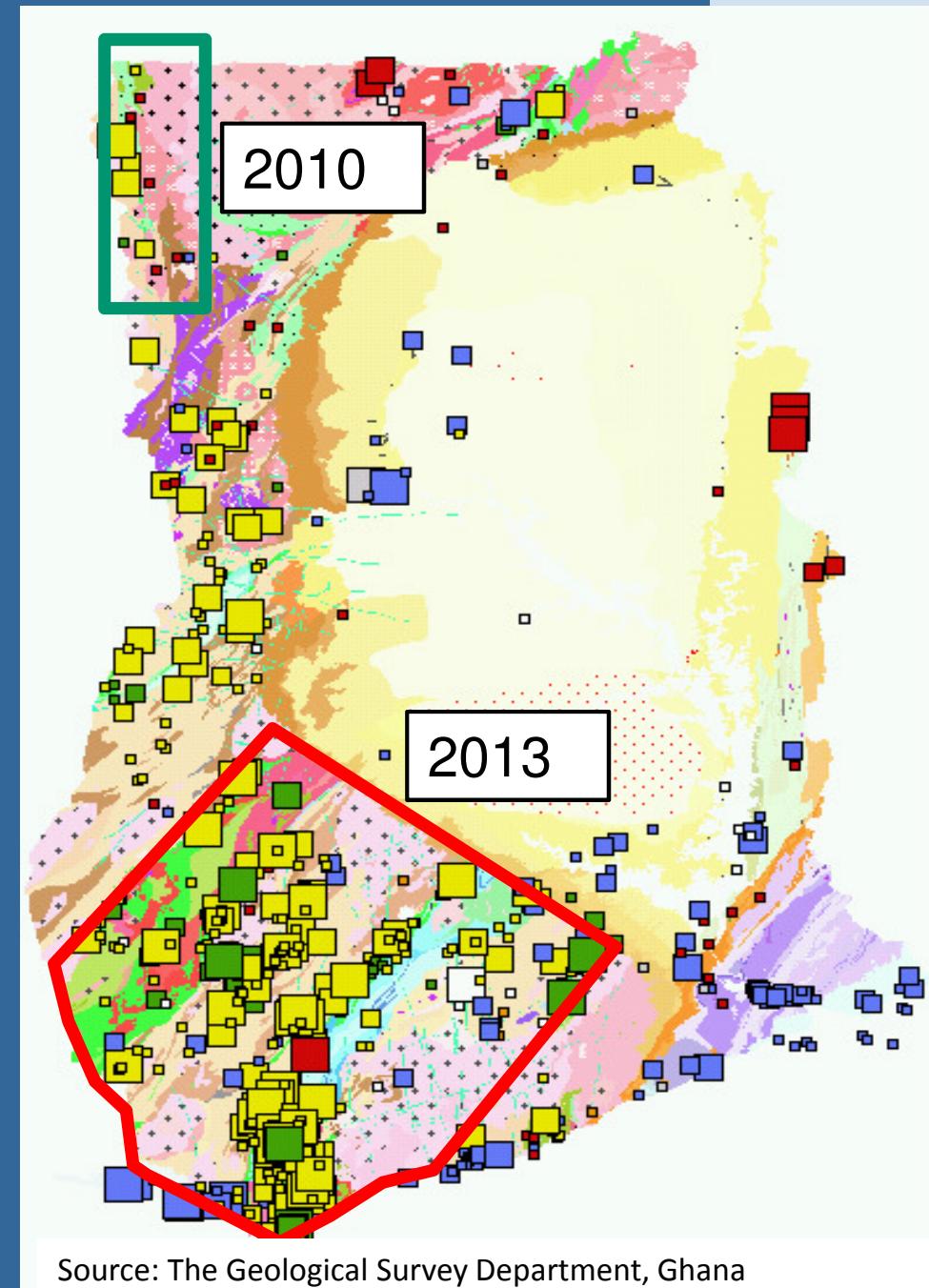
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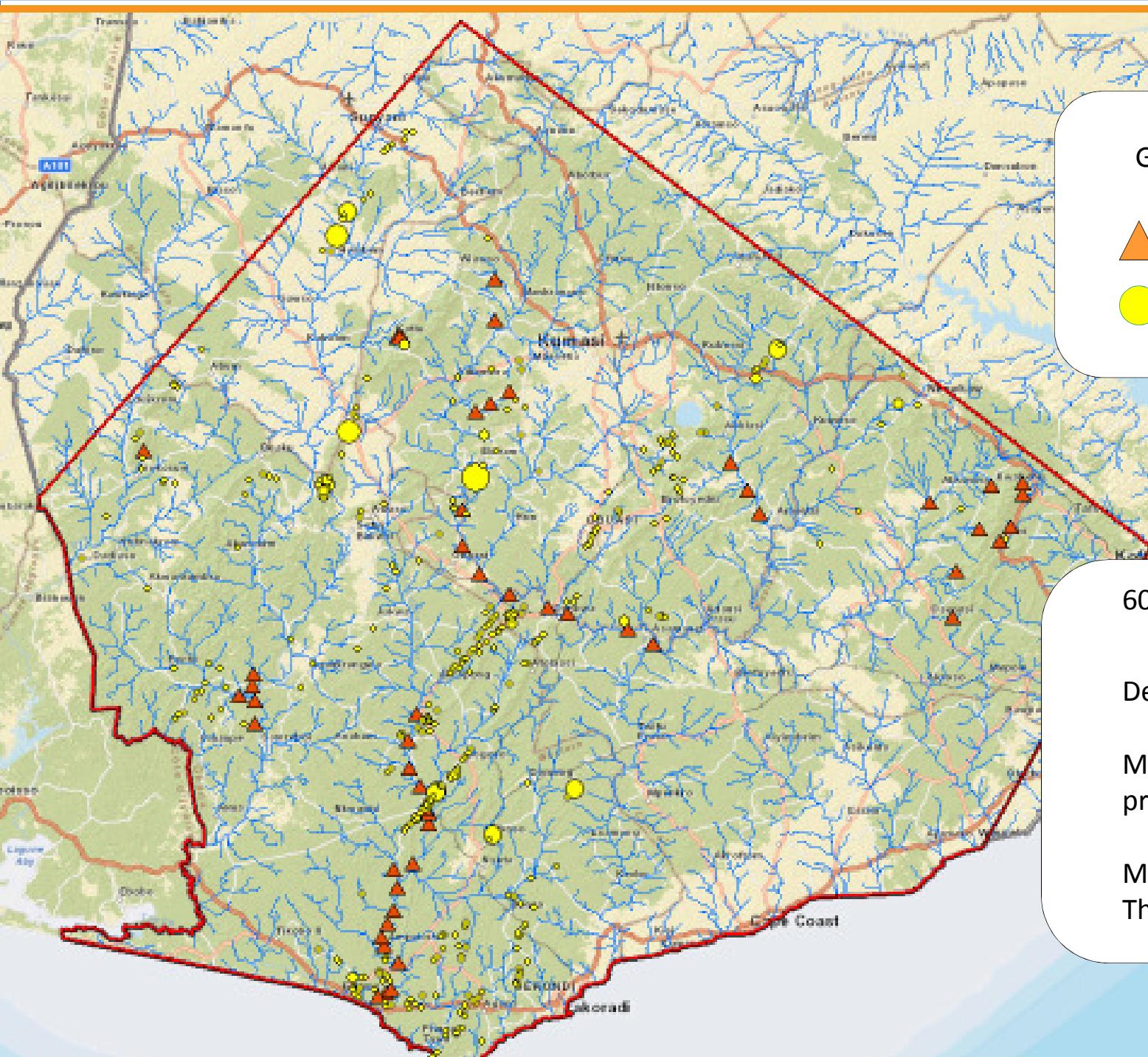
The project area

**Find new exploration targets
in well known mining areas**

- Reasonable size
- Acceptable data coverage
- Big economic importance
- Many stakeholders involved
- Base raster: 100m
- > 400 known occurrences



The project area



Gold deposit location



Placers



Hard rock

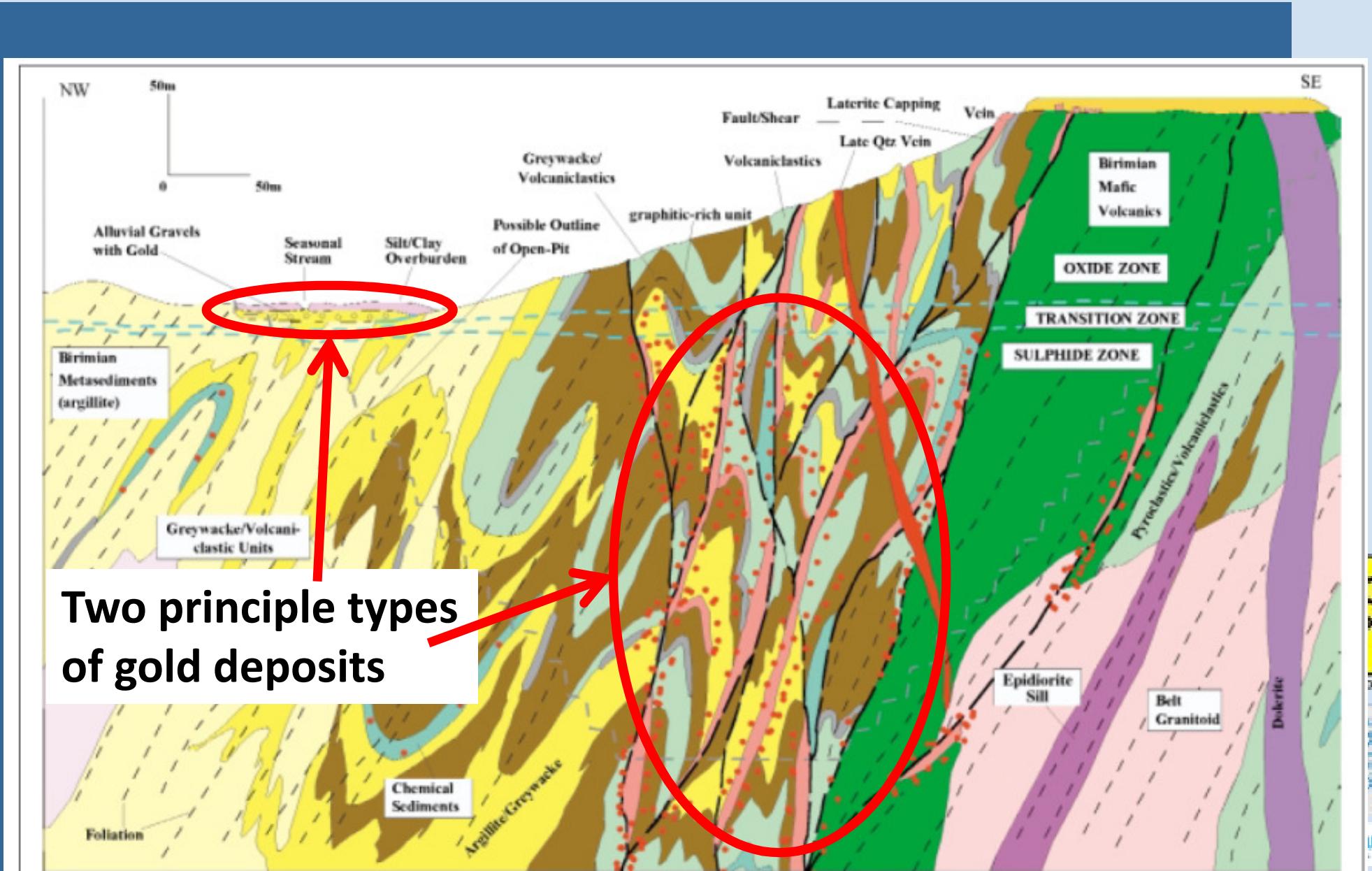
60,000 sqkm

Densely populated

Main area of gold production of Ghana

Mined for Hundreds/ Thousands of years

Metallogeny of hard rock & placer Gold in Ghana



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

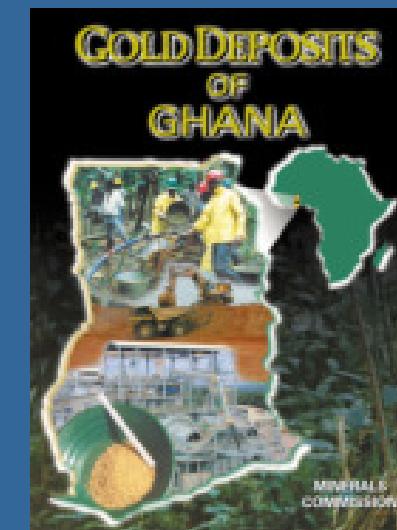
The metallogenic controlling factors

- Hard rock gold
 - Lithologies
 - Tectonic structures
 - Ages
- Placers
 - Distance from source
 - Power of source
 - Stream system properties



The Gold occurrence data

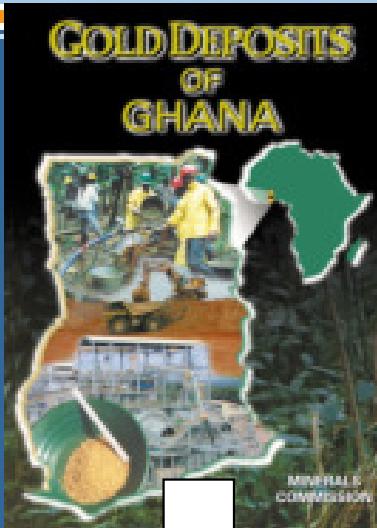
- Geodatabase Ghana, created during the MSSP 2005 – 2009:
 - Geological maps
 - Tectonic maps
 - Geophysical data
 - Mineral occurrence data
- Additional information:
 - published literature



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Harmonizing Gold occurrence data



ID COMMON	ID SIZE	COMMON SIZE	GENECA_CODE	DESCRIPTION	DEPOSITS	MENTIONED	PERIODICITY	TYPE	MIN. SIZE	SIZE_BUFF	SIZE_VALUE	Score	N
10	0	0	0	current producer		vein and stockwork system	0.073,460,28,402,17		0	500	50	4	
10	1	0	0	placer		vein system	11,121,30,3,201,480		0	200	5	2	
10	2	0	0	current producer		vein system	18,007,40		0	500	50	4	
10	1	0	0	current producer	metasediments and volcanoclastics	vein system	11,101,420		0	500	50	4	
10	1	0	0	prospect	metasediments and volcanoclastics	vein system	0,045,20,40	multiple oxide	0	500	50	4	
10	4	104	104	post prospect/producer	metasediments and volcanoclastics	vein system	1,620,3,200,40	multiple oxide	0	500	50	4	
10	4	104	104	post prospect/producer	sediments	vein system	0,469,000,70,2,1,660,120,1,1,60,24,5	conglomerates	0	500	50	4	
10	4	104	104	major prospect	metasediments and volcanoclastics	vein and stockwork system	2,602,1,40		0	500	50	4	
10	4	104	104	post prospect	metasediments and volcanoclastics	vein system	0,041,6,4,2,38,7,4,20,1,4,11,9,73		0	500	50	4	
10	4	104	104	post					0	500	50	4	
10	5	103	103	current					0	500	50	4	
10	0	0	0	current					0	500	50	4	
10	4	0	0	major					0	500	50	4	
10	1	101	101	pros					0	500	50	4	
10	1	0	0	pros					0	500	50	4	
10	1	0	0	pros					0	500	50	4	
10	4	0	0	major					0	500	50	4	
10	2	102	102	pros					0	500	50	4	
10	6	0	0	current					0	500	50	4	
10	1	101	101	pros					0	500	50	4	
10	1	101	101	major					0	500	50	4	
10	0	0	0	current					0	500	50	4	
10	4	0	0	major					0	500	50	4	
10	0	0	0	current					0	500	50	4	
10	4	104	104	pros					0	500	50	4	
10	6	0	0	current					0	500	50	4	
10	3	103	103	major					0	500	50	4	
10	1	101	101	pros					0	500	50	4	
10	4	0	0	major					0	500	50	4	
10	1	101	101	pros					0	500	50	4	
10	1	0	0	pros					0	500	50	4	
10	4	104	104	pros					0	500	50	4	
10	1	0	0	pros					0	500	50	4	
10	1	0	0	pros					0	500	50	4	
10	4	104	104	pros					0	500	50	4	
10	1	101	101	pros					0	500	50	4	

The project database

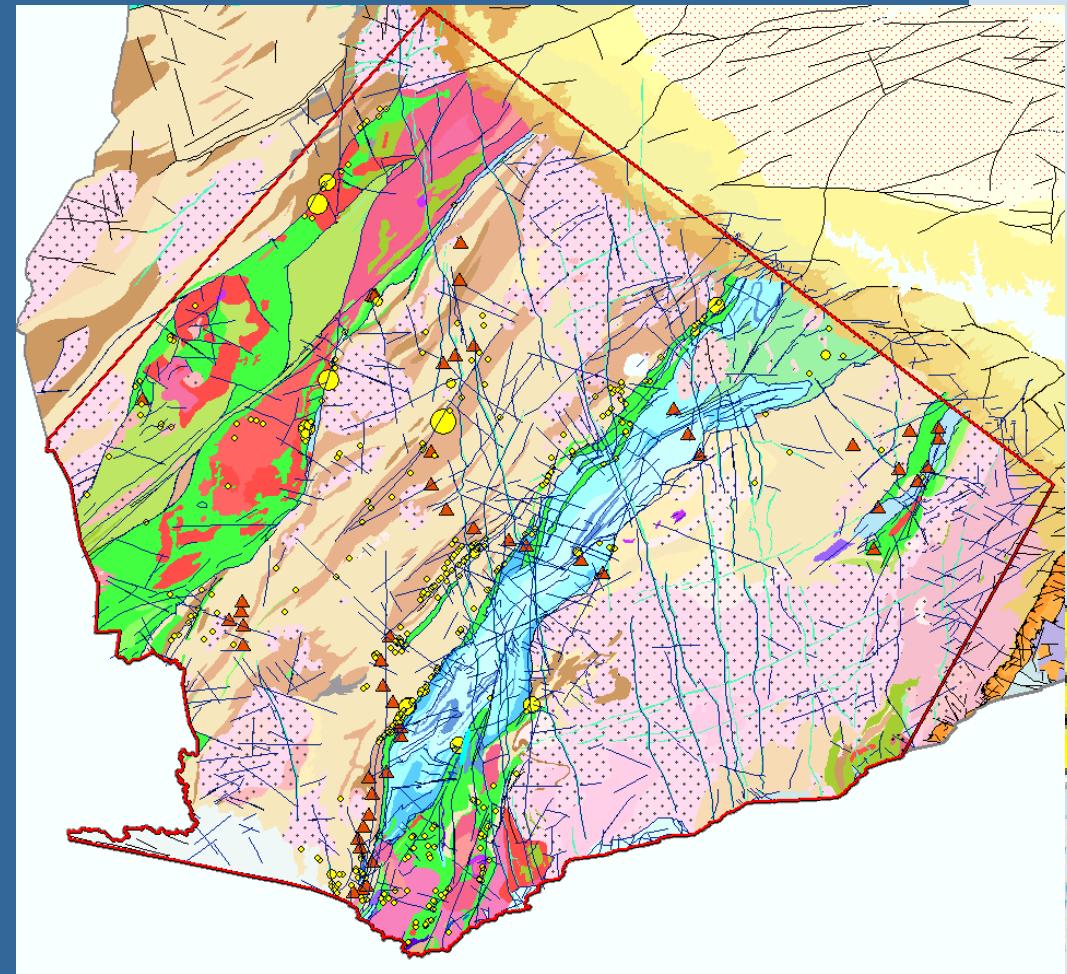
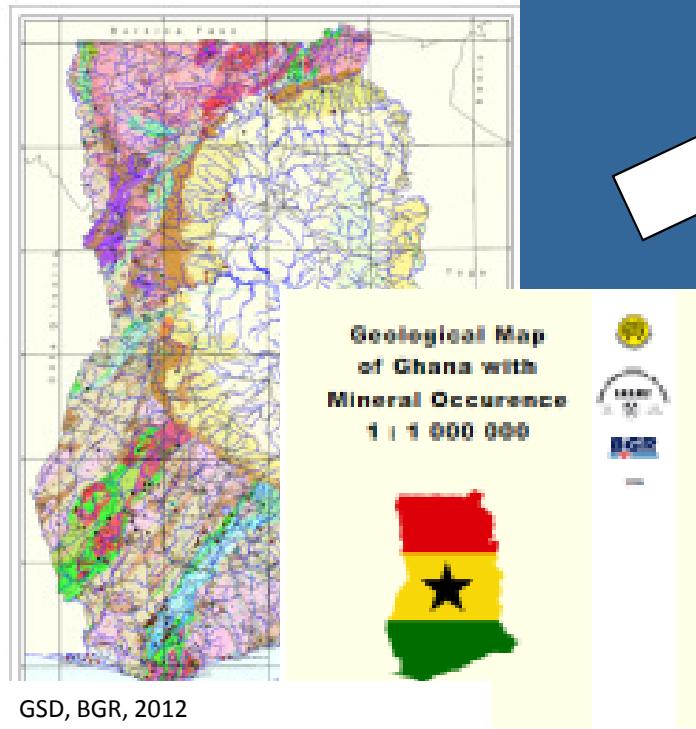
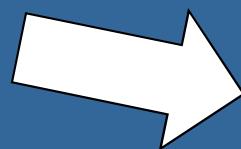
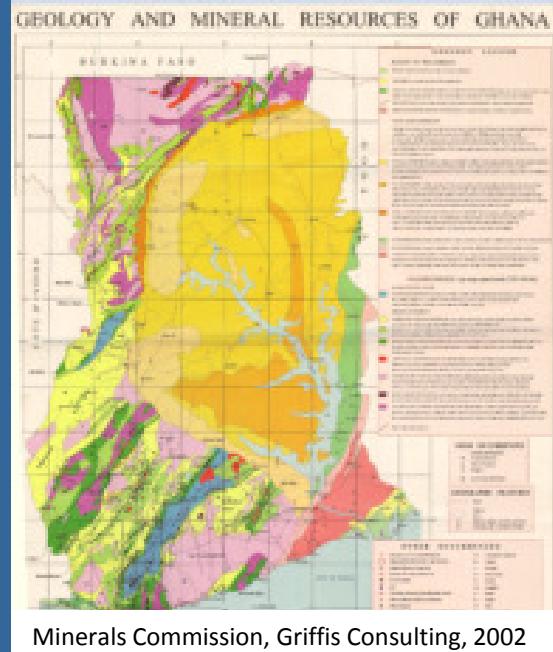
- Exact location
- Genetic type
- Host rocks
- Ressources
- Size
- Producer

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

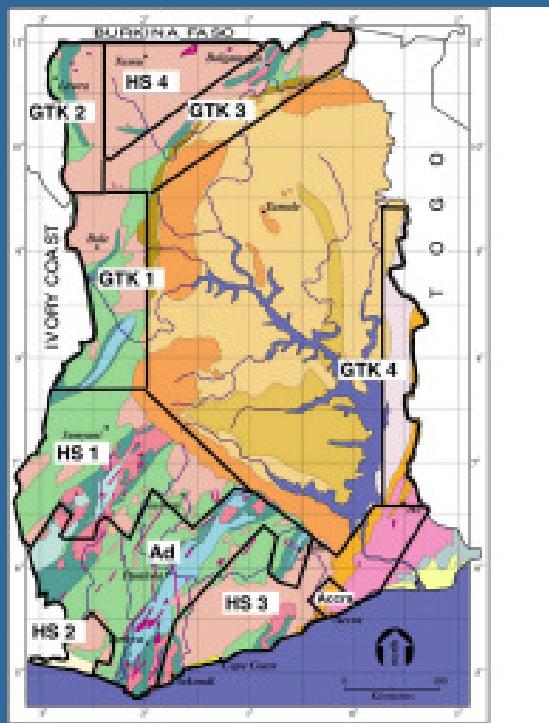
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Harmonizing geological & tectonic data



Processing / harmonizing geophysical data



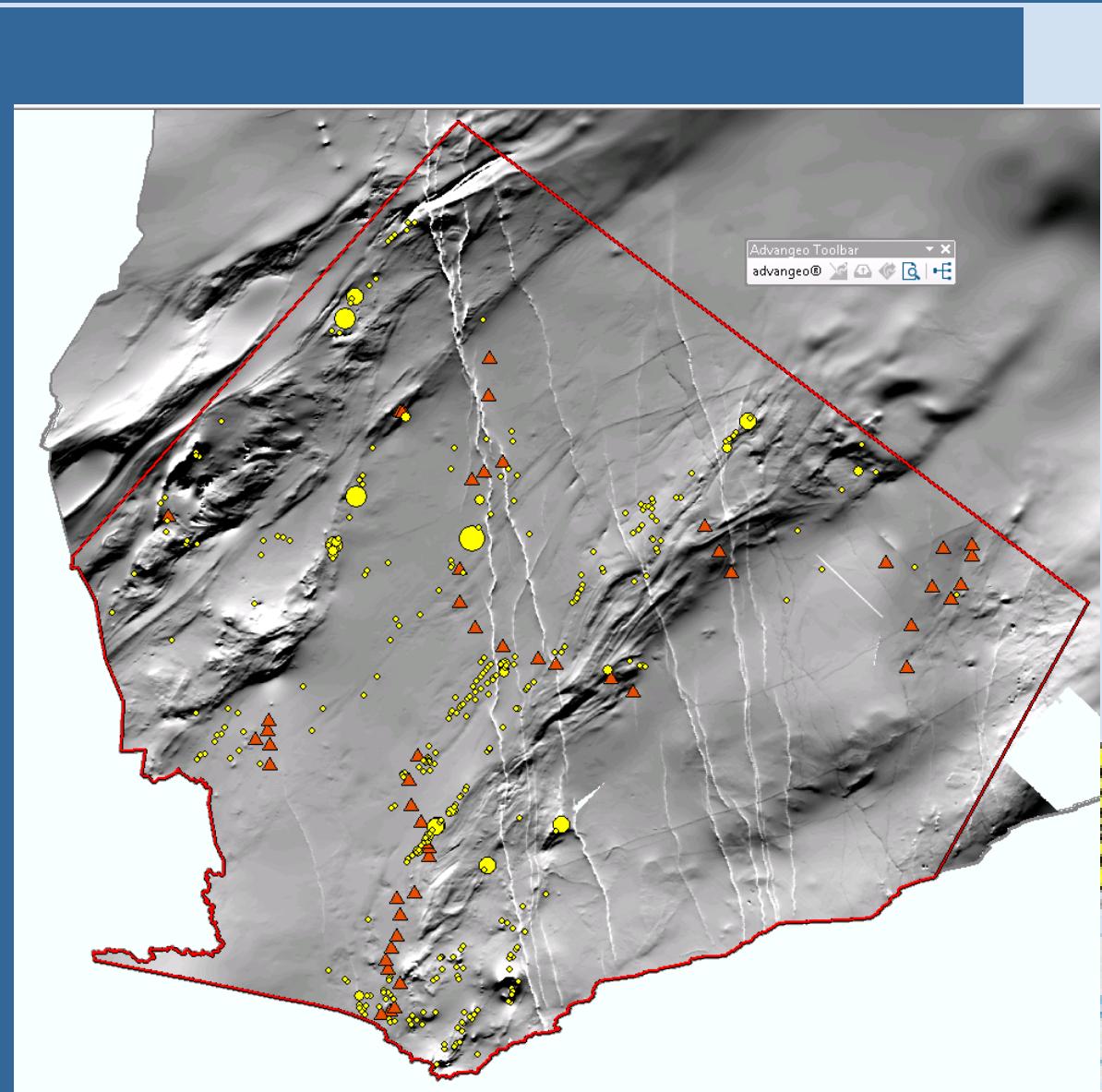
PROCESSING AND INTERPRETATION OF AIRBORNE GEOPHYSICAL DATA

AIRBORNE SURVEY 1999-2000

Philip Yaw Oduro Amoako
Samuel Kwabla Amedofu
Thomas Akamaluk

Geological Survey Department of Ghana

February 2004



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Source data preparation finalized

The screenshot shows the advangeo software interface with the title bar "advangeo - [List Base Data]". The menu bar includes Application, Data Processing, Extensions, GIS Tools, and Help. The left sidebar displays the "Projects" tree, which includes "Gold SW Ghana - Knobloch" with sub-folders like "Basic Data" (containing "Base Raster", "Project Area", "Model Area", "TrainArea", "TrainArea2") and "Source Data" (containing various geological and tectonic layers). The main workspace shows a table titled "Project\Gold SW Ghana - Knobloch\Base Data" with columns Name, File Name, and Creation Date. A single entry is listed: "TrainArea2" with file name "TrainArea2.hfp" and creation date "16.08.2013 08:40:04". Below the table, four red-bordered boxes define the steps of the process:

- Step 1: Setting model accuracy and area**
- Step 2: Selecting / harmonizing source data**
- Step 3: Processing source data**
 - Selecting attributes
 - Creating data layers
- Step 4: Preparing model input data**
 - Mapping source data to base grid
 - Leveling data values
- Step 4: Building models**

The bottom status bar shows the message "Project 'Gold SW Ghana - Knobloch' already loaded: Z:\Bearbeitung\advangeo\Ghana_01\Ghana_01.adv... WARNING" and a warning icon.

Accuracy:
1.50:000 -
1: 1,000,000

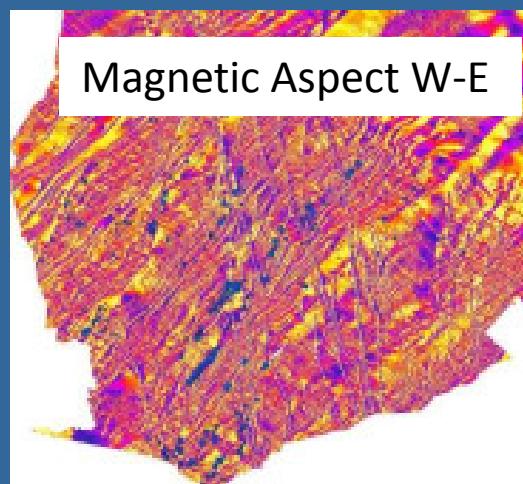
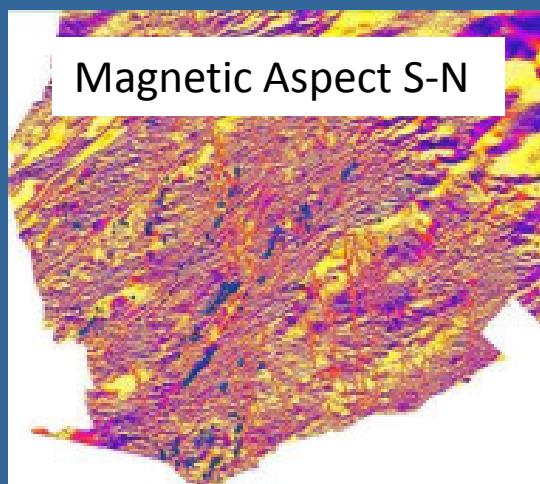
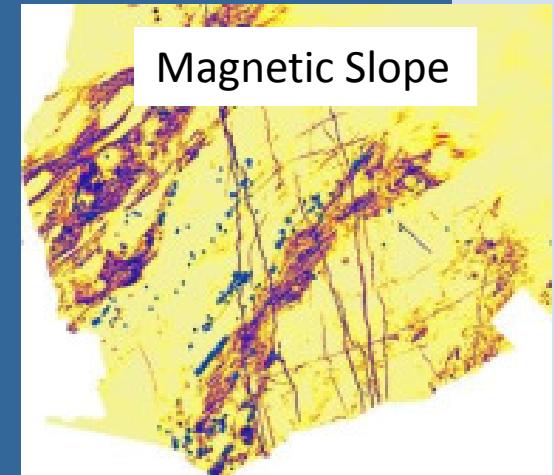
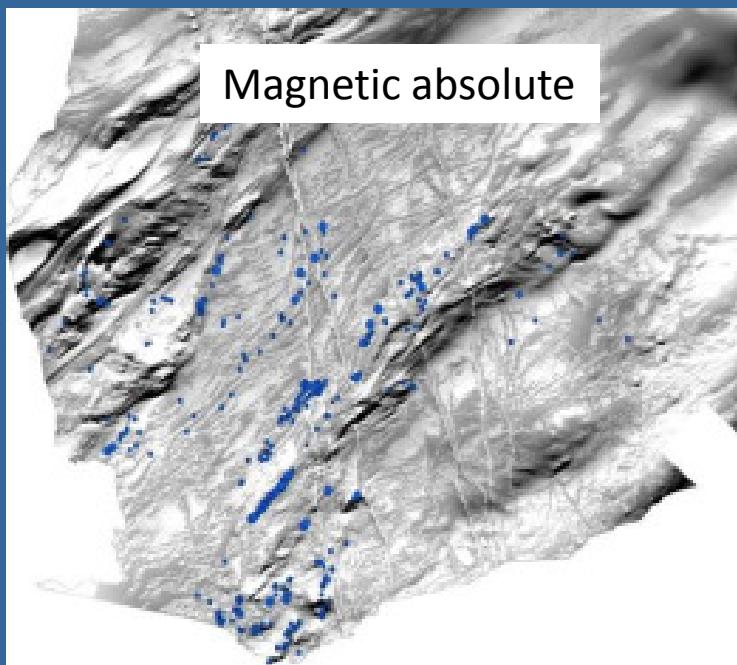
Actuality:
2000 - 2008



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Processing magnetic data: the derivatives

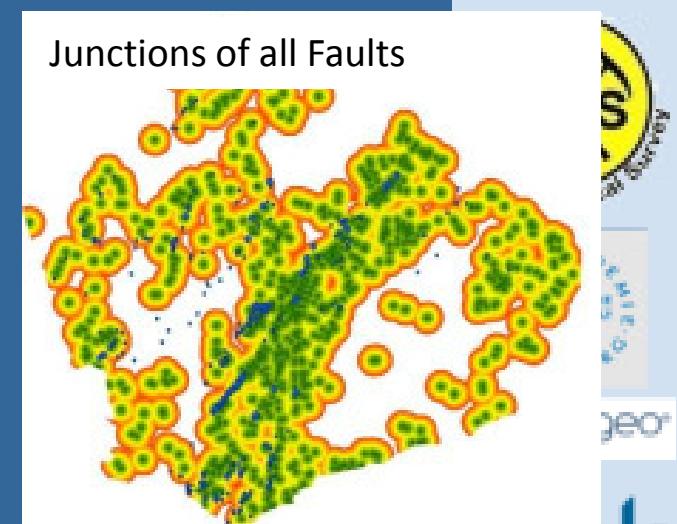
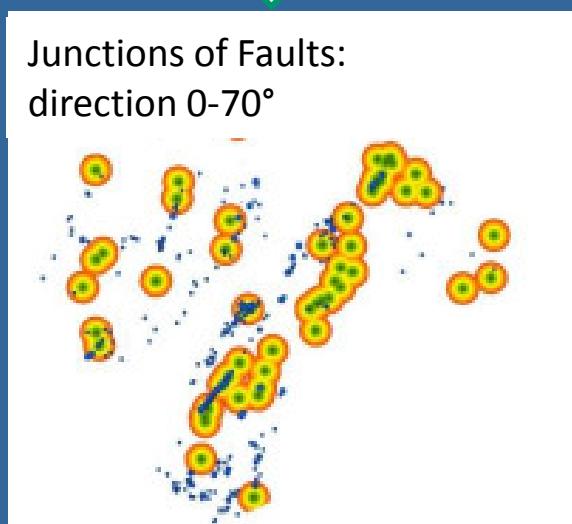
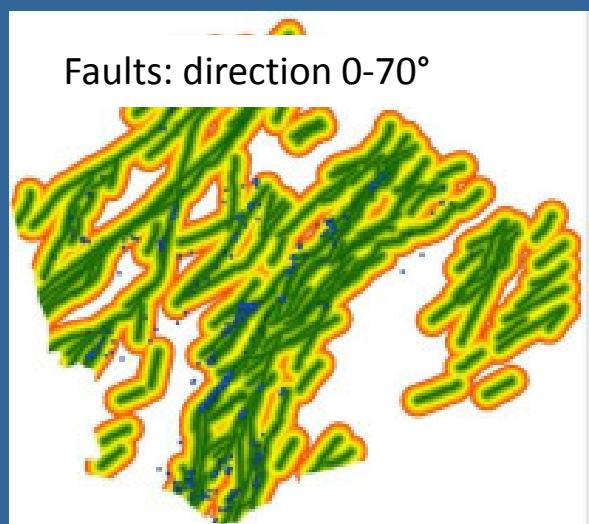
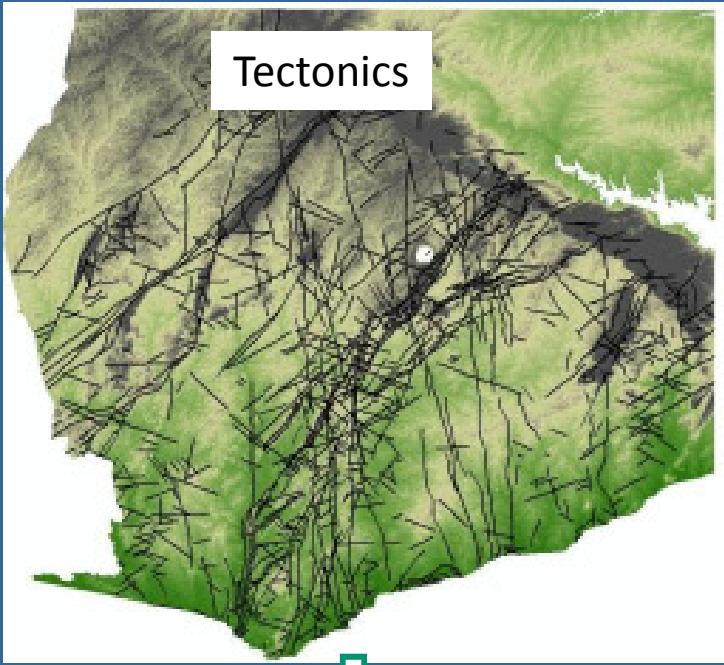


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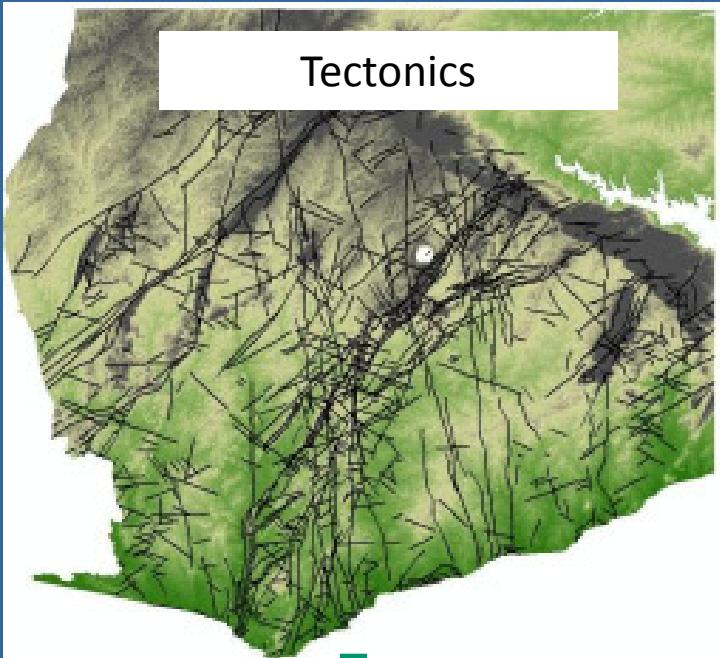
Processing tectonic data: by direction

What structures are
controlling Au
mineralisations ?

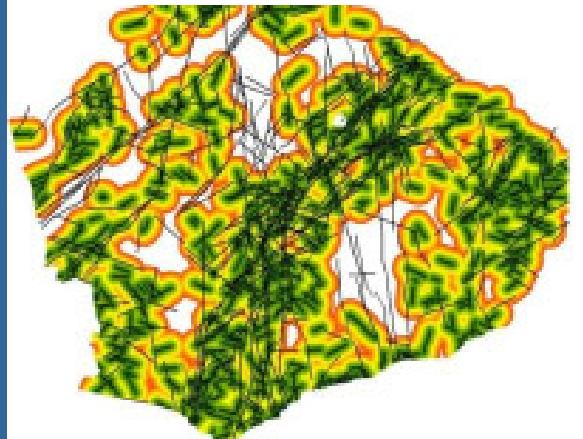


Processing tectonic data: by size

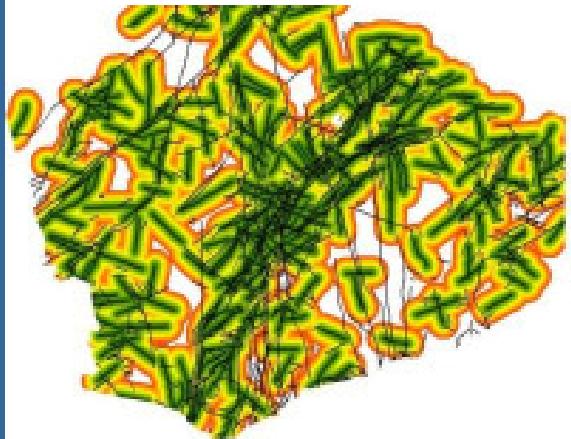
What structures are controlling Au mineralisations ?



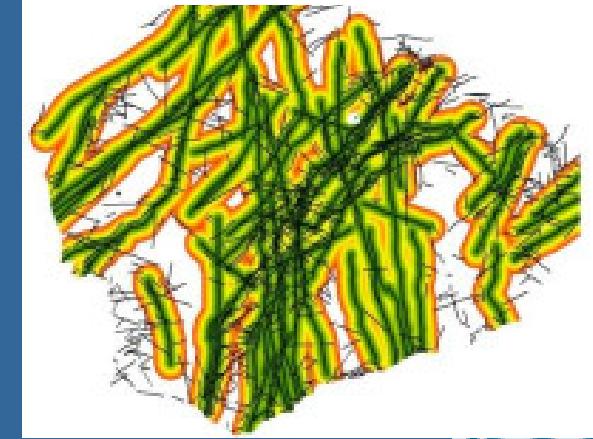
Faults (small < 14km)



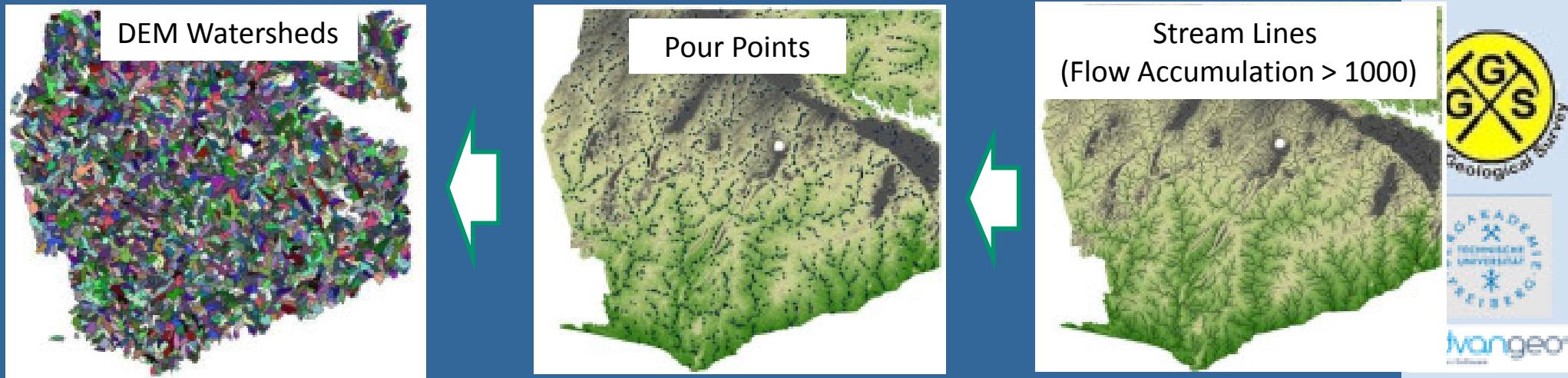
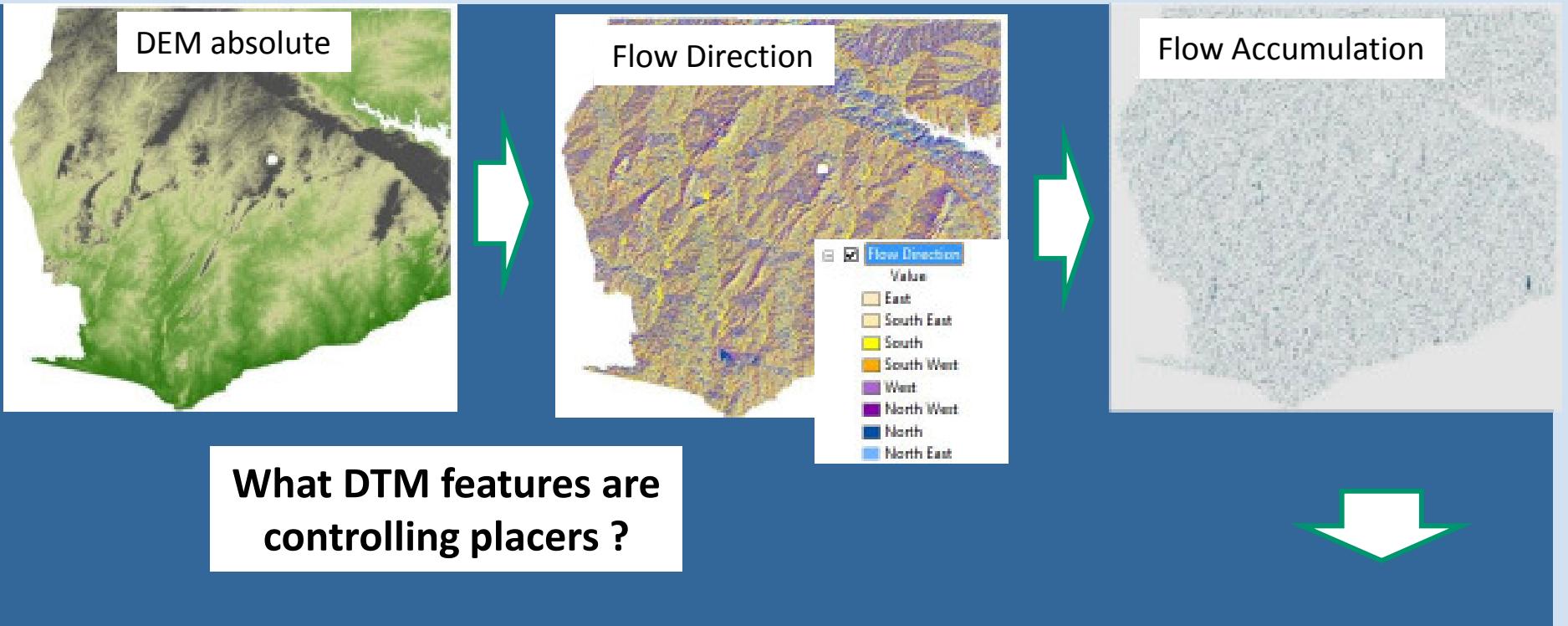
Faults (medium 14-36 km)



Faults (big > 36km)

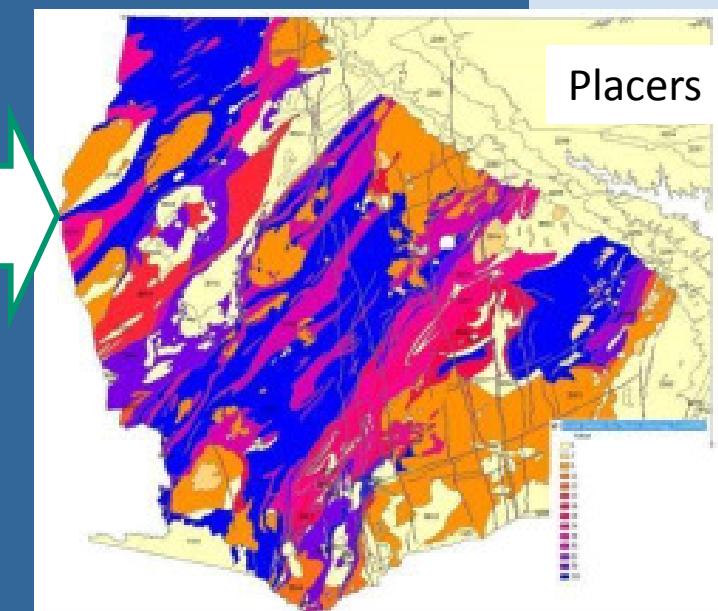
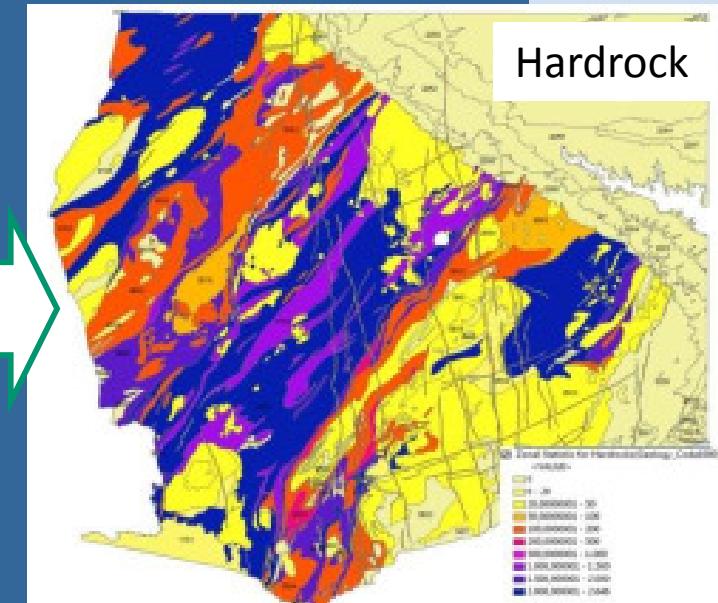
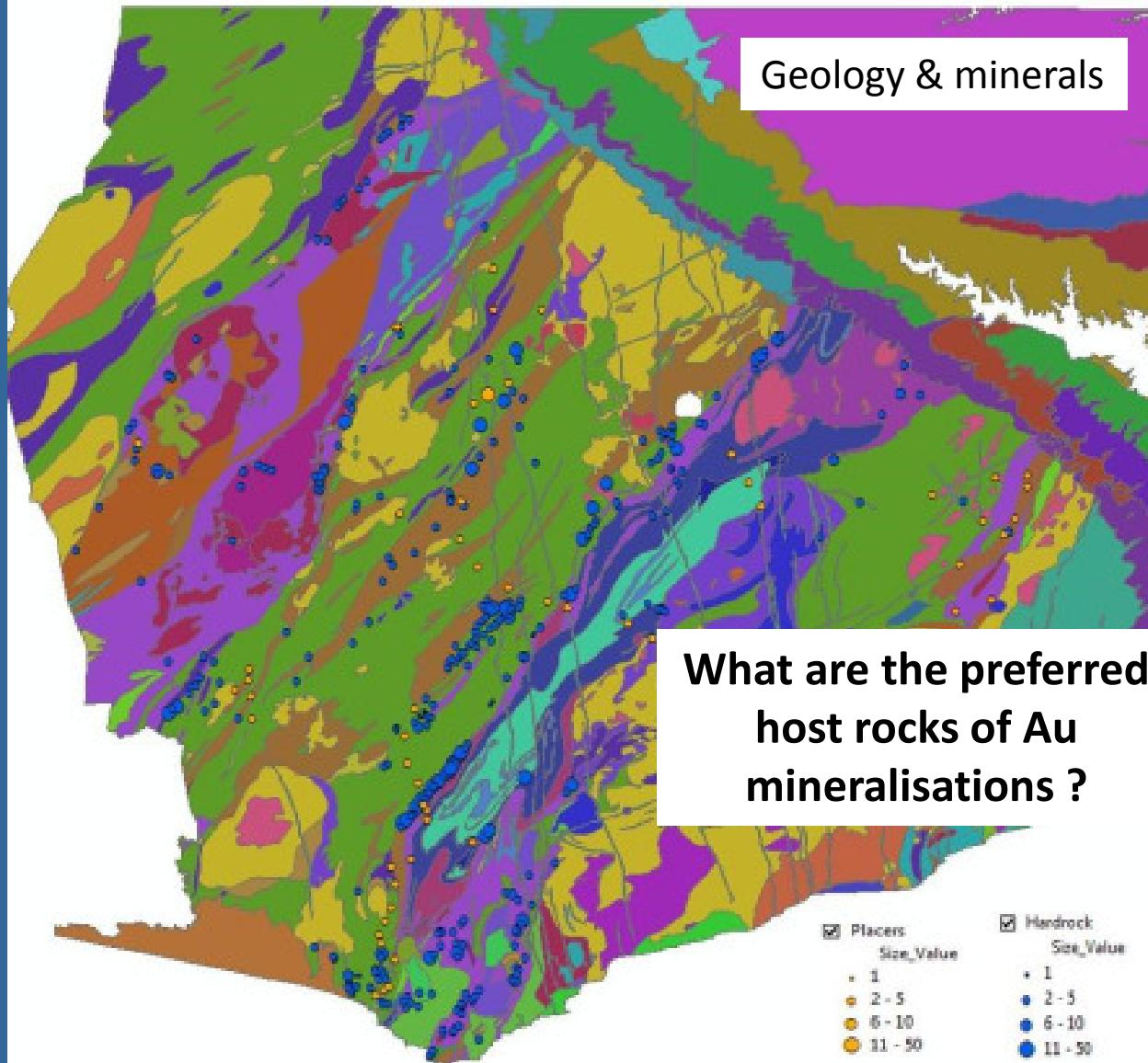


Processing elevation model data



Processing geological data

What are the preferred rock units ?



Model input data finalized

advangeo - [List Base Data]

Application Data Processing Extensions GIS Tools Help

Projects
Gold SW Ghana - Knobloch
Base Data
Project Area
Model Area
TrainArea
TrainArea2
Source Data
Deposits & Occurrences
Elevation
Geology (SW-Ghana)-1000m Buffer
Geology (SW-Ghana)-1000m Buffer by D
Geophysics - Magnetics 1
Geophysics - Magnetics 2
Stratigraphy (SW-Ghana) - 1000m Buffer
Tectonic (5-70 degrees; medium; big)
Tectonic
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AlluvialData
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Model BS1_028_1s_nagn_abi_slo_a
Model BS1_029_1s_ZStoF4accM25_d
Model BS1_031_1s_EDFlow425gE0
Model BS1_032_1s_M26_251stF4coN26_ED_FlowLines_FlowAccFromM25
Model BS1_033_1s_M26_251stF4coN26clipped_ED_FlowLines_FlowAccFromM25
Model BS2_4_005_BY (nagn_abi)
Model BS2_4_006 nagn_abi_slope
Model BS2_4_007 nagn_abi_slope_aspect

Project\Gold SW Ghana - Knobloch\Base Data

Name	File Name	Creation Date
TrainArea2	TrainArea2.hrp	16.08.2013 08:40:04
		6.99.44
		6.99.58
		3.05.21
		3.09.15

Step 1: Setting model accuracy and area

Step 2: Selecting / harmonizing source data

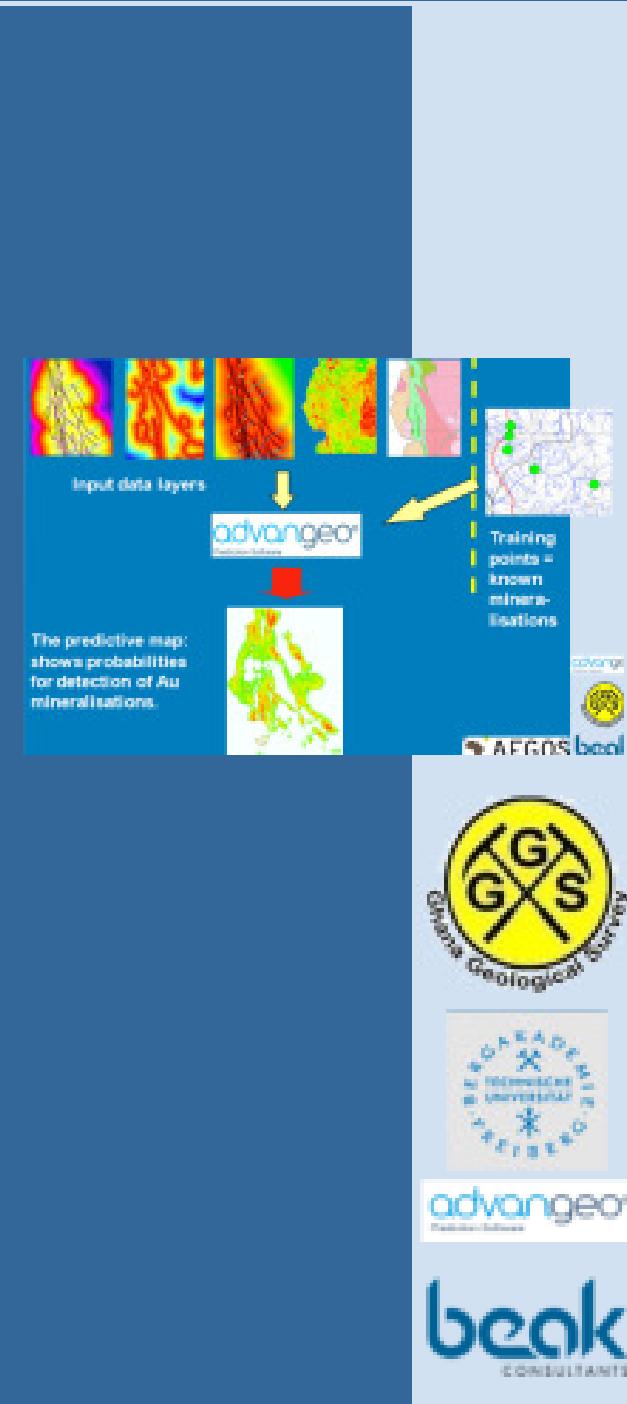
Step 3: Processing source data

- Selecting attributes
- Creating data layers

Step 4: Preparing model input data

- Mapping source data to base grid
- Leveling data values

Step 4: Building models



Building the model – hard rock Gold

advangeo - [List Base Data]

Application Data Processing Extensions GIS Tools Help

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Geology (SW-Ghana)-1000m Buffer
Geology (SW-Ghana)-1000m Buffer by C
Geophysics - Magnetics 1
Geophysics - Magnetics 2
Rock Contact (SW-Ghana) - 5000m Buffer
Stratigraphy (SW-Ghana) - 1000m Buffer
Tectonic 5-70
Tectonic - All
Tectonic - Direction
Tectonic - Length
Parameterized Model
Prediction
Model 001
Model 002
Model 003
Model 004
Model BS1_027_1s_magn_abs_slope
Model BS1_028_1s_magn_abs_slope
Model BS1_029_1s_ZSlopeM25gE0
Model BS1_031_1s_ED_FlowAcc25gE0
Model BS1_032_1s_M25_25fafFlow25_ED_FlowLines_FlowAccFromM25
Model BS1_033_1s_M25_25fafFlow25clipped_ED_FlowLines_FlowAccFromM25
Model BS2_4_005_BY (magn_abs)
Model BS2_4_006_magn_abs_slope
Model BS2_4_007_magn_abs_slope_aspect

Project:Gold SW Ghana - Knobloch\Basic Data

Name	File Name	Creation Date
TrainArea2	TrainArea2.hdp	16.08.2013 08:40:04

Step 1: Setting model accuracy and area

Step 2: Selecting / harmonizing source data

Step 3: Processing source data

- Selecting attributes
- Creating data layers

Step 4: Preparing model input data

- Mapping source data to base grid
- Leveling data values

Step 4: Building models

Info Error

Message Type

Project 'Gold SW Ghana - Knobloch' already loaded: Z:\Bearbeitung\advangeo\Ghana_01\Ghana_01.adva... WARNING

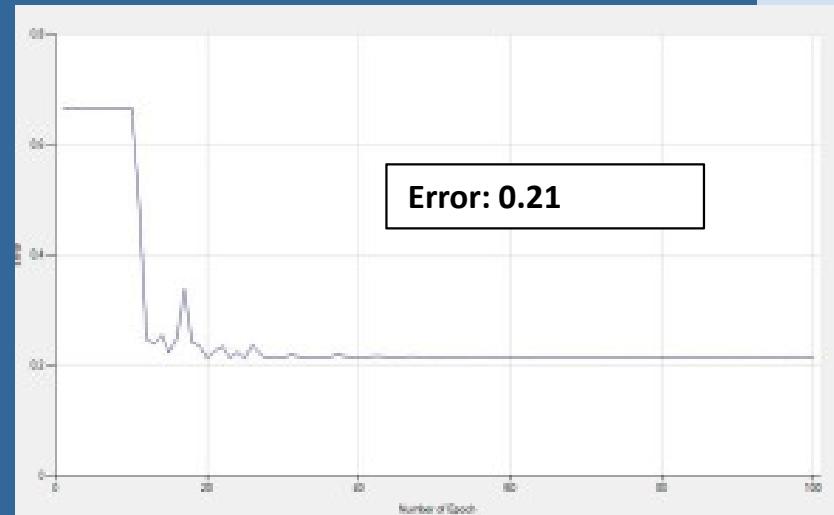
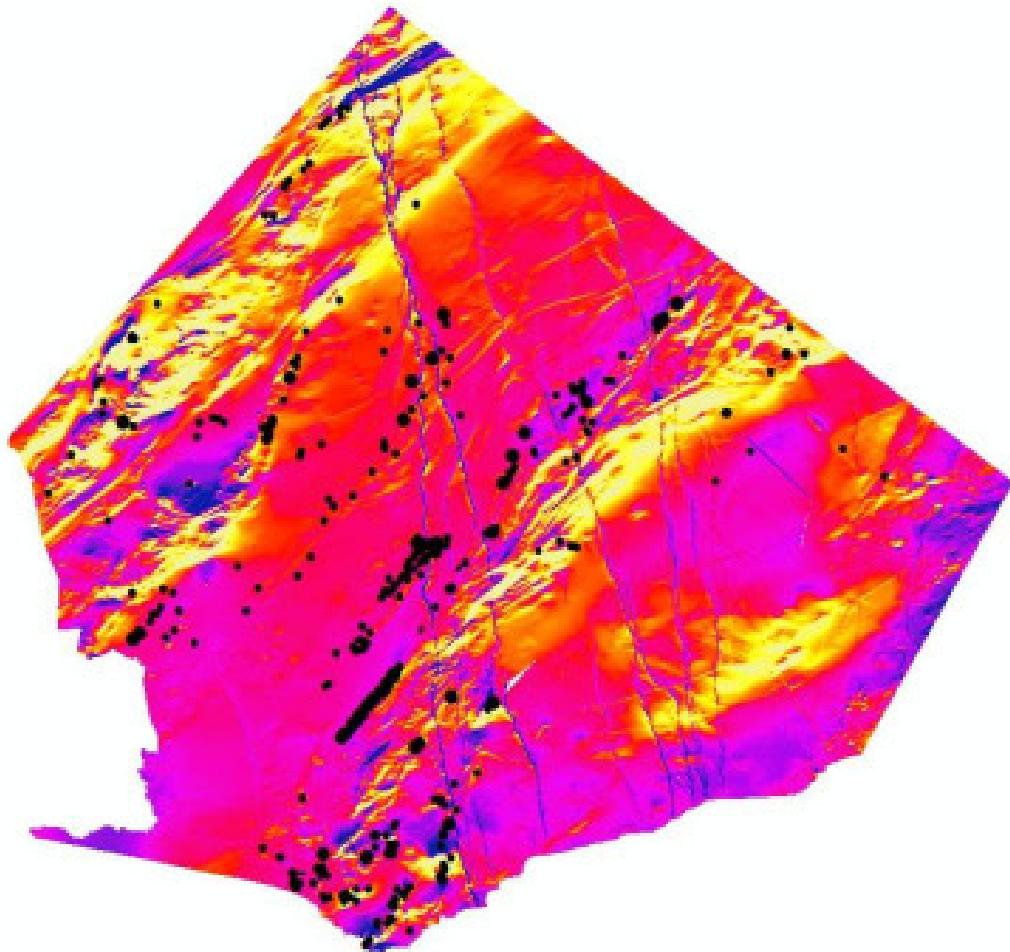


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Qualitative models - Is there Gold? Y/N

Magnetics, absolute value



- nearly all Au Occurrences are located in high potential zones,
- the prospective zones are big: >> 50 % of the total area
- the error is big: >0.2

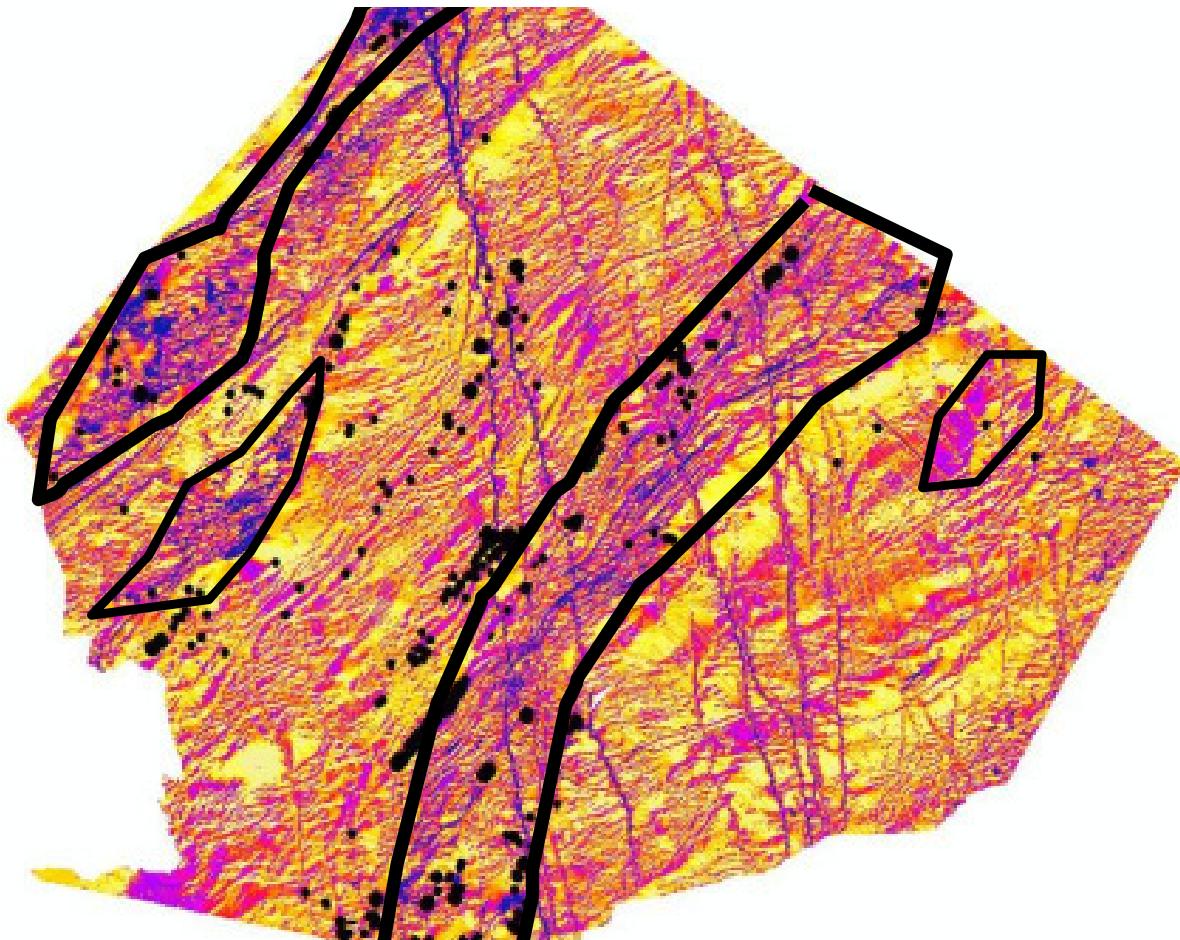


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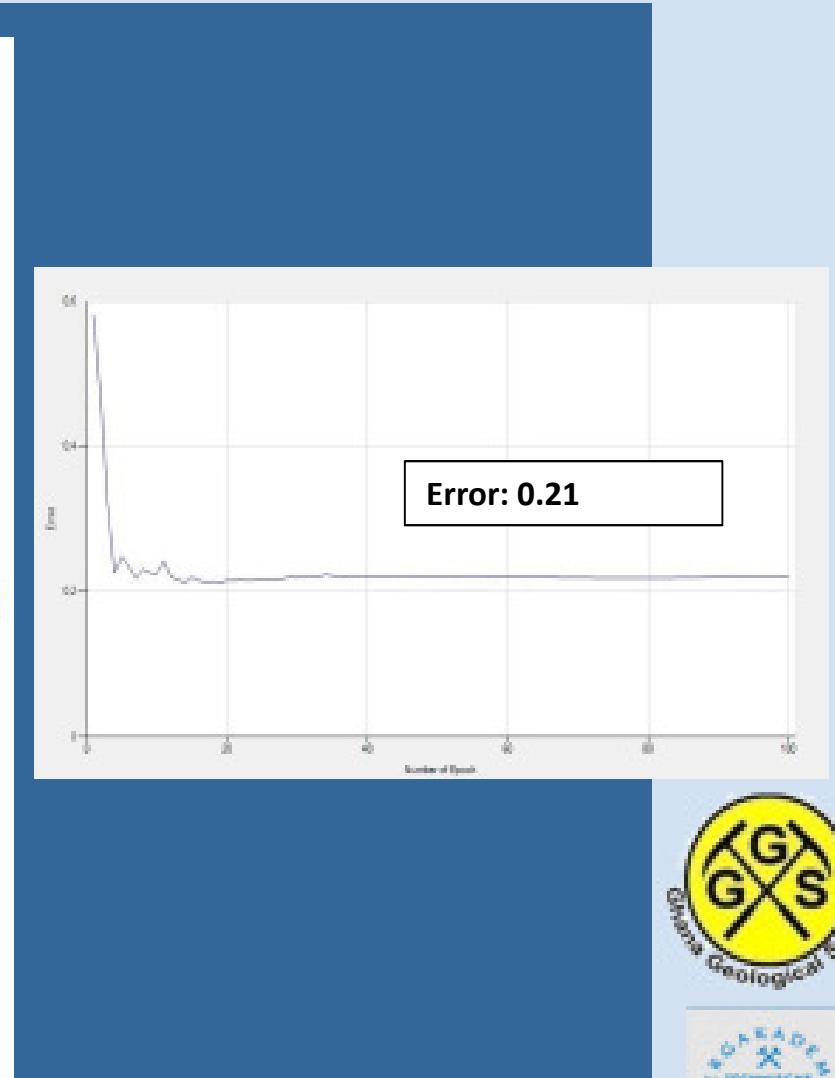
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Magnetics, all derivatives

Magnetics, slope, aspect



- there are some patterns of relationship ,
- the prospective zones are still big: > 50 % of the total area
- the prospective zones are spread over the entire area
- some target zones are exposing
- the error is still too big: >0.2

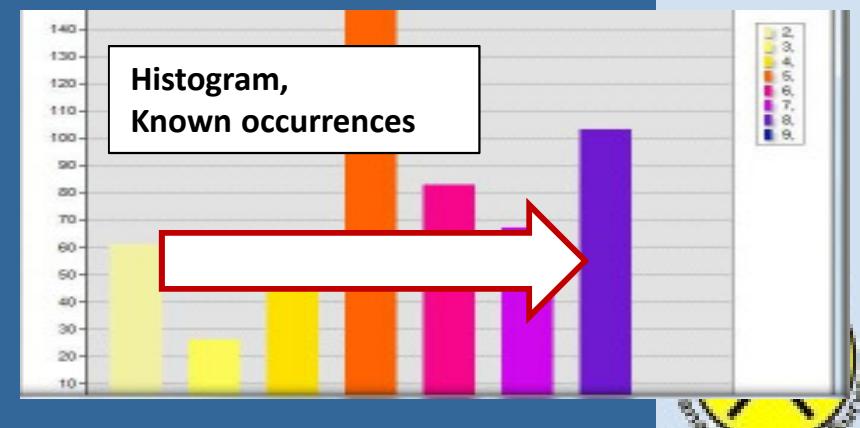
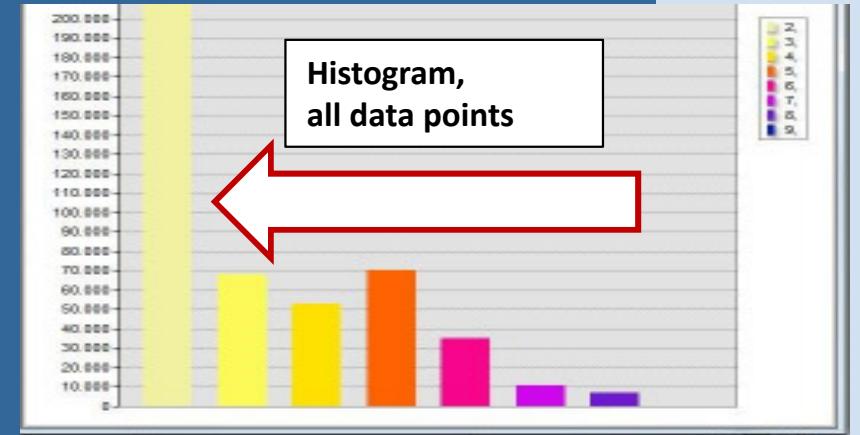
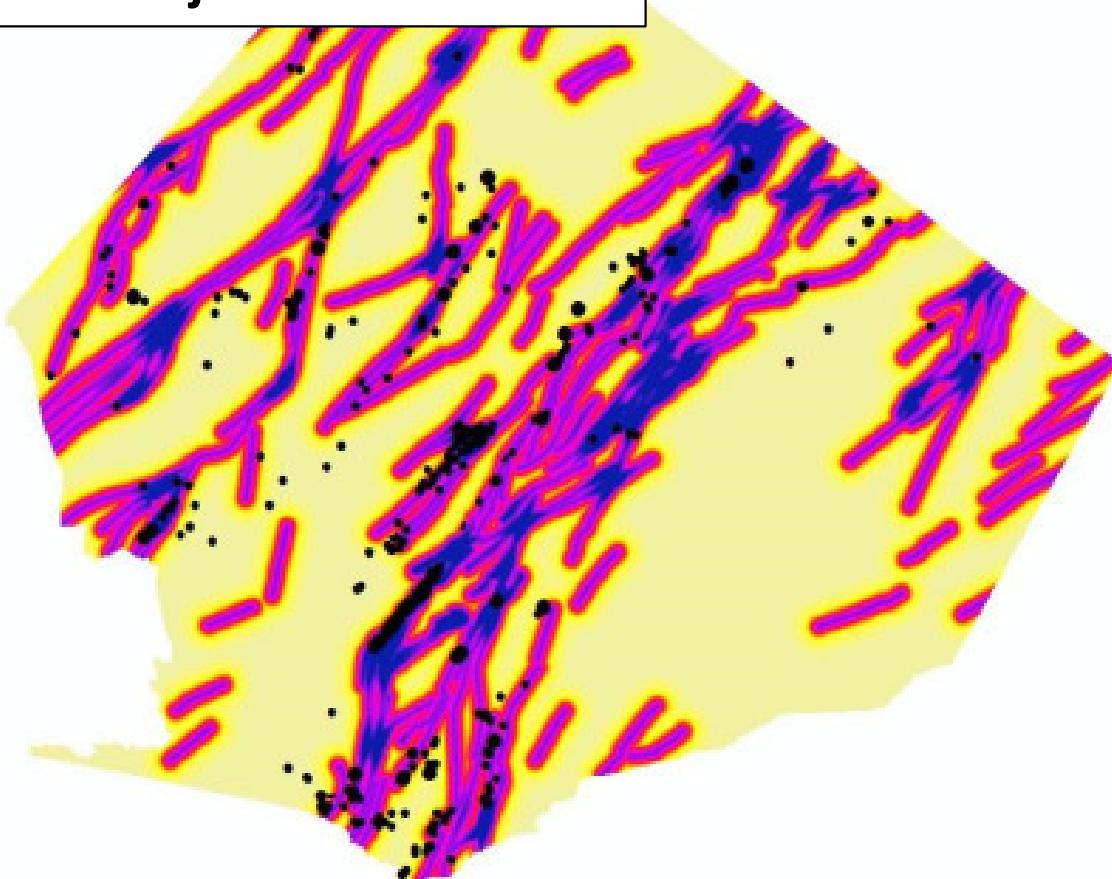


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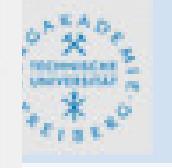
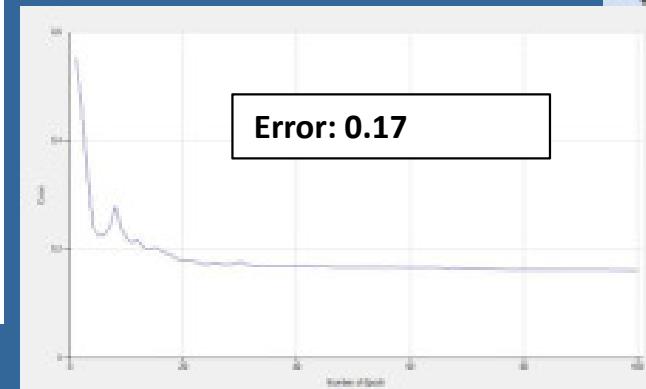
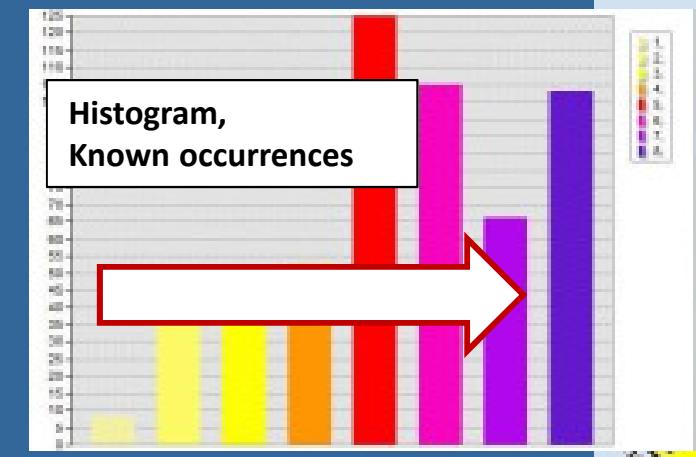
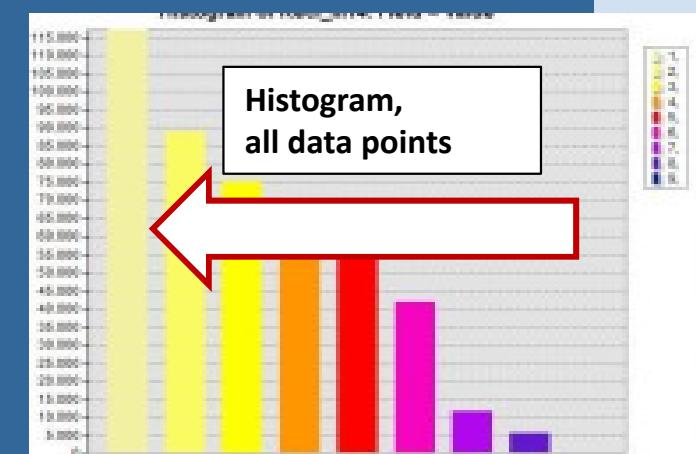
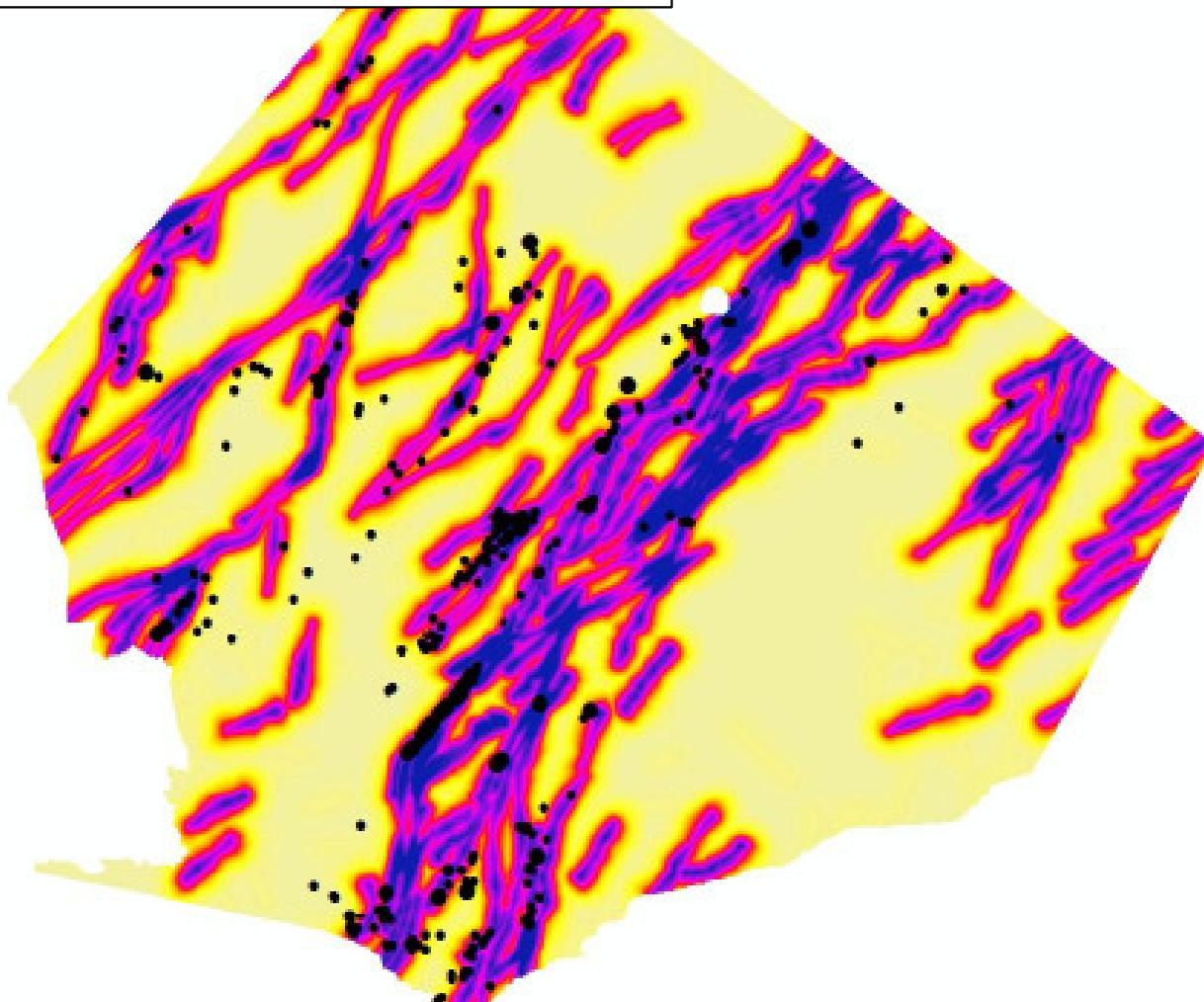
Tectonics I

Big Faults, striking 5 – 75 degrees and their junctions



Tectonics II

Big Faults, striking 5 – 75 degrees and their junctions, any small faults

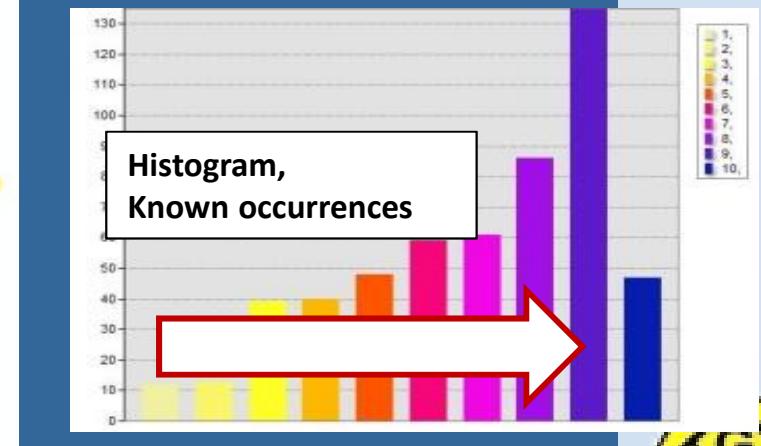
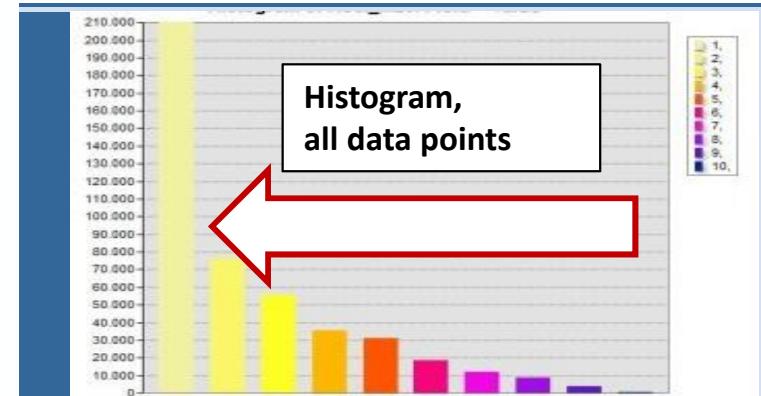
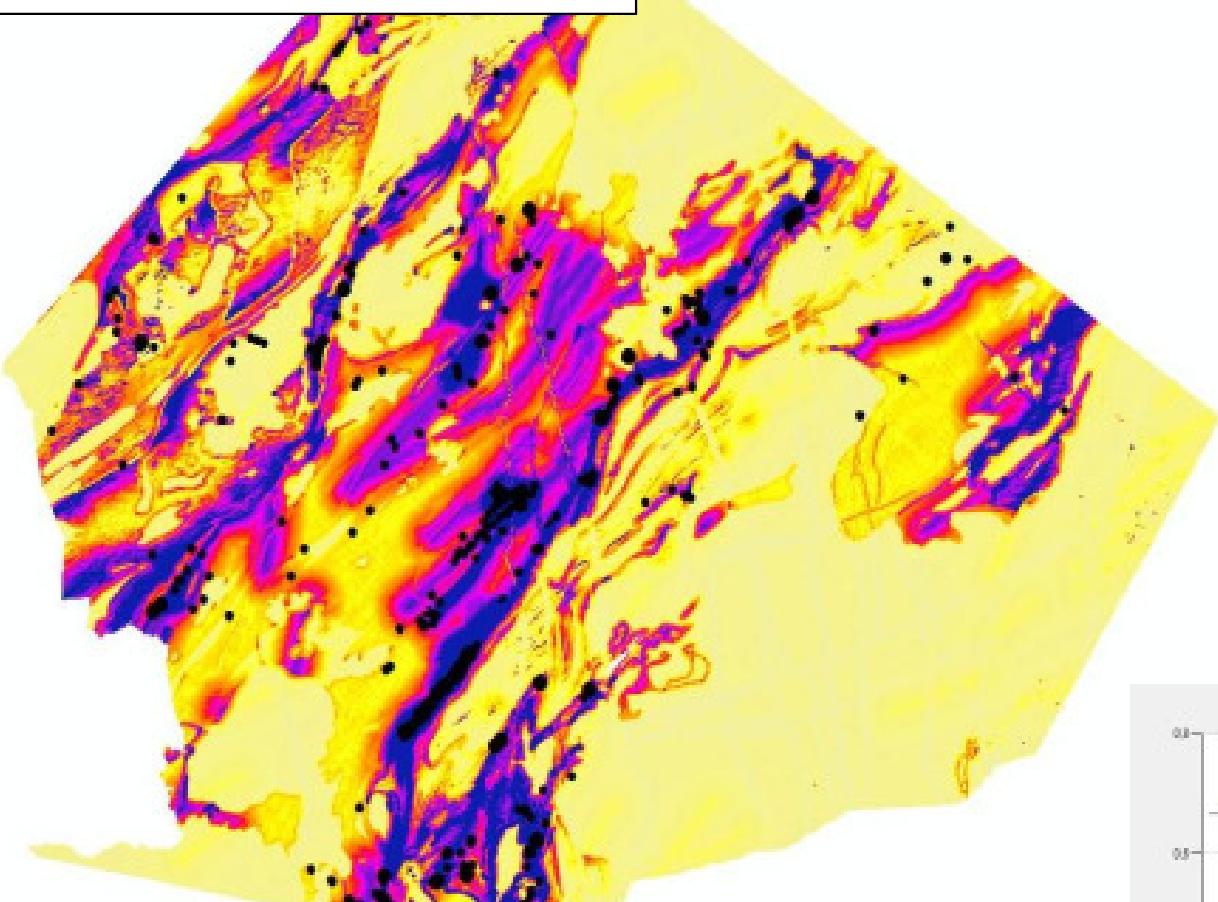


vango

eok
CONSULTANTS

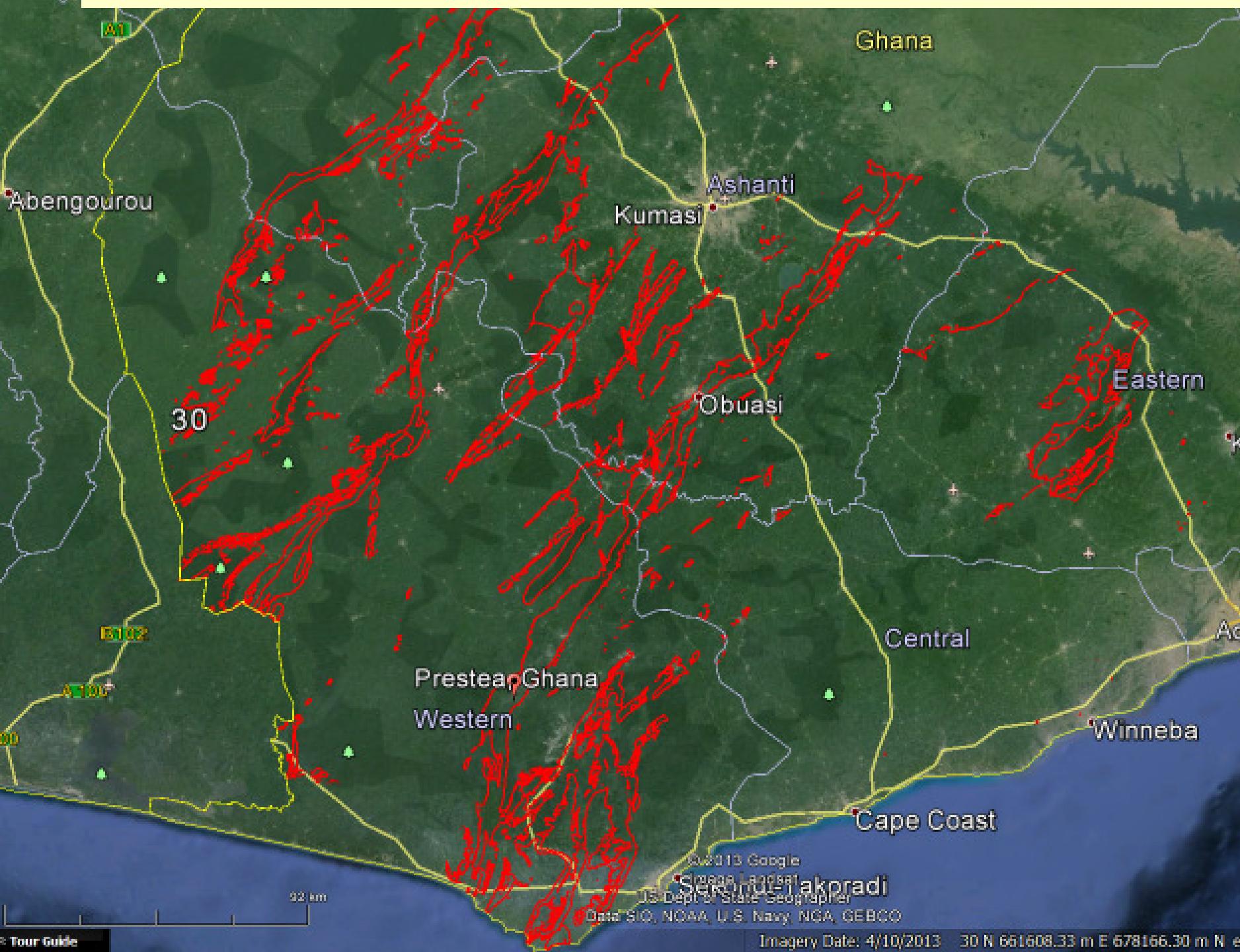
All data

Big Faults, striking 5 – 75° degrees and their junctions, any small faults, all geology



- very clear spatial pattern
- the prospective zones are small
- the prospective zones are focused
- most of known occurrences are located in high potential areas
- the error is low: approx. 0.15

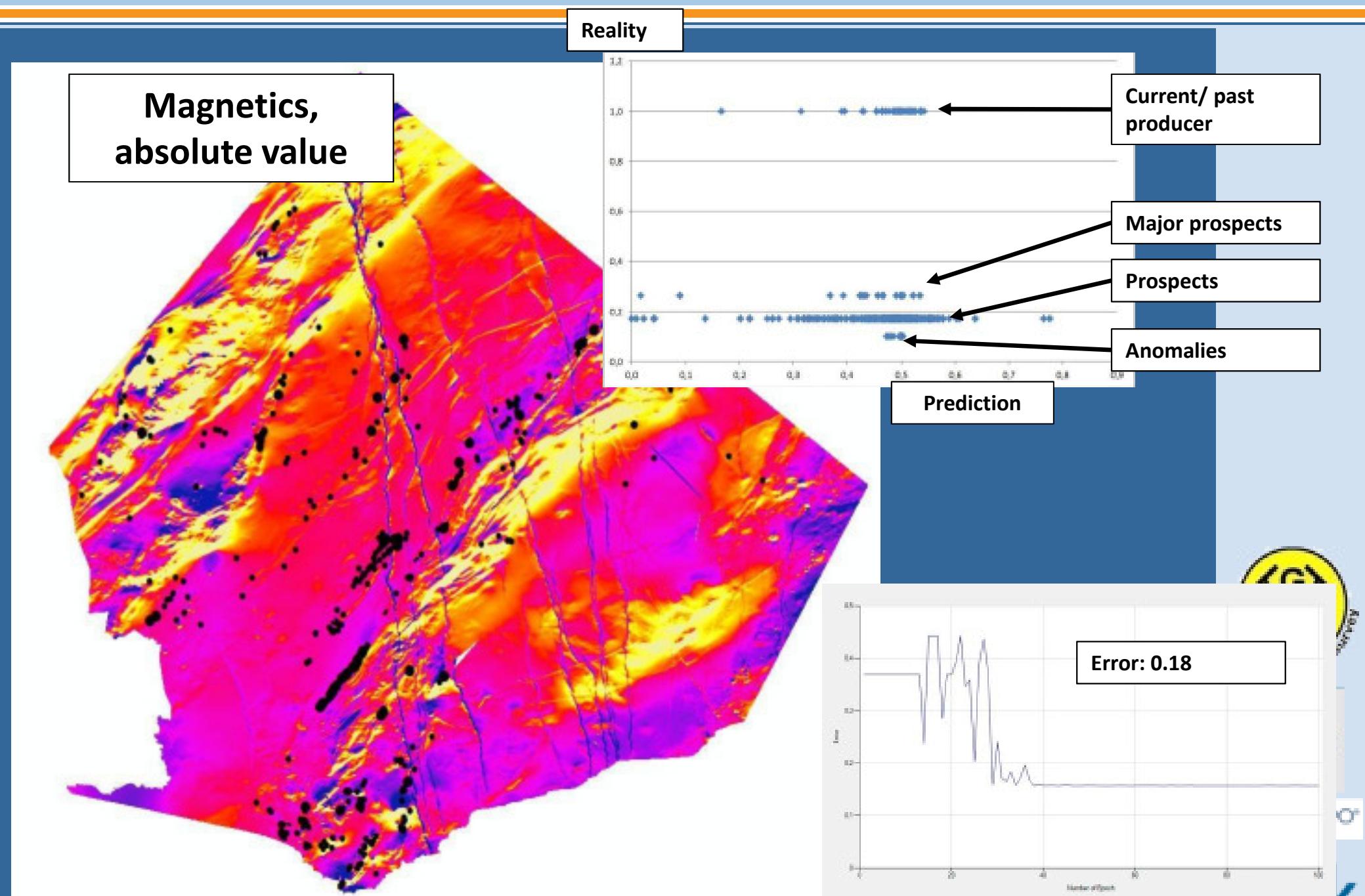
With full topography



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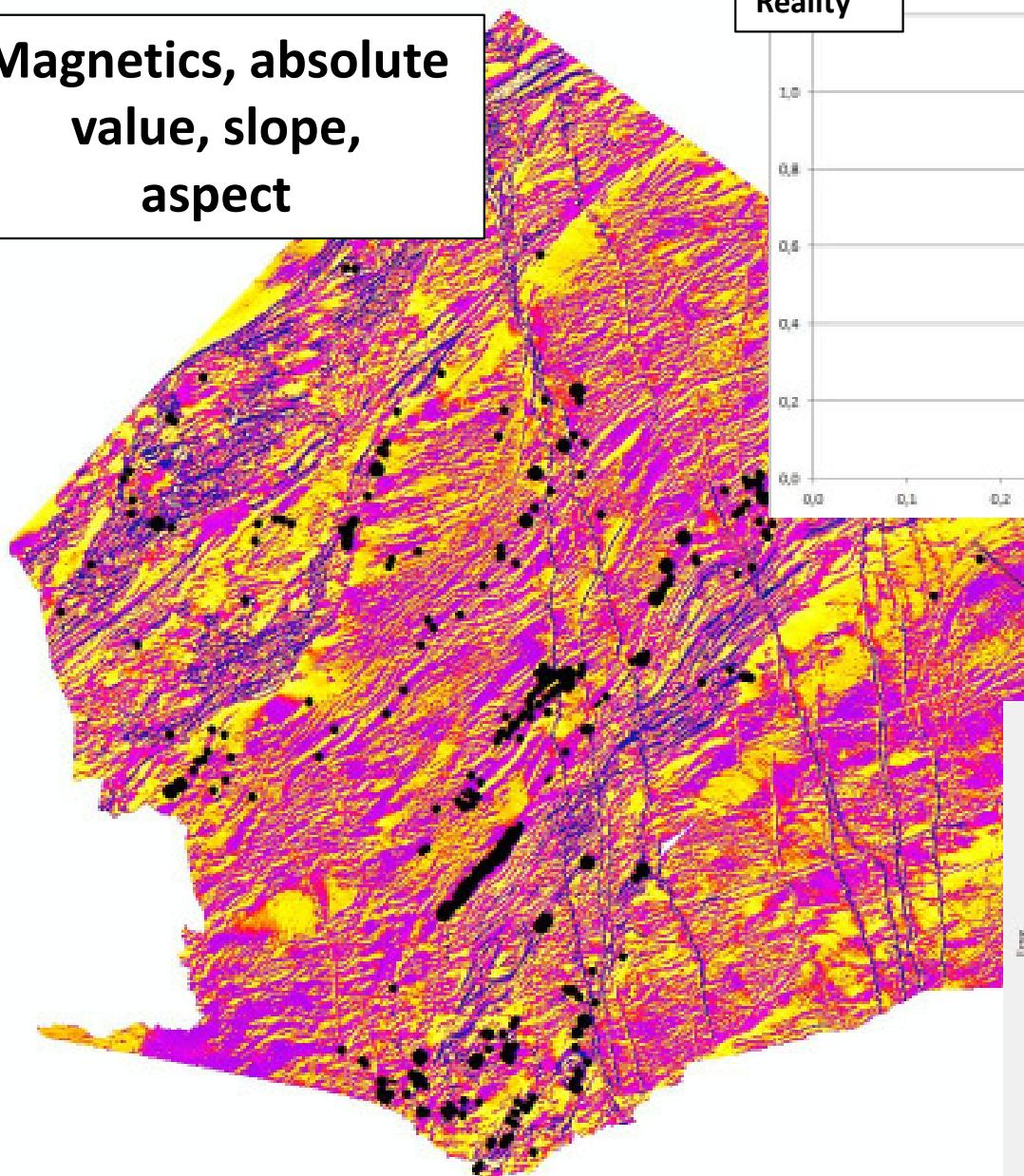
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Quantitative models: How big is a potential target?



Quantitative models: How big is a potential target?

Magnetics, absolute value, slope, aspect



Reality

app010

Prediction

Error: 0.15

Current/ past producer

Major prospects

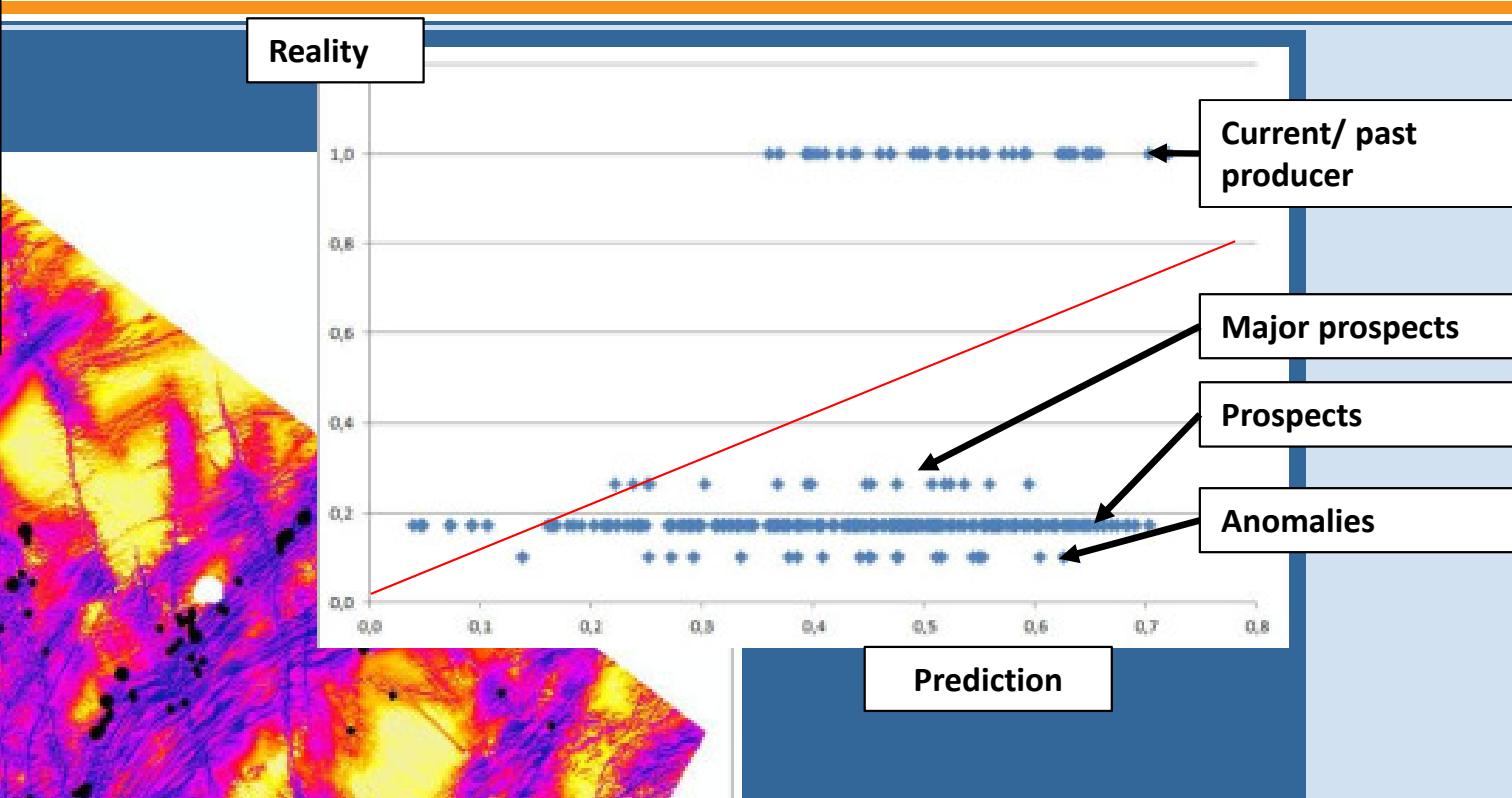
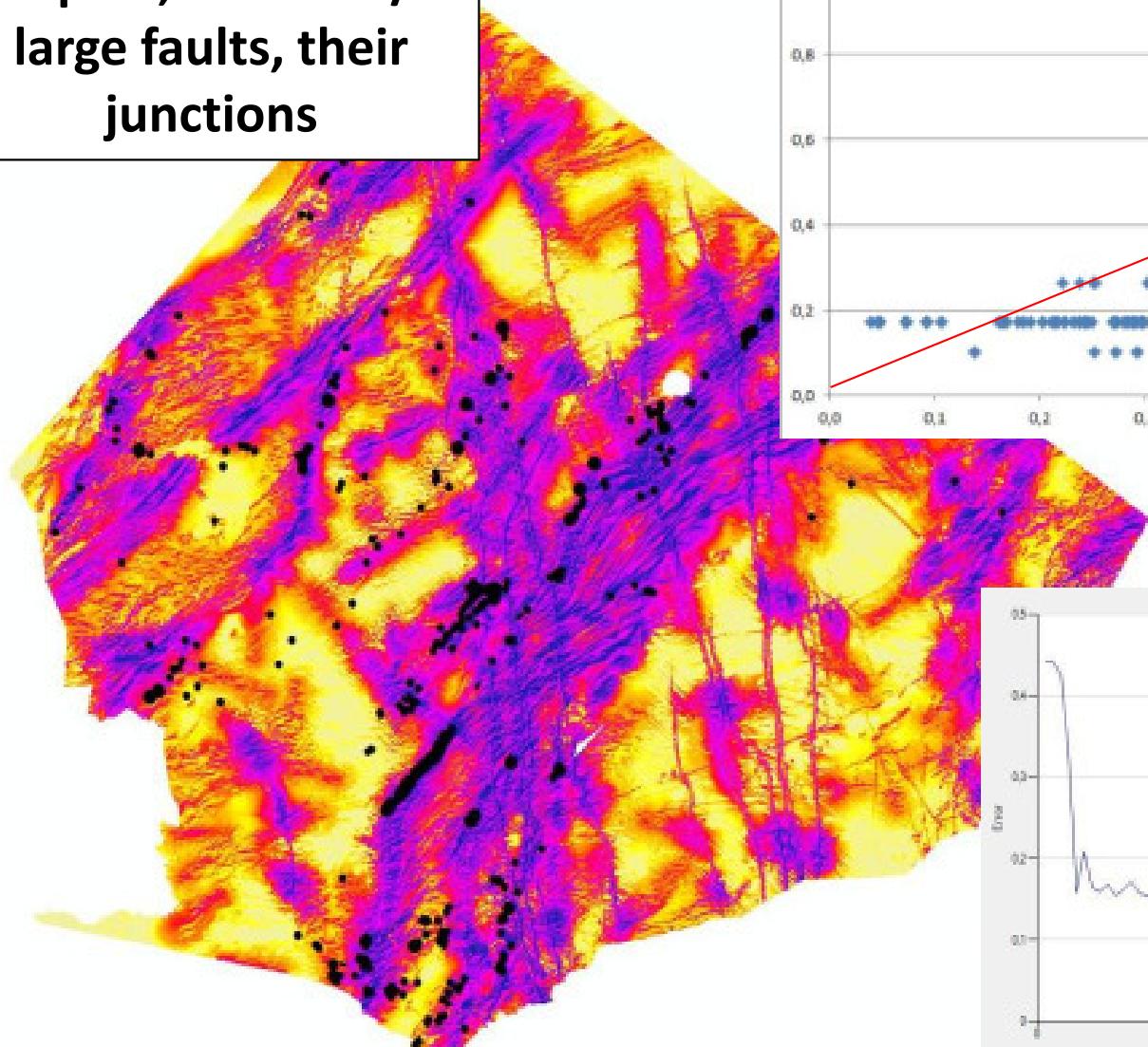
Prospects

Anomalies



Quantitative models: How big is a potential target?

Magnetics, absolute value, slope, aspect, medium/large faults, their junctions

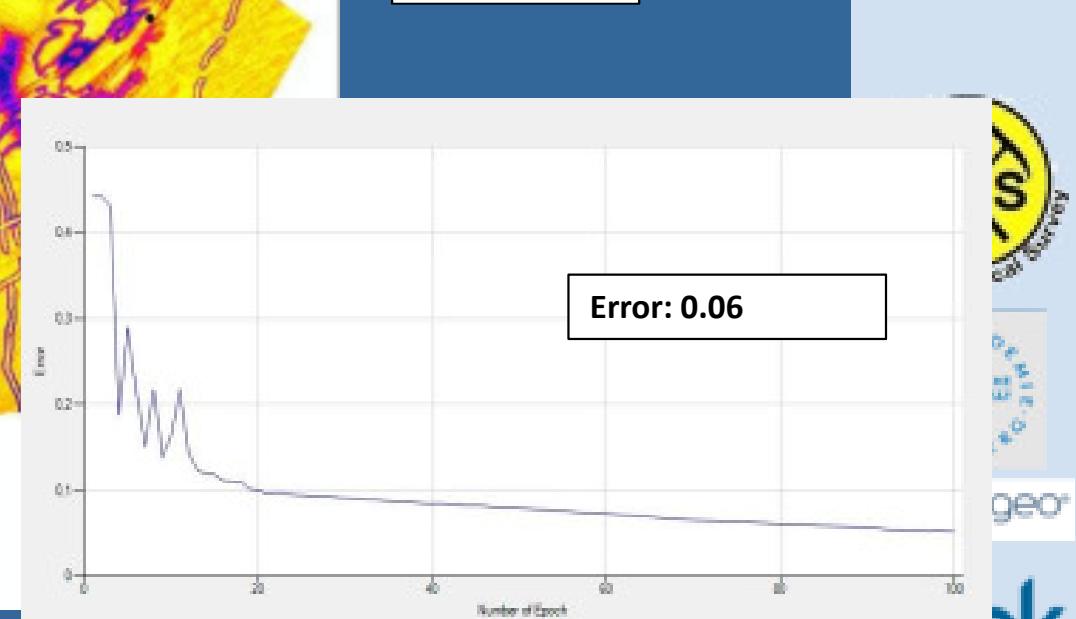
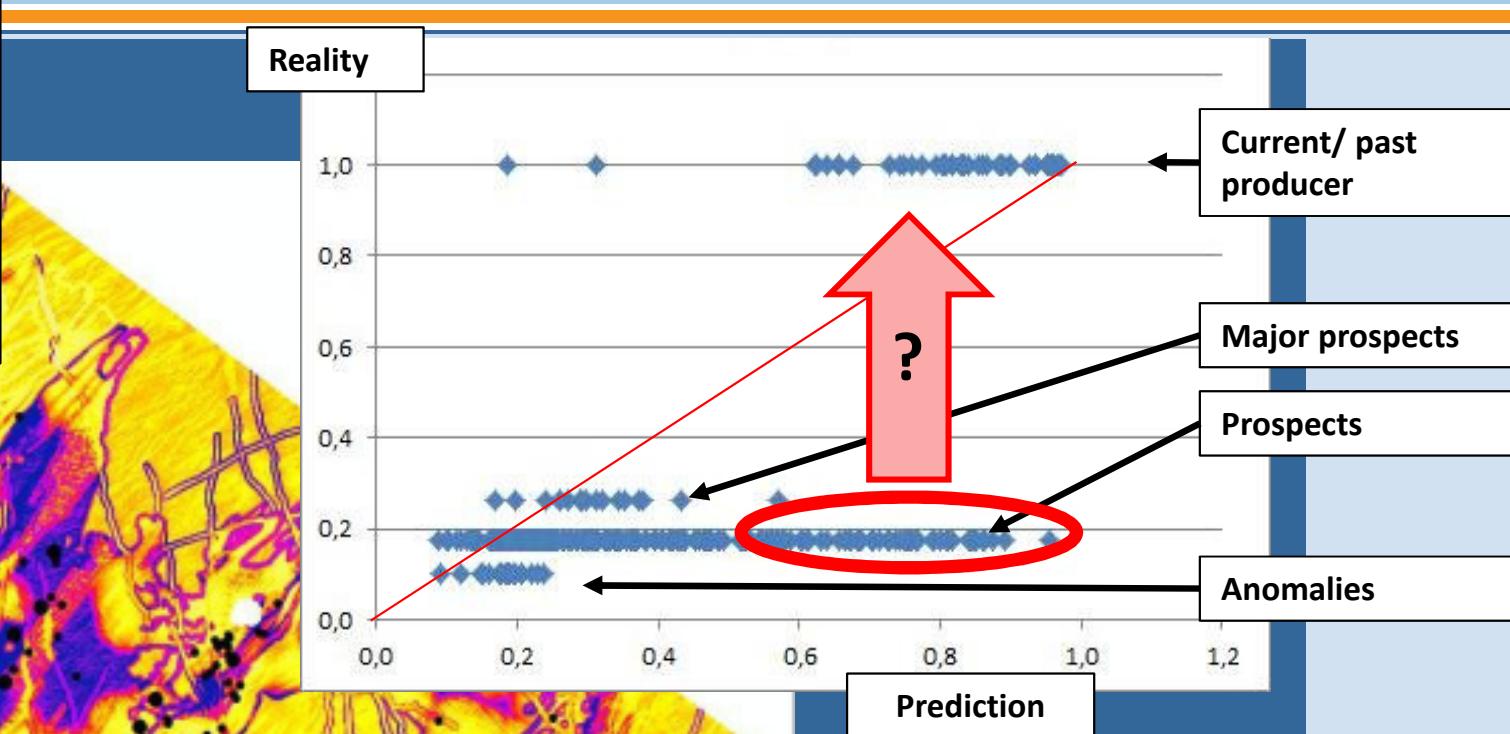
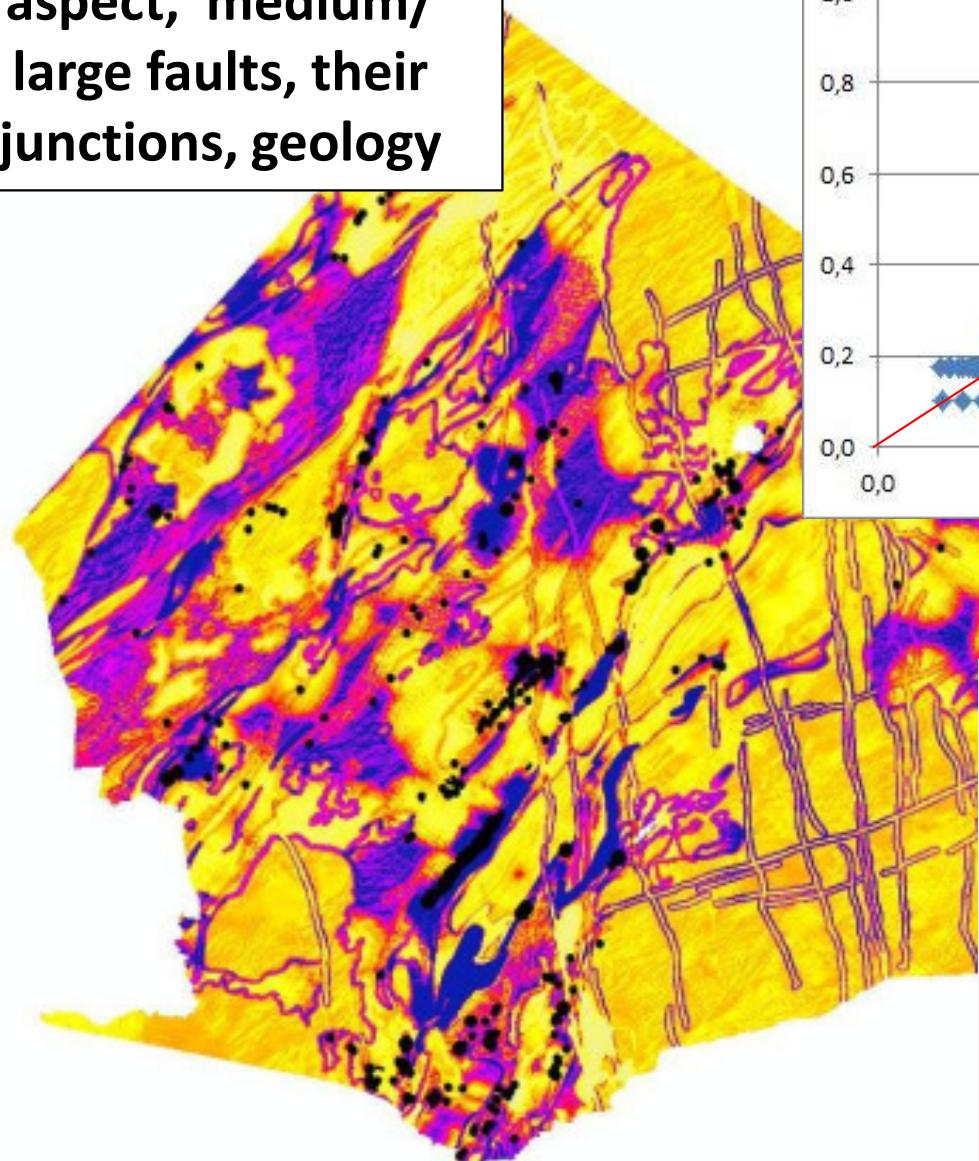


Geosoft
GEOPAK
GEOTRAC

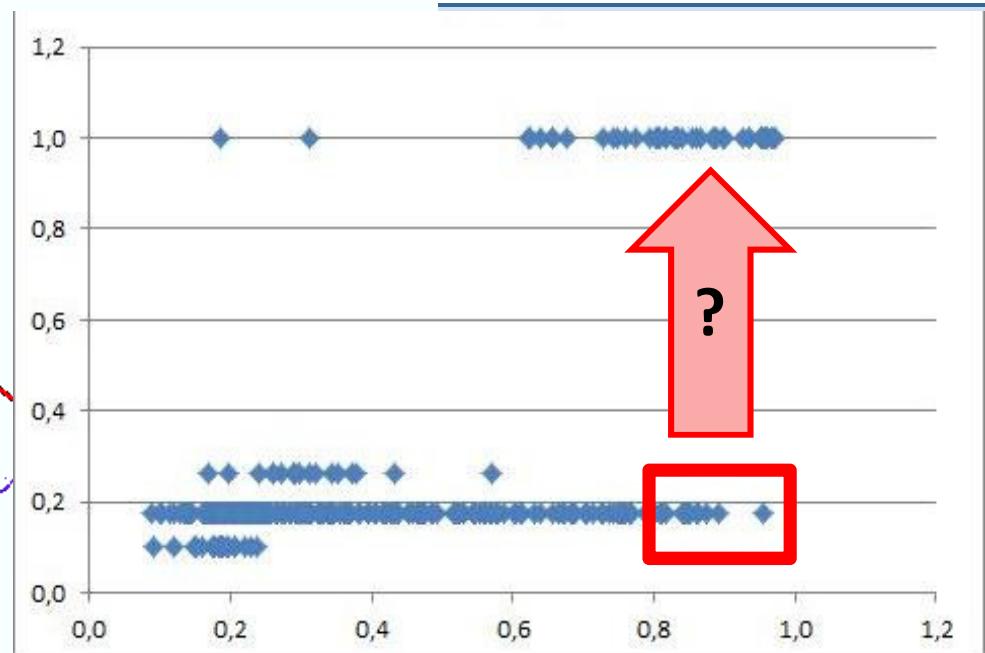
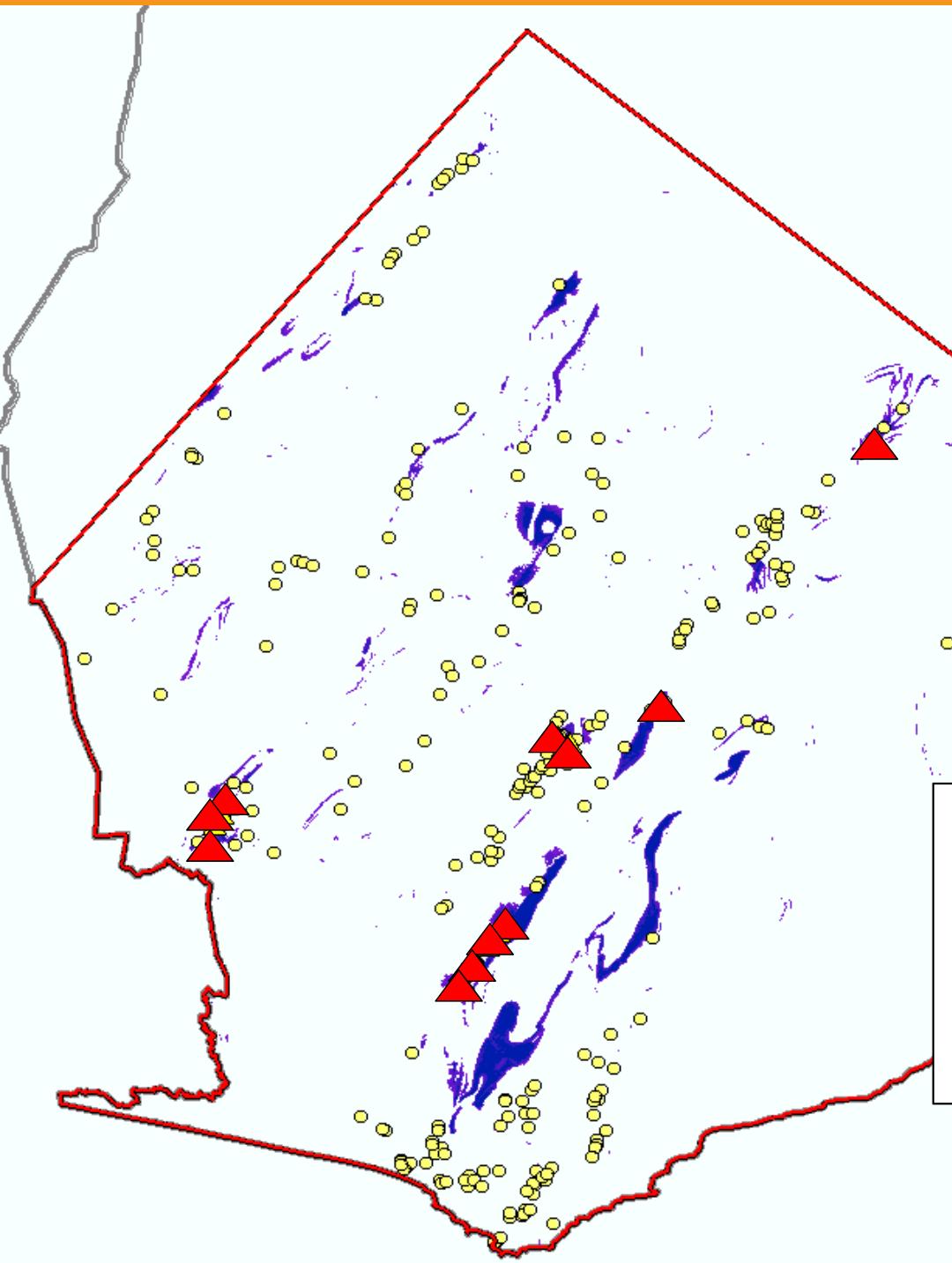
geo*

Quantitative models: How big is a potential target?

Magnetics, absolute value, slope, aspect, medium/large faults, their junctions, geology

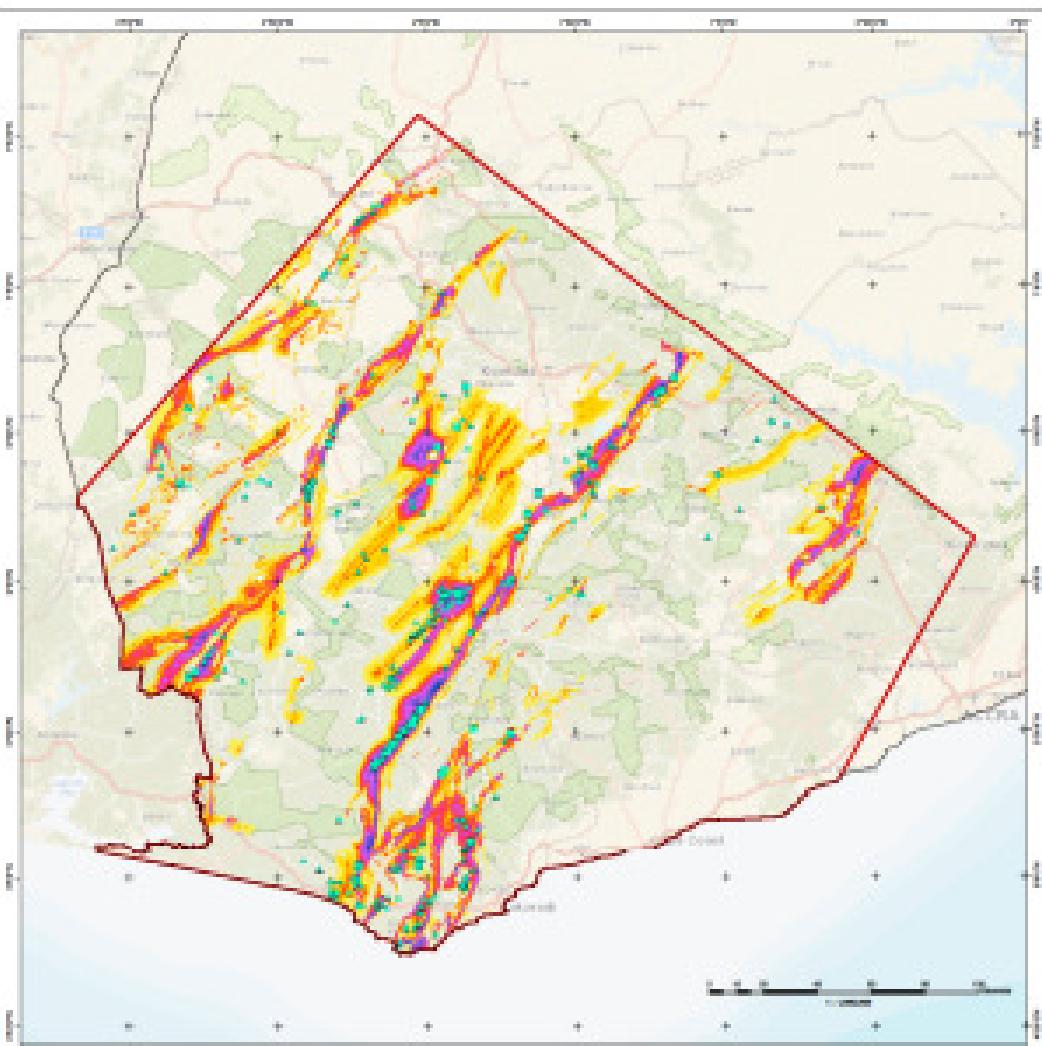


Where are the most prospective targets ?



- ▲ Prospects located in areas with a potential of $> 0,8$
- All other prospects

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



The product and its application

Mineral Potential Map – hard rocks

- Easy to read
- Sufficient accurate
- Represents existing knowledge
- Upgradable
- Usable for national/ regional planning activities
- Base for governance maps, to:
 - Protect resources
 - Guide big investment
 - Guide small scale mining
 - Analyze conflicts
 - Plan long term land use

Legend

Yellow	Gold Resources
Orange	Gold Resources
Red	Gold Resources
Grey	Gold Resources
Blue	Gold Resources
Cyan	Gold Resources
Green	Gold Resources
Purple	Gold Resources
Black	Gold Resources
White	Gold Resources
Light Blue	Gold Resources
Light Green	Gold Resources
Light Orange	Gold Resources
Light Red	Gold Resources
Light Purple	Gold Resources
Light Cyan	Gold Resources
Light Grey	Gold Resources
Light Black	Gold Resources
Light White	Gold Resources

Land Boundaries

Administrative Boundaries

Geological Survey Department

Boundaries

Geological Survey Department

Boundaries

Beek Consultants

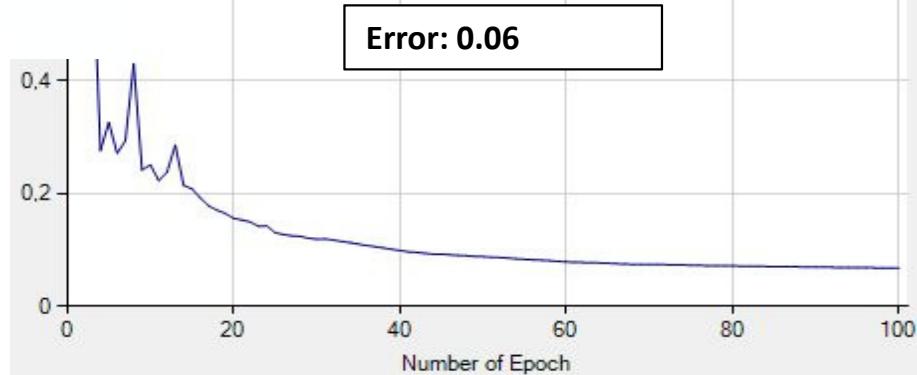
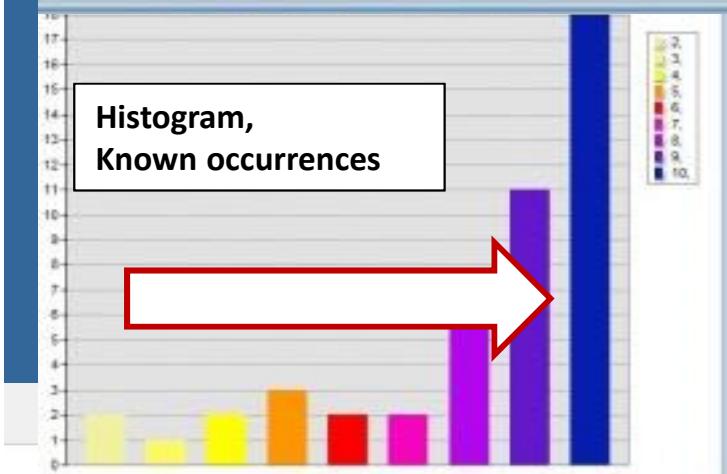
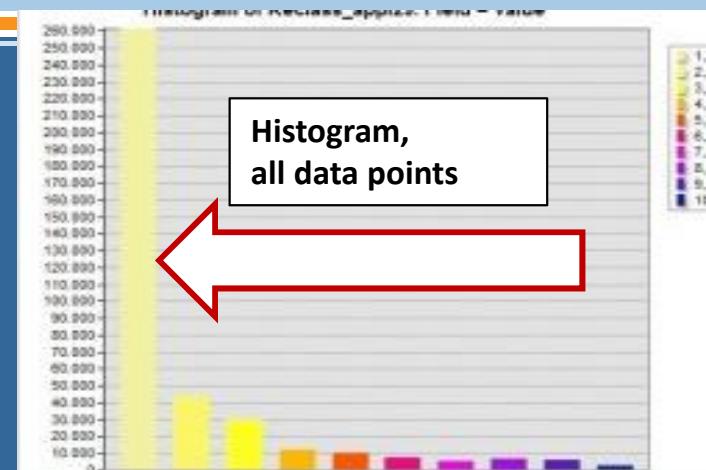
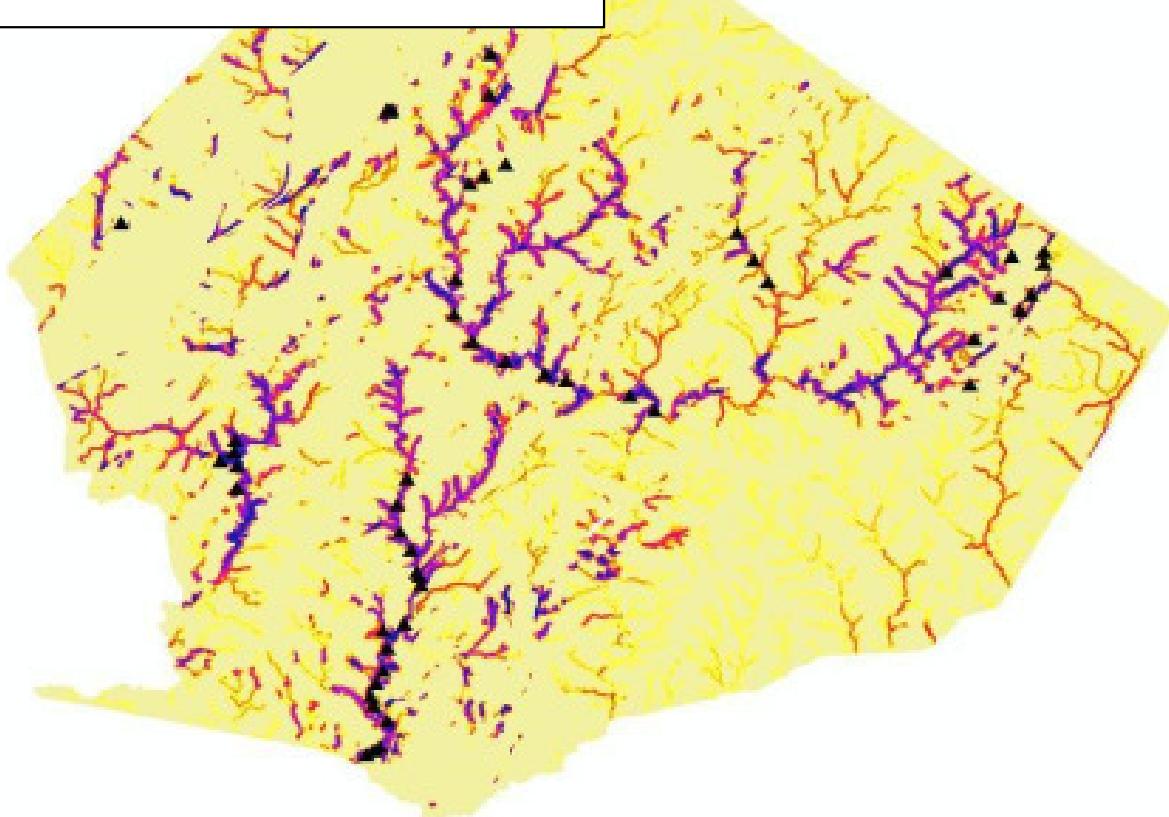
Boundaries

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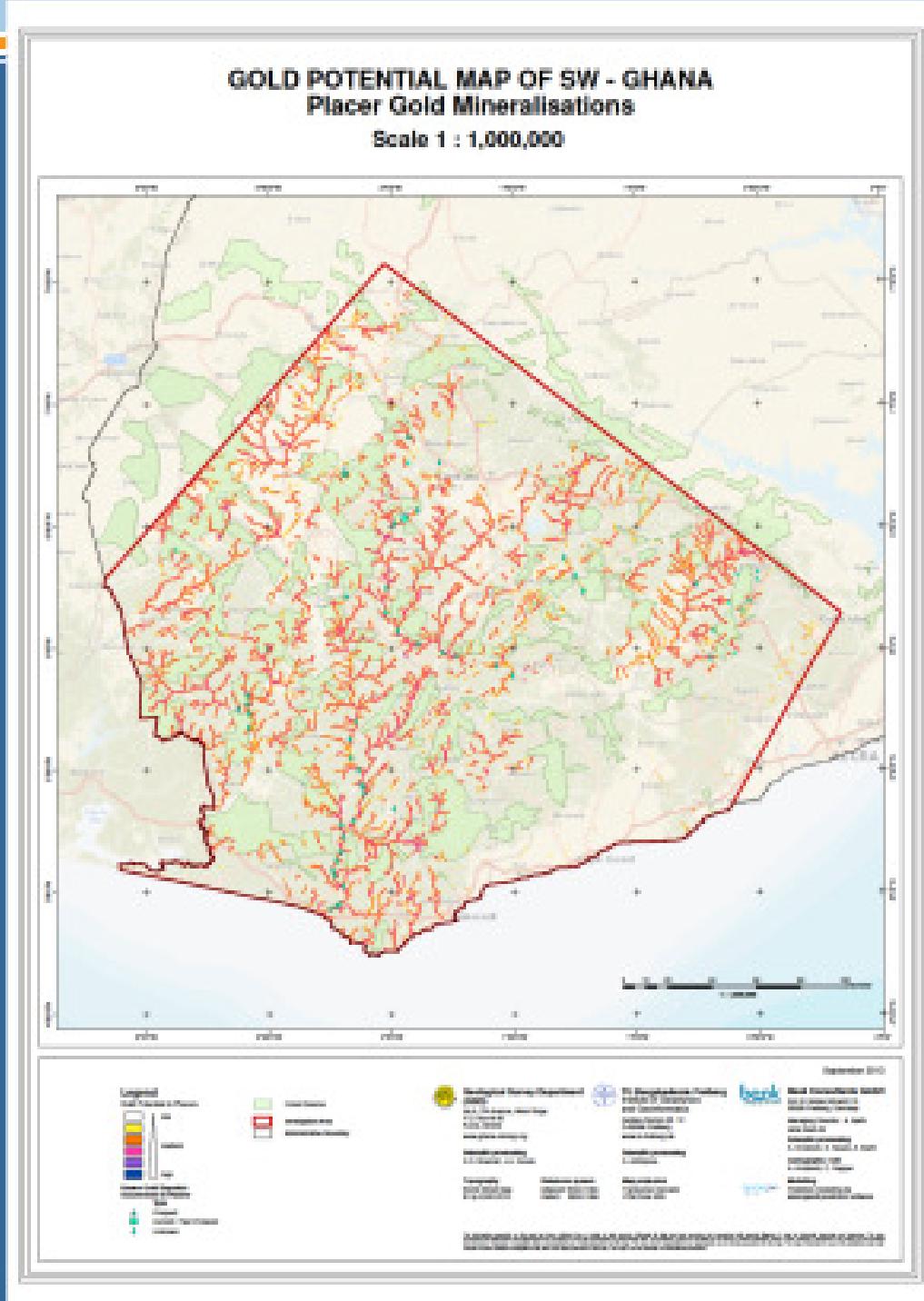
Placers are different....

Streams and their catchment areas, Gold source areas, distance from sources



- very clear spatial pattern
- the prospective zones are small
- the prospective zones are focused
- most of known occurrences are located in high potential areas
- the error is very low: approx. 0.06

The product and its application



Mineral Potential Map-placers

- Easy to read
- Sufficient accurate
- Represents existing knowledge
- Upgradable
- Usable for national/ regional planning activities
- Base for governance maps, to:
 - Protect resources
 - Guide small scale mining
 - Analyze conflicts
 - Plan long term land use



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How good are the maps ???

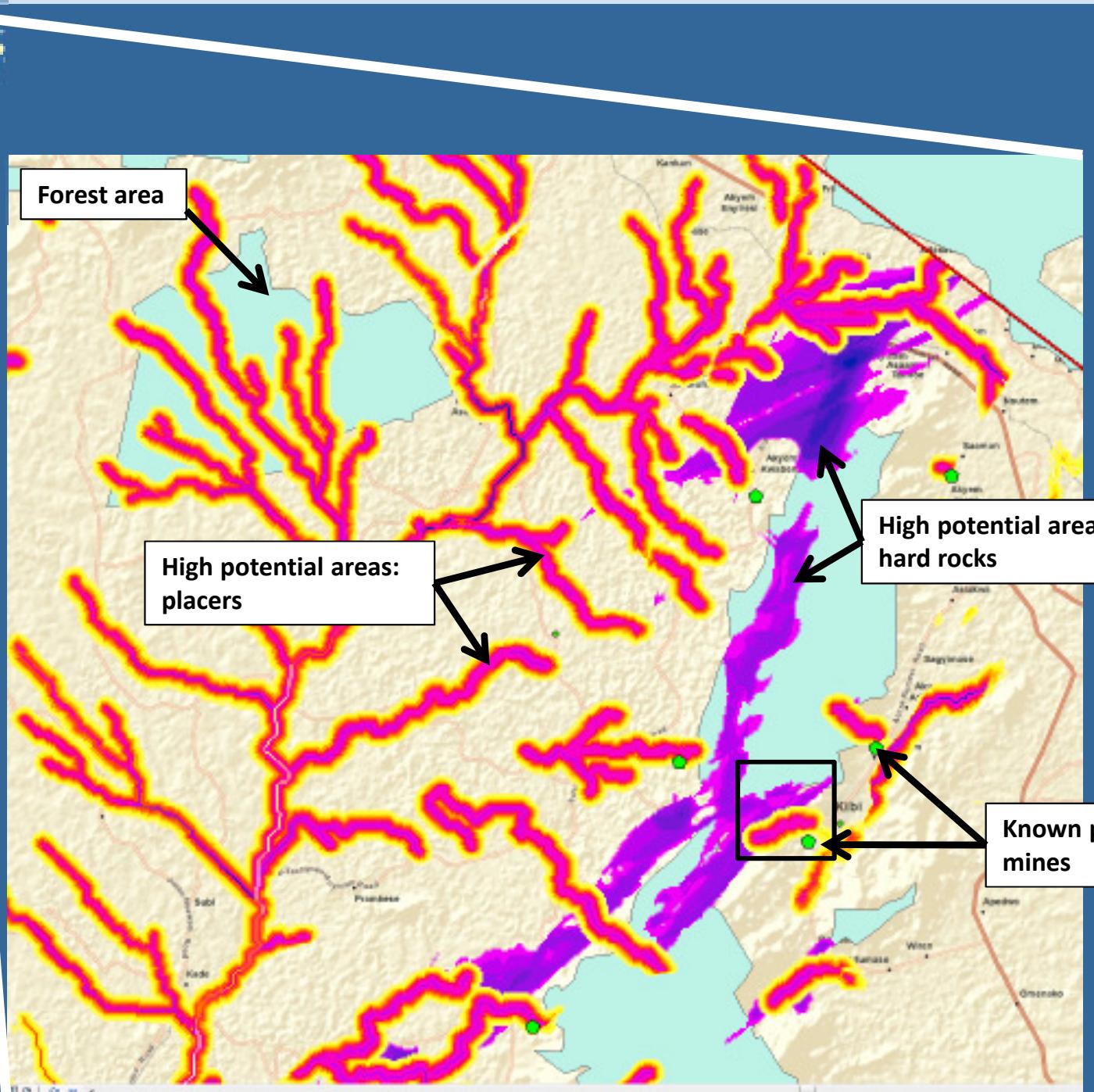
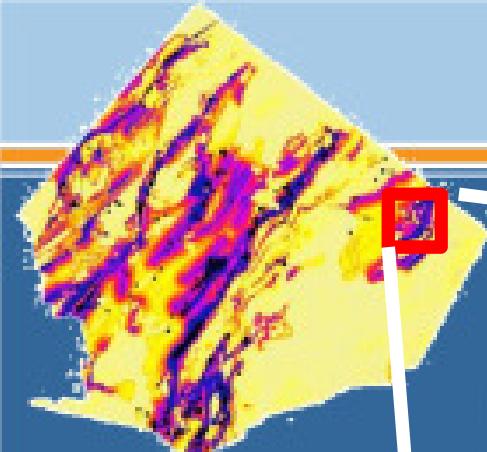
- As good as the input data is !
 - Locations and types of Au occurrences (used for training)
 - Location of ore controlling faults, lithologies,.....
 - Knowledge of geology
 - Geochemistry has not been used so far
- Neural network picks up the relationships, but wrong data will lead to wrong conclusions



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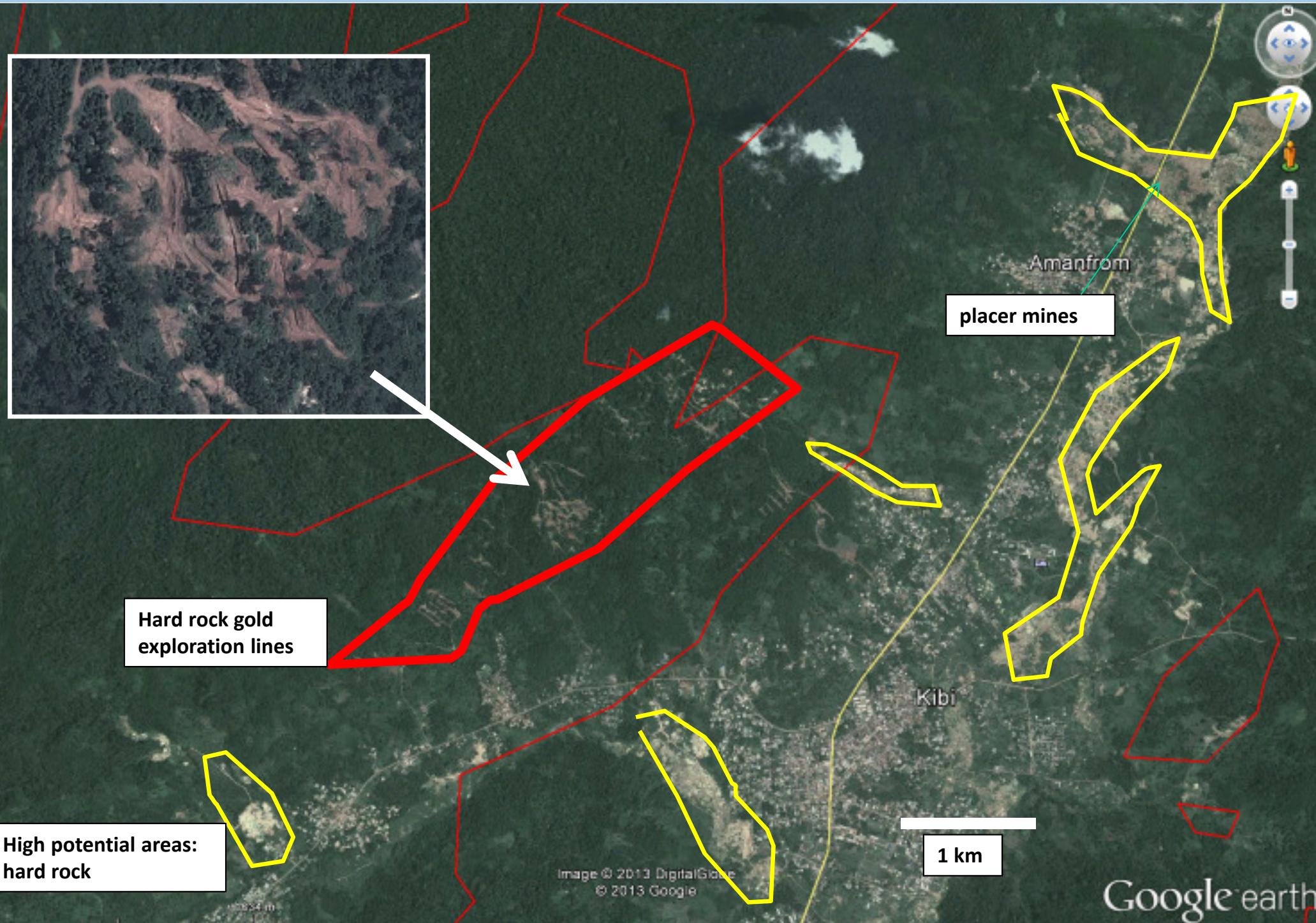
Details of Kibi prospects



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Details of Kibi area



How predictive maps can be used

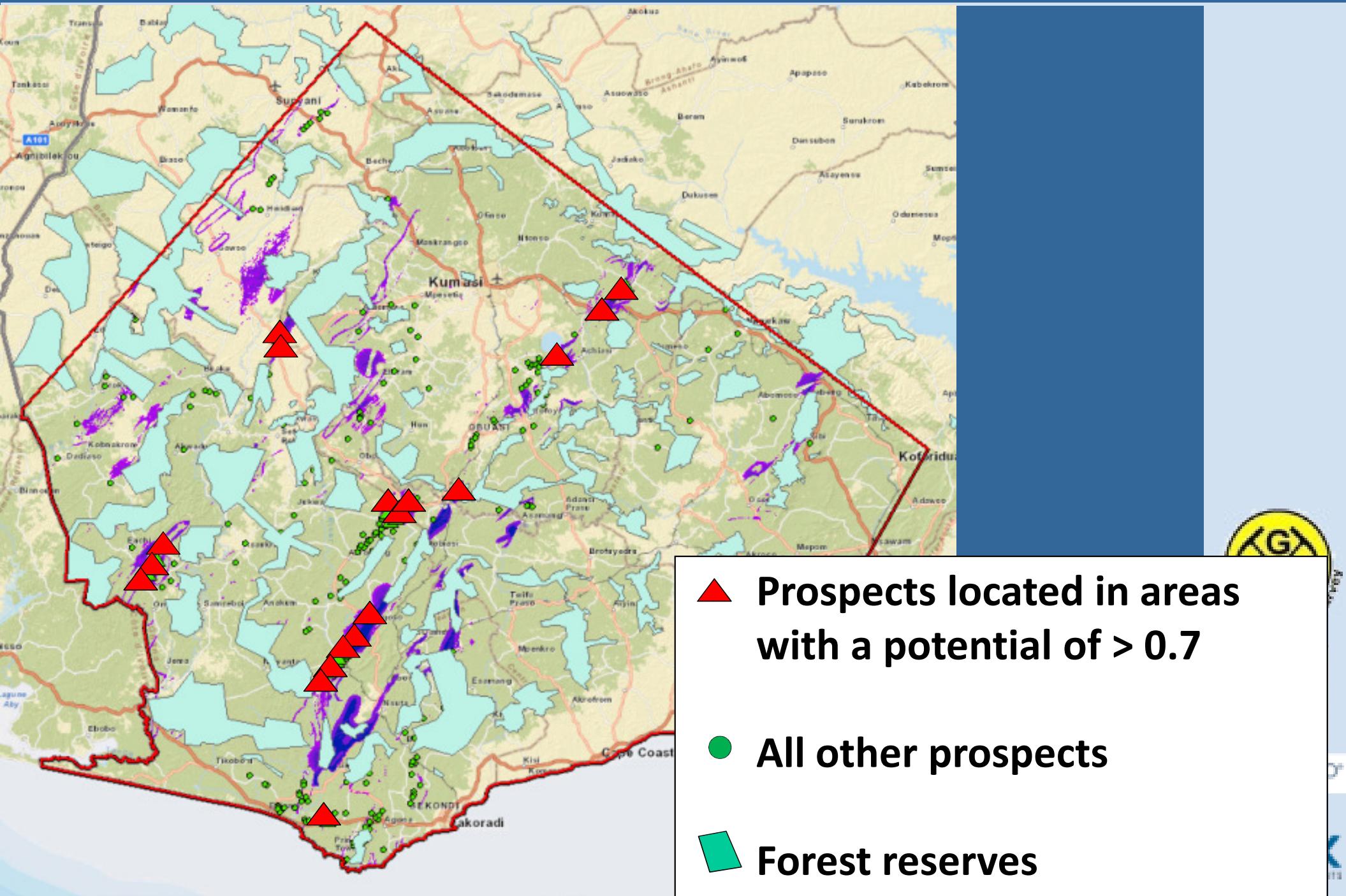
- Protect resources !!!
 - No further blocking by roads, settlements, water dams,....
 - Keep resources available for the future
- Guide exploration activities
 - Support exploration targeting
 - Support small scale mining
- Integrate mining into social and economic development
- Minimize conflicts
 - With agriculture
 - Nature conservation....



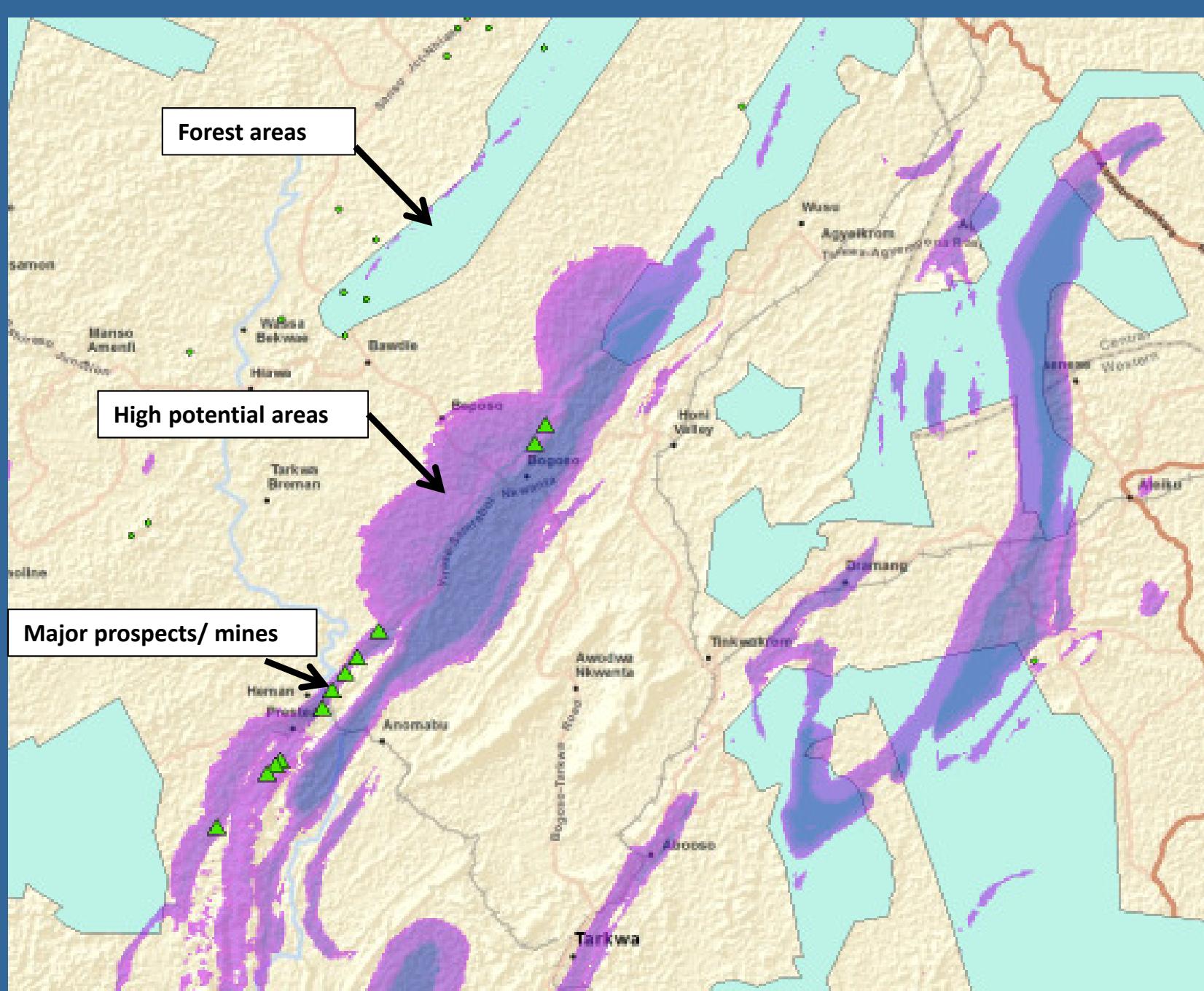
advanGeo
geospatial solutions

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What kind of restrictions appear ?



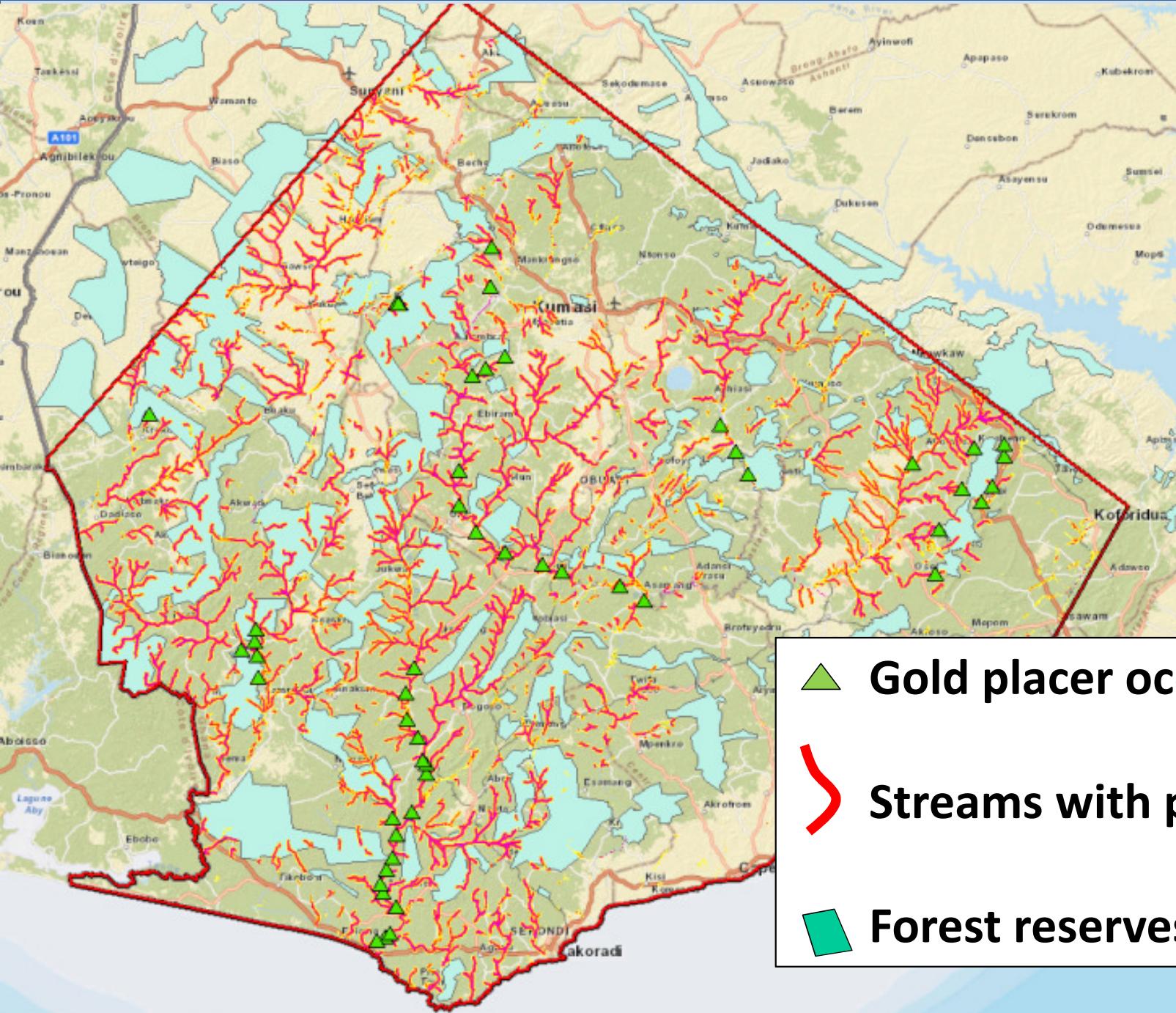
Detailed map of conflicts



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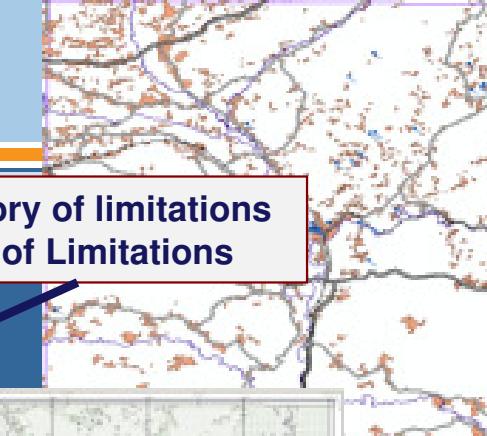
Conflicts with placers



- ▲ Gold placer occurrences
- Streams with placer potential
- Forest reserves

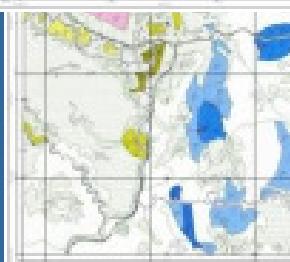


Land use conflict analysis



Inventory of minerals
Map of Minerals

Inventory of limitations
Map of Limitations

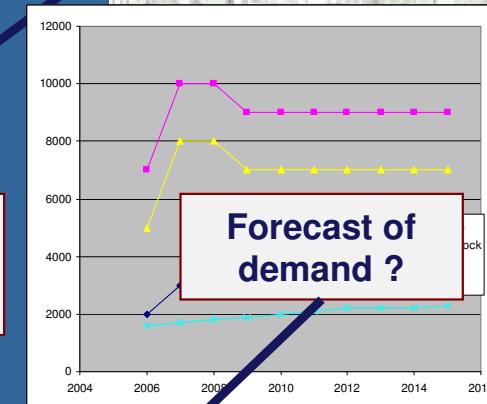


Map of non-blocked minerals

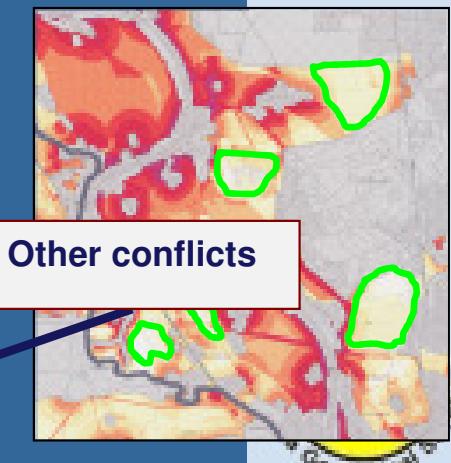
Map of legal status



Ranking according
value and legal
situation

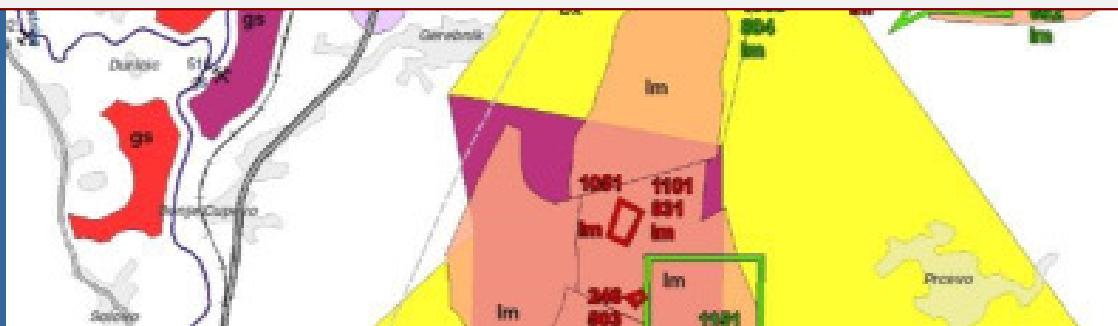


Forecast of
demand ?

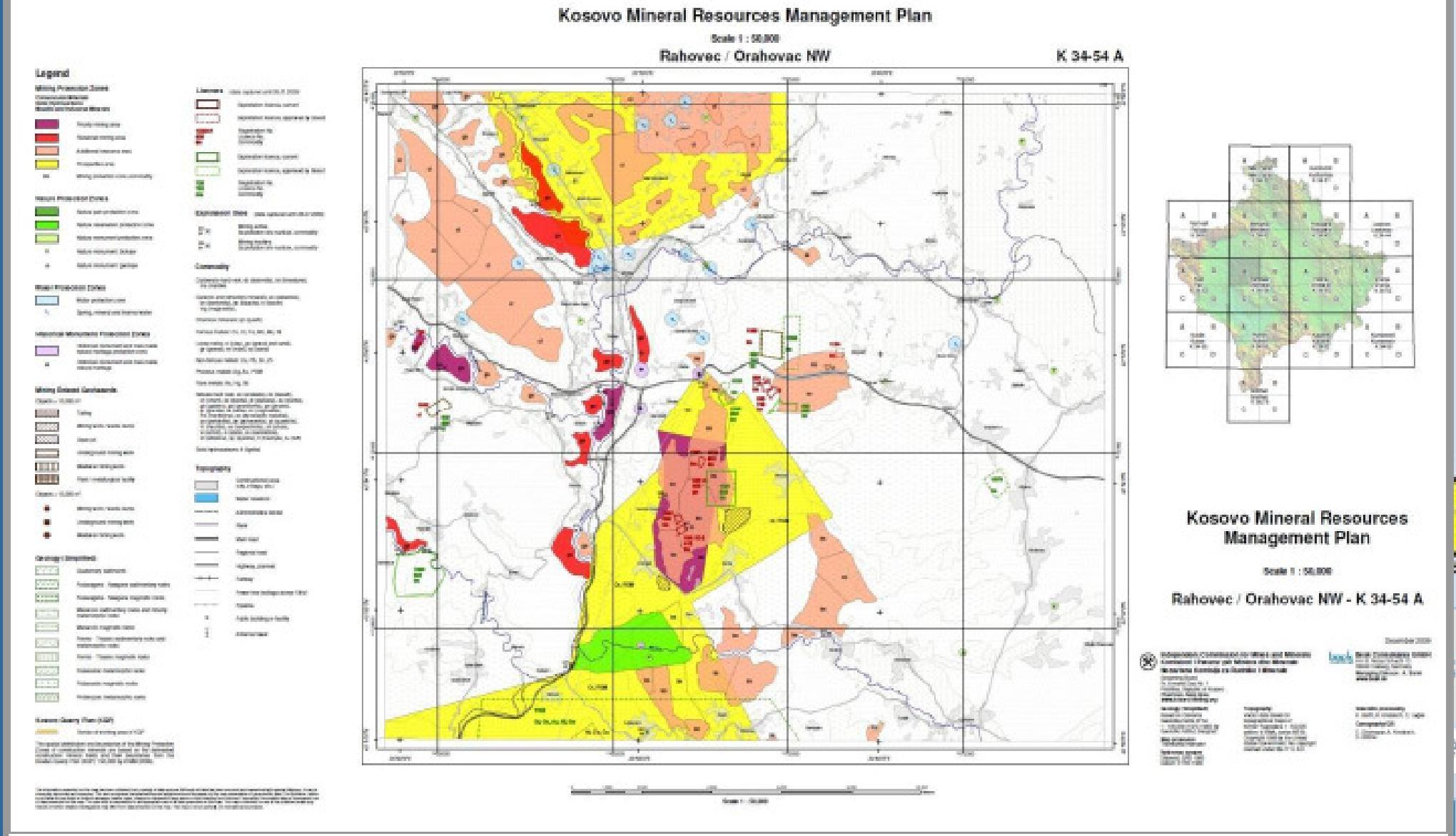


Other conflicts

Conclusions & recommendations = the mineral resources management plan

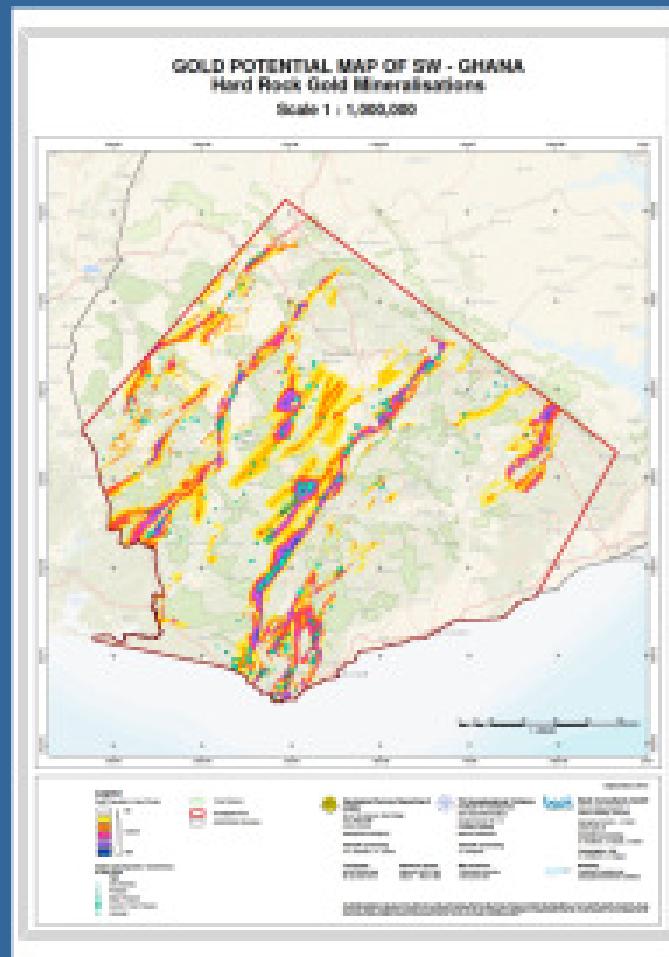


The Plan Document



Conclusions

- Gold predictive maps support:
 - informed decision making
 - investment attraction
 - Small scale mining
- Gold predictive maps safe:
 - Exploration funds
 - Use of land
- Gold predictive maps help:
 - Create mineral resource management plans
 - Develop infrastructure



Thank you for your attention

More information at
Our booth and our web site
www.beak.de

The predictive maps are available at our web site.

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

