advangeo®
Prediction Software

Advangeo® - exploration targeting by use of artificial neural networks. Background and experiences.

Andreas Barth

www.beak.de
andreas.barth@beak.de

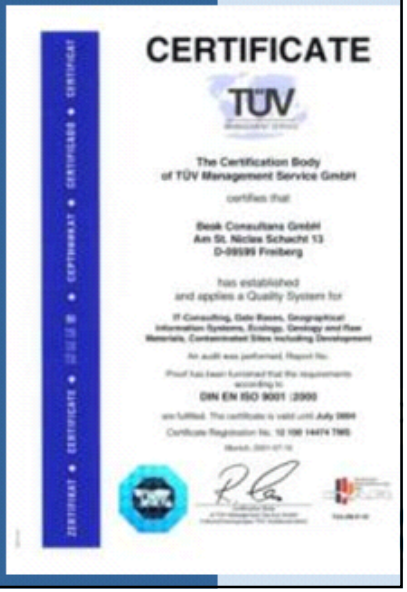
advangeo®
beak CONSULTANTS

Agenda

- Beak Consultants GmbH
- Artificial neural networks
- Application case: probabilities
- Application case: grades/ resources
- Current projects
- Conclusions

Beak Consultants GmbH

- Fields of business
  - Geology, exploration, environment
  - GIS and cartography
  - Tailor-made software
- World wide operation
- ISO 9001:2000 certificate
- 19 years of company experience
- Roots are the
  - East German Geological Survey
  - Canadian Beak Consultants International



CERTIFICATE

TÜV

The Certification Body
of TÜV Management Service GmbH

certifies that

Beak Consultans GmbH
Am St. Niclas Schacht 13
D-09599 Freiberg

has established
and applies a Quality System for

IT-Consulting, Data Bases, Geographical Information Systems, Ecology, Geology and Raw Materials, Contaminated Sites including Development

An audit was performed, Report No.

Proof has been furnished that the requirements according to

DIN EN ISO 9001 :2000

are fulfilled. This certificate is valid until July 2004

Certificate Registration No. 12 100 14474 TMS

Munich, 2001-07-16

Motivation

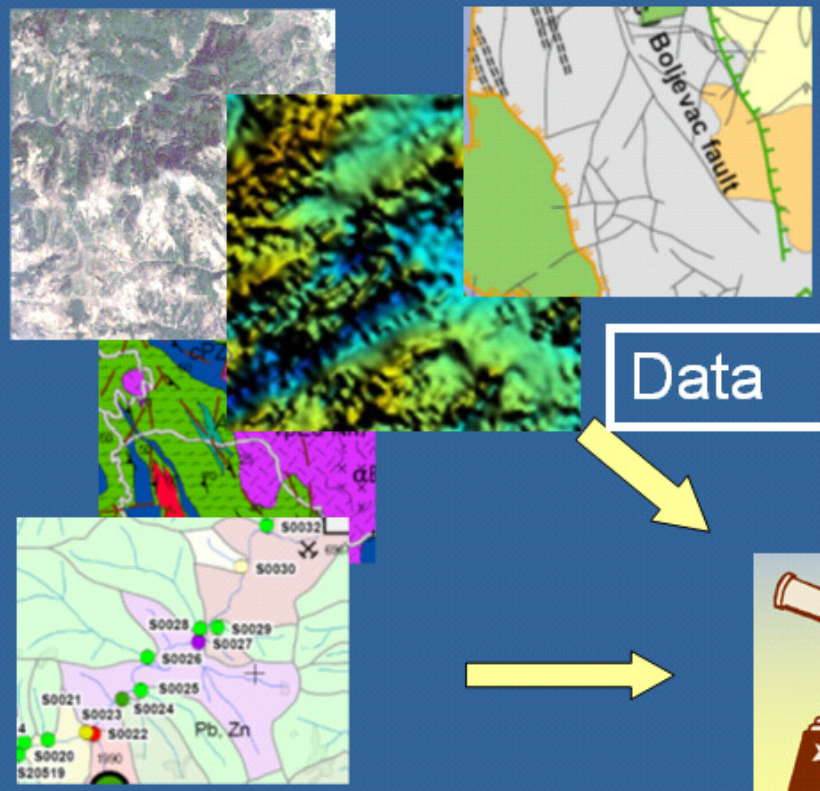
Where are prospective areas ?

Where are exploration targets ?

What can be expected:

- grades ?
- tonnage ?
- case histories

How to find exploration targets ?



Traditional interpretation methods: the expert´s knowledge / experience

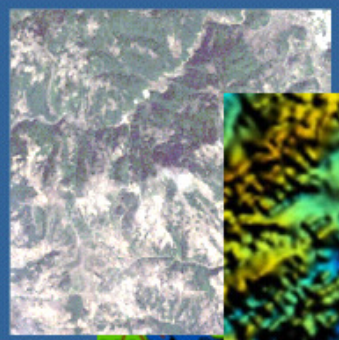
GIS methods, statistics ...

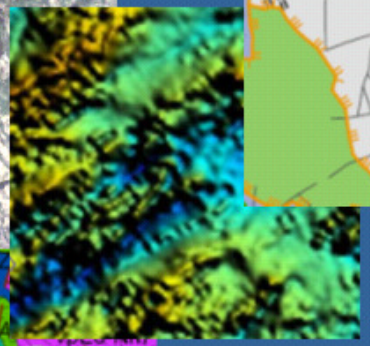
Target areas

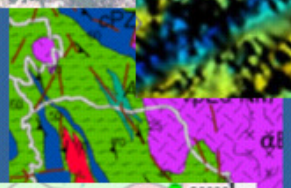
advangeo

beak CONSULTANTS

Using artificial neural networks

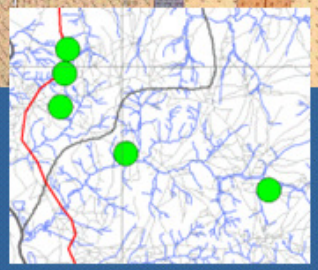




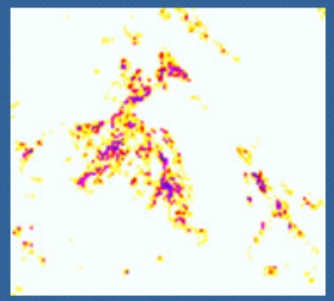


Data

Knowledge



Pre-Processing



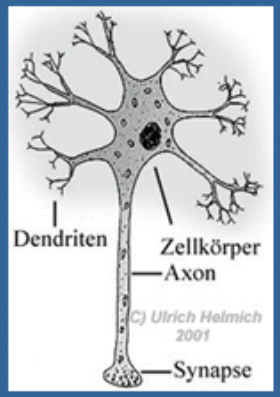
The predictive maps:

- probabilities
- grades
- resources ...

Validation

beak CONSULTANTS

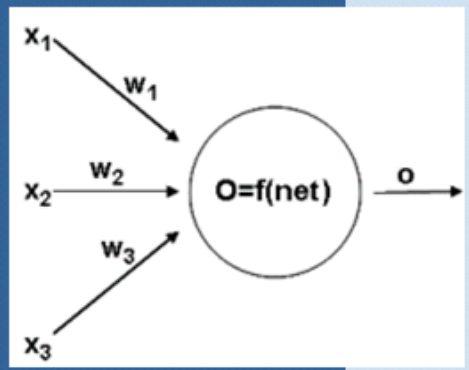
Background of Artificial Neural Networks



Modell: 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

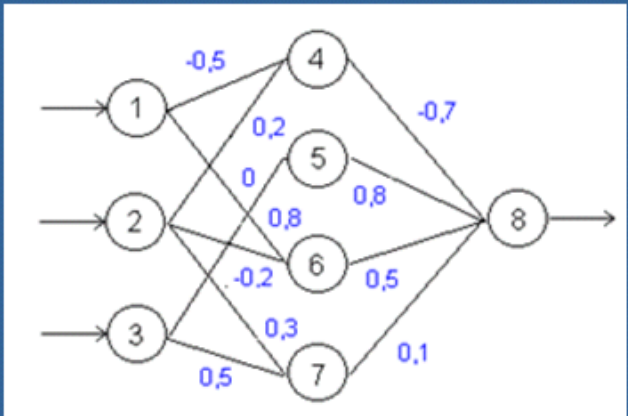


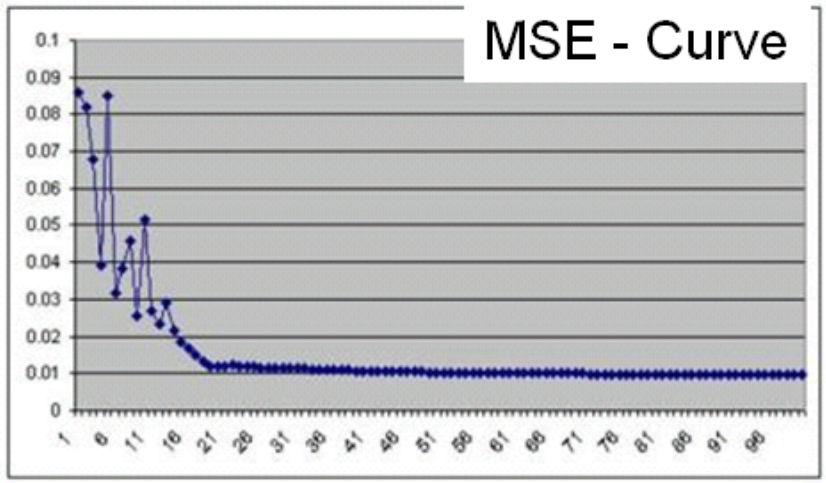
- **Connection between the neurons by weights w**
  - Enforce or reduce the level of the input information
  - Are directed, can be trained
- **Input signals**
  - Re-computed to a single input information: the propagation function
- **Output signals**
  - Activation function computes the output status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

How the network learns ?

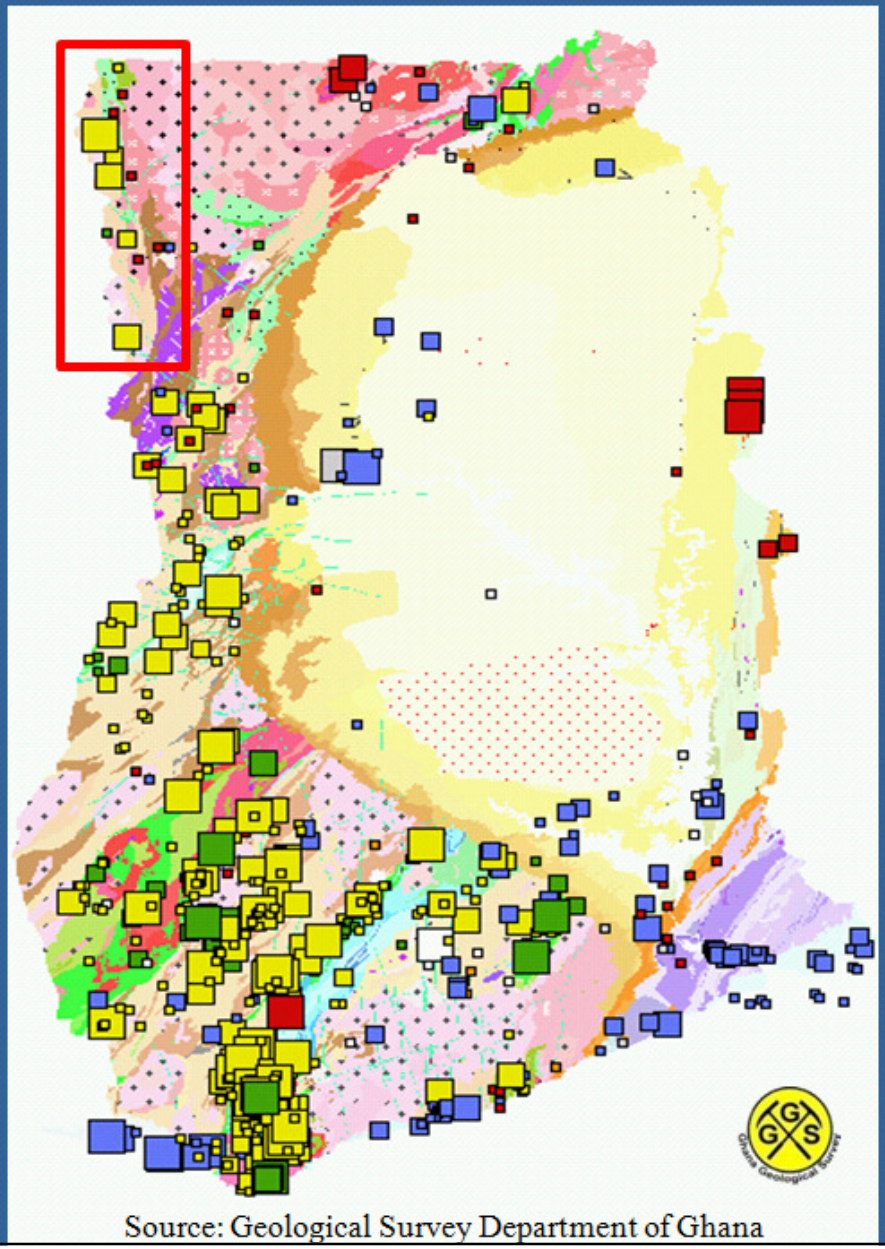
Learning Algorithm: Back-Propagation

- Repeated input of training data
- Modification of weights w
- Minimizes the error between expected value (the reality) and the actual calculation result
- Runs iterations up to a certain error





Create a probability map: Gold in NW Ghana



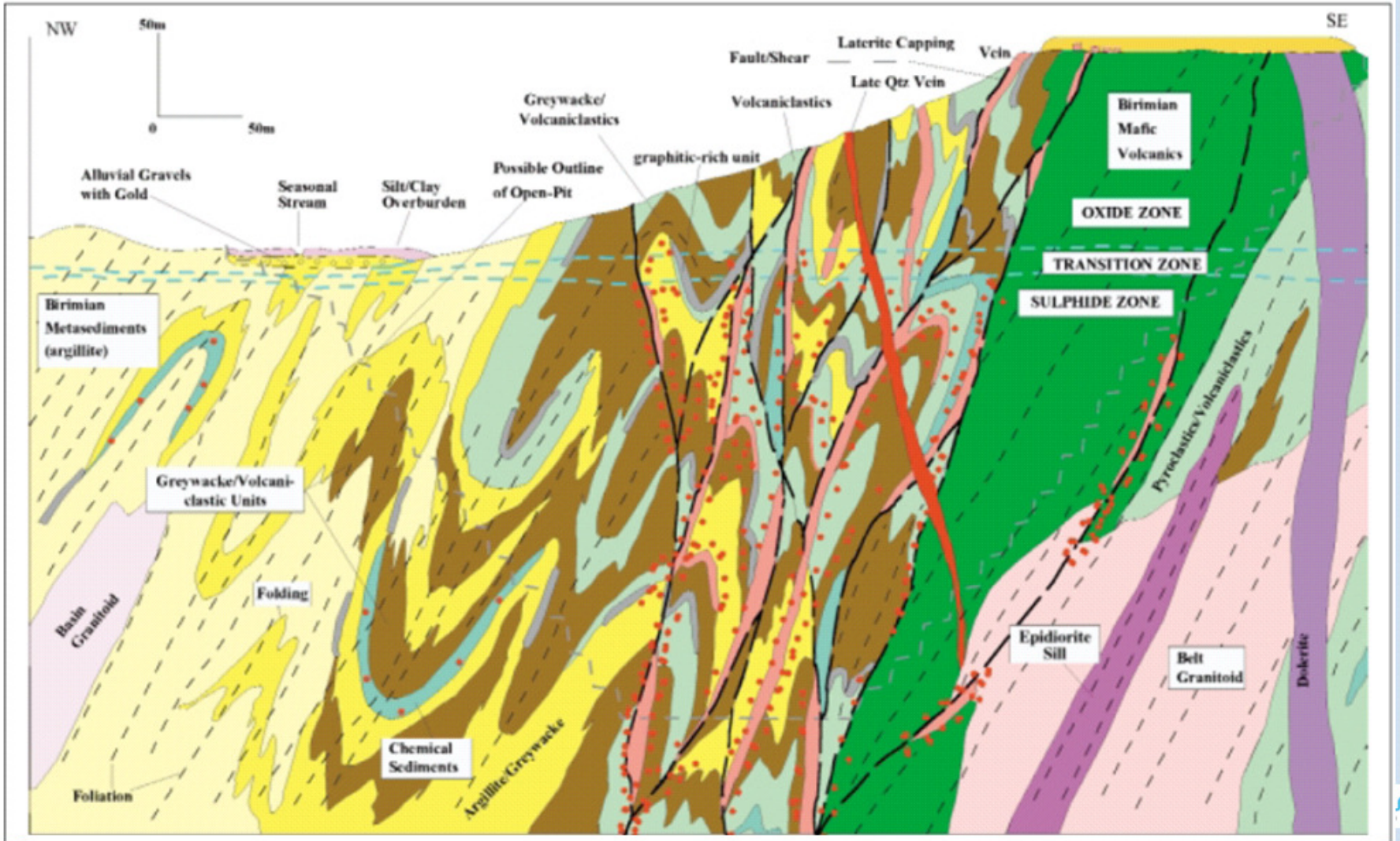
Prediction of prospective locations

Created with Mr. Solomon Anum and Mr. Kwame O. Boamah. Geological Survey Department, Ghana

advangeo

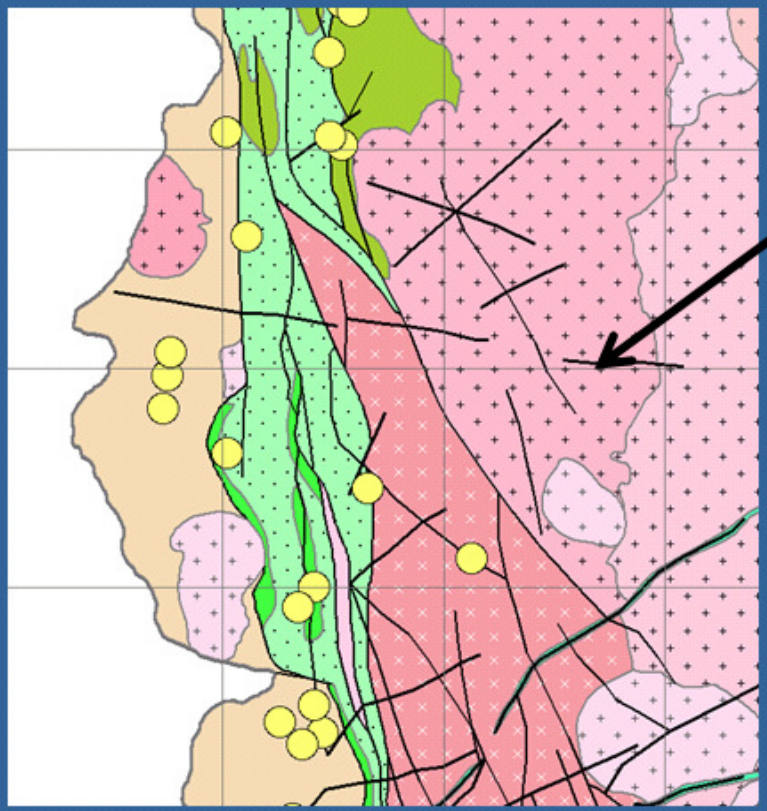
beak CONSULTANTS

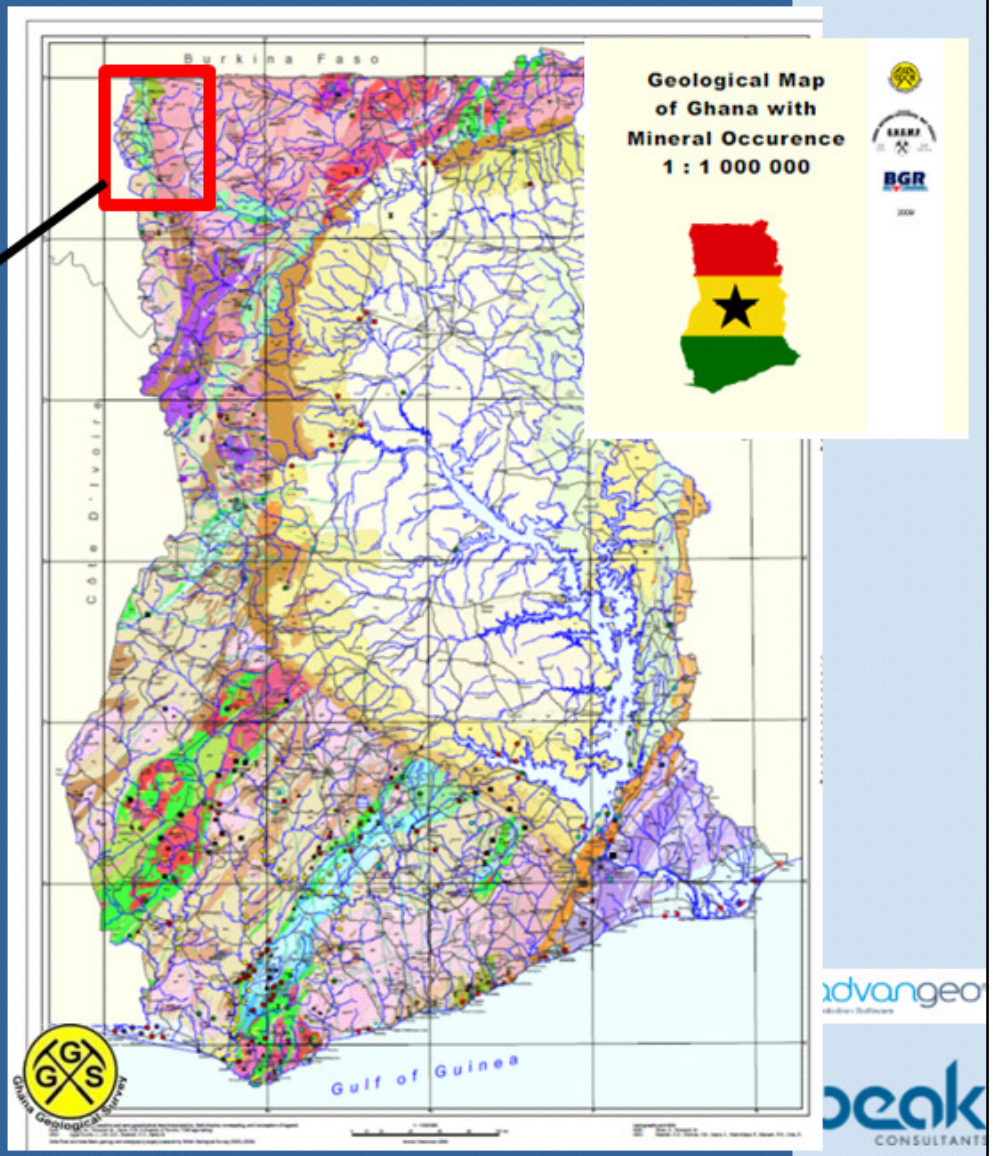
Knowledge: the metallogenetic model



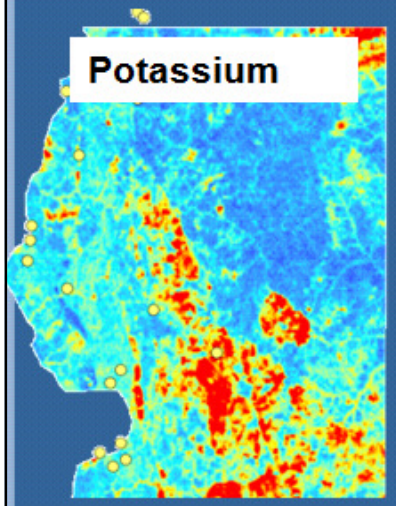
Source: Gold deposits of Ghana, Minerals Commission, Ghana, ROBERT J. GRIFFIS, KWASI BARNING, FRANCIS L. AGEZO, FRED K. AKOSAH, 2002

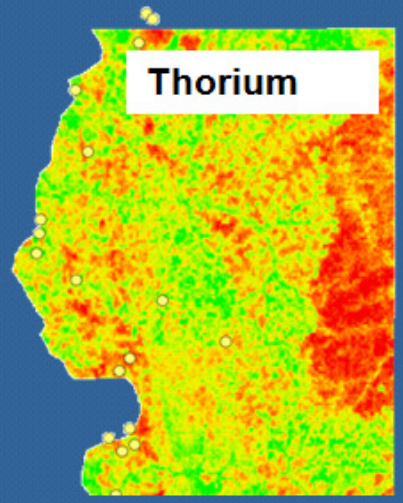
Geology, Structures & Occurrences

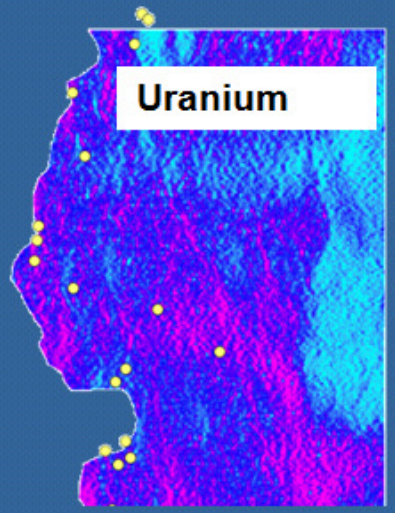


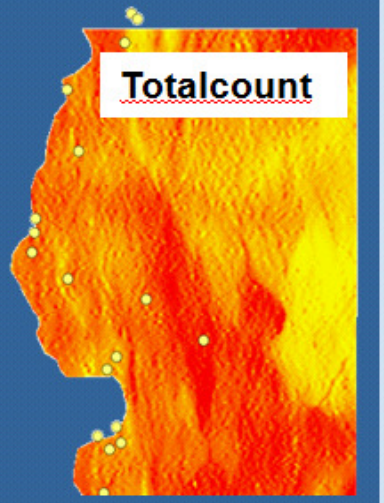


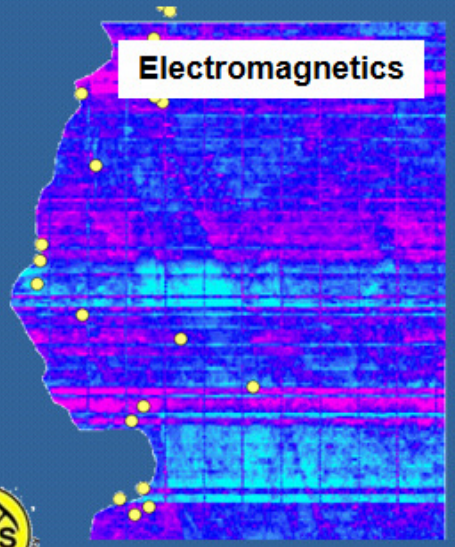
Airborne geophysics

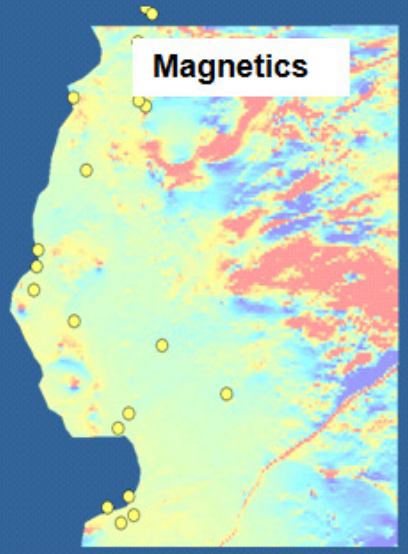












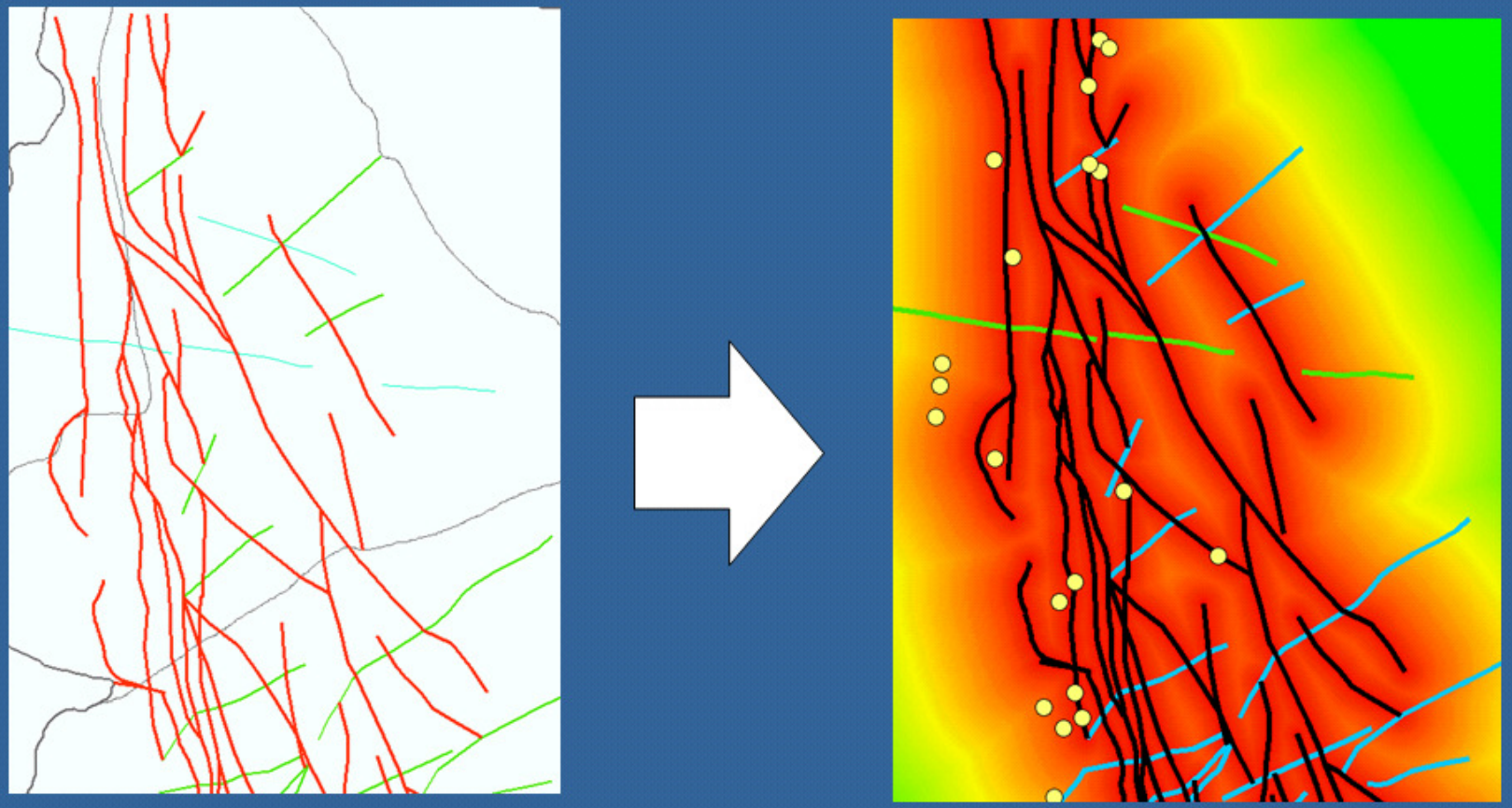
Created with Mr. Solomon Anum and Mr. Kwame O. Boamah. Geological Survey Department, Ghana

Source: Geological Survey Department of Ghana

advangeo

beak CONSULTANTS

Creation of model input data: shear zones

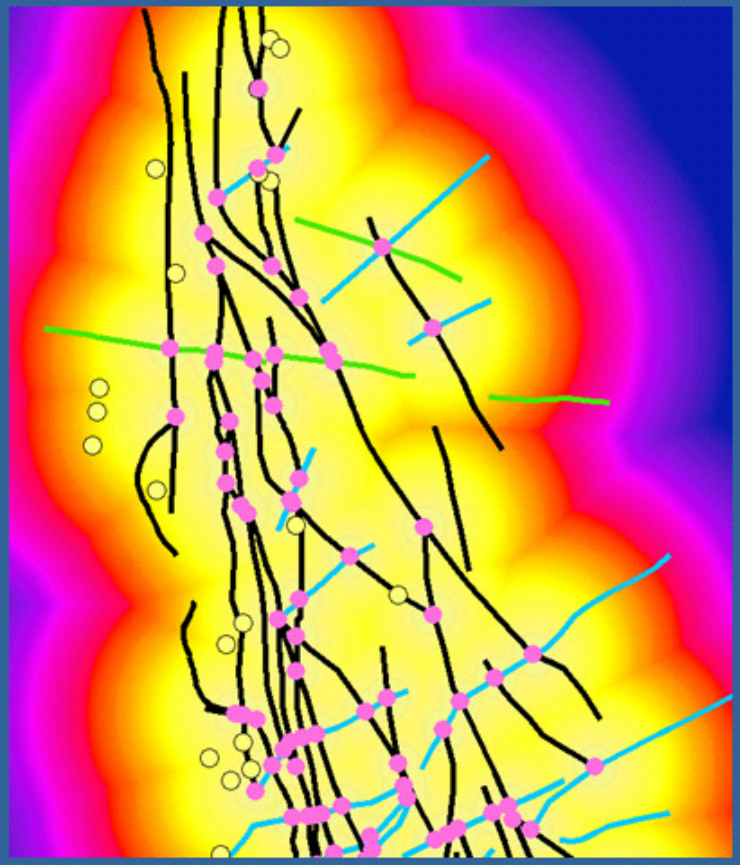


Creation of distance layers: how fare is a point from a structure ?

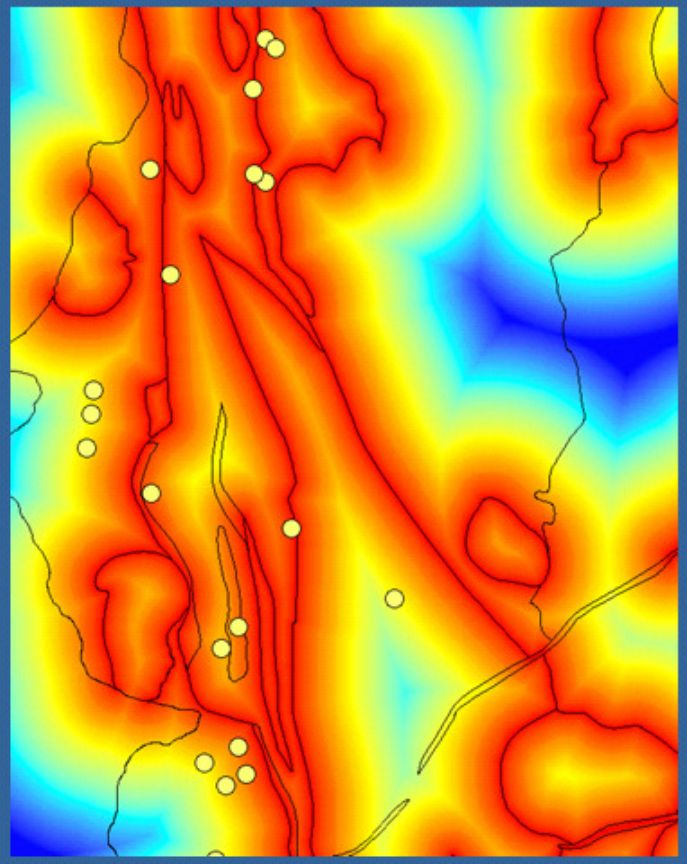
advangeo

beak CONSULTANTS

More model input data



Intersections of tectonic structures

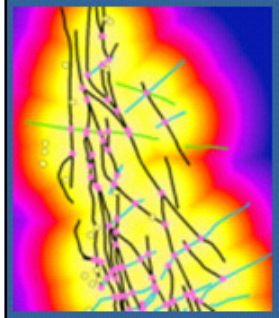
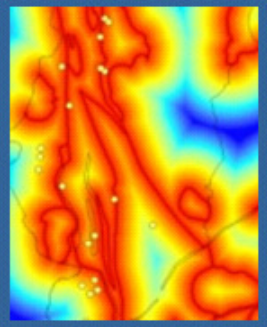
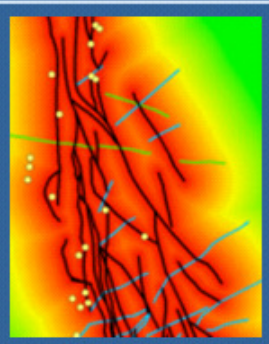
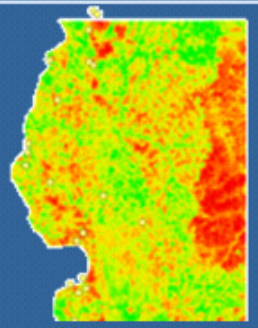
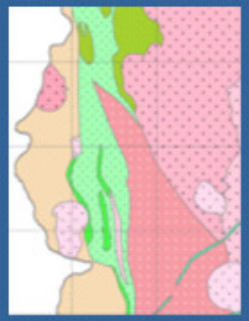


Important rock contacts

advangeo

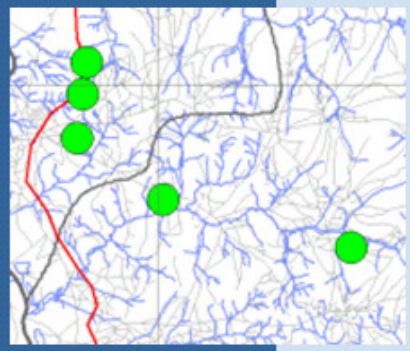
beak CONSULTANTS

The advangeo workflow

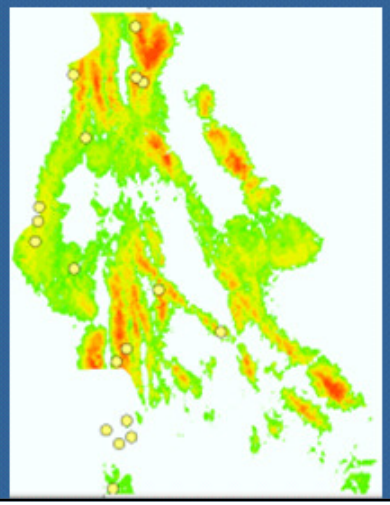
Input data layers

advangeo®
Prediction Software



Training points = known minera-lisations

Proba-bility map



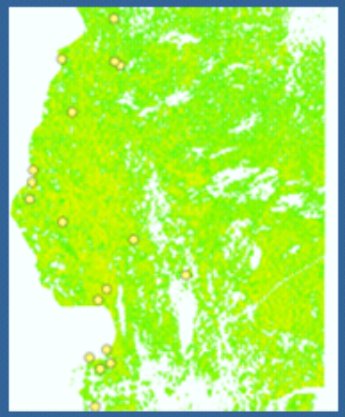
Created with Mr. Solomon Anum and Mr. Kwame O. Boamah. Geological Survey Department, Ghana

advangeo

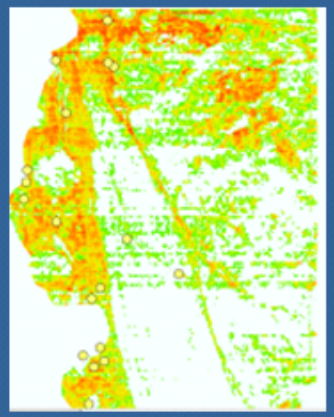
beak CONSULTANTS

Different models, the final target map

U, Th, K, total

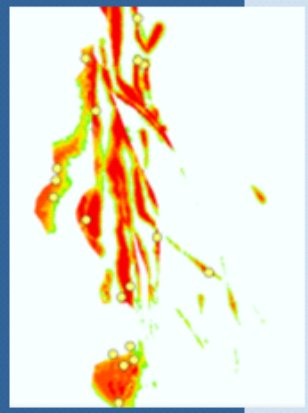


U, Th, K, total, magnetics

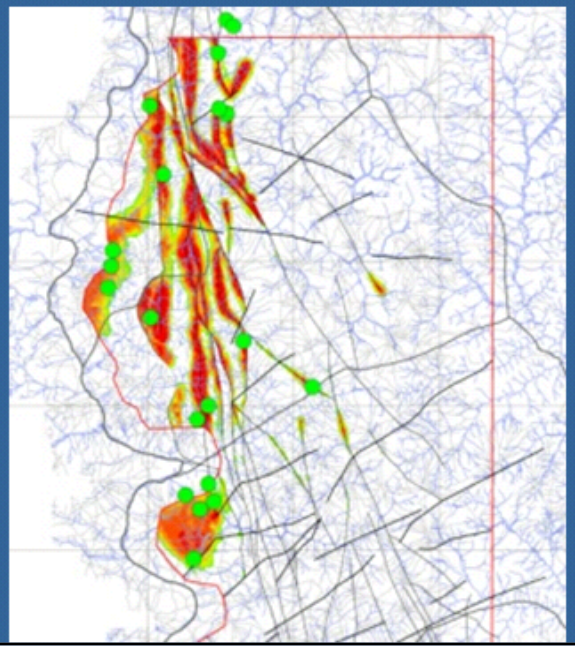


U, Th, K, total, magnetics, electromagnetics

U, Th, K, total, magnetics, structures



U, Th, K, total, magnetics, structures, rocks, intersections, rock contacts



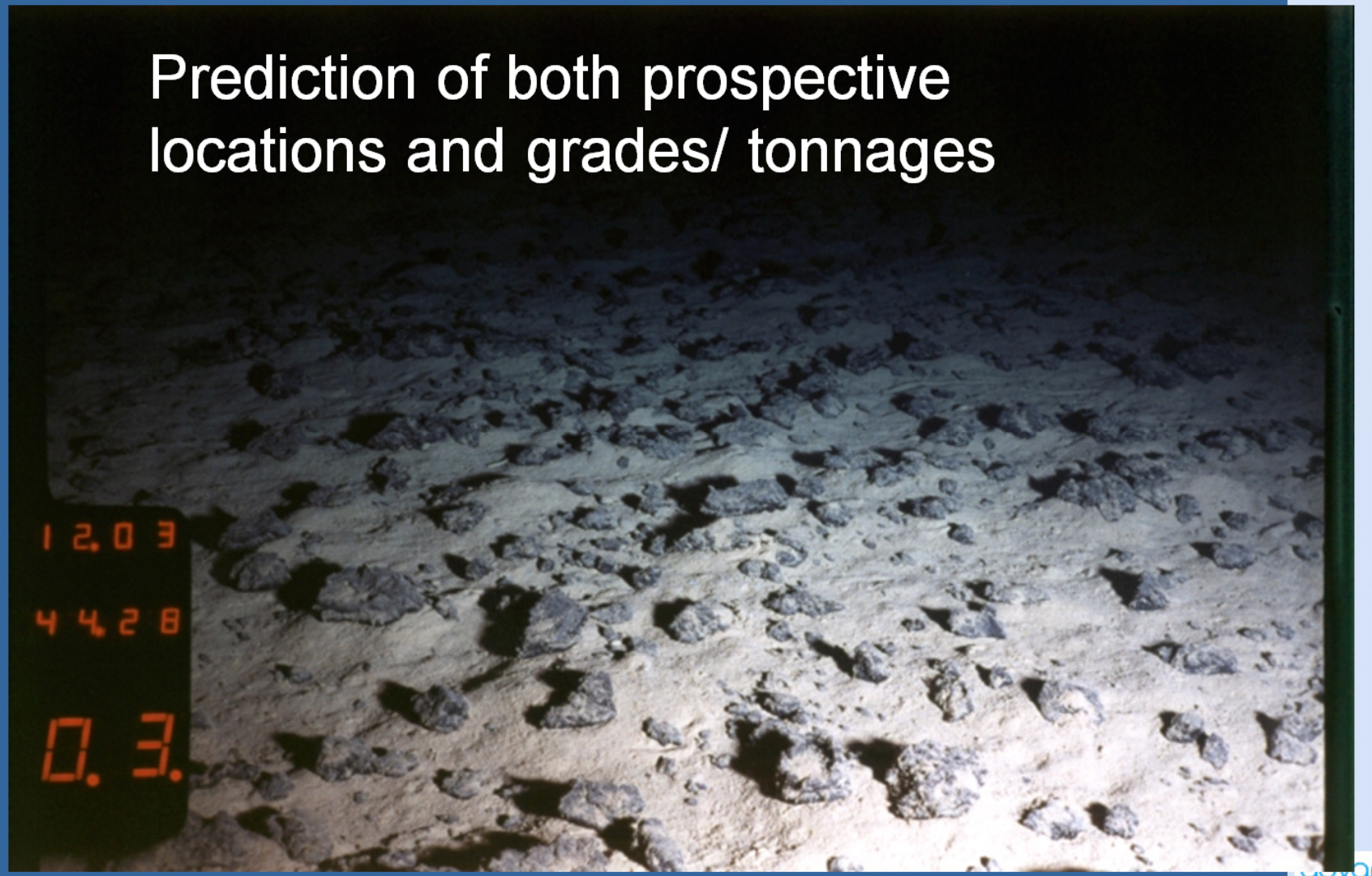
- **easy to read**
- **for long term national planning**
- **better use of exploration funds**
- **attracts and guides investment**

Created with Mr. Solomon Anum and Mr. Kwame O. Boamah. Geological Survey Department, Ghana

advangeo

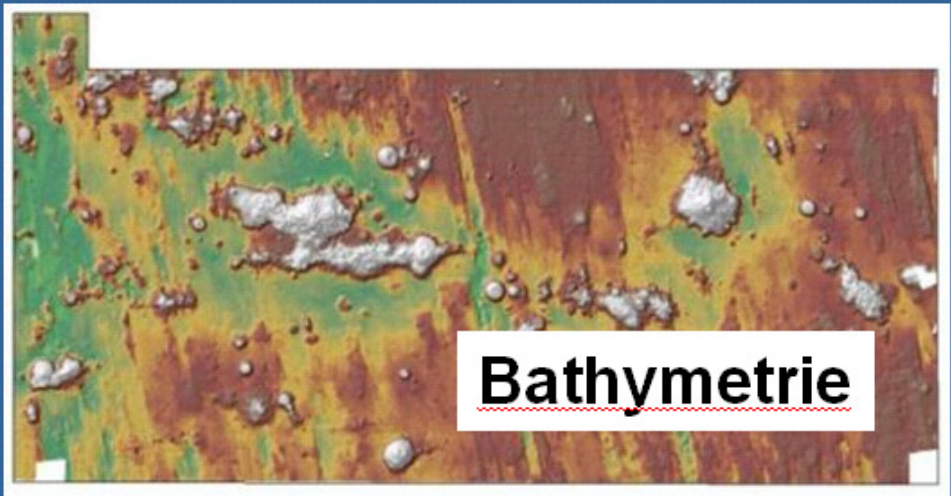
beak CONSULTANTS

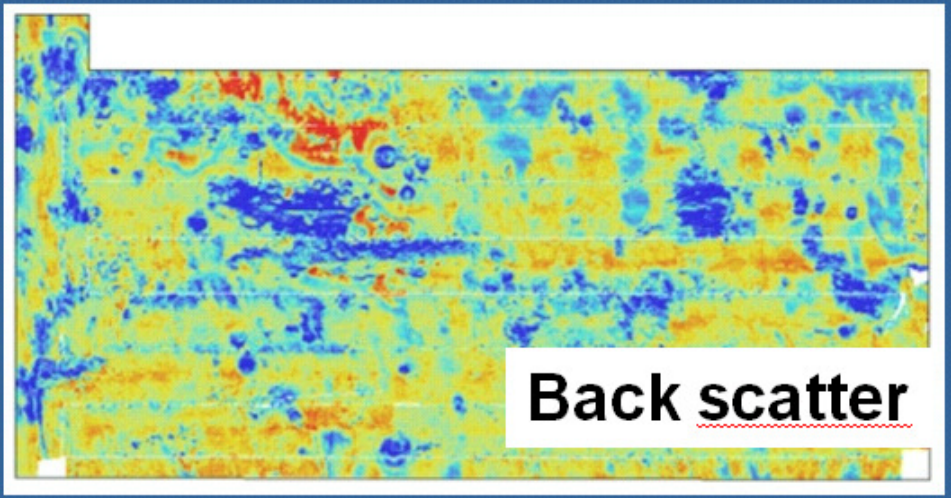
A quantitative predictive map: see floor Mn nodules

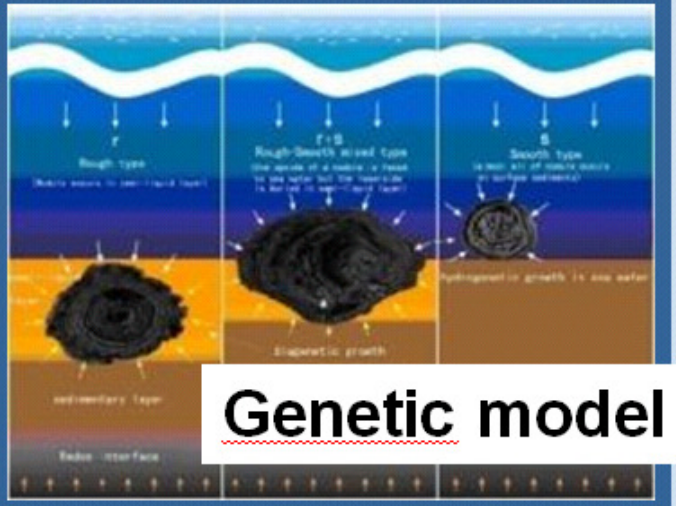


Mn nodules on the sea floor

Data and knowledge







advangeo

beak CONSULTANTS

Data layer creation

Bathymetry:

- absolute value
- slope gradients
- slope directions
- flow accumulation
- concavity
- structures:
  - sea mounts,
  - tranches
- distances to structures

Backscatter:

- absolute value
- slope gradients
- slope directions
- flow accumulation
- concavity
- structures
- distances to structures

Results: sensitivity analysis

Parameter	*Sensitivity*		
	high	*medium*	*low*
Bathymetry			
Absolute level		X	
Slope		X	
Exposition N/S		X	
Exposition W/E	X		
Concavity			X
Flow Accumulation	X		
Backscatter			
Absolute values		X	
Slope			X
Euclidic distance from…			
Seamounts		X	
Seamounts, Max. 10 km	X		
Lineaments	X		
Lineaments, Max. 10 km		X	

advangeo

beak CONSULTANTS

Workflow

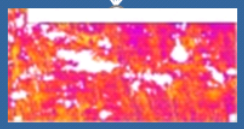
Input Data / Layers

weights

Hidden Layers

weights

Output Layer



Values !!!

Ressources kg/sqm

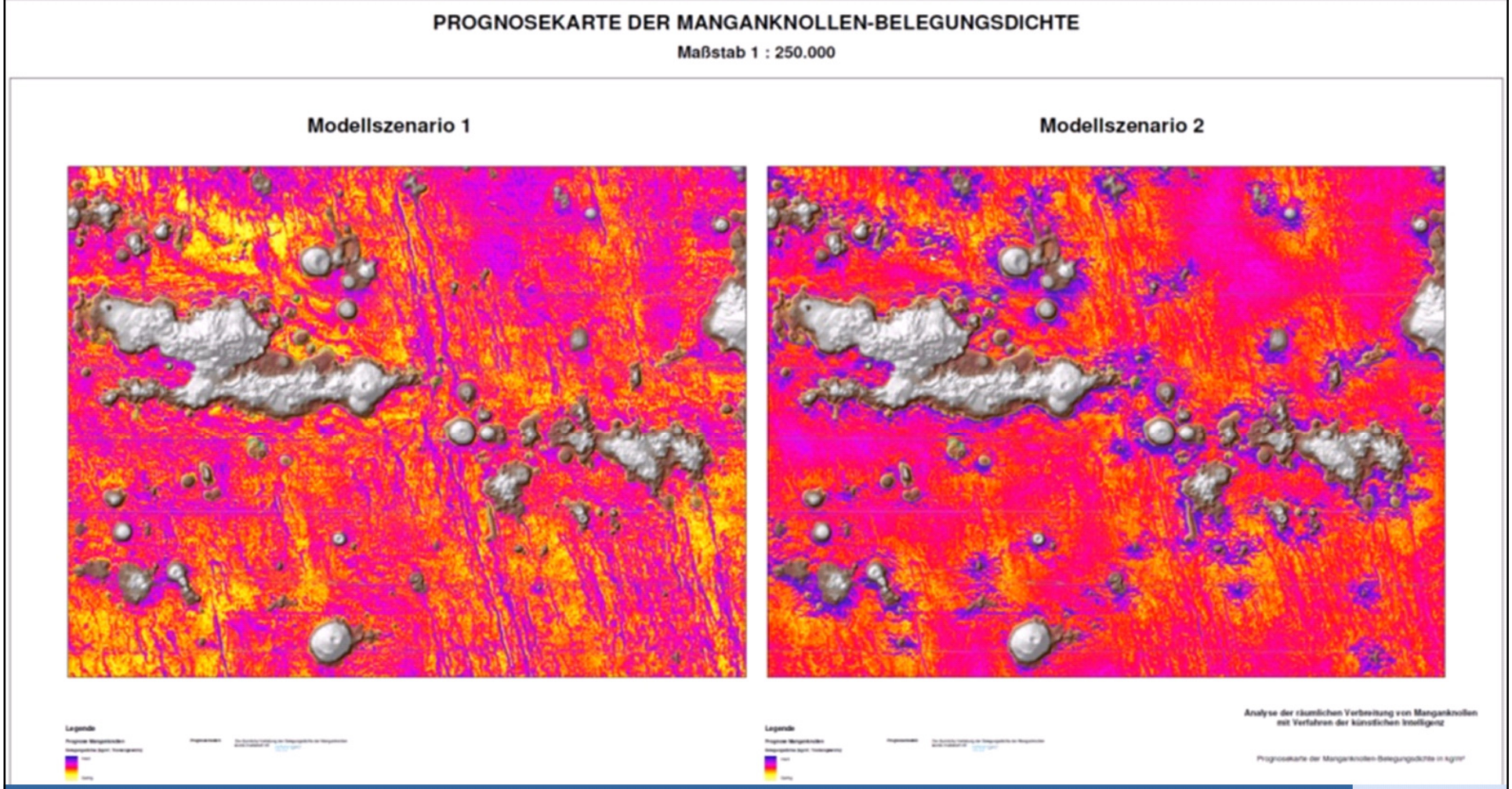
Training-data

Sample locations & analytics

advangeo

beak CONSULTANTS

Comparing two models

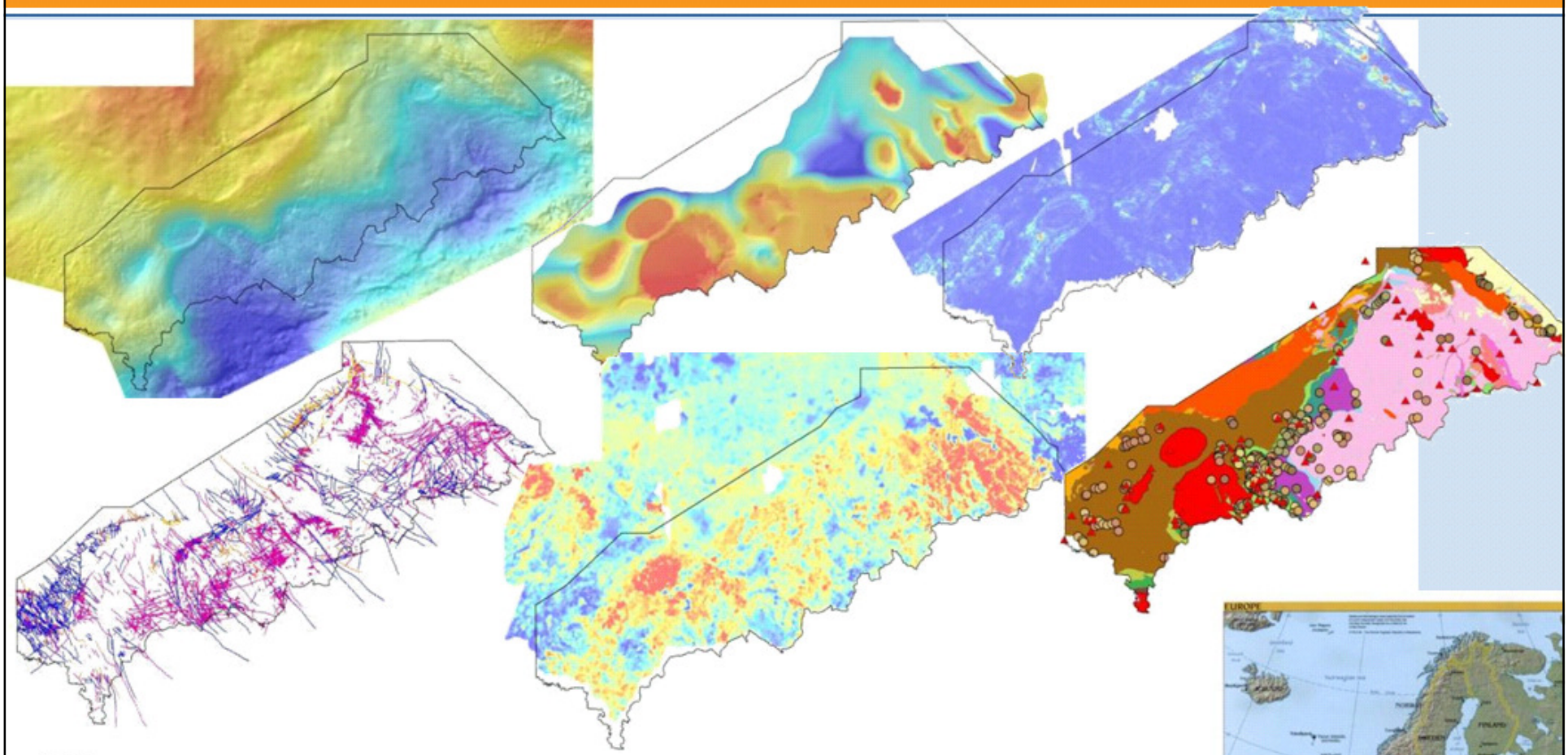


< 20 % difference between the two models

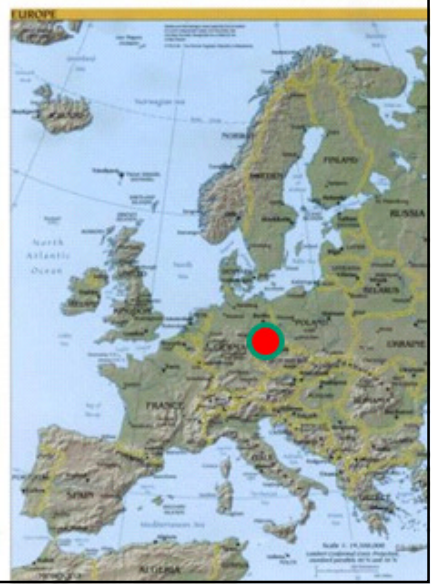
advangeo

beak CONSULTANTS

Re-evaluation of the the Erzgebirge



10 km



Prospectivity maps for Sn, W, Mo, Pb, Zn, ...

Re-discovery of Sn skarns

Tin skarn prospectivity map

Big skarn deposits
Hämmerlein/ Tellerhäuser:
240 kt contained Sn
JV:
Saxony Mines Ltd./
Beak Consultants

Recently re-discovered
Sn skarns
JV:
AVRUPA Minerals/
Beak Consultants

10 km

advangeo

beak CONSULTANTS

Conclusions

- Data driven
- Subjective factor is minimal
- Useable without knowledge
- Analyzes sensitivities
- Applicable in low data scenarios
- Fast
- Applicable for:
  - Minerals
  - Geohazards
  - Pollution
  - Hydrogeology
  - Mapping

Advangeo® new release available soon

advangeo

beak CONSULTANTS

Thank you for your attention

More information at

- www.advangeo.com
- Our memory sticks

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