



Application of artificial neural networks for selection and evaluation of exploration targets

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Agenda

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



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Prediction Software

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Motivation

Where are prospective areas ?

Where are exploration targets ?

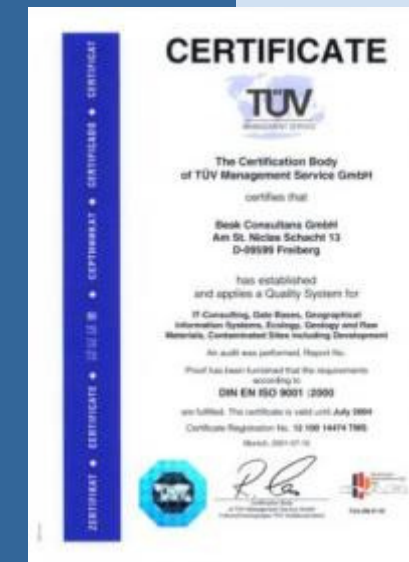
What can be expected:

- grades ?
- tonnage ?



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



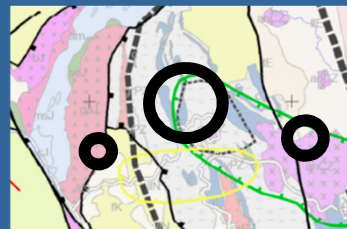
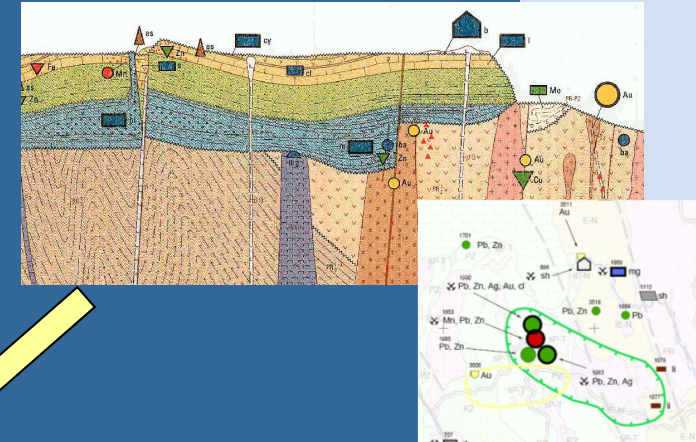
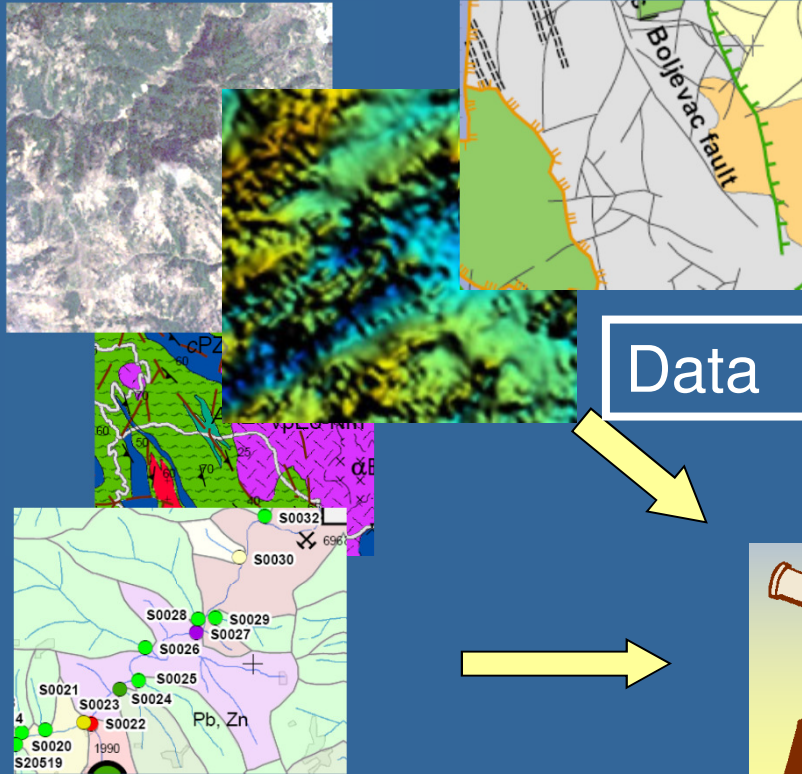
The usual approach

Knowledge

Data

Traditional interpretation methods: the expert's knowledge / experience
GIS methods, statistics ...

Target areas



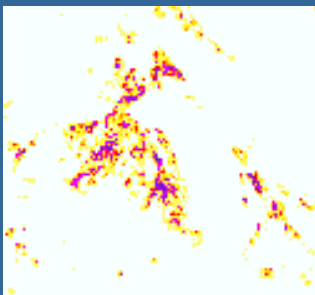
Using artificial neural networks

Knowledge

Data

Pre-Processing

Validation



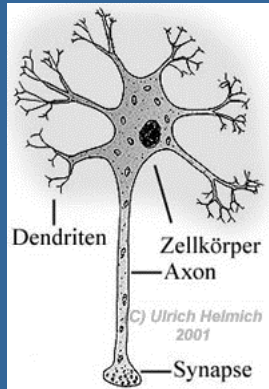
The predictive maps:

- probabilities
- grades
- resources ...



Background of Artificial Neural Networks

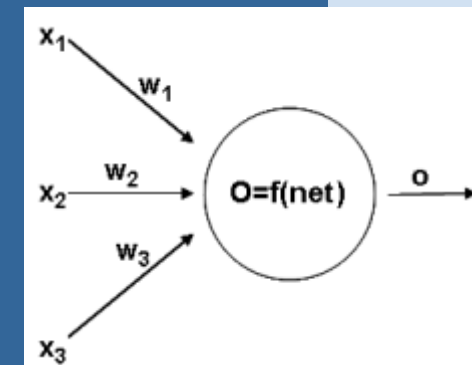
Modell: Neuron Cell



- 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

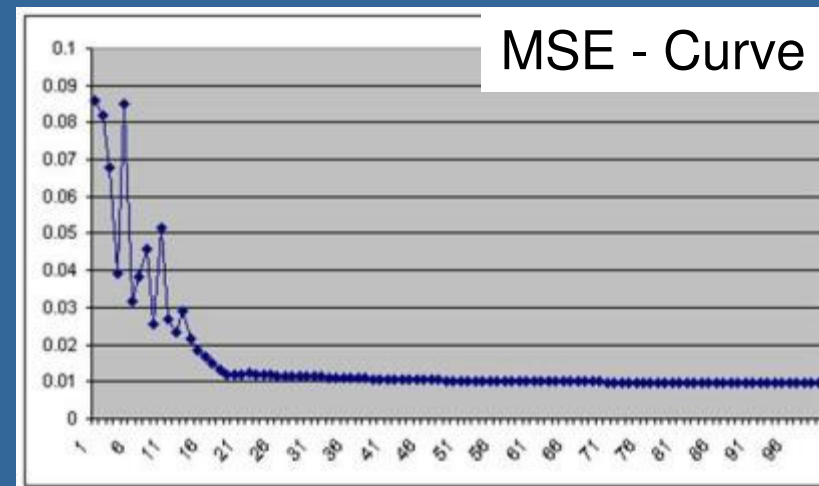
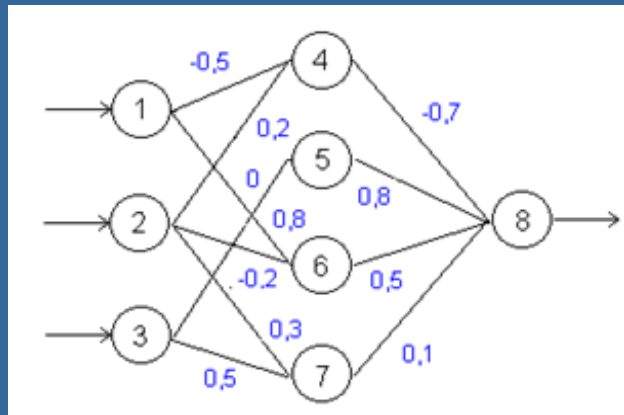
- **Connection between the neurons by weights w**
 - Enforce or reduce the level of the input information
 - Are directed, can be trained
- **Input signals**
 - Re-computed to a single input information: the propagation function
- **Output signals**
 - Activation function computes the output status of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



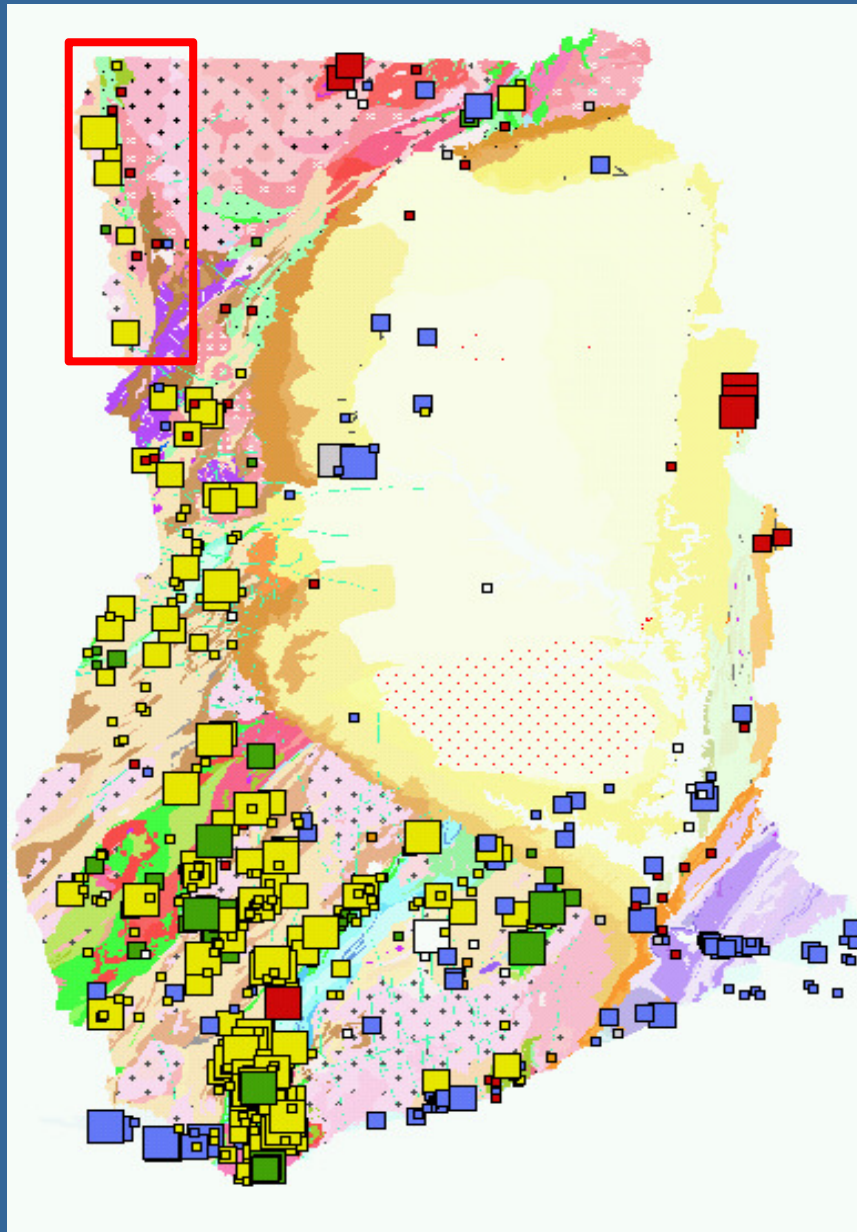
How the network learns ?

Learning Algorithm: Back-Propagation

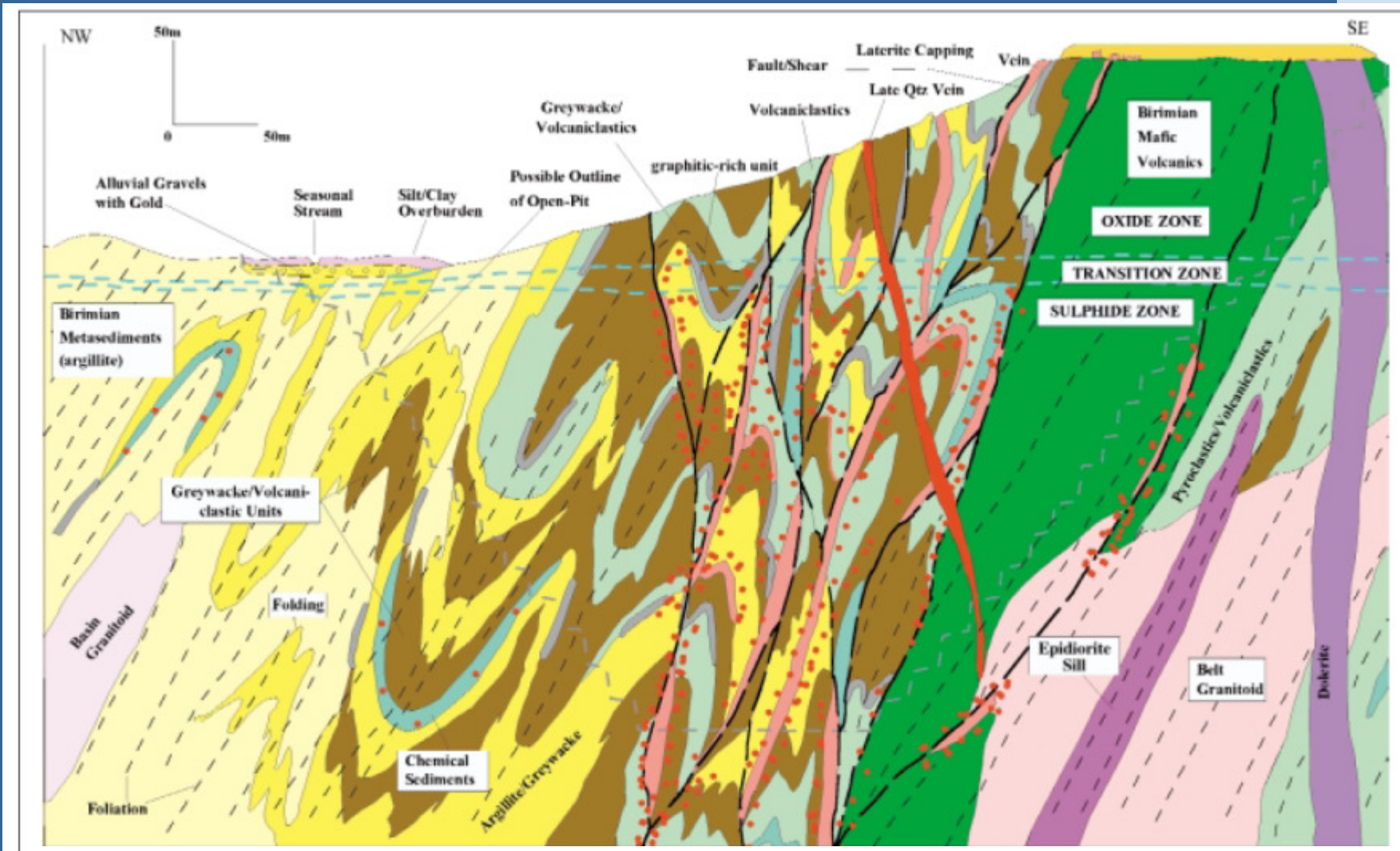
- Repeated input of training data
- Modification of weights w
- Minimizes the error between expected value (the reality) and the actual calculation result
- Runs iterations up to a certain error



Create a **probability** map: Gold in NW Ghana

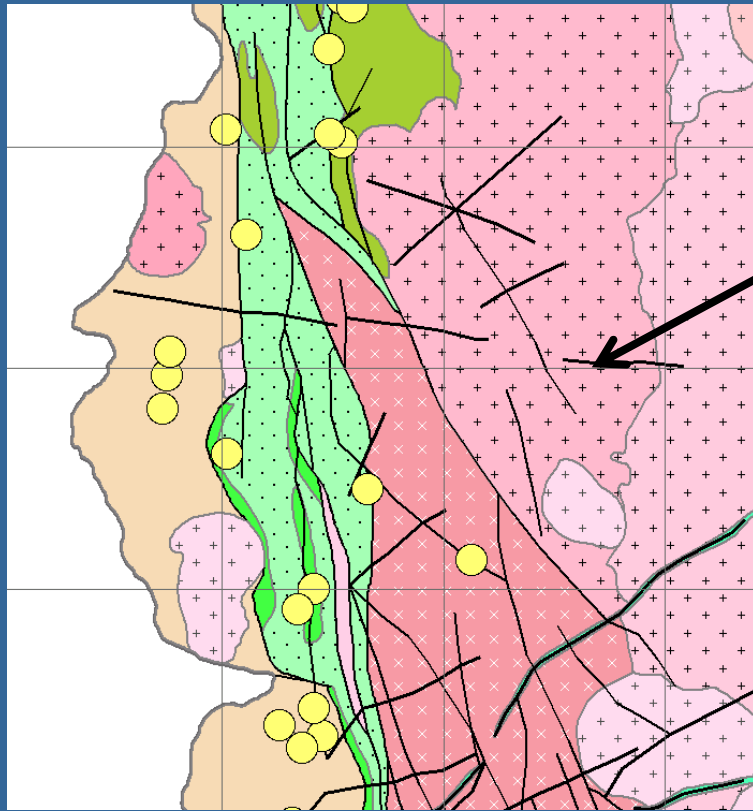


Knowledge: the metallogenic model

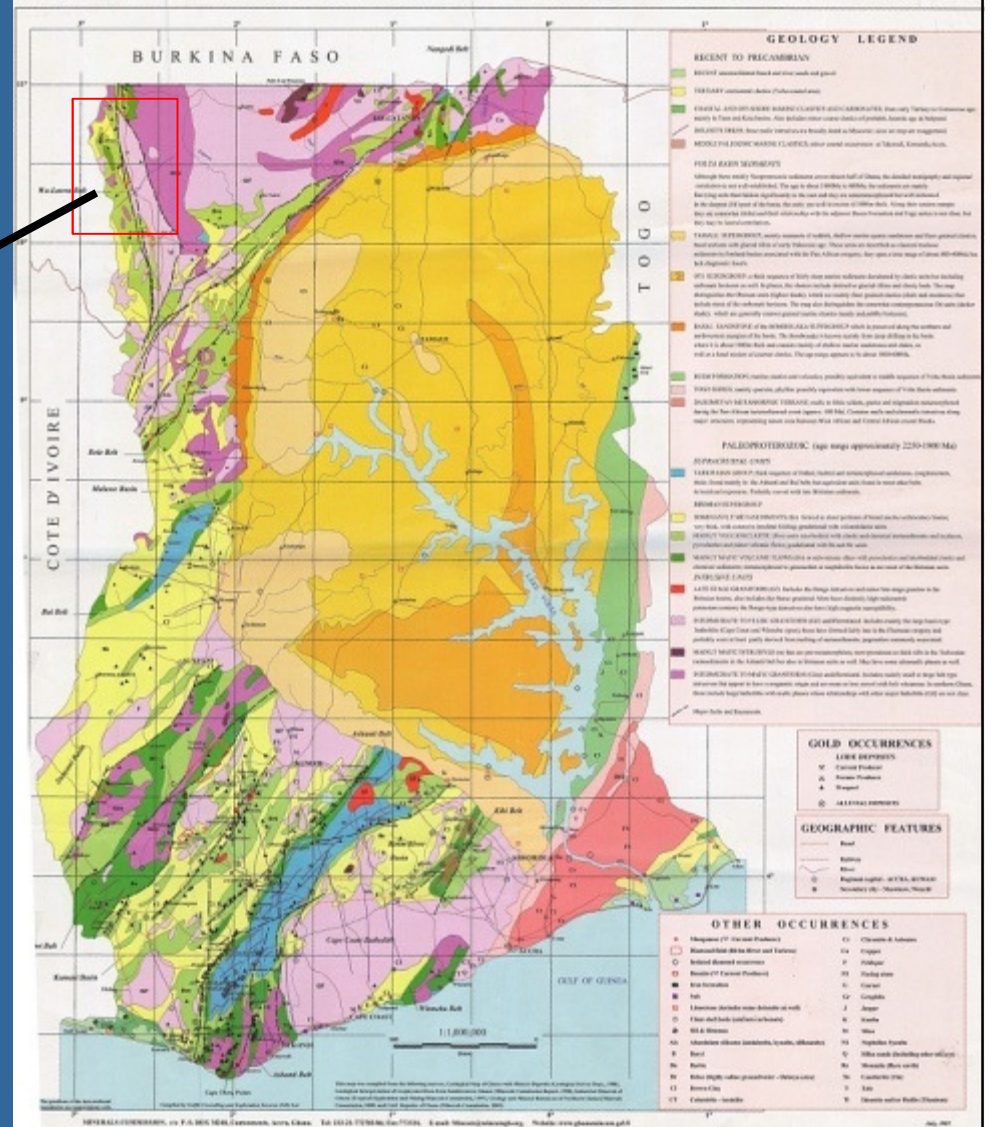


Source: Gold deposits of Ghana, Minerals Commission, Ghana, ROBERT J. GRIFFIS, KWASI BARNING, FRANCIS L. AGEZO, FRED K. AKOSAH, 2002

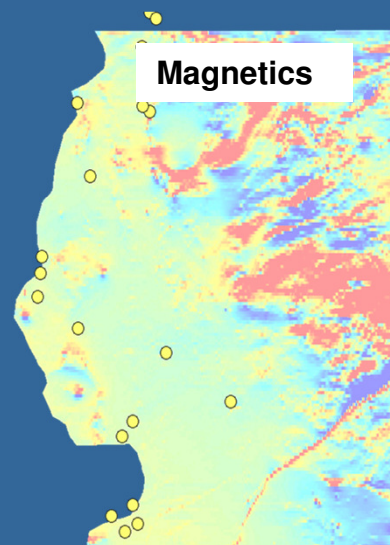
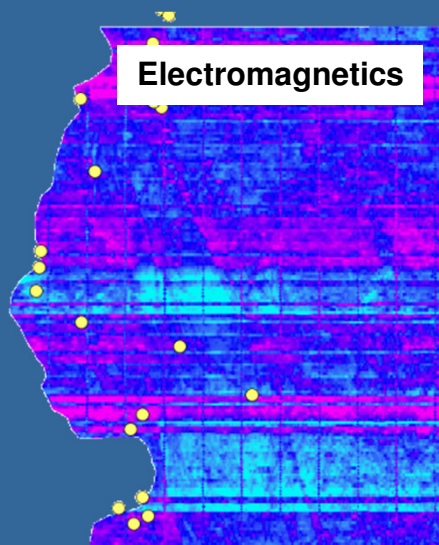
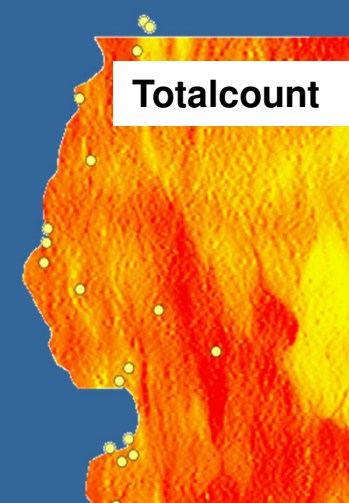
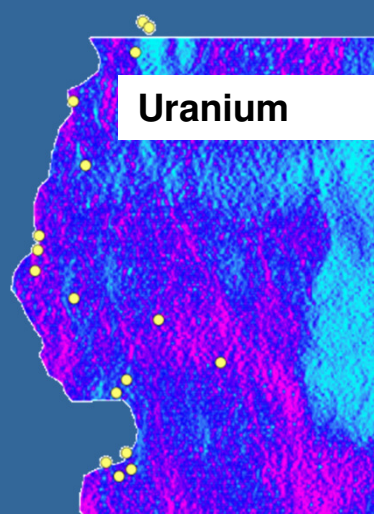
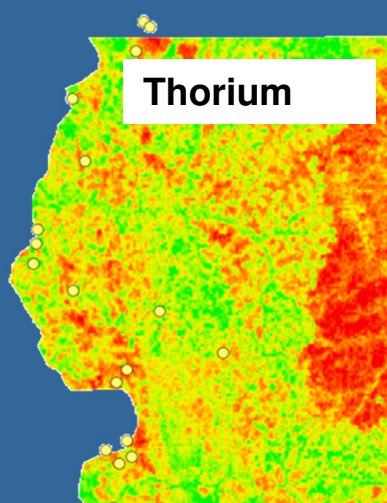
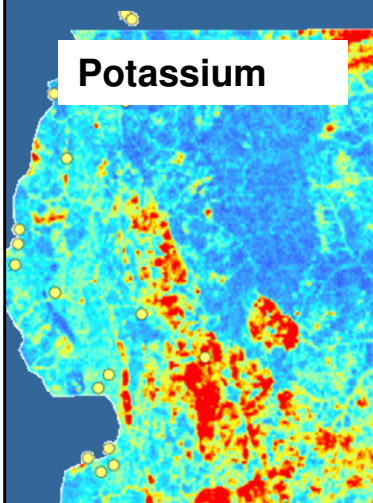
Geology, Structures & Occurrences



GEOLOGY AND MINERAL RESOURCES OF GHANA



Airborne geophysics

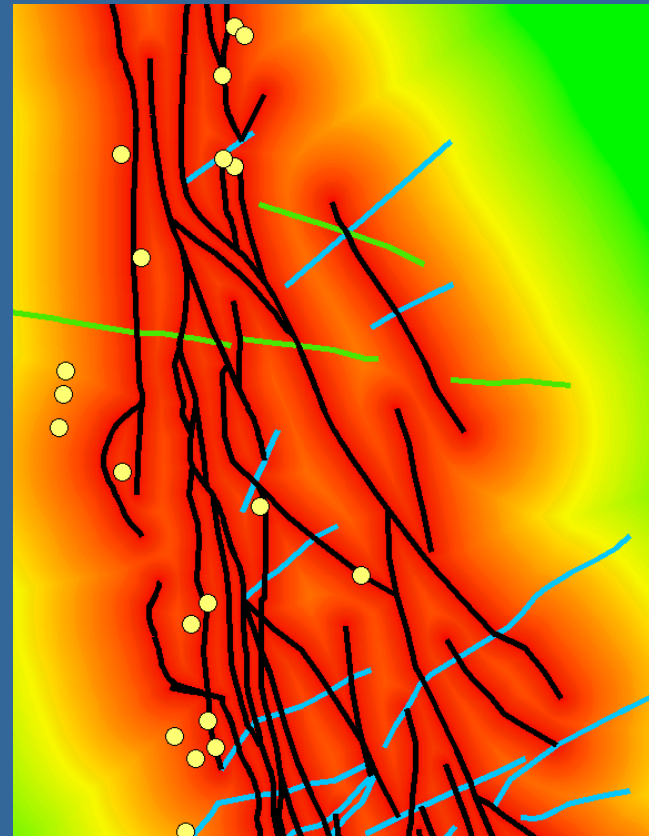
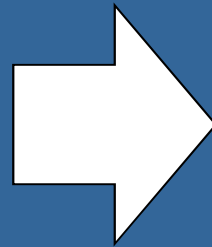
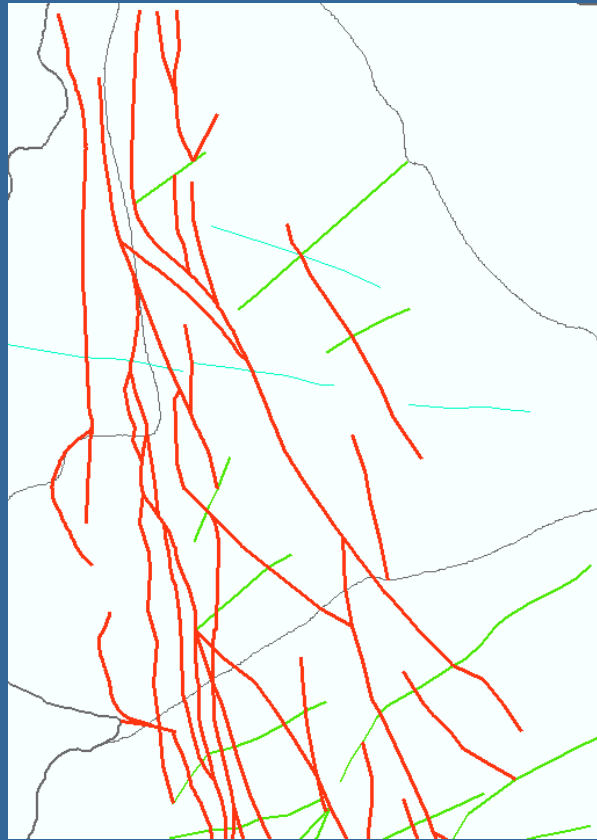


Source: Geological Survey Department of Ghana

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Production Software

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Creation of model input data: shear zones

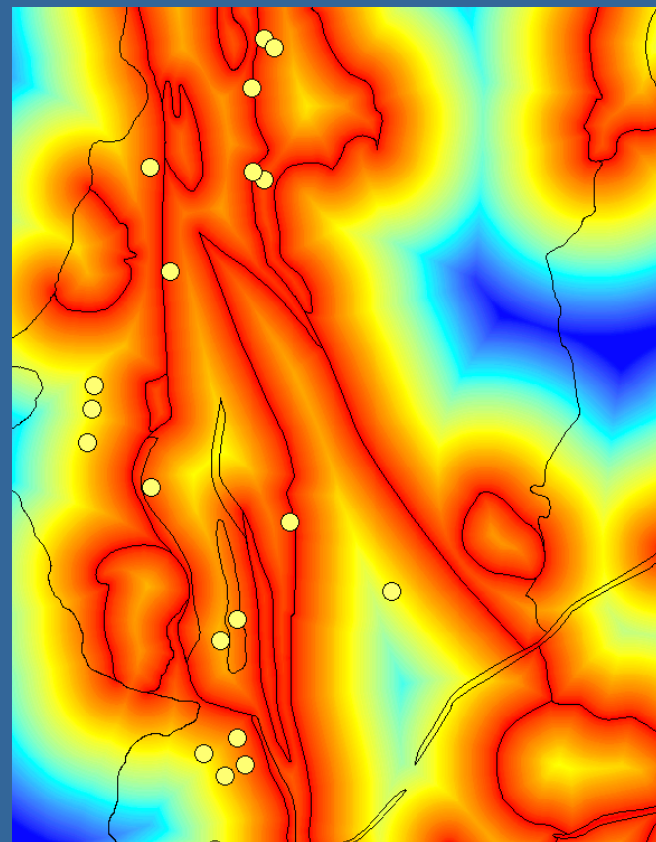


Creation of distance layers: how far is a point from a structure ?

More model input data

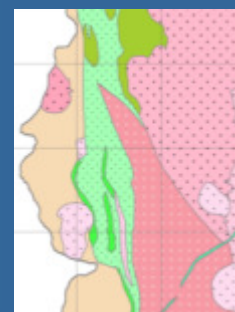
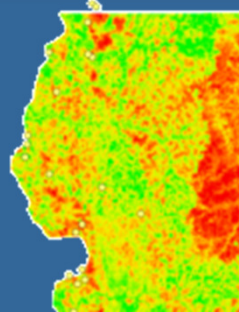
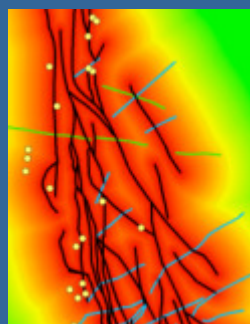
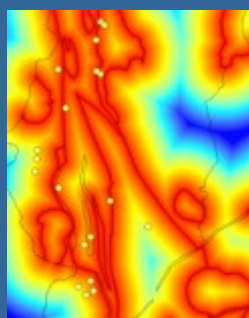
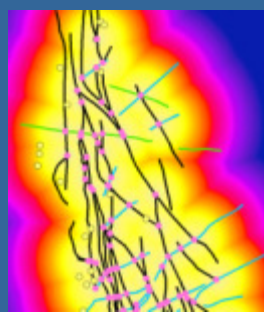


Intersections of
tectonic structures



Important rock
contacts

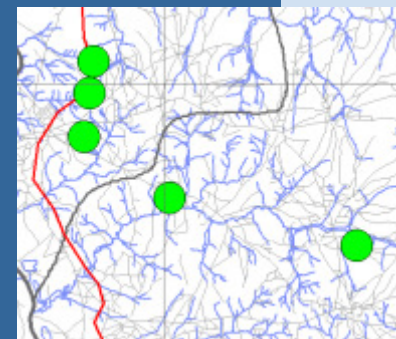
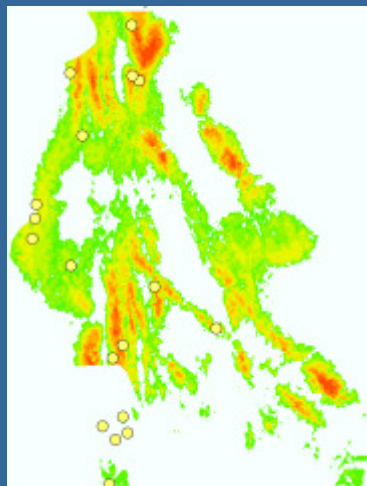
The advangeo workflow



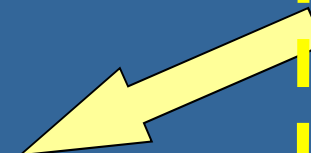
Input data layers



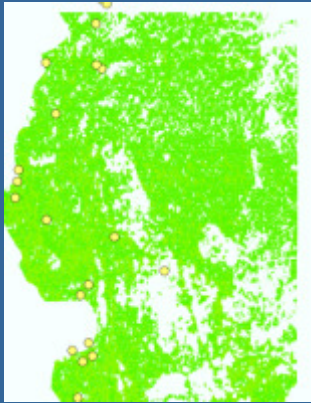
Probability map



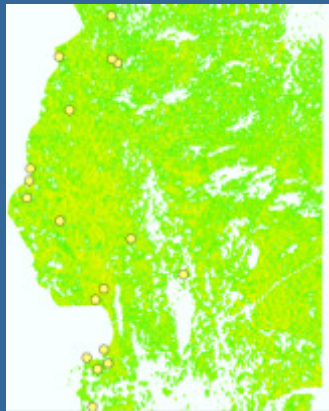
Training points = known mineralisations



Different models, the final map



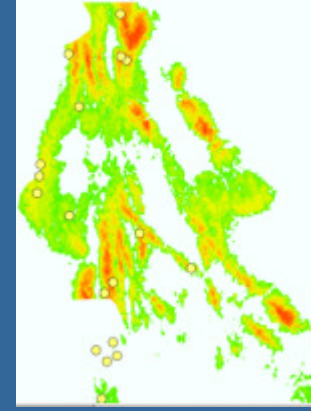
U, Th, K,
total



U, Th, K, total,
magnetics



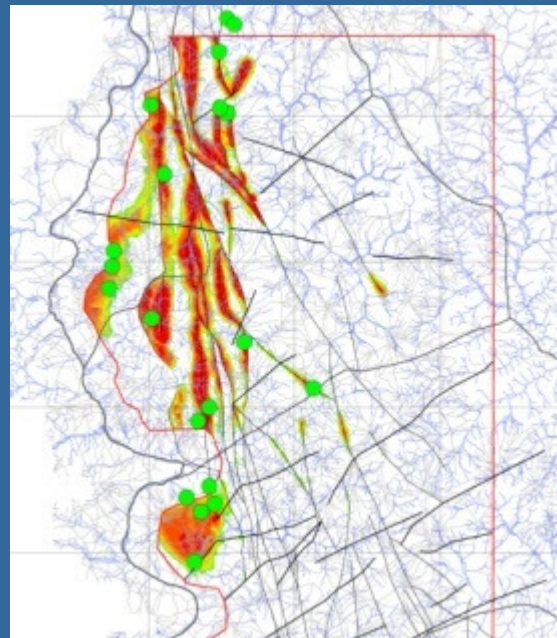
U, Th, K, total,
magnetics,
electromagnetics



U, Th, K, total,
magnetics,
structures



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



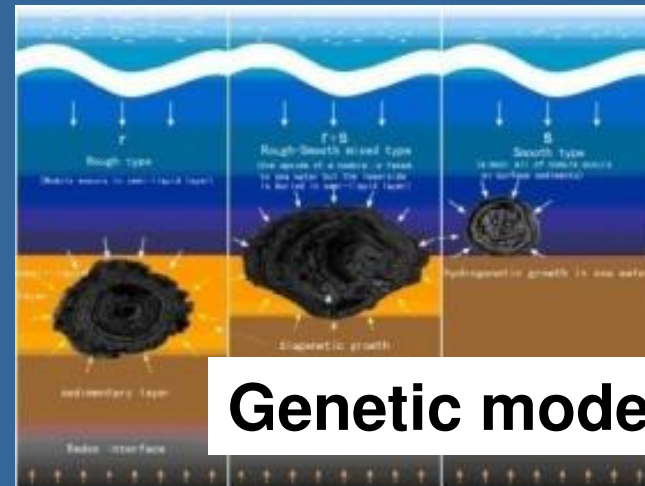
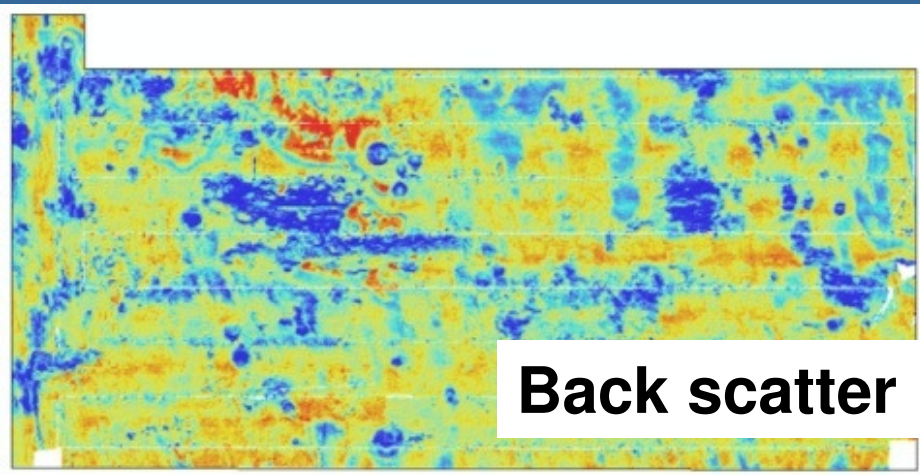
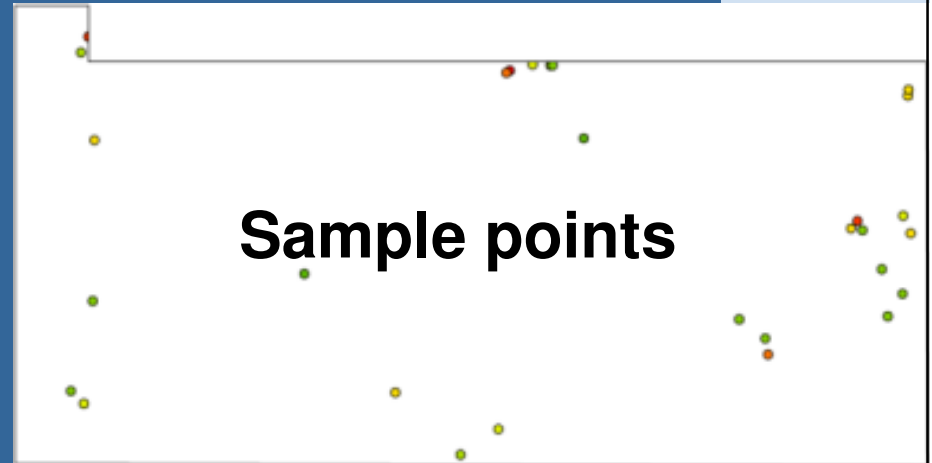
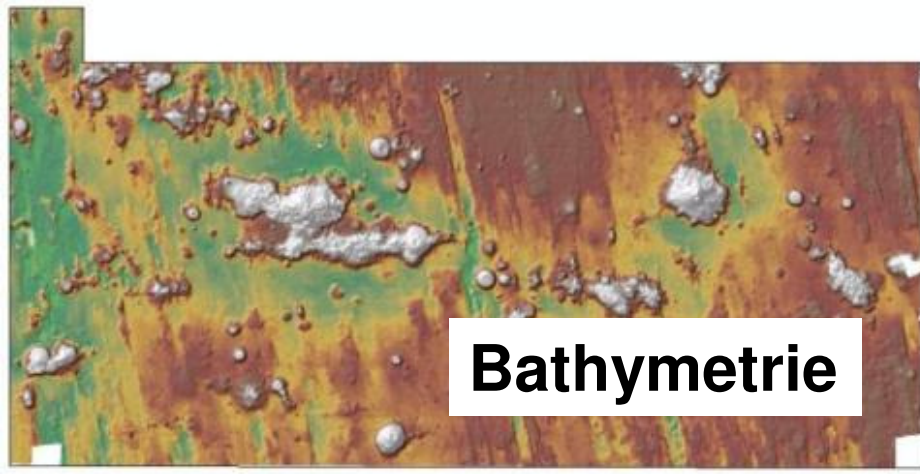
- easy to read
- for long term national planning
- better use of exploration funds
- attracts and guides investment

A **quantitative** predictive map: see floor Mn nodules



Mn nodules on the sea floor

Data and knowledge



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

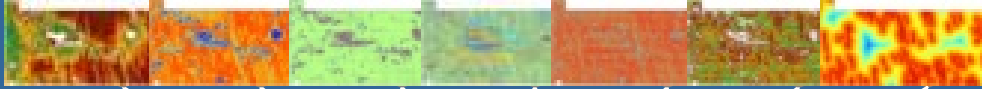


Results: sensitivity analysis

<i>Parameter</i>	<i>Sensitivity</i>		
	<i>high</i>	<i>medium</i>	<i>low</i>
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	

Workflow

Input Data / Layers



weights

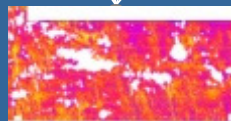
Hidden Layers



weights

Output Layer

Values !!!



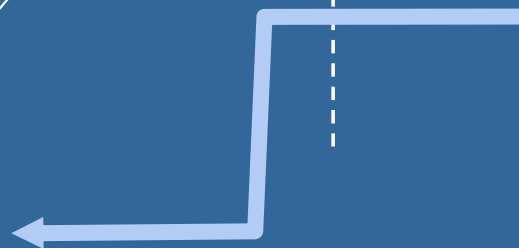
Ressources

kg/sqm

Training-data



Sample locations & analytics

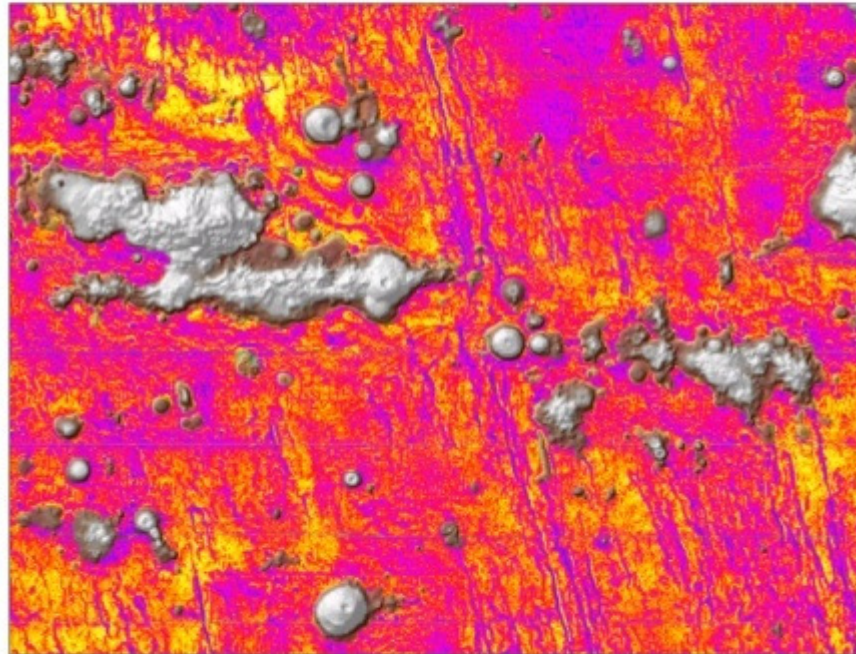


Comparing two models

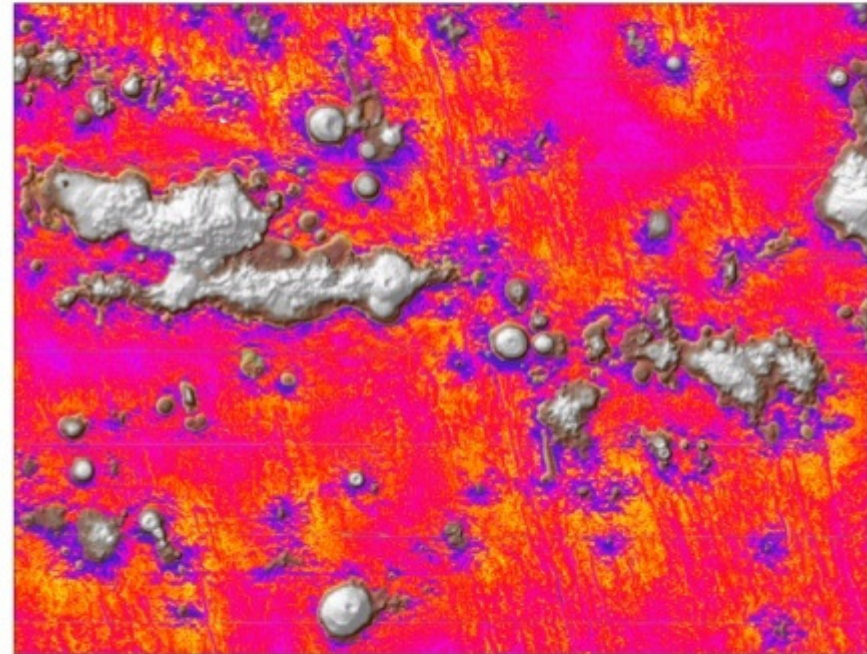
PROGNOSEKARTE DER MANGANKNOLLEN-BELEGUNGSDICHTE

Maßstab 1 : 250.000

Modellszenario 1



Modellszenario 2

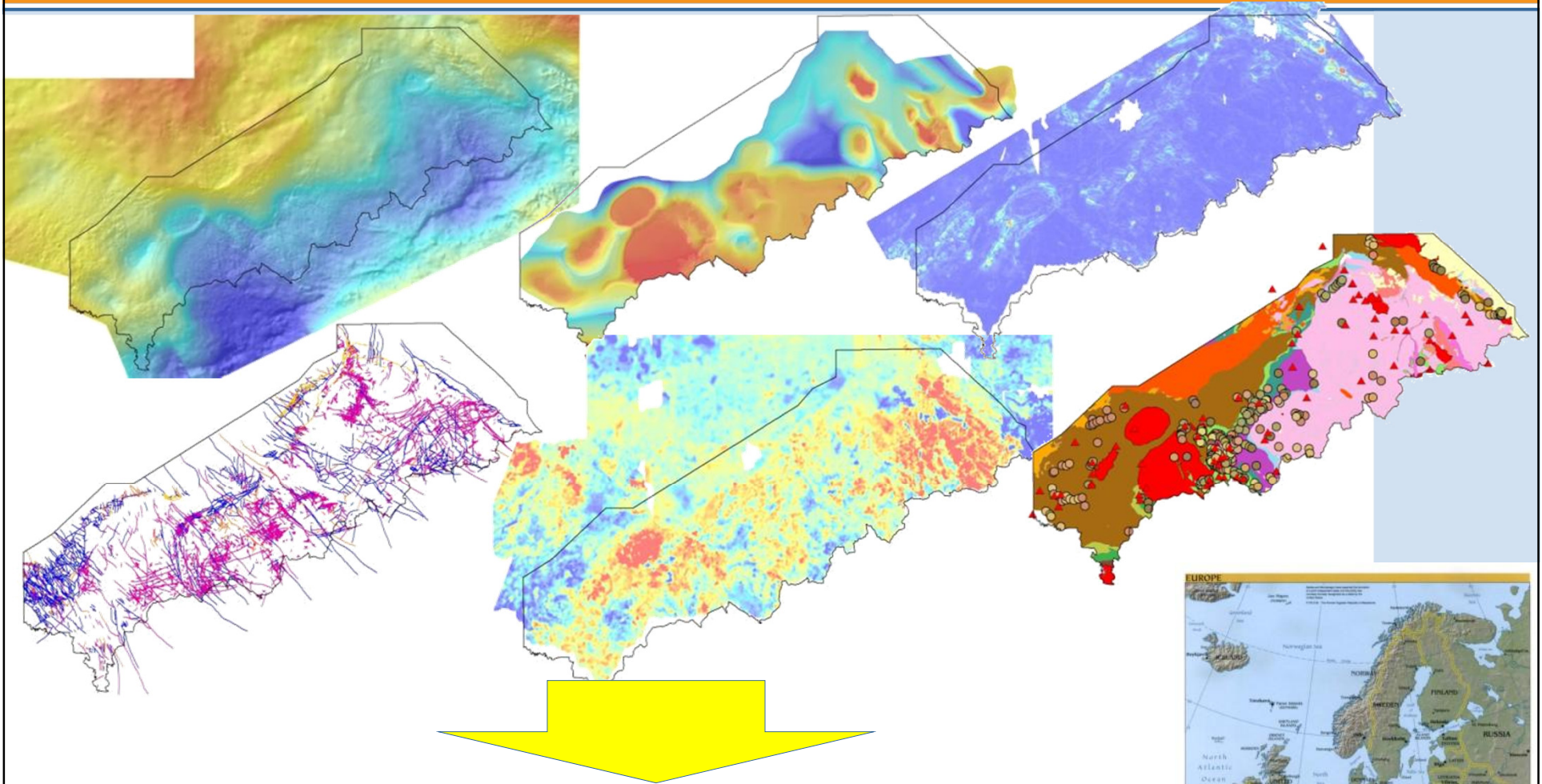


Analyse der räumlichen Verteilung von Manganknollen
mit Verfahren der künstlichen Intelligenz

Prognosekarte der Manganknollen-Bedeckungsdichte in Aggr.

< 20 % difference between the models

Re-evaluation of the the Erzgebirge



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



Conclusions

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



Thank you for your attention

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- Our memory sticks

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

