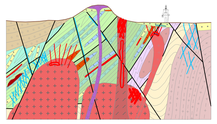
# Metallogenic Epochs

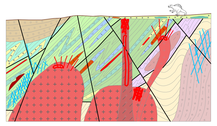
### Riftogenic Stage



**70 – 0 Ma**

The formation of the Eger rift above a mantle plume began with the intrusion of ultramafic alkaline dikes, followed by extensive volcanism (30 Ma). Small volumes of mafic and alkaline volcanics are emplaced throughout the Erzgebirge/Vogtland area in dykes, pipes and maars. Faults were reactivated; heat domes led to continued mineralisation processes in mostly pre-existing tectonic structures (e.g. barite and fluorite veins, U, Co, Ni, Ag, As, Bi veins).

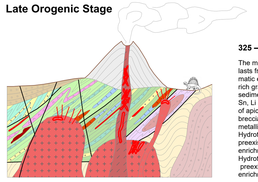
### Transition and Platform Stage



**290 – 70 Ma**

During the Permian to Cretaceous, fault zones with dominant NW-SE strike dissect the Erzgebirge/Vogtland into several tectonic blocks. Concurrent with the tectonic activities, heat domes produce several generations of metalliferous hydrothermal systems (e.g. fluorite, U, As, Sn, Cu, Pb, Zn, Au, Ag, relocating metals and minerals from former deposits into vein structures and seams using suitable lithologies as geochemical traps. Decreasing tectonic and thermal activities lead towards a slow cessation of endogenic activities in the upper Permian (257 Ma). In the Cenomanian to Turonian the area is partially covered by fluvial and shallow marine deposits hosting modest tin and gold placers.

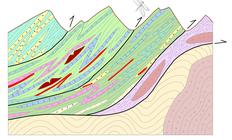
### Late Orogenic Stage



**325 – 290(?) Ma**

The main intrusion phase of the Variscan Granites lasts from 325 to 315 Ma. Minor extensive magmatic events occurred until 290 Ma. Rising fluid rich granitic melts assimilate metal bearing metasediments and redistribute the metal content. Sn, Li and W are enriched in suitable structures of apical parts of intrusions, volcanic pipes, breccias and fault zones, partly with a rich poly-metallic component (Cu, Sb, Bi, Co, As, In). Hydrothermal-metasomatic processes overprint preexisting stratiform deposits producing further enrichments in suitable lithologies. Hydrothermal-metasomatic processes overprint preexisting stratiform deposits producing further enrichments in suitable lithologies.

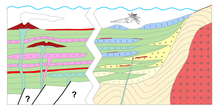
### Variscan Orogeny



**340-330 Ma**

The Gondwana-Laurussia collision results in the Variscan orogeny. Peak metamorphic conditions (UHP) occurred around 340 Ma. At about 330 Ma, the orogenic collapse and exhumation of the subduction-accretionary complex led to the recently observed configuration of the nappe pile. Metal bearing mounds and muds form various stratiform mineralisations including sulfide seams, metamorphic skarns and similar metal-enriched formations. The redistribution of Hg, Sb, Au, As and Ag in different parts of the nappe pile depends on the specific metamorphic P-T conditions.

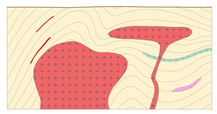
### Passive Continental Margin



**470 – 360 Ma**

From the Ordovician to the Devonian, extensive plate-reorganization due to back-arc rifting form passive continental margins with sequences of turbiditic sediments with intercalations of carbonates, quartz sandstones and conglomerates. Bimodal volcanism and hydrothermal activity with metal bearing mounds and mud were interbedded with the sediments. Main metals are Fe, Zn, Cu, Sn, W, Co, Bi, Sb, Ag, and Au.

### Cadomian Basement

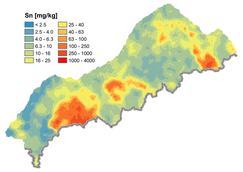


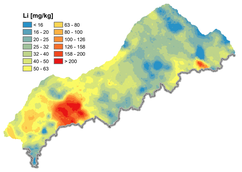
**580(?) – 510 Ma**

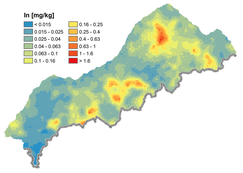
During the late Proterozoic and the Cambrian, turbiditic sediments with intercalations of carbonates, contemporarily intruded by granodioritic batholiths, form an active continental margin of Northern Gondwana. Carbon bearing layers in metasediments act as geochemical traps in later stages. Possibly accumulation of Fe, As, Sb, Ag, ±Au in sedimentary strata.

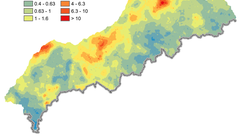
# Stream Sediment Geochemistry

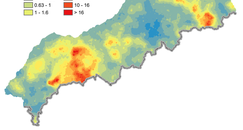
## Potentially Economic Commodities

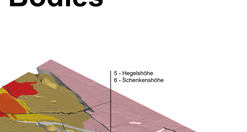


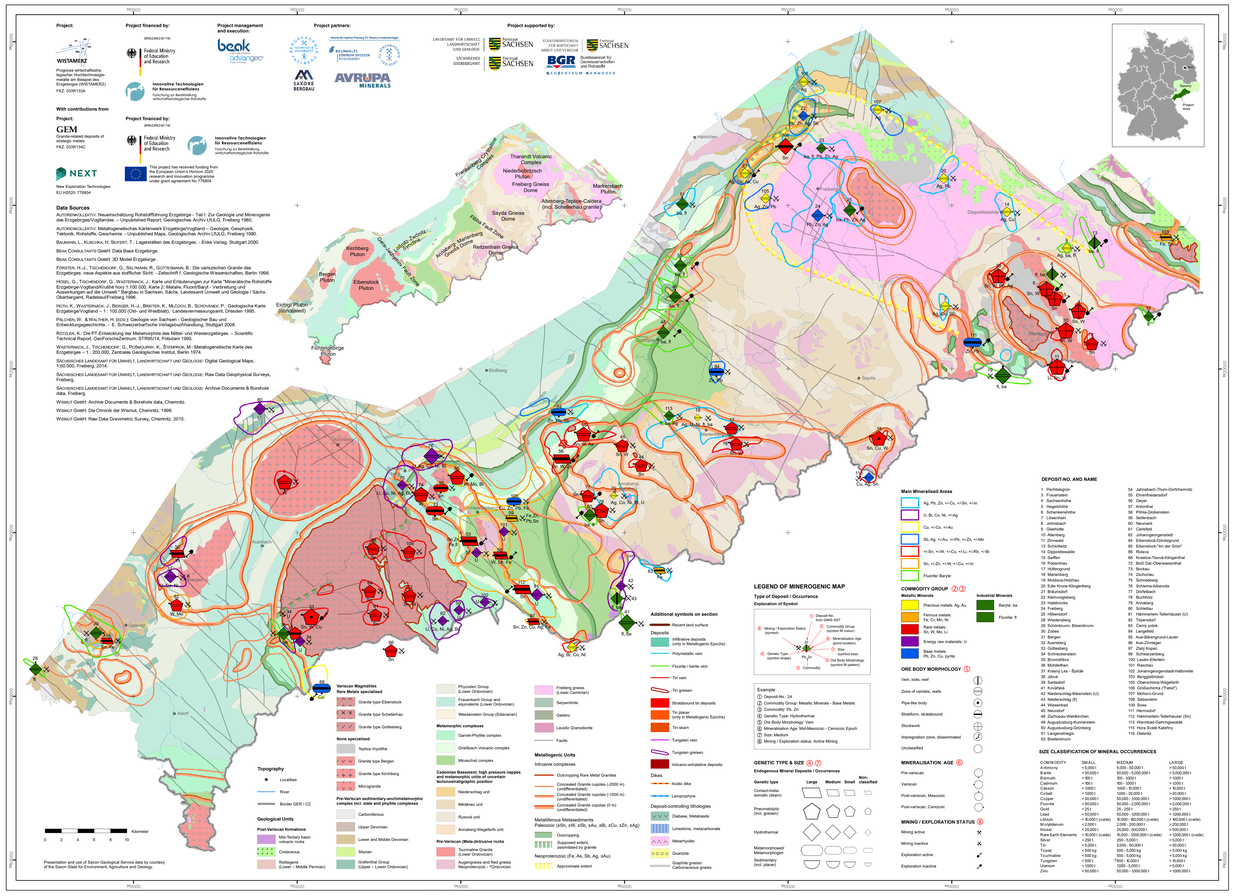



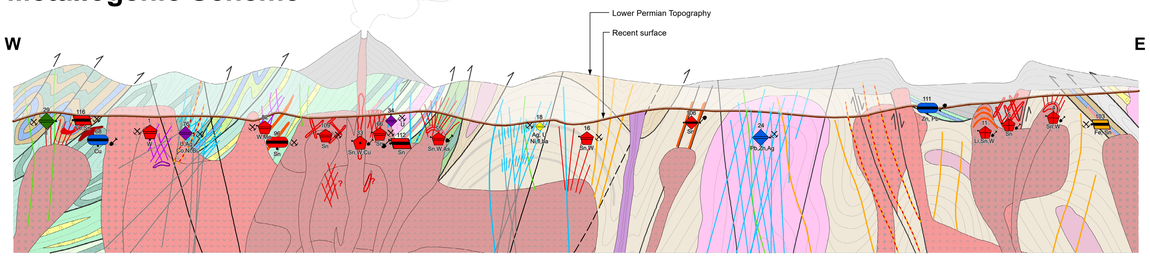




# Metallogenic Map of the Erzgebirge / Vogtland Area

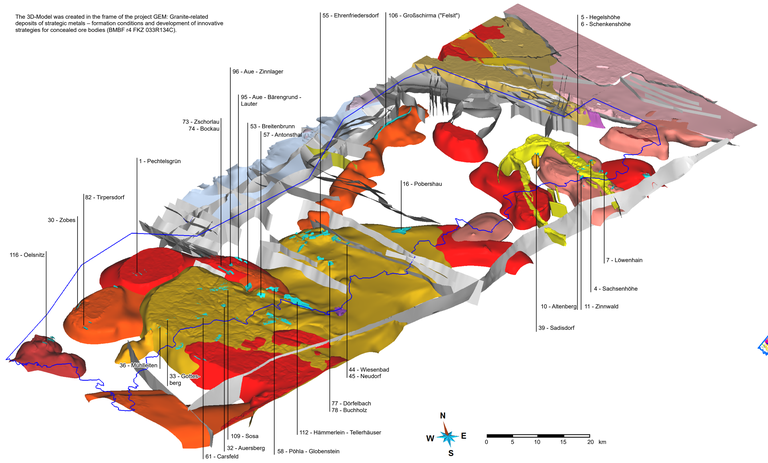



# Metallogenic Scheme




# 3D-Model - Intrusive Bodies

The 3D-Model was created in the frame of the project GEM: Granite-related deposits of strategic metals – formation conditions and development of innovative strategies for concealed ore bodies (BMBF-HI FKZ 033R134C).

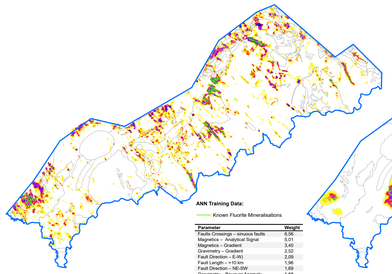




**DISCLAIMER**
The information presented on this map has been collected from a variety of data sources. Although all data has been processed and researched with special diligence, it is inevitably inaccurate and imprecise. The user recognizes that alterations and adjustments are necessary for the map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


# Mineral Potential Maps

### Prediction Map Fluorite

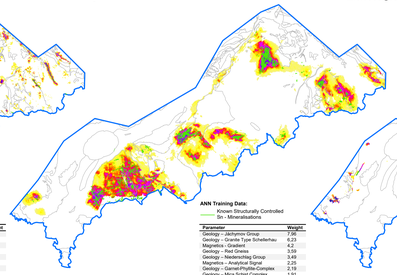


The Mineral Potential Maps have been created in the frame of the projects WISTAMERZ and NEXT.

**ANN Training Data:**
Known Fluorite Mineralisations

| Parameter | Weight |
|---|---|
| Faults Crossings – sinuous faults | 6,56 |
| Magnetics – Analytical Signal | 5,01 |
| Faults Crossings – faults | 4,61 |
| Gravimetry – Gradient | 2,52 |
| Fault Direction – E-W1 | 2,09 |
| Fault Length: ->10 km | 1,96 |
| Fault Direction – NE-SW | 1,69 |
| Gravimetry – Bouguer Anomaly | 1,67 |
| Gravimetry – Profile Curvature positive | 1,55 |
| Gravimetry – Profile Curvature negative | 1,51 |
| Fault Length: -2 – 4 km | 1,33 |
| Fault Direction – N-S | 1,3 |
| Faults Sinuosa | 1,29 |
| Fault Direction – NW-SE | 1,17 |
| Fault Length: 4 – 10 km | 1,06 |
| Fault Direction – E-W | 1,05 |
| Stream Sediment Geochemistry – Bi | 0,9 |
| Fault Crossings – all faults | 0,87 |

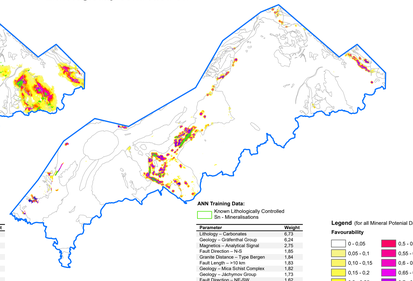
### Prediction Map Structurally controlled Sn



**ANN Training Data:**
Known Structurally Controlled Sn - Mineralisations

| Parameter | Weight |
|---|---|
| Geology – Jáchymov Group | 7,98 |
| Geology – Granite Type Schellenhau | 6,23 |
| Magnetics – Analytical Signal | 3,79 |
| Geology – Red Gneiss | 3,59 |
| Geology – Niederwiesa Group | 3,49 |
| Magnetics – Analytical Signal | 2,25 |
| Geology – Garnet-Phyllite-Complex | 2,19 |
| Geology – Mica Schist Complex | 1,91 |
| Geology – Rusová Formation | 1,61 |
| Fault Length: -2 – 4 km | 1,57 |
| Geology – Wildenau Formation | 1,48 |
| Stream Sediment Geochemistry – Pb | 1,03 |
| Geology – Granite Type Eibenstock | 1,01 |
| Fault Direction – E-W1 | 0,82 |
| Fault Direction – NW-SE | 0,77 |
| Gravimetry – Profile Curvature positive | 0,75 |
| Granite Distance – Type bn granites | 0,73 |
| Fault Length: - 4 – 10 km | 0,72 |

### Prediction Map Lithologically controlled Sn



**ANN Training Data:**
Known Lithologically Controlled Sn - Mineralisations

| Parameter | Weight |
|---|---|
| Lithology – Carbonates | 6,73 |
| Geology – Gräfenthal Group | 6,24 |
| Magnetics – Analytical Signal | 5,85 |
| Fault Direction – NnS | 1,85 |
| Granite Distance – Type Bergen | 1,84 |
| Fault Length: -> 10 km | 1,83 |
| Geology – Mica Schist Complex | 1,82 |
| Geology – Jáchymov Group | 1,81 |
| Fault Direction – NE-SW | 1,62 |
| Fault Length: -2 – 4 km | 1,62 |
| Gravimetry – Profile Curvature positive | 1,52 |
| Gravimetry – Gradient | 1,5 |
| Geology – Garnet-Phyllite-Complex | 1,48 |
| Magnetics – Gradient | 1,39 |
| Fault Crossings – all faults | 1,36 |
| Fault Length: - 4 – 10 km | 1,35 |
| Fault Length: -> 10 km | 1,32 |
| Fault Direction – E-W | 1,3 |

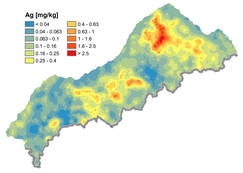
**Legend** (for all Mineral Potential Data)

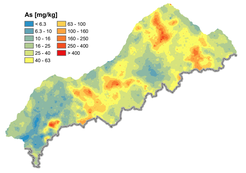
**Favourability**

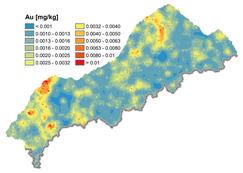
| | |
|---|---|
| 0 - 0,05 | 0,5 - 0,55 |
| 0,05 - 0,1 | 0,55 - 0,6 |
| 0,10 - 0,15 | 0,6 - 0,65 |
| 0,15 - 0,2 | 0,65 - 0,7 |
| 0,2 - 0,25 | 0,7 - 0,75 |
| 0,25 - 0,3 | 0,75 - 0,8 |
| 0,3 - 0,35 | 0,8 - 0,85 |
| 0,35 - 0,4 | 0,85 - 0,9 |
| 0,4 - 0,45 | 0,9 - 0,95 |
| 0,45 - 0,5 | 0,95 - 1 |

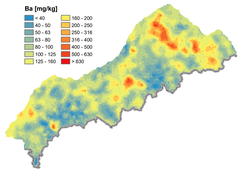
# Stream Sediment Geochemistry

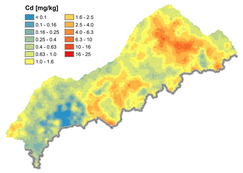
## Additional Elements

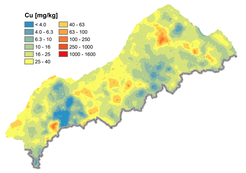


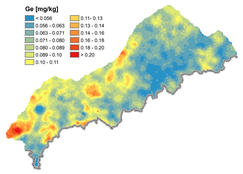



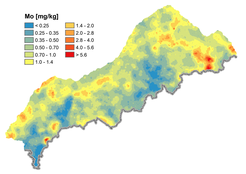



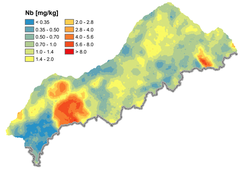



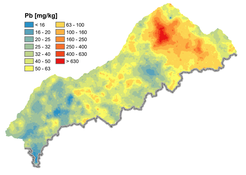



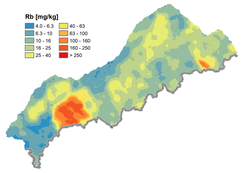



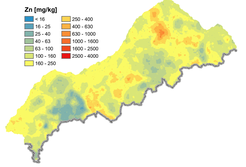




## Short Map Explanation

The Metallogenic Map of the Erzgebirge/Vogtland area was created within the frame of the project WISTAMERZ, aiming at the development of advanced methods for predicting the rare and high-tech metals potential (RHTM, such as Ga, Ge, In, Li, Sb, Se, Sn, Ta, Te, W) in large areas. As an example, the famous Erzgebirge/Vogtland area, well-known for centuries for its mineral wealth, was selected.

New geochemical data were gathered by a multi-element stream-sediment survey and combined with portable XRF technologies for on-site identification of hard-to-find disseminated and oxidized mineralisation. New unconventional RHTM mineralisations have been detected within low-grade geochemical anomalies and in rocks previously regarded as non-prospective. New exploration models have been developed.

The combination of lower Paleozoic sedimentary and rifting related hydrothermal/volcanogenic processes is recognised as the key precondition for the metallogenic predisposition of the large Erzgebirge mining region. Processes of collision-related metamorphic re-distribution of metals and their assimilation during processes of formation of melts and granitic intrusion led to the formation of a wide range of mineral occurrences of different shape and structural position, from stratiform, granite-related high temperature formations, and structure-controlled hydrothermal veins to Mesozoic and Cenozoic placers.

Late small intrusions led to a further re-distribution of metals within large metalliferous intrusives into breccia pipes and their environment even deep inside of big granite batholiths. Iron bearing metalliferous sediments were transformed into metamorphic and contact-metamorphic skarns with rich Sn and W mineralisation.

The metallogenic model positions the different mineral deposit types into a logic chain of metallogenic events forming within a history of almost 450 M years.

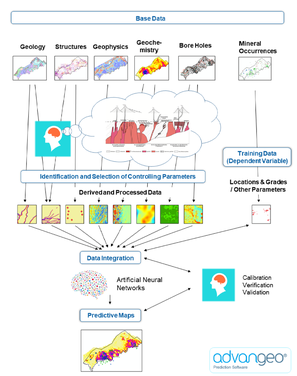
As an important practical consequence the reviewed metallogenic concepts open the doors for new discoveries of RHTM occurrences especially in the following environments:

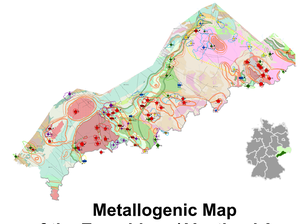
- Geochemical anomalies of Au, Sb, Bi, In, Li, Sn, W
- Meta-sediments with/without reactive rocks, especially on top of hidden granite intrusives
- Breccia pipes and structures within bigger granite batholiths on top of small intrusions

Using a combination of knowledge-based (exploration models) and data driven methods (artificial neural networks) mineral predictive maps have been calculated for key mineralisation types.

# Data processing Scheme

## Artificial Neural Networks (ANN) based Mineral Predective Mapping Workflow



# Metallogenic Map of the Erzgebirge / Vogtland Area

- Metallogenic Scheme -
- Metallogenic Epochs -
- Geophysical Data -
- Stream Sediment Geochemistry -
- 3D-Model - Intrusive Bodies -
- Mineral Potential Maps -
- Data Processing Scheme -


gefördert vom
Bundesministerium für Bildung und Forschung
WISTAMERZ
beak advangeo
**Beak Consultants GmbH**
Am Bi. Reiche Schacht 13
09599 Freiberg, Germany
Managing Director: Dr A. Barth
www.beak.de

**Map Compilation**
A. Barth, A. Brosig, E. Kattmeier, C. Legler, St. Schaefer, P. Bock, A. Klotzbach, R. Raßlmann, Th. Herbeg, G. Volkmer, K.-P. Starke, Th. Seifert

**Map projection**
Transverse mercator
(UTM Zone 33N)

**Reference system**
Spheroid: GRS 1989
Datum: D_ETRS_1989

**Cartography & Layout**
C. Rogger, H. Schulz

**Information Management & GIS**
Th. Berndt, M. Stahl

May 2019

ISBN 978-3-932-982-00
9 783932 982100