

Geology and Minerals of Kosovo*

* under UNSCR 1244

Opportunities for National Development

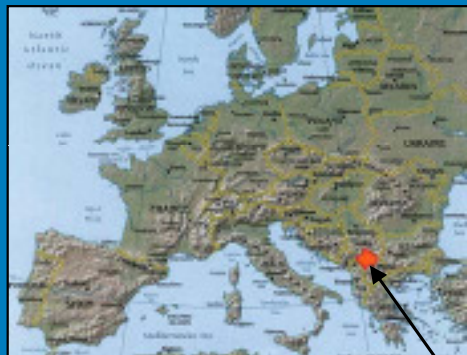
A. Knobloch¹, Dr. C. Legler¹, Dr. A. Barth¹, A. Rexhaj²

- 1 Beak Consultants GmbH, Freiberg / Germany
- 2 Independent Commission for Mines and Minerals, Prishtina / Kosovo

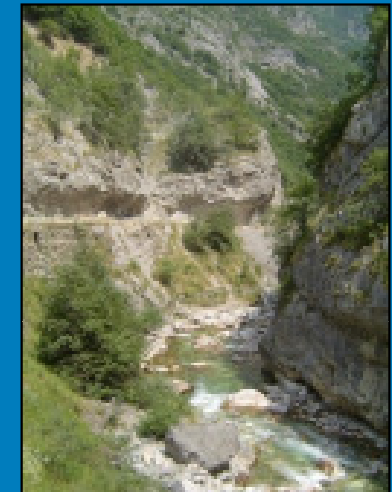


Outline

- **Short Review: Raw Material Potential of Kosovo**
- **Past / Ongoing Geoscientific Projects at ICMM / Kosovo**
- **Exploration Targeting in Kosovo using advangeo® (Artificial Neural Networks + GIS Technologies)**
- **Summary / Conclusion**



Kosovo



Solid Hydrocarbons

- **Lignite** with approx. 14 bn. t at 5th place of the world resources after Germany, Australia, USA and China
- In the next years, a third power plant is going to start production



Lignite: Mirash, Bardh (Kosovo-Basin)



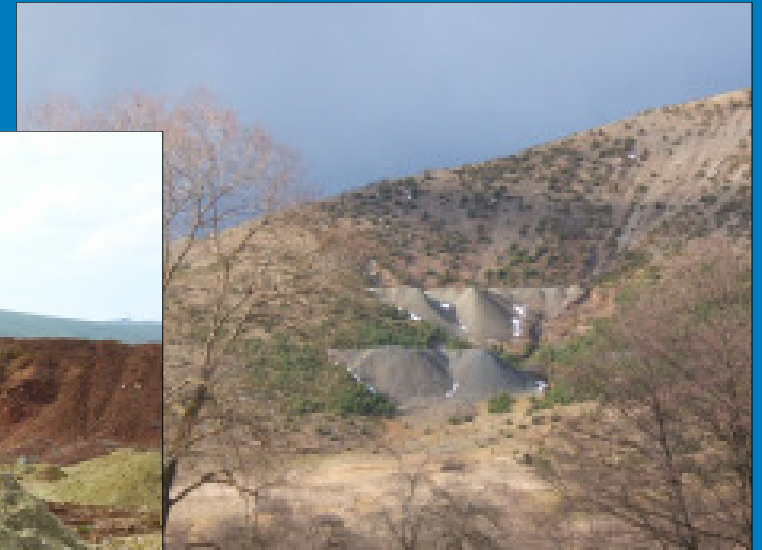
Metallic Minerals

- **Pb-Zn-Ag (-Au)** with approx. 24 m. t ore (111-Proven Reserve and 112 Probable Reserve) as well as additionally approx. 26 m. t (333 Resources) with approx. 5 % Pb, 4 % Zn, 100 g/t Ag and up to 1.6 g/t Au (Trepça belongs to Europe's largest Pb-Zn deposits)
- **Ni-Co** with approx. 13,2 m. t Ni-hydrosilicate ore with 1.3 % Ni and 0.07 % Co
- Resources of **Cr** within possible PGM-bearing chromitites.



Pb-Zn: Belo Brdo (Kopaonik)

Ni: Magurë



Cr: Brezovicë

Industrial Minerals

- **Magnesite** with approx. 4,5 m. t ore (belongs to Europe's largest deposits)
- **Bauxite** with approx. 5 m. t Fe-rich ore with 45-52 % Al_2O_3
- **Halloysite, Kaolin, Bentonite, Quartz, Talc, Diatomite, Feldspar, Garnet, Asbestos**



Magnesite: Strezovc

Bauxite: Gremnik



Kaolin: Karaçevë i Ultë



Industrial Rocks (Construction Minerals, Decorative Stones)

- Andesite, Tuff, Gabbro, Pyroxenite, Quarzite, Gneiss, Sandstone
- Limestone, Marble, Marl, Travertine, Dolomite
- Clay, Sand and Gravel

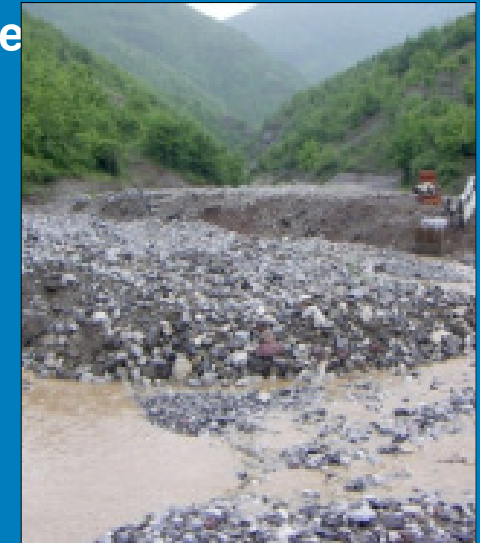


Limestone: Prizren



Marble: Deçani

Gravel: Kapoanik



Clay: Podujevë





Independent Commission
for Mines and Minerals

www.kosovo-mining.org

Tasks:

- Issuance and management of licenses,
- Legal and geological-technical evaluation and monitoring of the mining companies,
- Data provision for potential investors.



Office Prishtinë / Priština



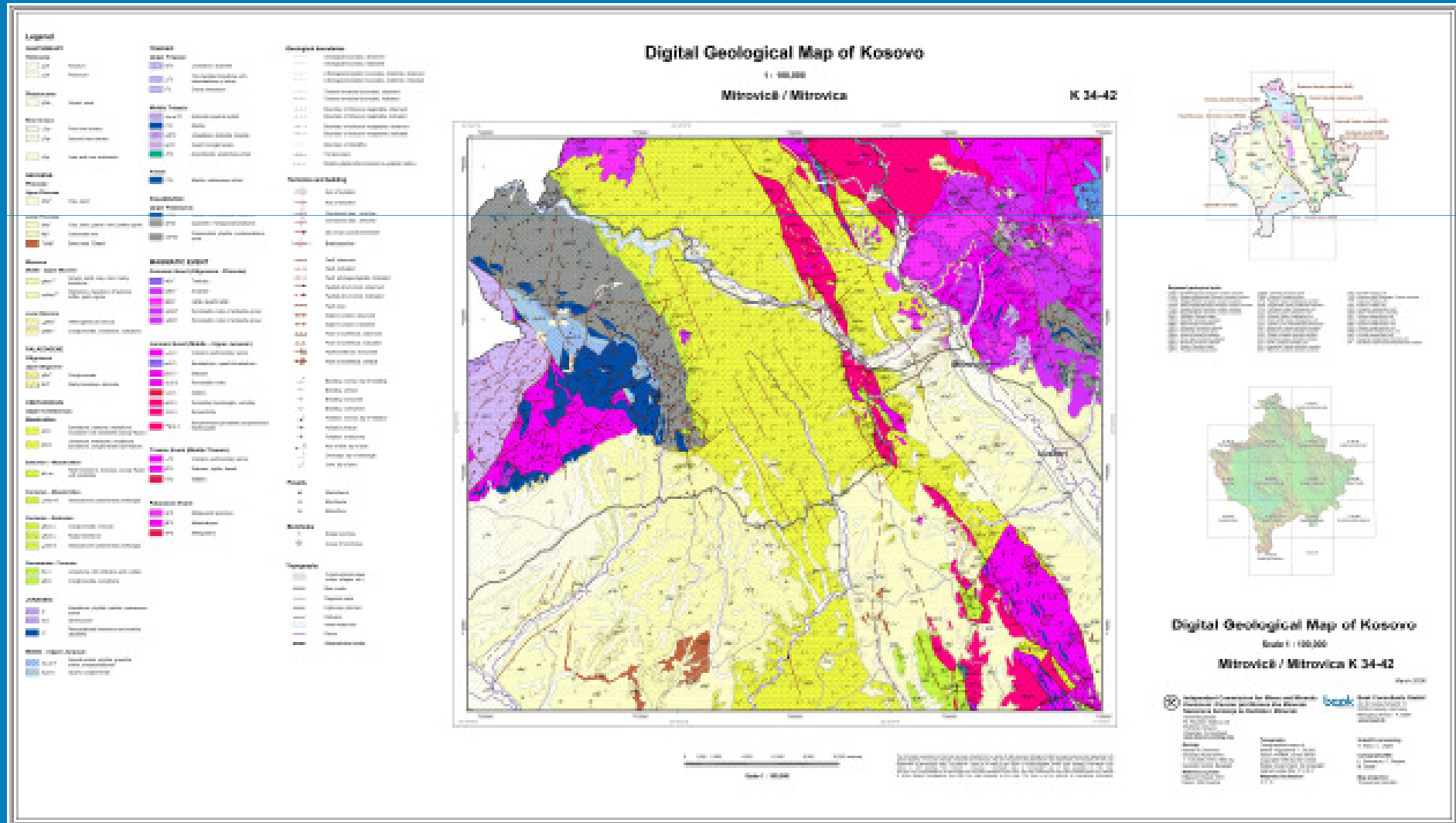
Past / Ongoing Geoscientific Projects at ICMM

- *2003 – 2006: GEO-Database Kosovo (GDK)*
- *2004: Controlling and Verification of Licenses and Processing Plant Data*
- *2004 – 2006: Kosovo Quarry Plan (KQP)*
- *2005 – 2006: Implementation of Interactive ICMM Web Site*
- *2004 – 2008: Compilation of Geoscientific Maps (GSM)*
- *2006 – 2008: Geochemical Survey (Stream Sediment Sampling)*
- *2006 – 2007: Airborne Geophysical Survey*
- *2006 – 2007: Development of a Mining Sector Strategy*

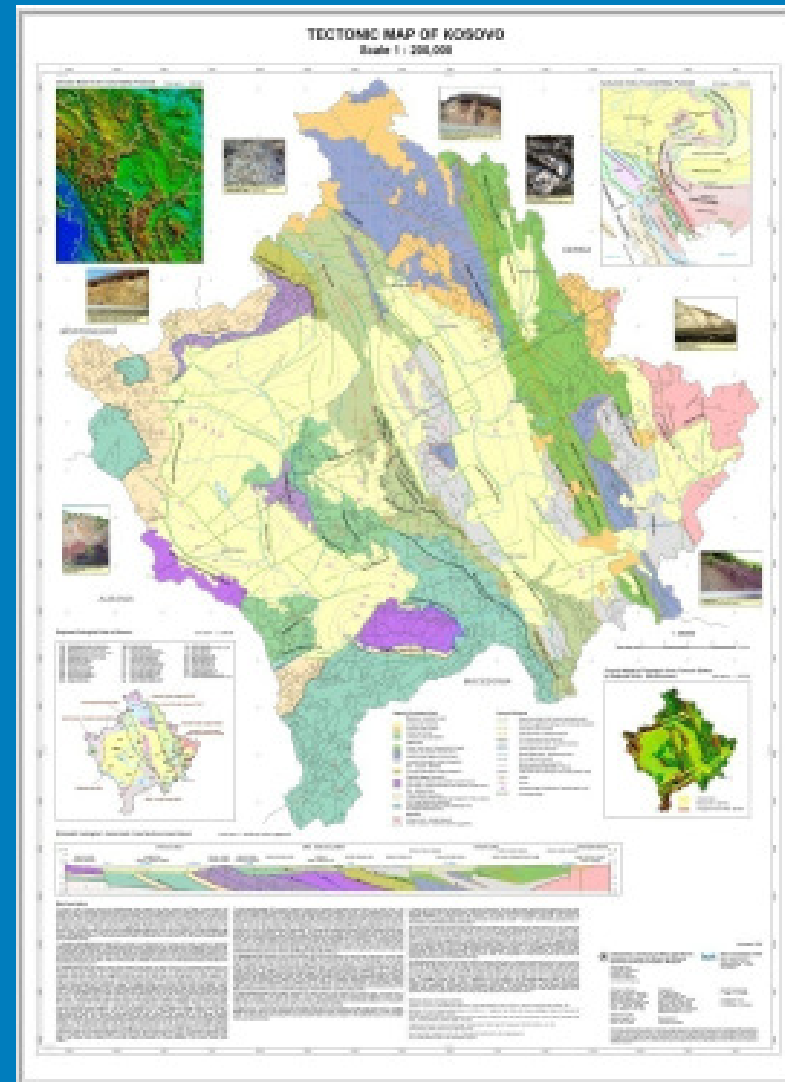
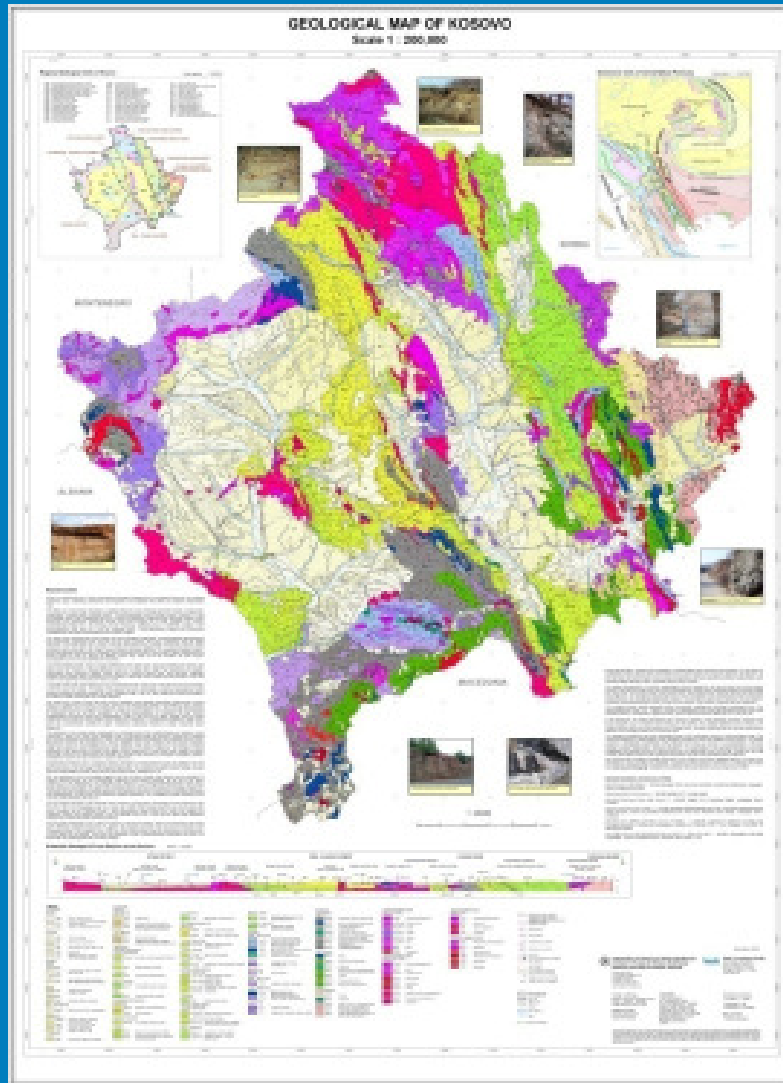
- **2009 – 2010: Kosovo Mineral Resources Management Plan (KMRMP)**
- **2010 – 2011: Geochemical Survey (Stream Sediment Sampling)**
- **2009 – : Mapping of Geological Map Sheets 1:25.000**



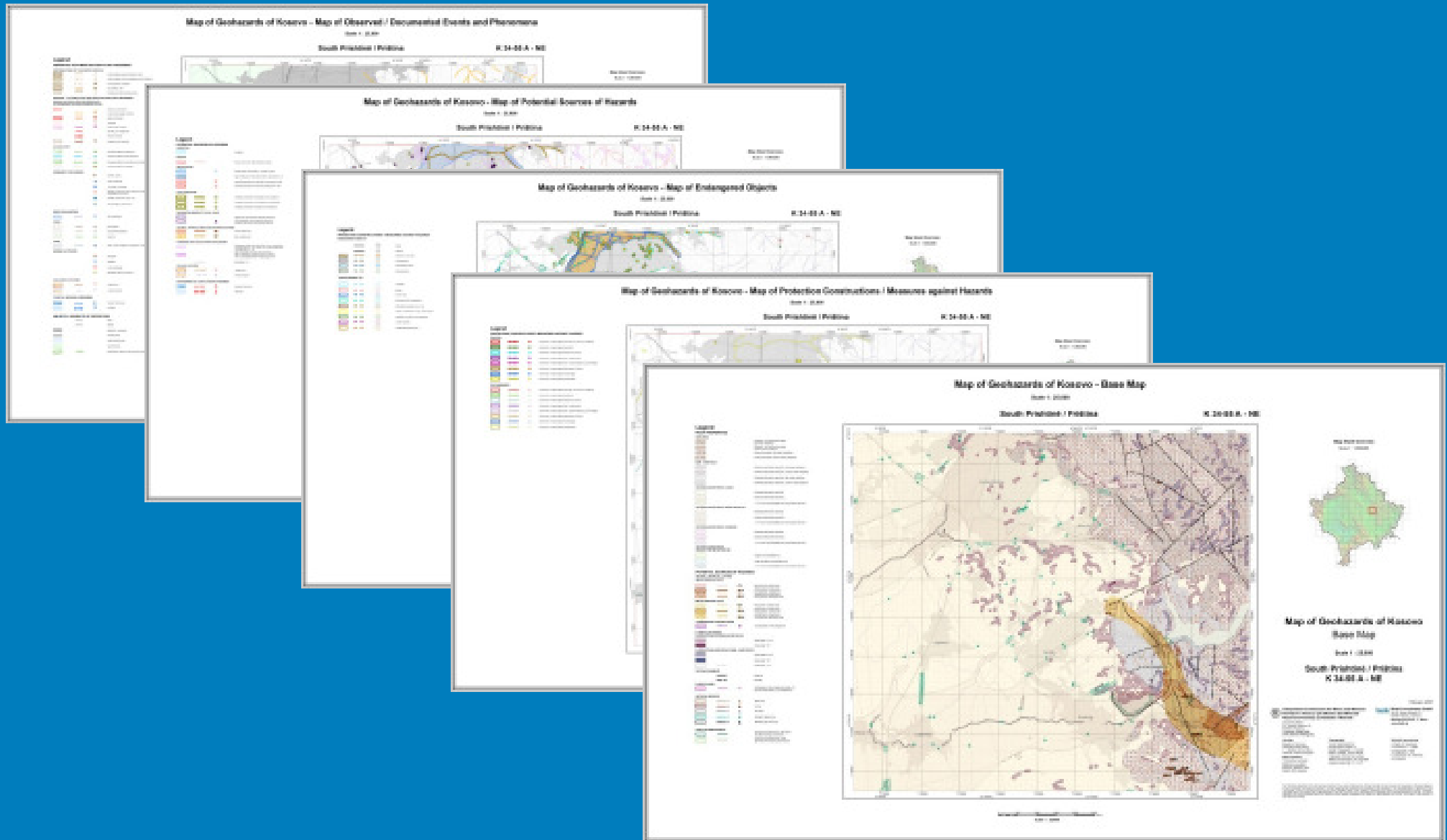
Digital Geological Map of Kosovo 1:100,000



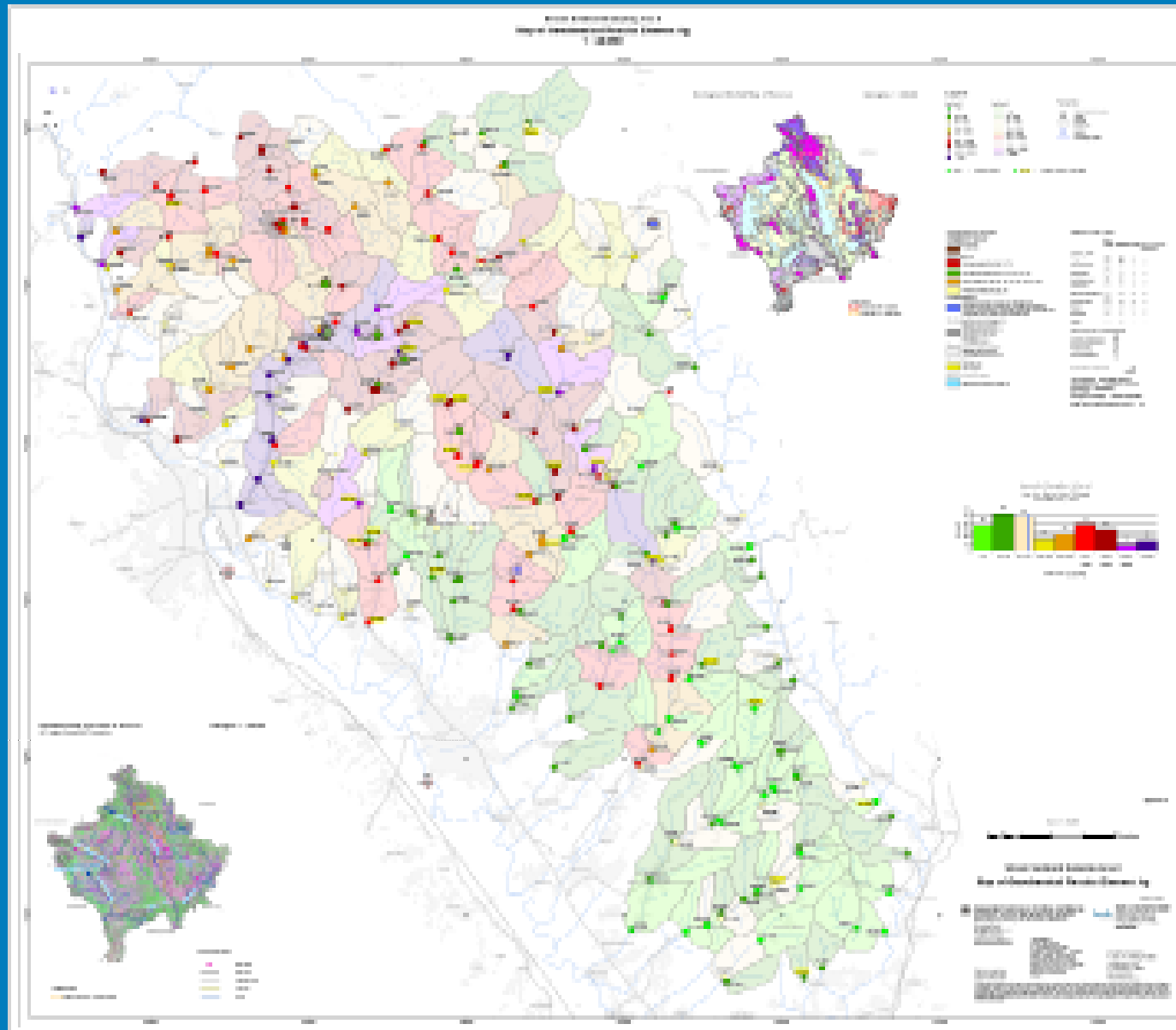
Geoscientific Map Set of Kosovo 1:200,000



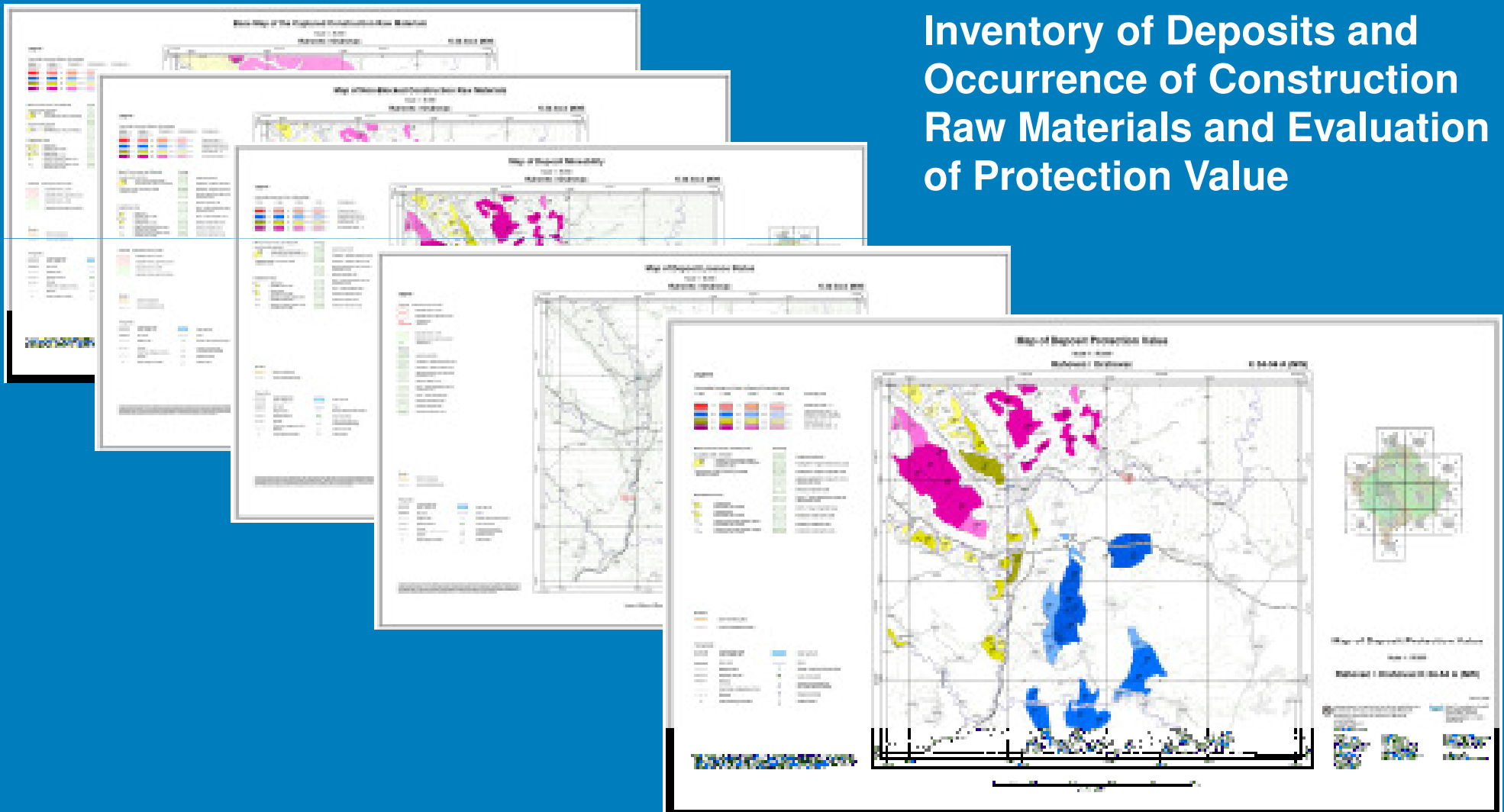
Geohazard Map 1:25,000 (Pilot Map Sheet)



Stream Sediment Sampling Map of Kosovo 1:50,000



Inventory of Deposits and Occurrence of Construction Raw Materials and Evaluation of Protection Value

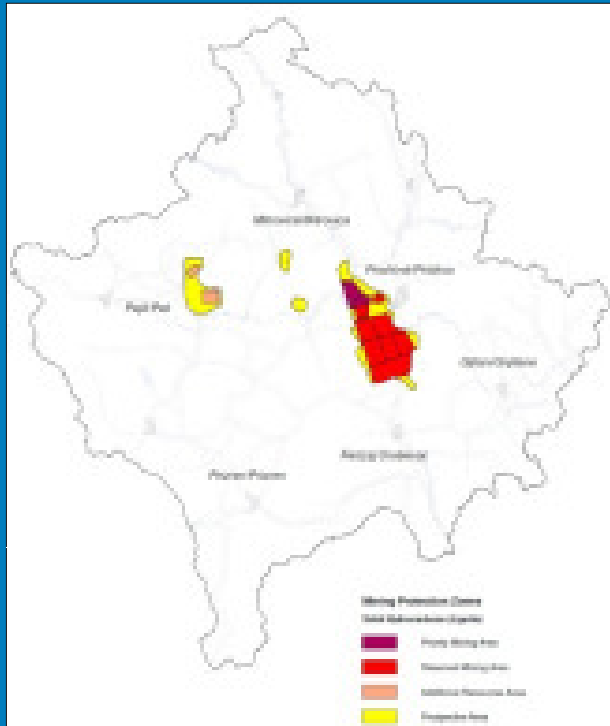


Deposit Protection Value = f (Mineability, Legal Status)

Mining Protection Zones

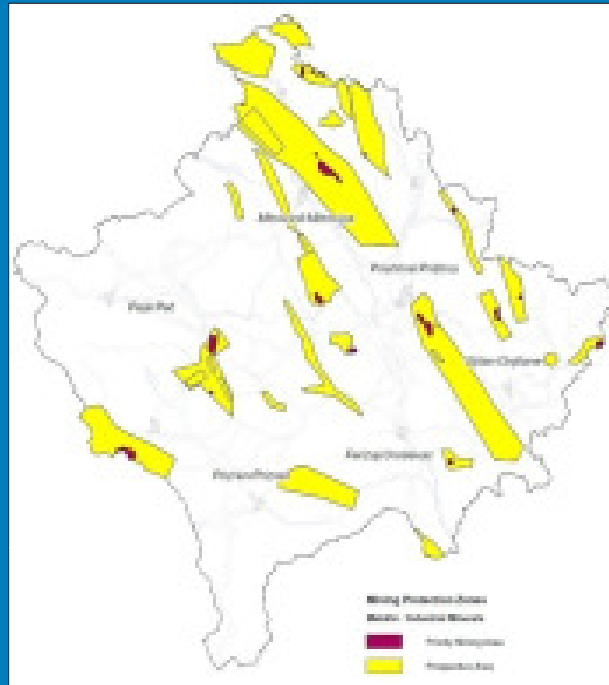
Lignite

Priority, Reserved, Additional Resource und Prospective Areas



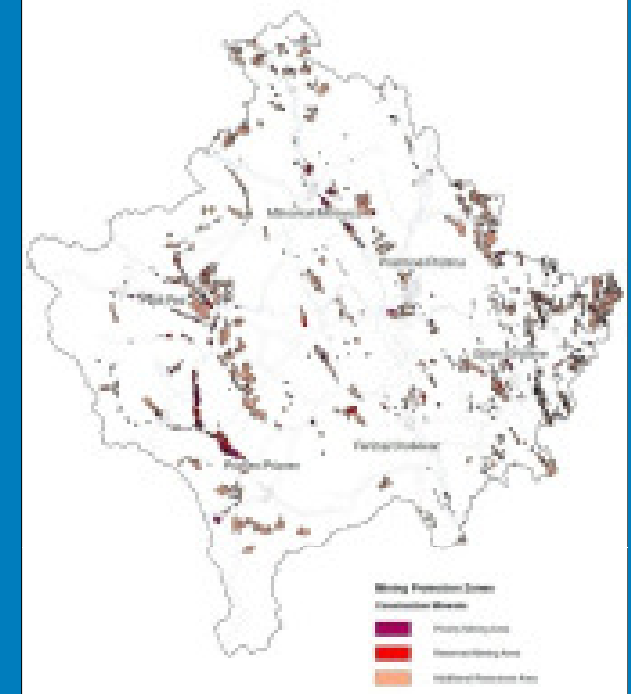
Metallic and Industrial Minerals

Priority und Prospective Areas



Industrial Rocks

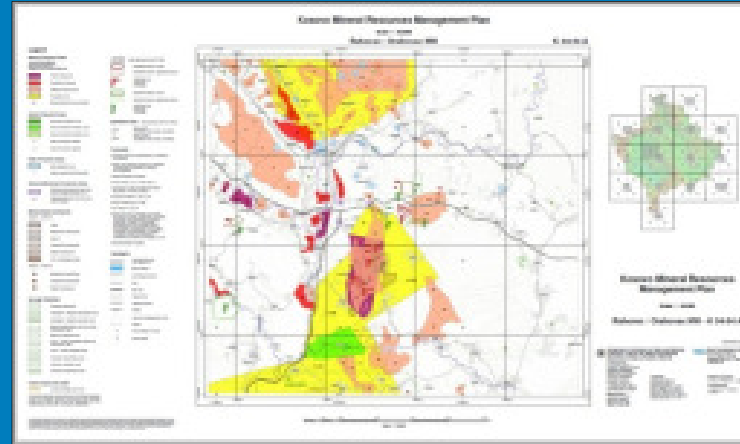
Priority, Reserved und Additional Resource Areas



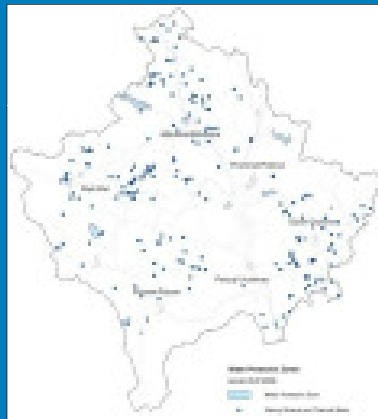
→ 4 Types: Priority, Reserved, Additional Resource und Prospective Areas

Spatial Conflict Analysis

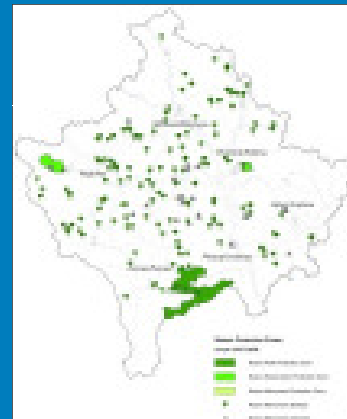
GIS-supported Conflict Analysis with Mining Protection Zones



Water Protection
Zones



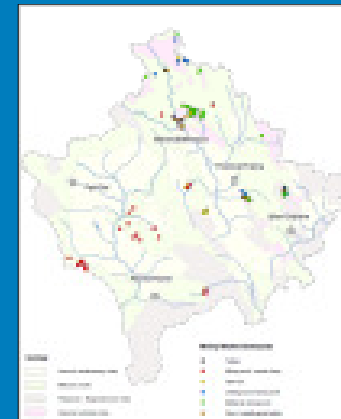
Nature Protection
Zones



Historical Monument
Protection Zones



Mining Related
Geohazards



GEO-Database Kosovo (GDK)

GEO-Database Kosovo

File Module Language Help

Main Menu

Mining

- Applications and Licences
- Exploitation Sites
- Processing Plants
- Blasting Permits
- Explosives Register

Economic Geology

- Deposits and Occurrences
- Kosovo Quarry Plan

Geology

- Boreholes
- Samples and Analytics
- Geological Fieldwork
- Map Legends
- Legend for DSGCM100

Environment

- Contaminated Sites

Administration

- Reference Tables
- User Management
- Database Change Log
- Options

Metadata Database

- Reports
- Documents

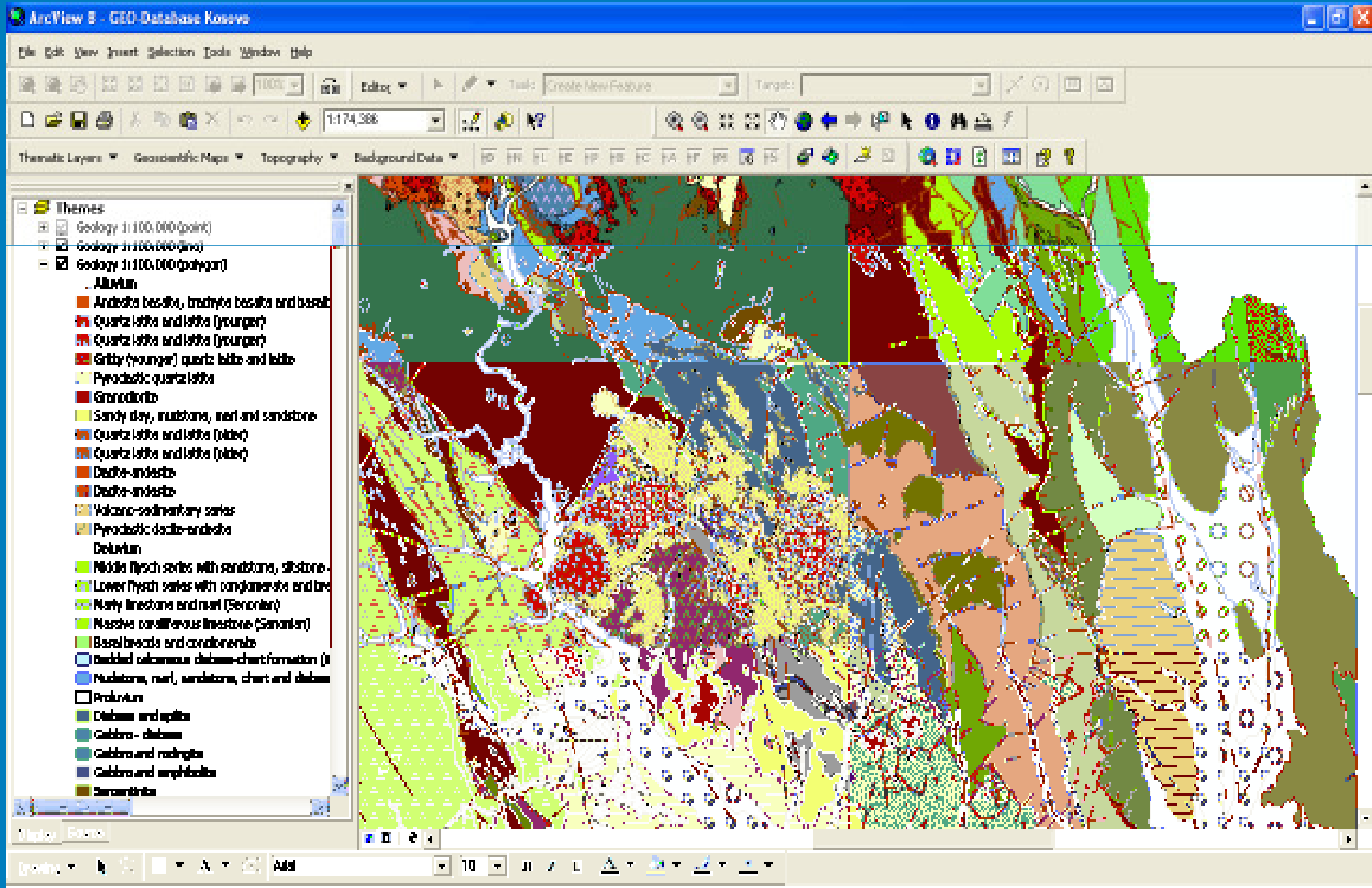
Business Data

- Persons and Companies
- Parcels

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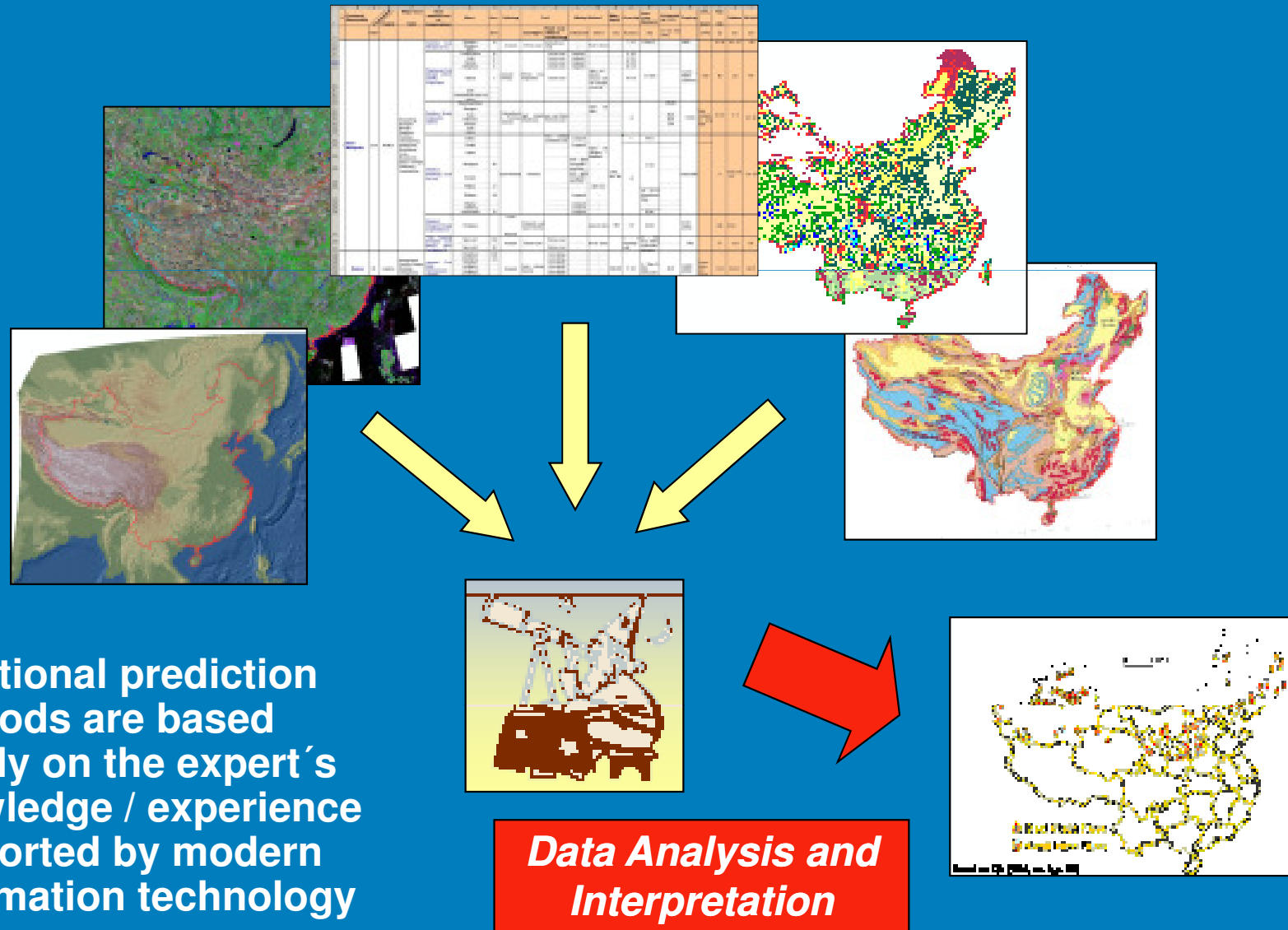
GEO-Database Kosovo (GDK)



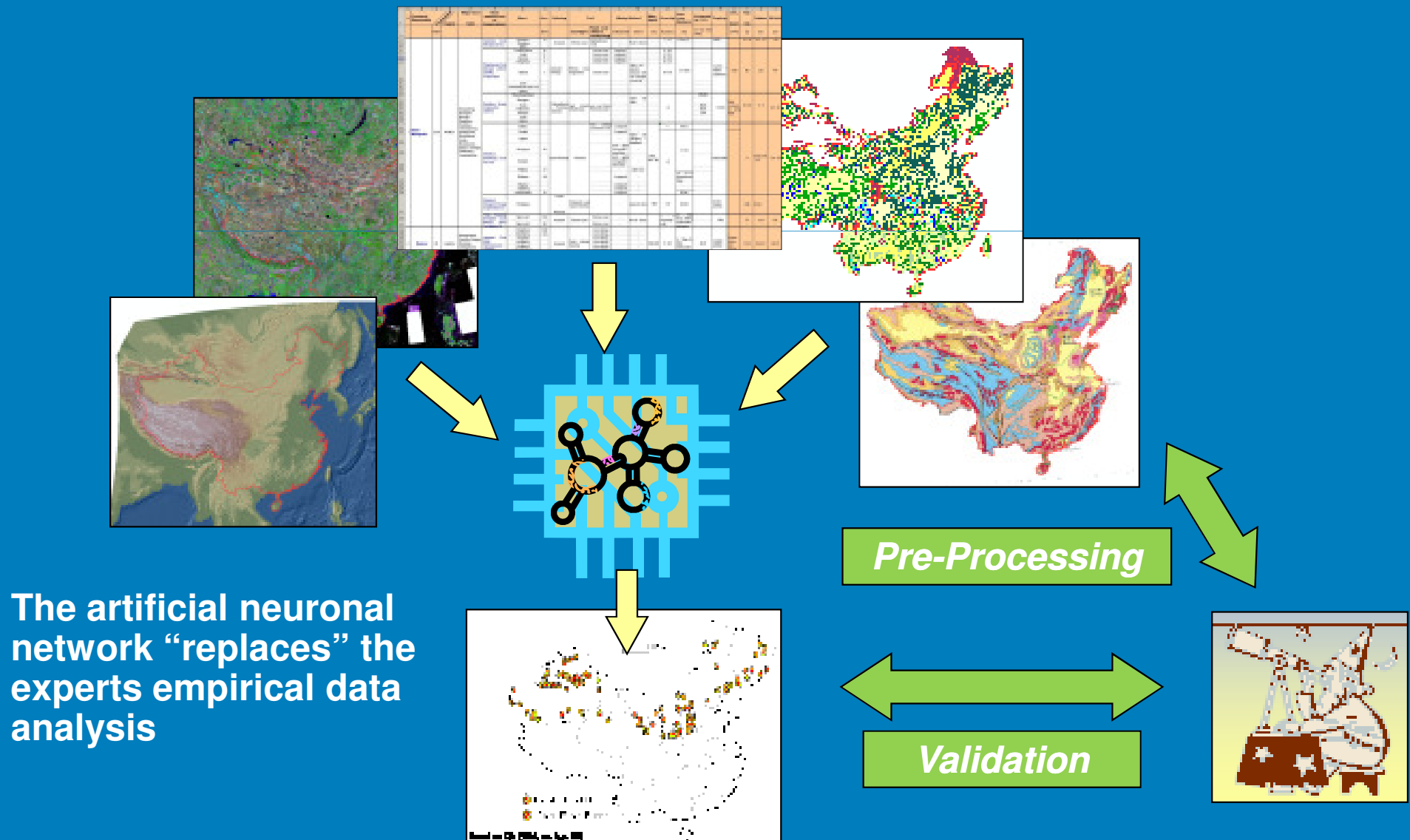
Case Study: Computer-Aided Knowledge Based Prediction



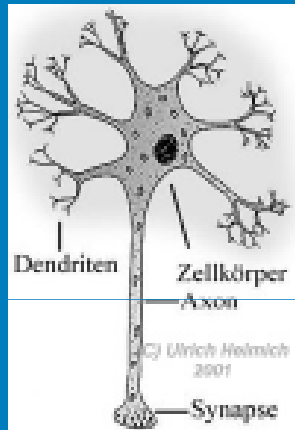
Traditional Approach



Modern Approach Using Artificial Intelligence



Definition: Artificial Neural Networks

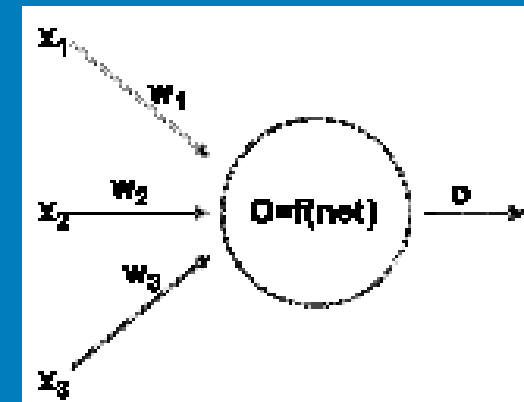


Model: Neuron Cell

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

The Neuron Cell as a Processor

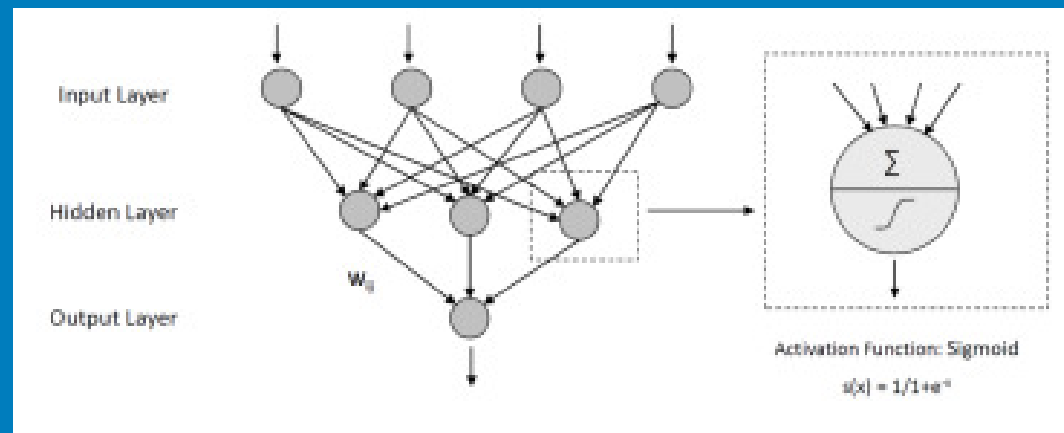
- Connection between the neurons by **weights w**
 - Enforce or reduce the level of the input information
 - Are directed, can be trained
- Input signals
 - Re-computed to a single input information: the **propagation function**
- Output signals
 - **Activation function** computes the output status of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



Principles of Artificial Neural Networks

Network Topology: MLP (Multi Layer Perceptron)

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



Learning Algorithm: Back-Propagation

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

Advantages / Disadvantages of Artificial Neural Networks

Advantages

- **learnable**: learning from examples
- **generalisation**: able to solve similar problems that have not been trained yet
- **universal**: prediction, classification, pattern recognition
- able to analyse complex, **non-linear relationships**
- **fault-tolerant** against noisy data (e.g. face recognition)

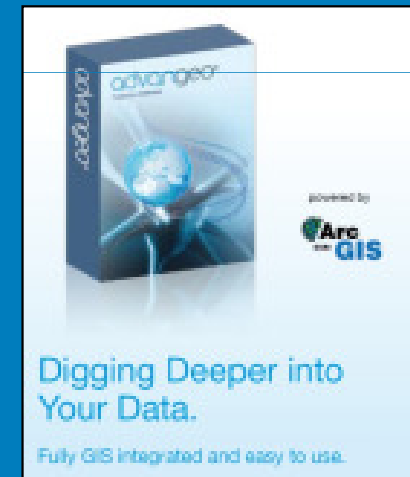
Disadvantages

- choice of **topology** and **training algorithm** not easy
- **black box system**: limits of the networks are unclear (e.g. whether non-relevant data will be analysed and used)

Software: advangeo

- Easy Access to Methods of Artificial Intelligence for Spatial Prediction
- Documentation of Working Steps
- Capture and Management of Metadata for Geodata
- Tools for Data Pre-Processing, Post-Processing and Cartographic Presentation
- Integration into Standard ESRI ArcGIS-Software

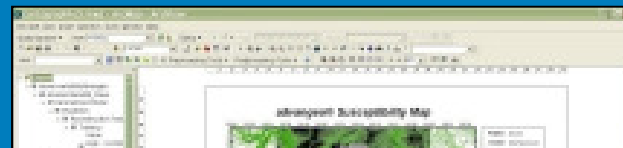
advangeo®
Prediction Software



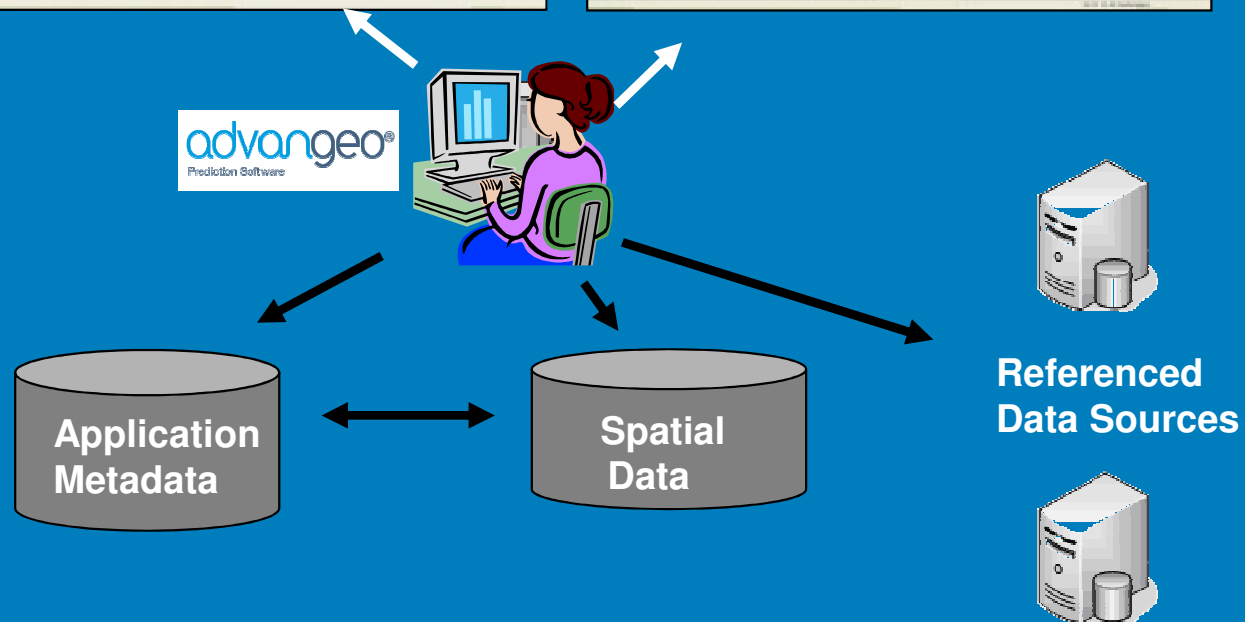
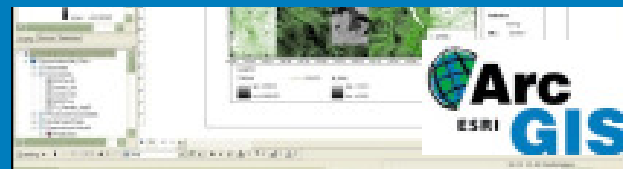
Software Components



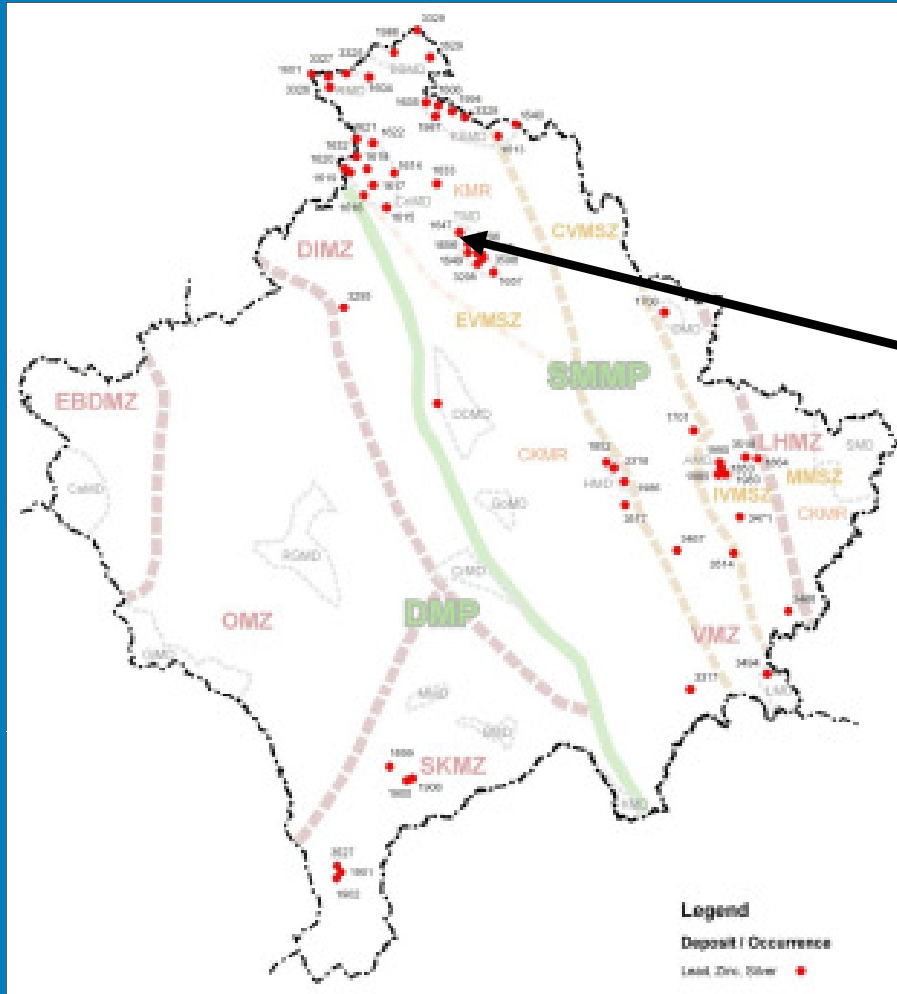
Data- and Model Explorer



GIS Extension



Training Data: Known Pb/Zn-Deposits and Occurrences

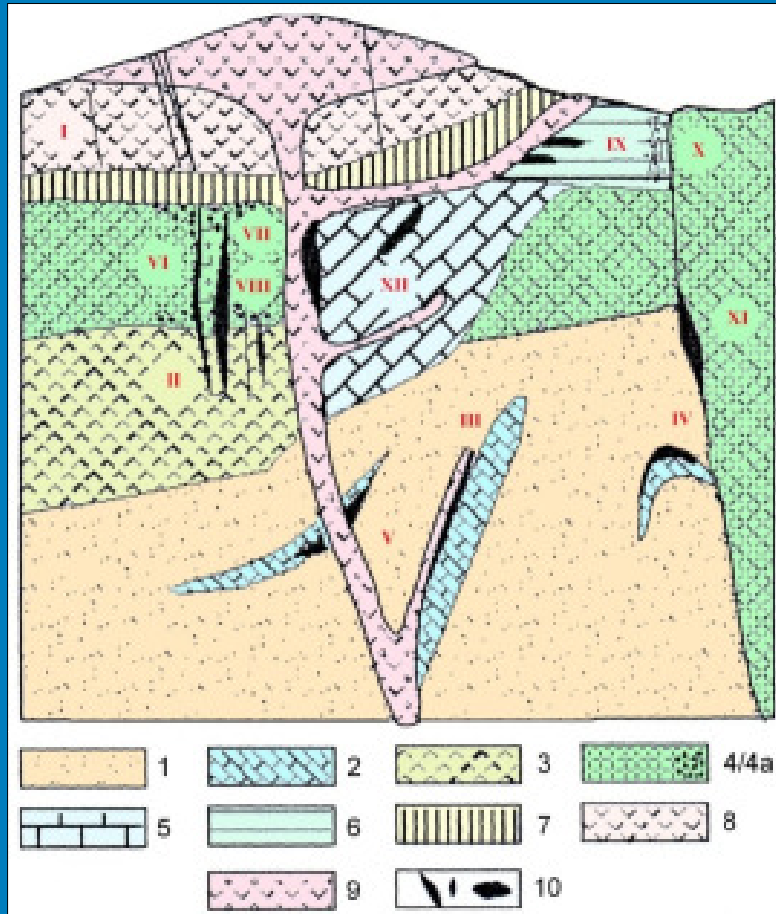


Trepca

Deposit Model:

- **Lithological bound** (controlled) to heterogeneous sedimentary series with carbonatic intercalations and with other reactive rocks (e.g. serpentinite, partly graphitic schist) of Paleozoic and partly Mesozoic age, micro-tectonically per-marked with good cleavage, ruptures and joints
- **Tectonically bound** (controlled) to large structures of faults and thrusts,
- **Magmatic bound** to Oligocene to Miocene high potassium grade andesite-trachyte sub- and effusive volcanism, partly with extensive and intensive pyroclastic and breccious activities (pipe breccias)
- Main minerals: galena, sphalerite, pyrite; minor minerals: chalkopyrite, arsenopyrite, pyrrhotine, rarely gold; main gangue minerals: quartz, calcite; minor gangue minerals: dolomite, Fe-Mn-carbonate
- **Replacement deposit** of Pb/Zn sulphides in carbonatic rocks, sometimes as skarn, as veins and veinlets, as paleokarst fillings, massive, compact, lens-like, disseminated etc.
- **Neogene hydrothermal mineralisation**, metal source uncertain

Deposit Model: Controlled by NNW-SSE-Faults and Volcanic Centers

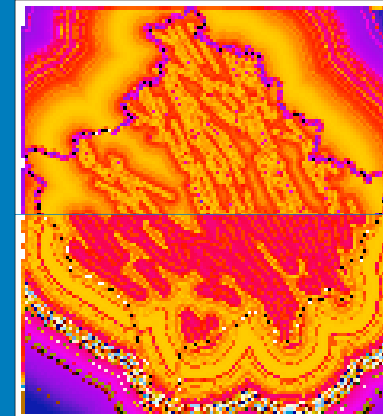
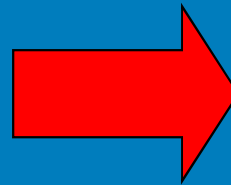
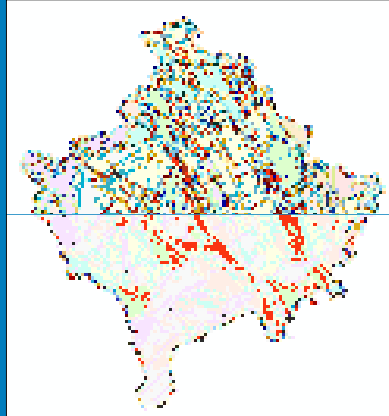


Simplified Schema of Genetic and Structural Types of Pb/Zn-Deposits in the Vardar Zone after ANKOVIĆ, JELENKOVIĆ, VIJUĆ (2003).

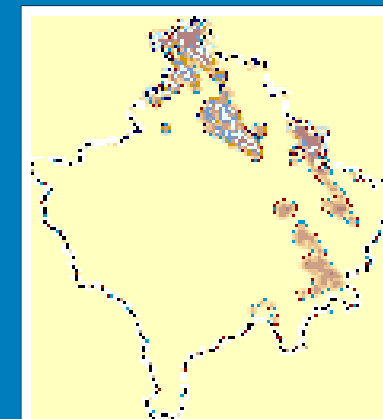
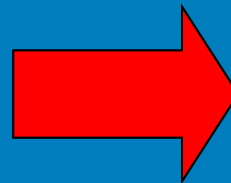
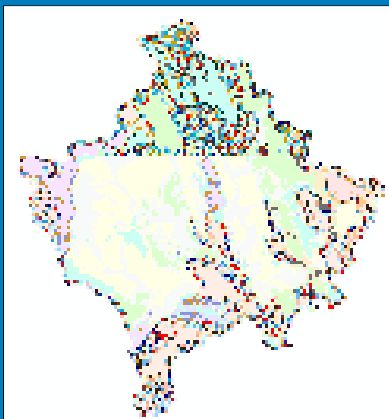
1 – Palaeozoic and Triassic Crystalline Schists, 2 – Upper Palaeozoic Marbles, 3 – Amphibolite and Amphibole schist, 4 – Serpentinite and 4a - Listvenite, 5 – Upper Cretaceous Limestones, 6 – Upper Cretaceous Carbonatic Flysch, 7 – Miocene “Red Series”: Conglomerates, Sandstones, Slates and Marlstones, 8 – Andesitic Lavas and Pyroclastic Rocks, 9 – Subvolcanic and Volcanic Quartz Latite and Trachyte incl. Pipe Breccias, 10 – Pb-Zn Ore Bodies

I – Belo Bërdë / Belo Brdo, II – Crnac / Crnac, III – Staritërg / Stari Trg, IV – Hajvali / Ajvalija, V – Novo Bërdë / Nove Brdo, VI – Koporiç / Koporić, VII – Shuta Prlina / Žuta Prlina, VIII – Jelakse / Jelakce, IX – Shatoriza / Šatorica, X – Kishnicë / Kišhnica, XI – Badovac / Badovac, XII – Crepulja / Crepulja

Input Data: Euclidian Distance to NNW-SSE Faults

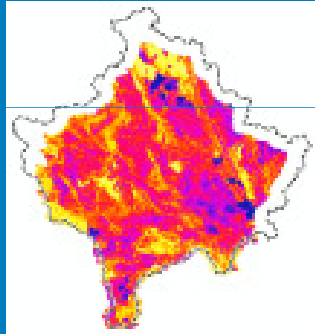


Input Data: Euclidian Distance to Young Volcanic Centers

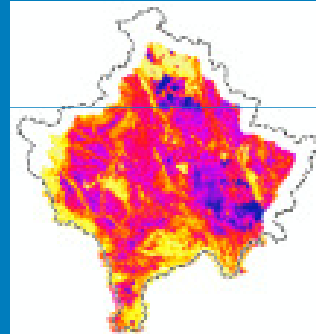


Input Data: Airborne Geophysical Survey Data

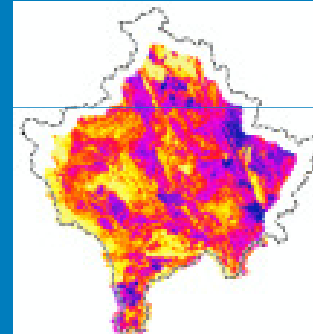
- Radiometrics



Uranium

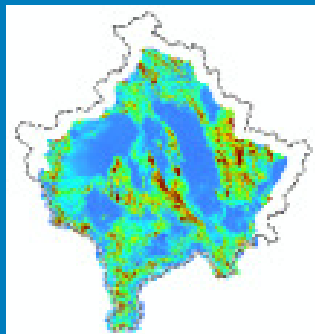


Thorium

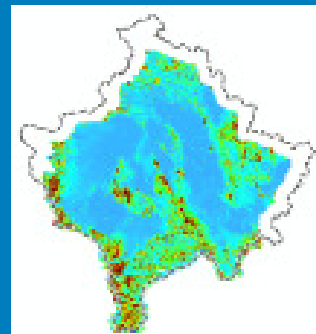


Potassium

- Electromagnetics

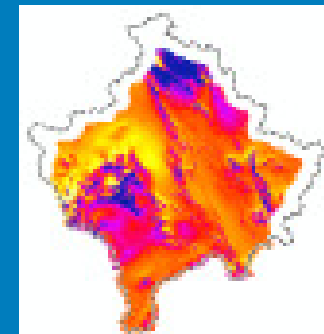


9 kHz



12 kHz

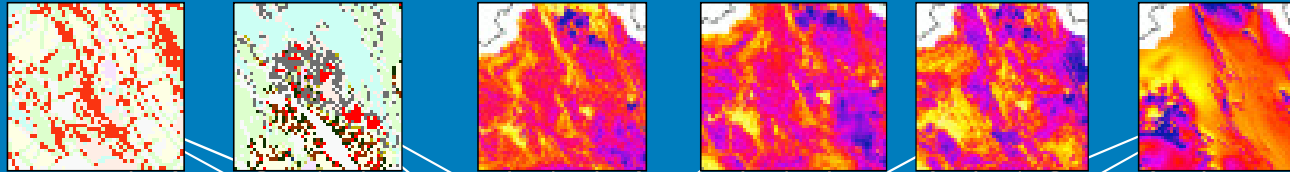
- Magnetics



Total

Exploration Targeting in Kosovo with advangeo®

Input
Data /
Layers



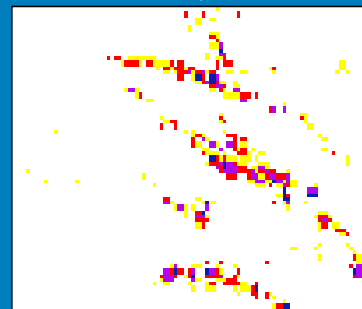
Weights

Hidden
Layers

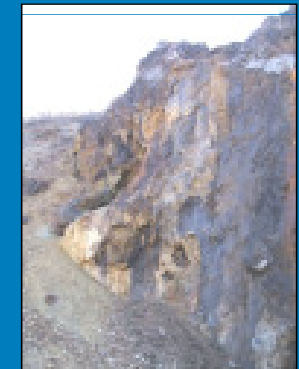


Output
Layer

Results:
Probability



Training
Data

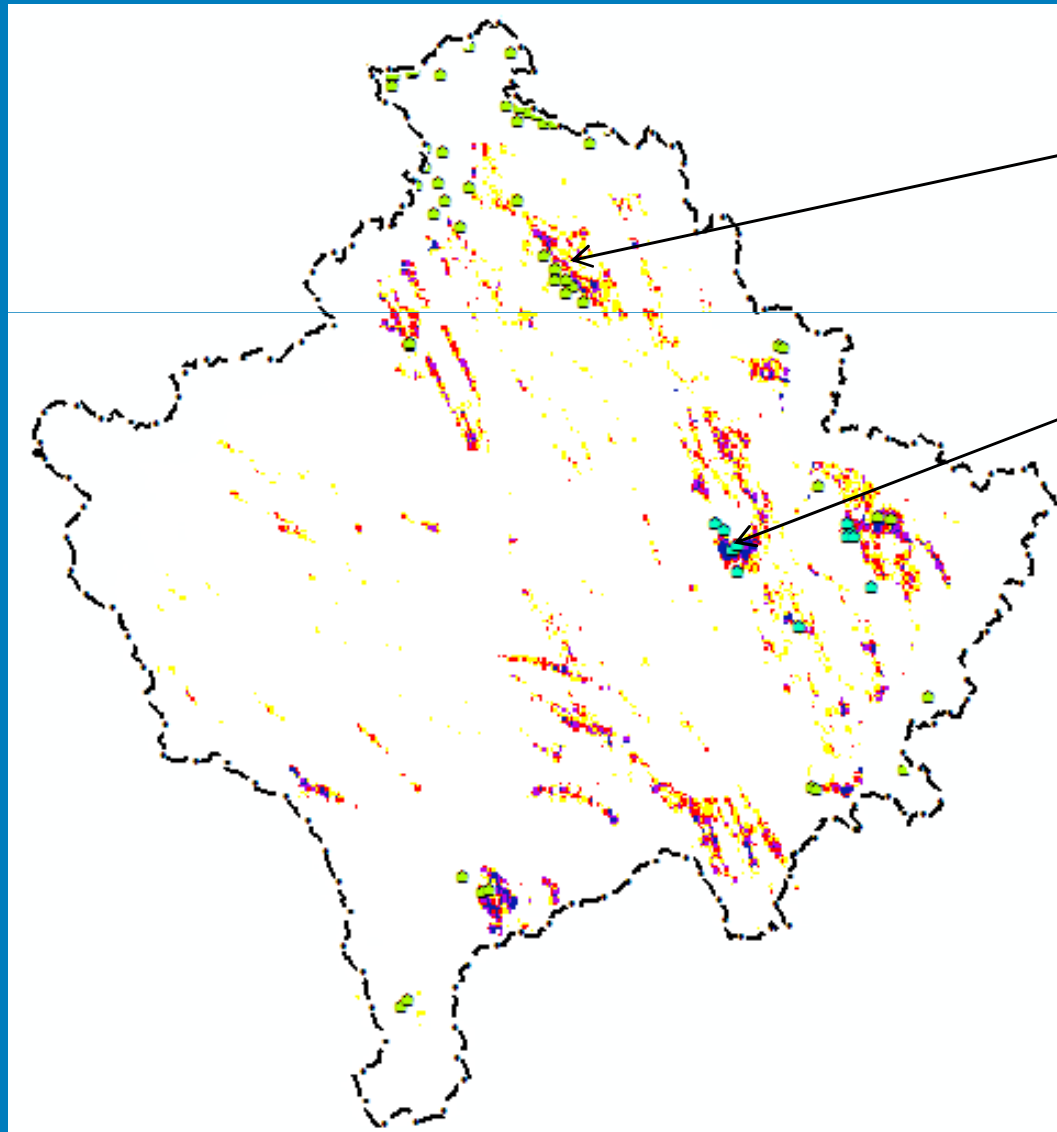


Known
Deposits

Validation



Exploration Targeting in Kosovo with advangeo®

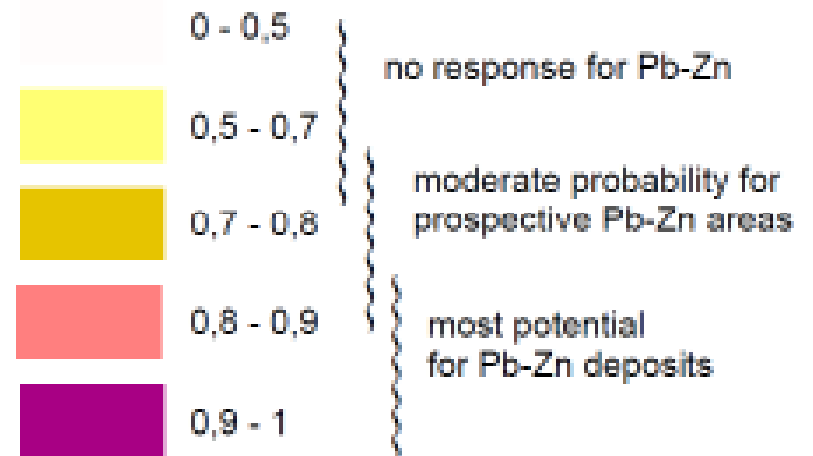


Test Points

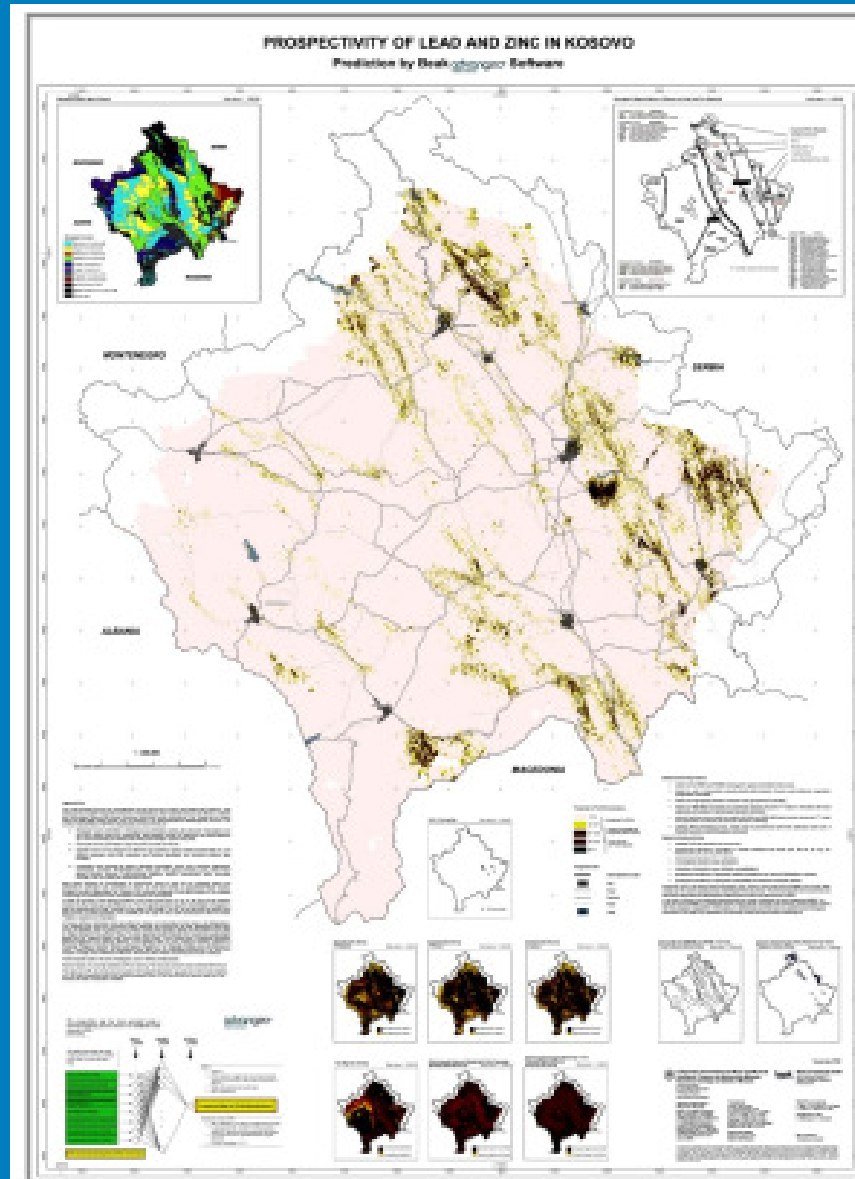
Training
Data

Training Points

Probability for Pb-Zn Mineralisations



Prospectivity Maps of Kosovo 1:200,000



Prospectivity Maps compiled / available for:

- Pb/Zn
- Au
- Cr

Application in different fields:

- Economic Geology (Deposits)
- Environmental Geology
- Geohazards / Risk Assessment
- Geology (Rocks, Minerals)
- Pedology (Soil Parameter)
- Hydrogeology
- Insurance
- Health

advanceo[®]
Prediction Software



Prerequisites for a Sustainable Resource Management in the Future:

- Digital Geoscientific Database (Raw Material Inventory)
- Raw Material Prospectivity Maps
- Mineral Resources Management Plan
- Mining Sector Strategy



Mining Journal
(July 2009)

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