Geology and Minerals of Kosovo

* under UNSCR 1244

Opportunities for National Development

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Outline

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

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 chromatites.
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 % Al₂O₃
- **Halloysite, Kaolin, Bentonite, Quartz, Talc, Diatomite, Feldspar, Garnet, Asbestos**
Short Review: Raw Material Potential of Kosovo

Industrial Rocks (Construction Minerals, Decorative Stones)

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

Gravel: Kapoanik
Clay: Podujevë
Limestone: Prizren
Marble: Deçani
Tasks:

• Issuance and management of licenses,
• Legal and geological-technical evaluation and monitoring of the mining companies,
• Data provision for potential investors.
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
Geoscientific Map Set of Kosovo 1:200,000

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Metallogenic / Minerogenic Map of Kosovo 1:200,000

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Stream Sediment Sampling Map of Kosovo 1:50,000

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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

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Spatial Conflict Analysis

GIS-supported Conflict Analysis with Mining Protection Zones

- Water Protection Zones
- Nature Protection Zones
- Historical Monument Protection Zones
- Mining Related Geohazards

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GEO-Database Kosovo (GDK)
Case Study: Computer-Aided Knowledge Based Prediction
Traditional prediction methods are based mainly on the expert's knowledge/experience supported by modern information technology.

**Data Analysis and Interpretation**
Modern Approach Using Artificial Intelligence

The artificial neuronal network “replaces” the experts empirical data analysis.
**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)
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
Training Data: Known Pb/Zn-Deposits and Occurrences

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Deposit Model:

- **Lithological bound** (controlled) to heterogeneous sedimentary series with carbonatic intercalations and with other reactive rocks (e.g. serpentine, 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-effusive volcanism, partly with extensive and intensive pyroclastic and breccious activities (pipe breccias).

- Main minerals: galena, sphalerite, pyrite; minor minerals: chalkopyrite, aresenoprite, 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

I – 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


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

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Exploration Targeting in Kosovo with advanceo®

Input Data / Layers
- Weights

Hidden Layers

Output Layer
- Results: Probability

Training Data
- Known Deposits

Validation

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Test Points

Training Data

Training Points

Probability for Pb-Zn Mineralisations

- 0 - 0.5: no response for Pb-Zn
- 0.5 - 0.7: moderate probability for prospective Pb-Zn areas
- 0.7 - 0.8: most potential for Pb-Zn deposits
- 0.8 - 0.9: moderate probability for prospective Pb-Zn areas
- 0.9 - 1: most potential for Pb-Zn deposits

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Prospectivity Maps of Kosovo 1:200,000

Prospectivity Maps compiled / available for:

- Pb/Zn
- Au
- Cr
**Summary:** Neural Networks are Universal

**Application in different fields:**

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

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Conclusion: Opportunities for National Development

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

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