

Information systems and mineral potential mapping – preconditions for mining sector development

Barth, A. Beak Consultants GmbH
Freiberg, Germany

We thank our colleagues and partners from:
 Geological Survey of Tanzania, Tanzania
 Geological Survey Department, Ghana
 Geological Survey of Namibia
 Minirena, Rwanda
 Department of Geological Survey and Mines, Uganda
 Independent Commission for Mines and Minerals, Kosovo
 Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie



Beak Consultants GmbH

- **Fields of business**

- Geology, exploration, environment
- GIS and cartography
- Tailor-made software



- **High quality standards:**

- ISO 9001:2008 certificate

- **25 years of company experience:**

- Beak International Inc. founded 1965 in Canada
- Beak Consultants GmbH founded 1994 in Freiberg/Germany
- North American operations acquired by Stantec Consulting Limited in 2003
- German operations launched as an independent company, retaining the rights to the name Beak

- **Up to 35 years employee experience:**

- Our roots are the former East German Geological Survey

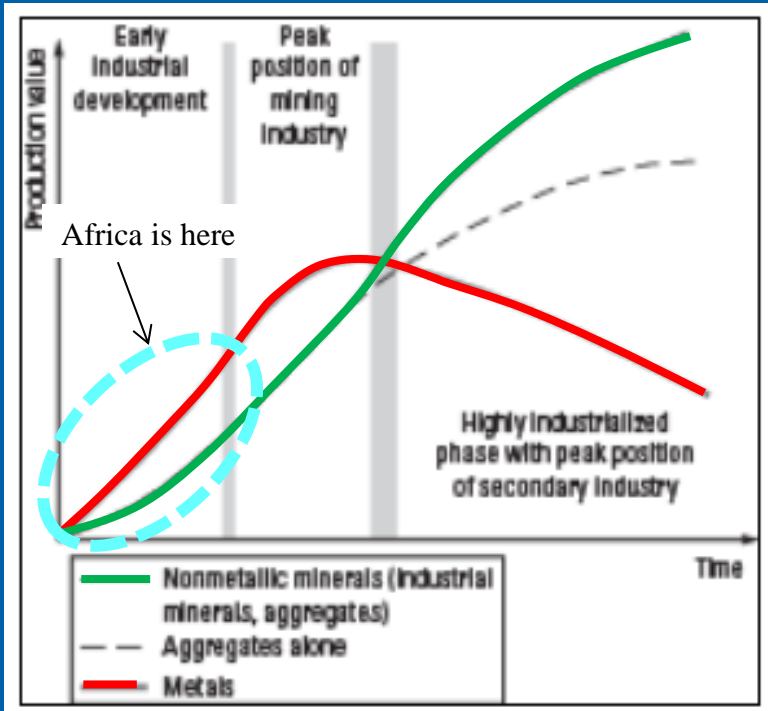


Agenda

- African Mining Sector specifics
- The mineral knowledge base
- The value of information
- How to make data available?
- Value adding products
- Conclusions



The African Mining Sector



After Wellmer & Decker-Platen, 2007

- Few big mines focussed on valuable minerals & their export (Au, metals, diamonds,)
- Large ASM sector, employing Millions of people
- Demand to fill the gap → medium size enterprises
- Growing demand for non-metallic materials
- Opportunities with new commodities (Li, Co, graphite ...)



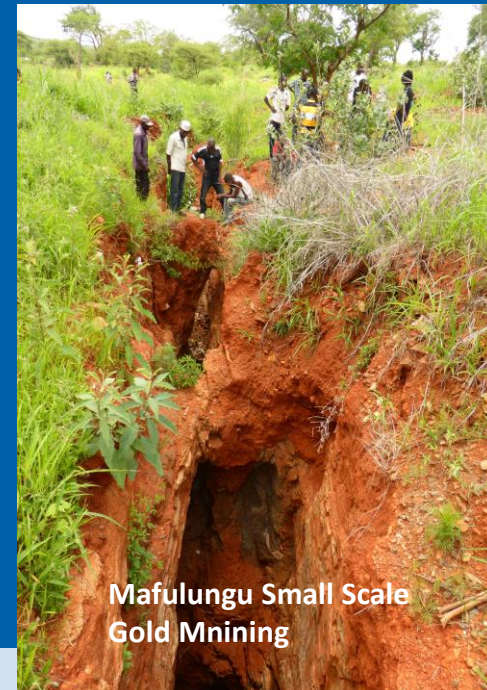
What do we have? Where is it?

Wher could be more?

Whom does it belong to? What restrictions exist?

Example: Tanzania

- Few large mines: Gold Bulyanhulu, Buzwagi, Geita, North Mara and New Luika, and the Mwadui Diamond Mine
- Few medium size mines: Phosphate Minjingu, Merelani Tanzanite One Mine, Coal Mines of Songwe-Kiriwa and Ngaka, Salt Brine workings of Uvinza
- Thousands of artisanal and small mines (ASM): gold, gemstones, ...
- Vast potential



Example: Rwanda - High Losses in ASM Operations (Rwanda)

- High mining losses (70 % ?)
- High metallurgical losses (up to 900 ppm Ta in stream sediments)

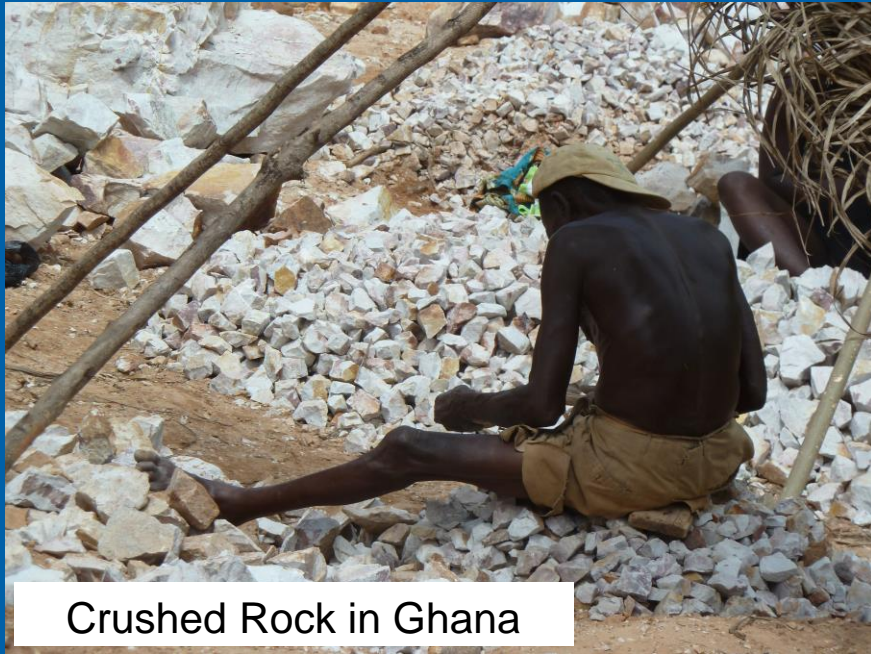


Pegmatite border
This is loss

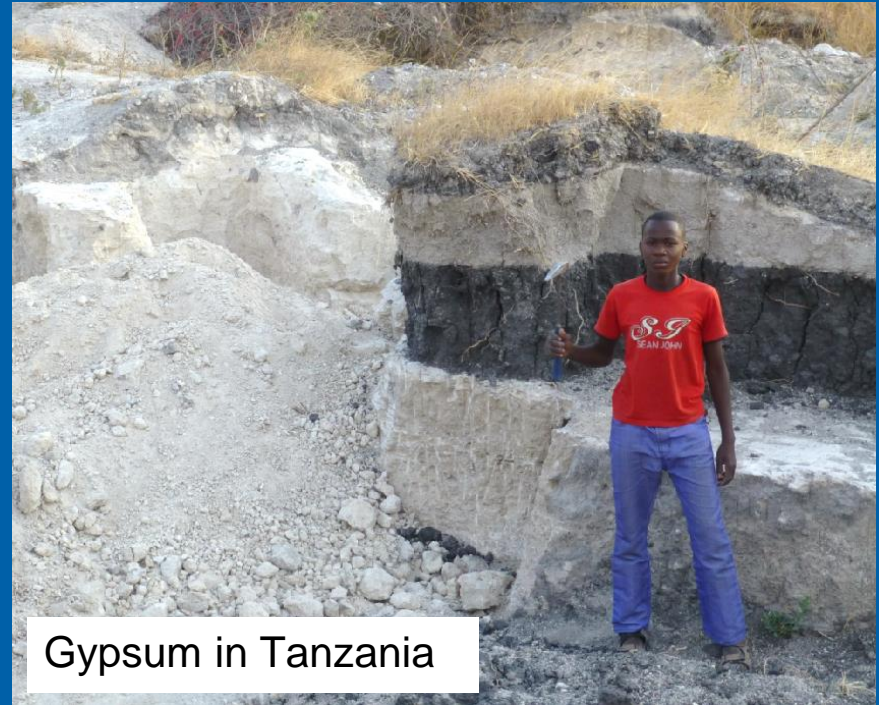


Example: Low Productivity Non-metallic Sector

- Much manual work
- No technology
- Low productivity
- Low quantities



Crushed Rock in Ghana



Gypsum in Tanzania

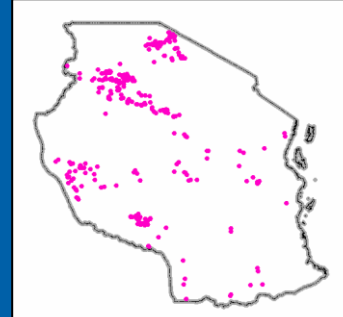
- Missing knowledge:
 - Locations ?
 - Quantity?
 - Quality ?

Problem: Missing Data

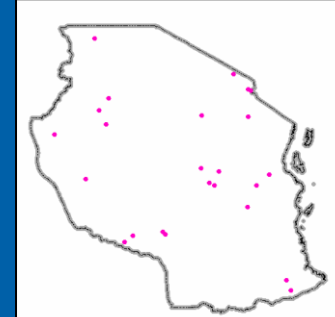
- Considerable knowledge about profitable metallic minerals (Au, Cu, U, ...) and diamonds
- Not much knowledge about other metals and non-metallic minerals
- Much of the systematic data is from Colonial times



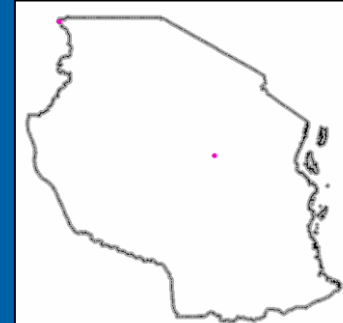
Knowledge base for mining sector diversification is weak.



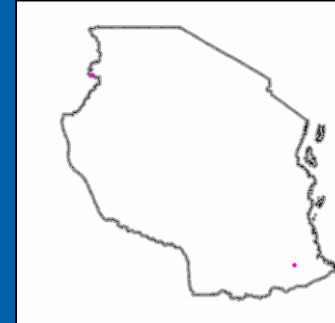
318 precious metals



24 decorative and dimension stones



2 Lithium



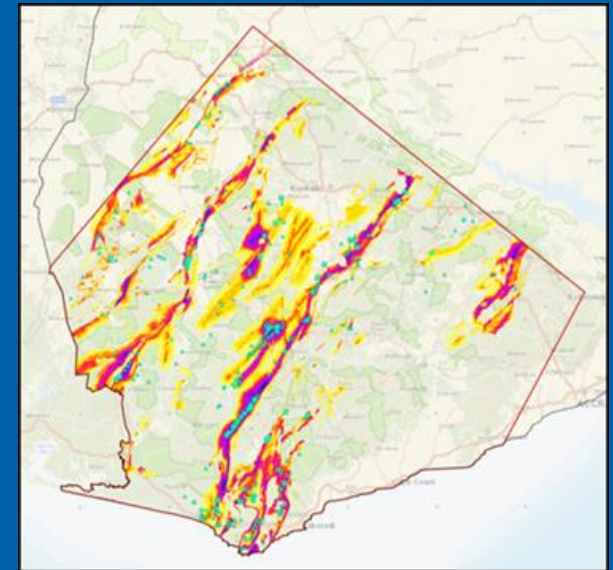
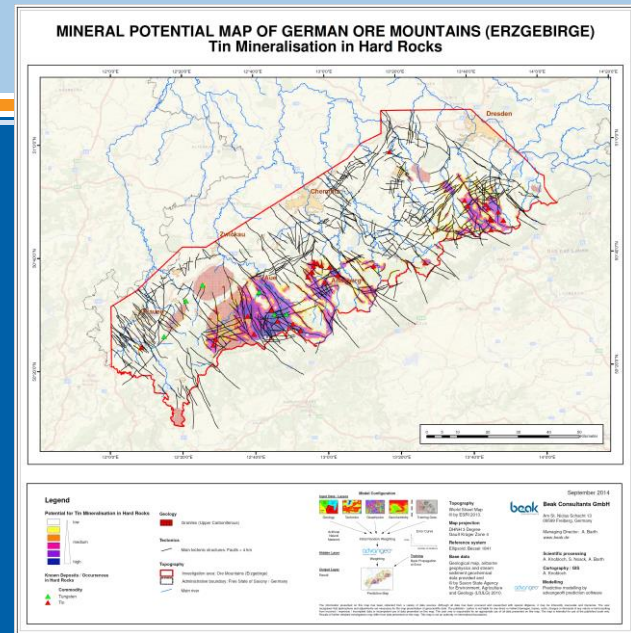
2 Cobalt

Where are the opportunities ?

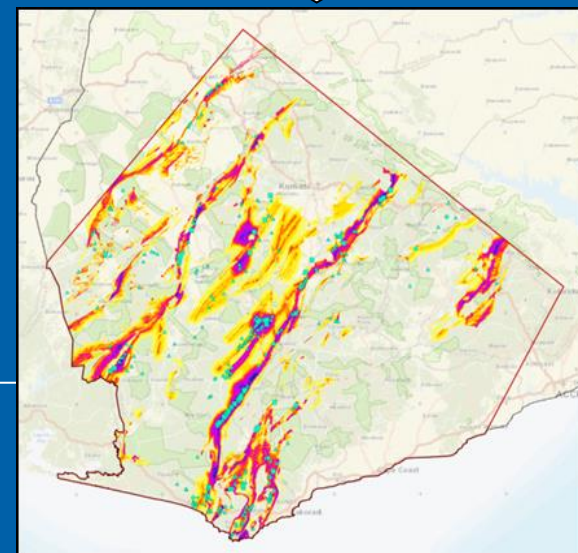
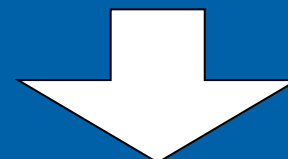
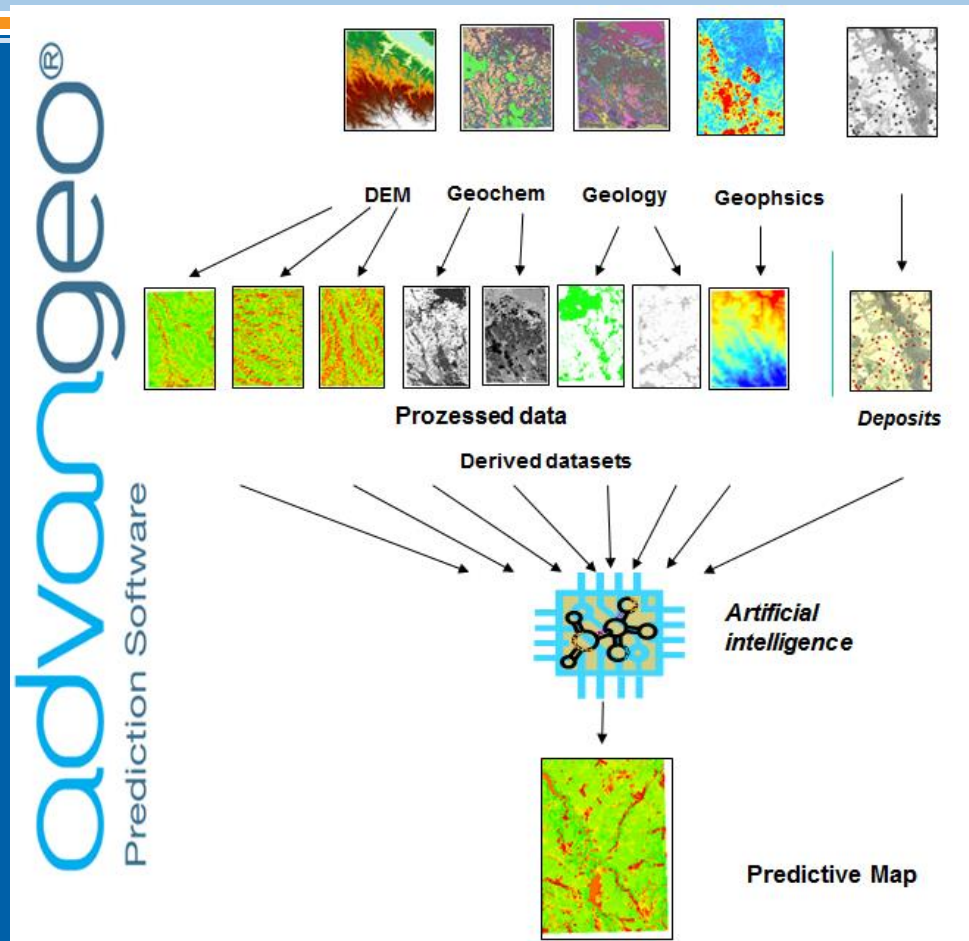
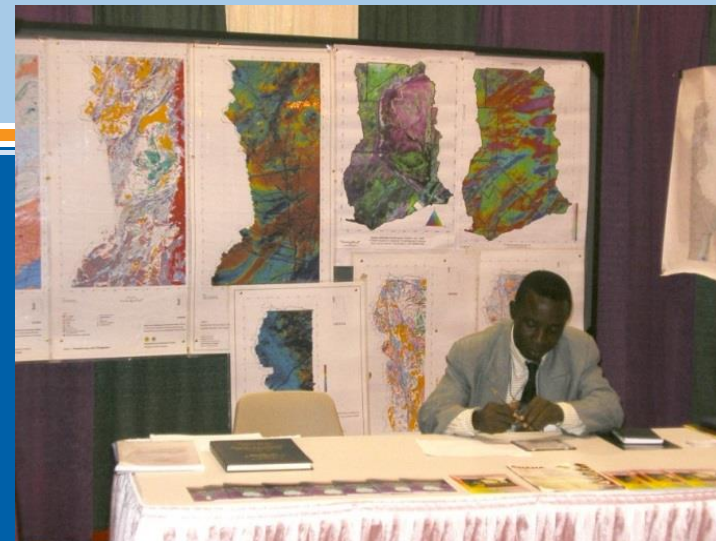
- There is (some??) systematic knowledge about existing mines/ deposits
- Mineral potential maps are missing
- Guidance for medium industry?
- Guidance for small scale mining?



Value adding products is the solution



From data to opportunities



Available Data & Value Added Products:
Key Factors for Mining Sector Development

Example Uganda: Digitising the archives

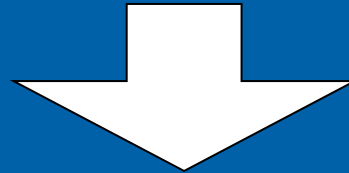
- **Billions of Dollars** were spent for mineral resources and geological exploration
- **Data** is the key issue for:
 - mining sector development
 - land use and infrastructure planning
 - environmental protection
 - geo-hazard prevention
 - forestry, agriculture
 - water management
 - ...
- Data availability is of top priority



Data is Money ? → Available Data is money !

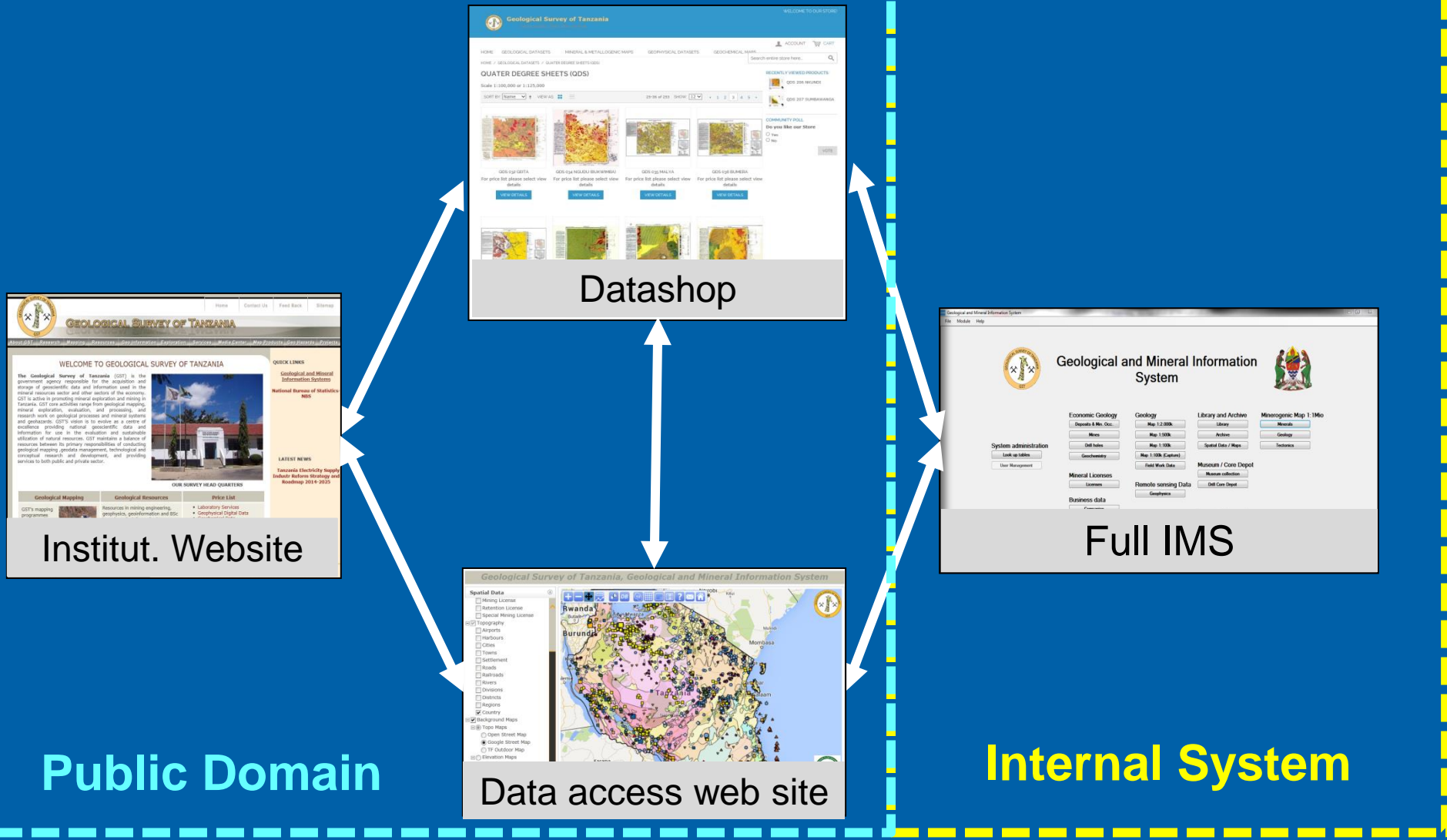
How to Make Data Available ?

- Have data „on stock“
- Centralise data management
- Standardize data structures and coding
- Have instruments for data distribution
- Regulations for data release/usage
- Guarantee data security
- Prevent loss of data

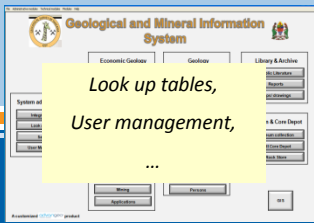


Information Management System (IMS)

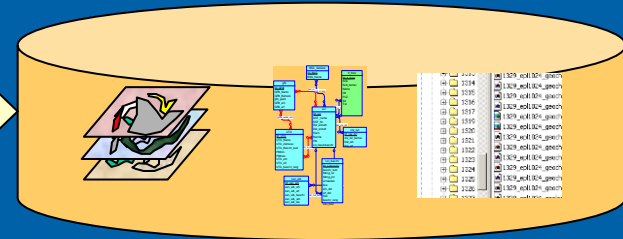
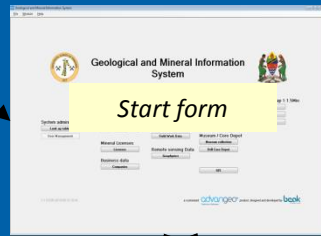
Components of a Modern IMS



The Data Content

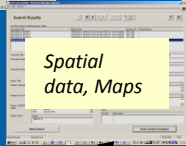
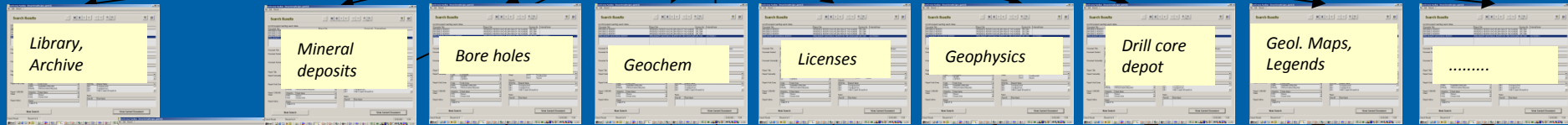


Database
Management

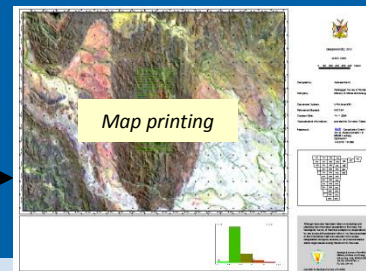
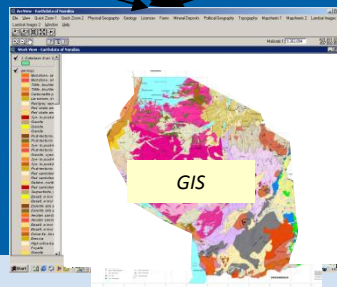
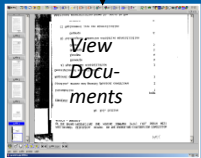


Meta data & files

Real data



View Maps in GIS



The Data Access Web Portal

Geological Survey of Tanzania, Geological and Mineral Information System

Spatial Data

- Geo-Economic Data (1:2M)
- Mineral Occurrences [Download](#)
- Mines [Download](#)
- Geology [Download](#)
- Structures
- Mining Licenses
 - Primary Mining License
 - Prospecting License
 - Mining License
 - Retention License
 - Special Mining License
- Topography
 - Airports
 - Harbours
 - Cities
 - Towns
 - Settlement
 - Roads
 - Railroads
 - Rivers
 - Divisions
 - Districts
 - Regions
 - Country
- Background Maps
 - Topo Maps
 - Open Street Map
 - Google Street Map
 - Satellite Maps
 - Elevation Maps

Database Query

Mineral Occurrence Mines Archive Library Mineral Licences

Name:

Region:

Commodity Group: Metallic Minerals: Base Metals

Commodity:

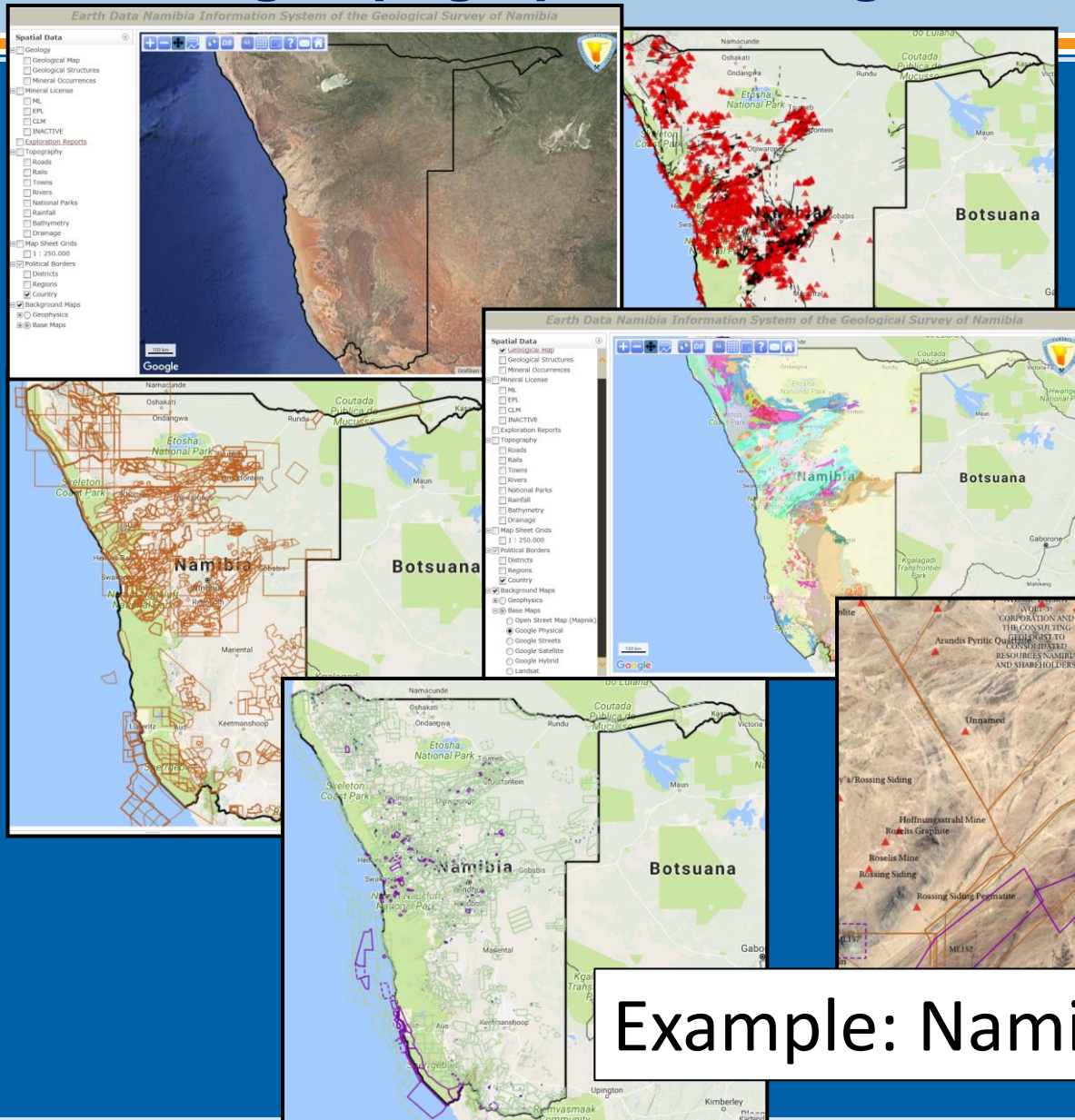
Genetic Type:

Example: Tanzania

- Access to GIS and database
- Geological and Cadastral data under one roof
- Free Download of low resolution data
- Link to Institution's web site and Data Shop

- www.gmis-tanzania.com
- www.earthdatanamibia.com
- www.kosovo-mining.org

Linking Topographic, Geological, Mineral and Legal Data



- One Stop Information
- Easy to use
- Informative
- Value added products integrateable
- Guidline to further information

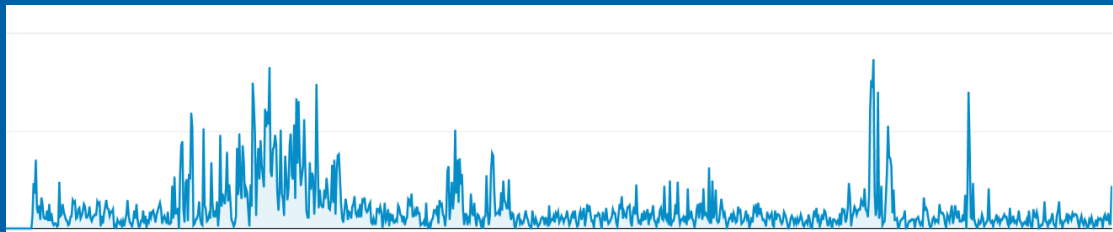
Example: Namibia

The Internet tells us: Who is using our data?



Number of users/ country/ time period

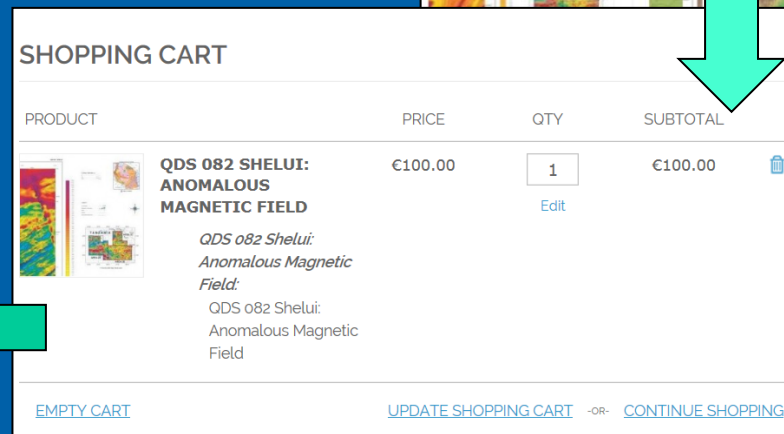
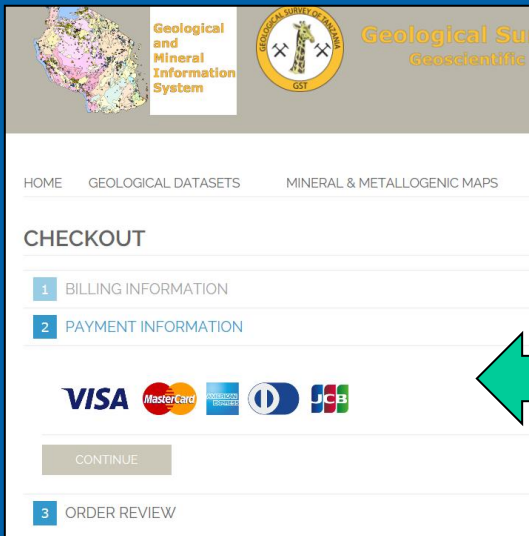
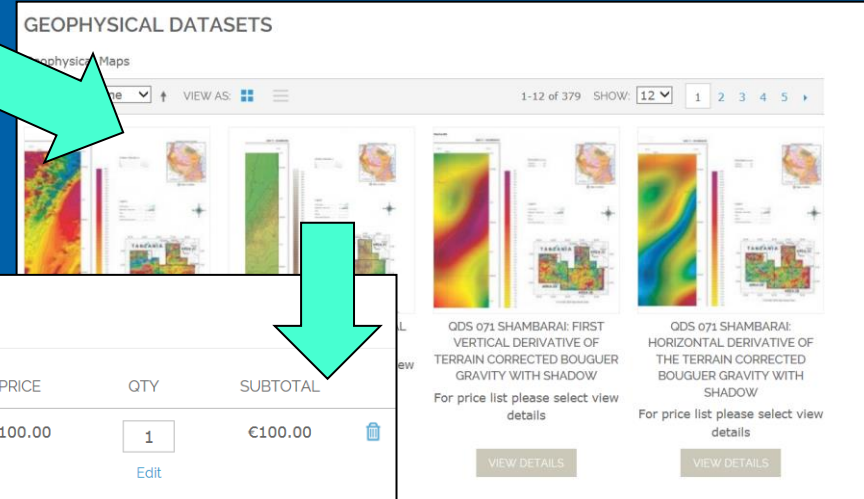
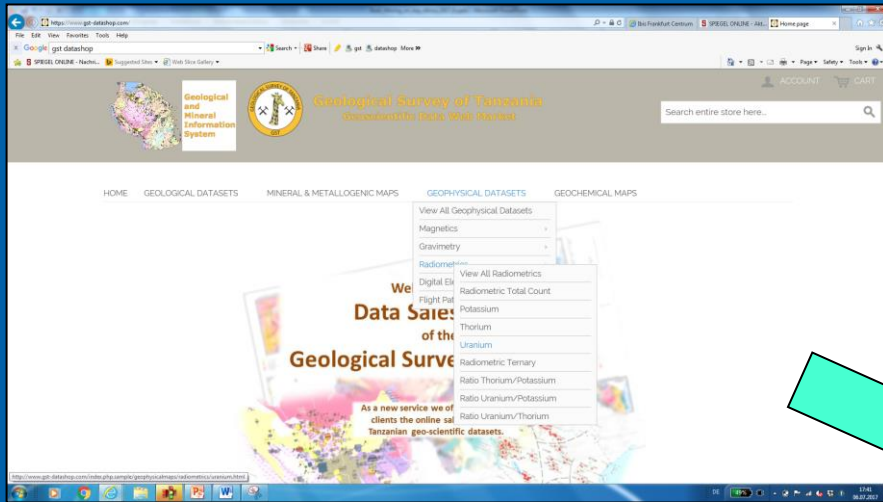
| | | |
|-----|----------------|-------|
| 1. | Russia | 4.442 |
| 3. | United States | 1.667 |
| 4. | (not set) | 1.107 |
| 5. | Germany | 1.009 |
| 6. | United Kingdom | 500 |
| 7. | India | 329 |
| 8. | China | 296 |
| 9. | Brazil | 284 |
| 10. | Australia | 212 |
| 11. | Japan | 200 |
| 12. | South Africa | 200 |
| 13. | Canada | 160 |
| 14. | Italy | 158 |
| 15. | Netherlands | 152 |
| 16. | Kenya | 140 |



Access histories reflect stakeholder response

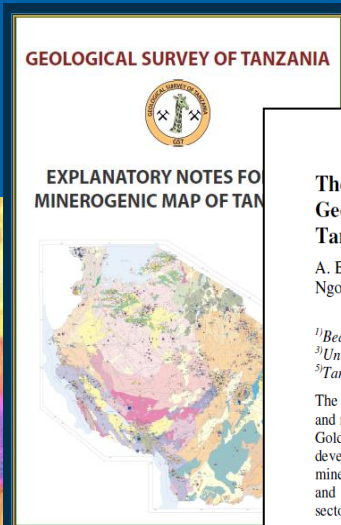
The Data Shop

- Purchase of data with common Credit Cards
- 24/7 availability
- Reliable, affordable and quick
- Data comes via e-mail



About Value Added Products

- Evaluations
 - Compilations
 - Recommendations
 - Guidelines/ Laws
- Metallogenic Map
 - Mineral Potential Maps
 - Mineral Occurrence Passports
 - Investment Opportunities
 - Governmental Maps
 - And much more ...



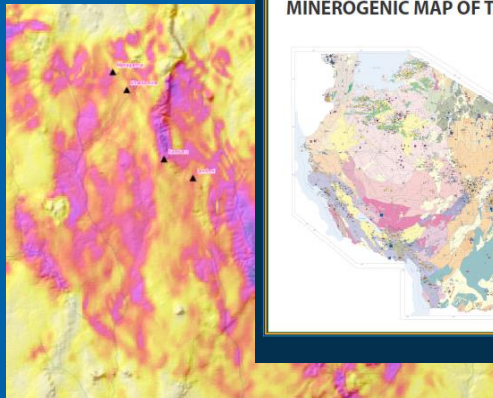
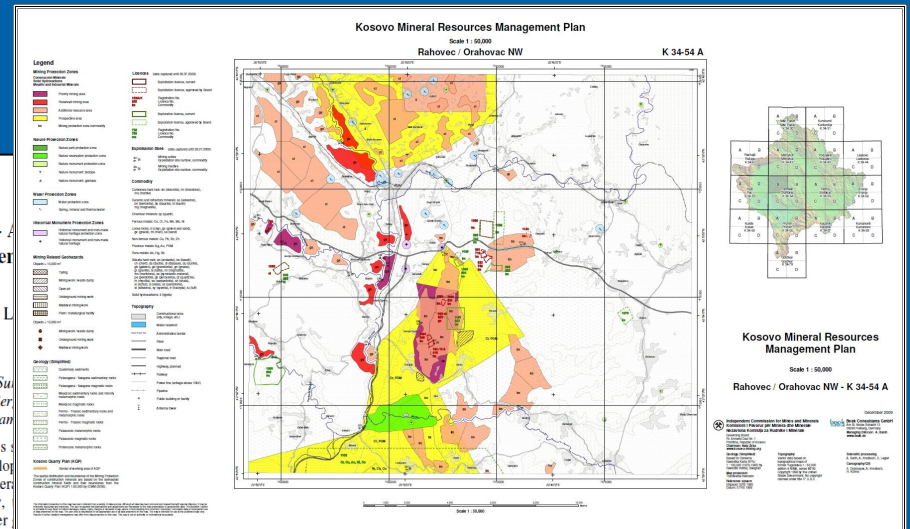
The New Mineralogical Map of Tanzania – A Geological and Mineral Information System

A. Barth¹⁾, N. Boniface²⁾, M. Kagya³⁾, A. Knobloch¹⁾, C. L. Ngole²⁾, K. Stanek⁴⁾, T. Stephan¹⁾

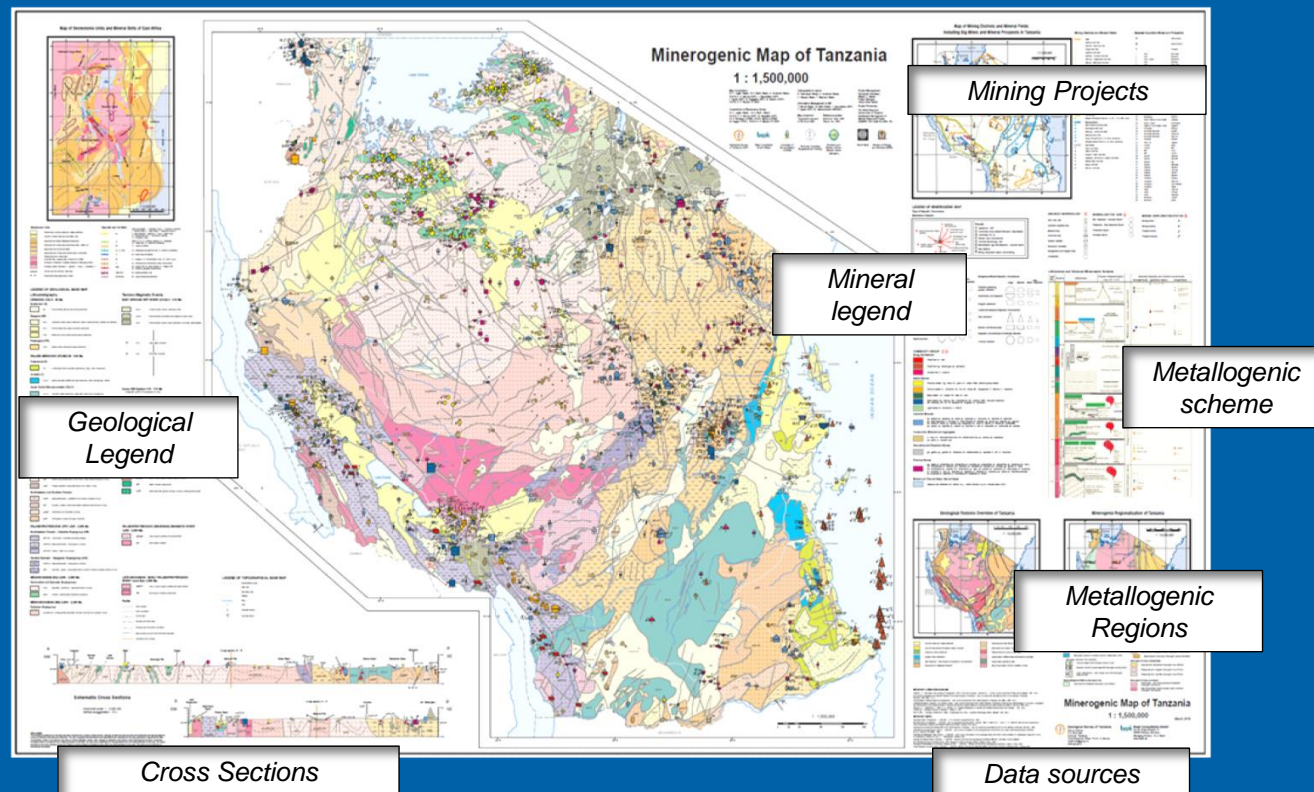
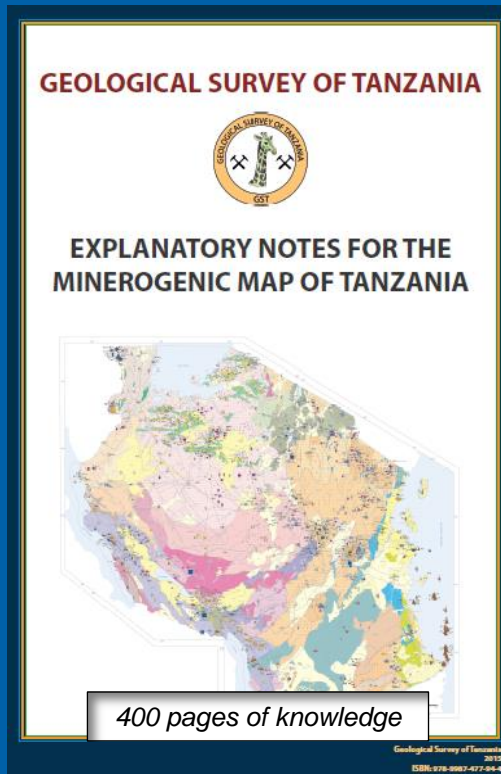
¹⁾Beak Consultants GmbH, Freiberg, Germany, ²⁾Geological Survey of Tanzania, ³⁾University of Dar es Salaam, Dar es Salaam, Tanzania, ⁴⁾TU Bergakademie Freiberg, ⁵⁾Tanzania Petroleum Development Corporation, Dar es Salaam

The mineral wealth of Tanzania comprises of many valuable and non-metallic minerals. Especially since the massive development of the country became obvious. Consequently, the mineral sector as one of the key factors to contribute to further development and publication of mineral and geological data is a strategic task to guide both the state and private mineral sectors to new discoveries, enhance investment and support national planning activities.

Since 2013, the Geological Survey of Tanzania (GST) and Beak Consultants GmbH are implementing a modern Geological and Mineral Information System (GMIS). The system is designed to host and manage the principle geo-scientific information about the territory of Tanzania, such as geo-scientific maps, mineral occurrence

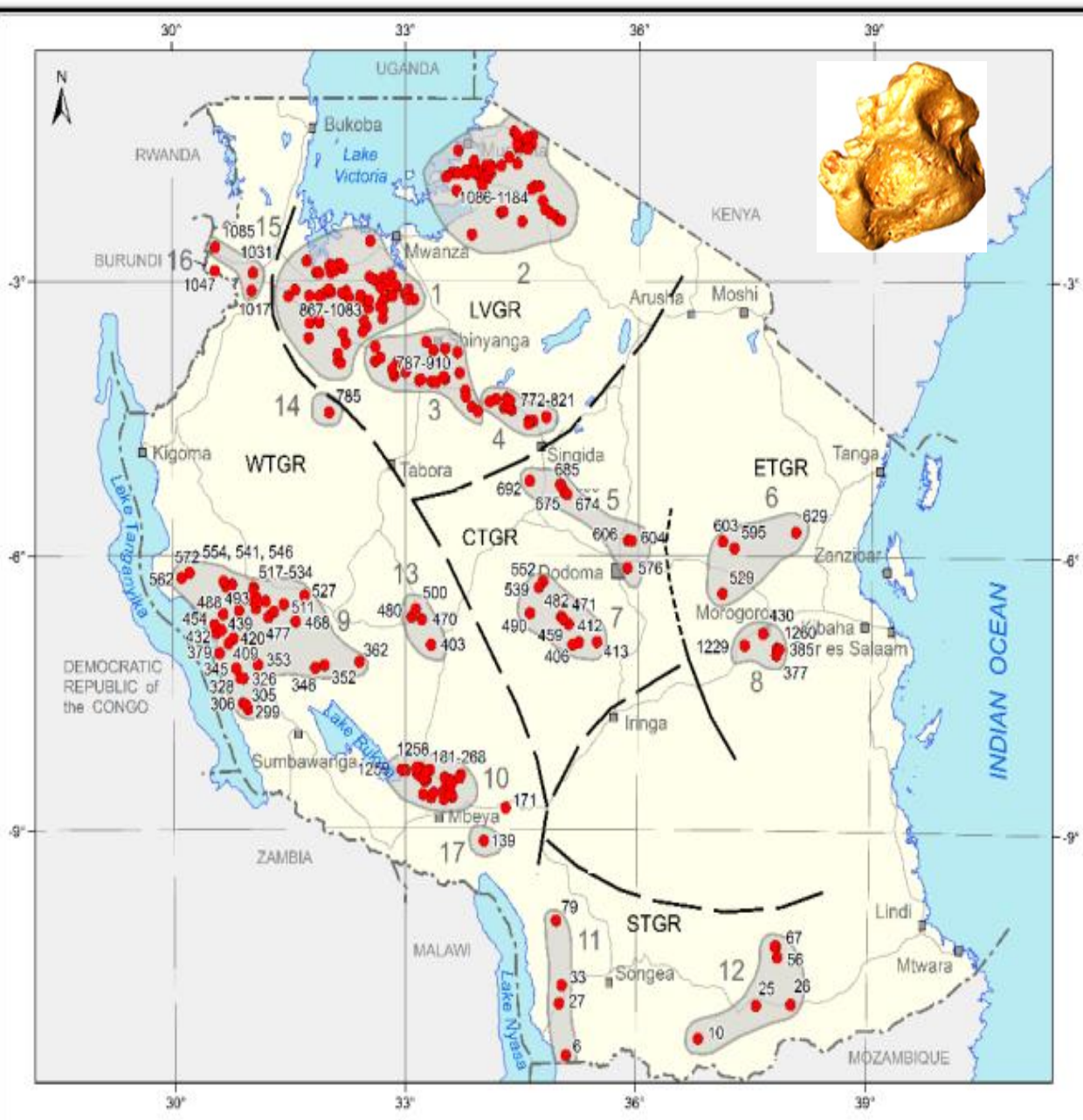


Example: Minerogenic Map of Tanzania



Summary of geology and tectonics, descriptions of 1100 mineral occurrences, metallogenic considerations and conclusions

Mineral Potential of Tanzania: Gold



Big Mines:

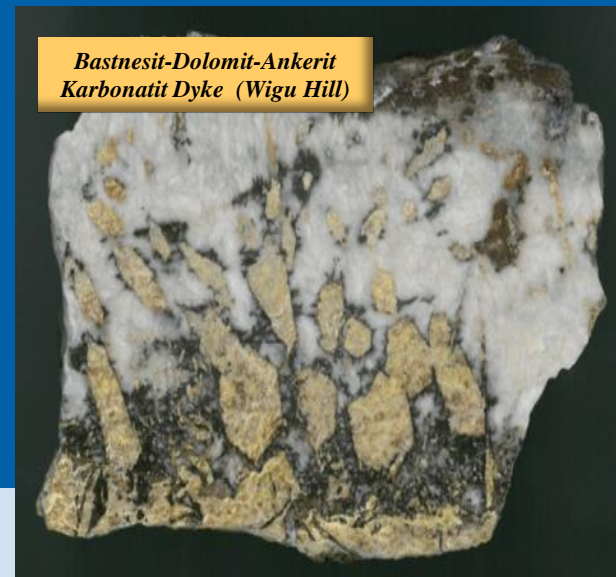
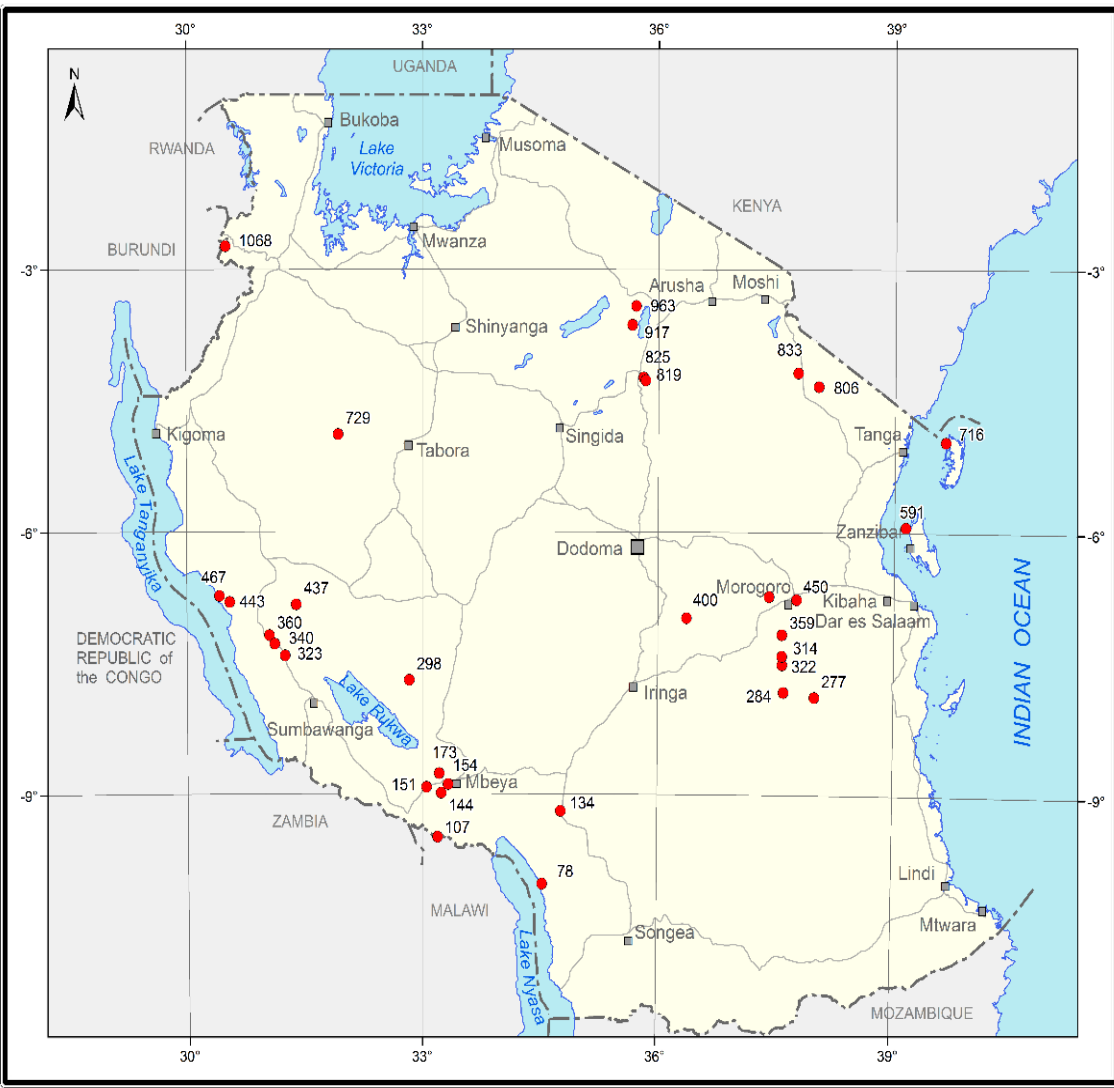
- Geita
- Buzwagi
- Bulyanhulu
- North Mara
- New Luika

Thousands of small scale operations

The potential is exceptional

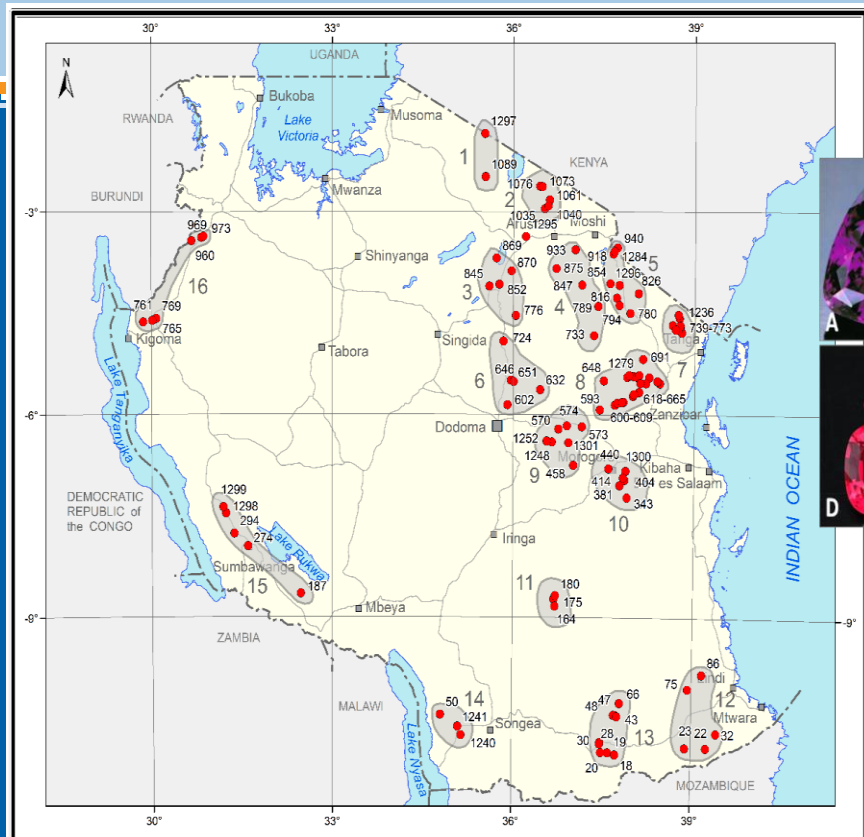
Mineral Potential of Tanzania: Rare Earth Elements

- Located in Carbonatites
- Often together with Apatite, Fluorite and Nb
- Bound to rift structures of different ages
- Considerable resources, e.g.
- 42 Mt @ 4.19 % REE (Ngualla),
- Very high grade, up to 20 % REE (Wigu Hill).
- Vast potential



*Bastnesit-Dolomit-Ankerit
Karbonatit Dyke (Wigu Hill)*

Mineral Potential of Tanzania: Coloured Gemstones

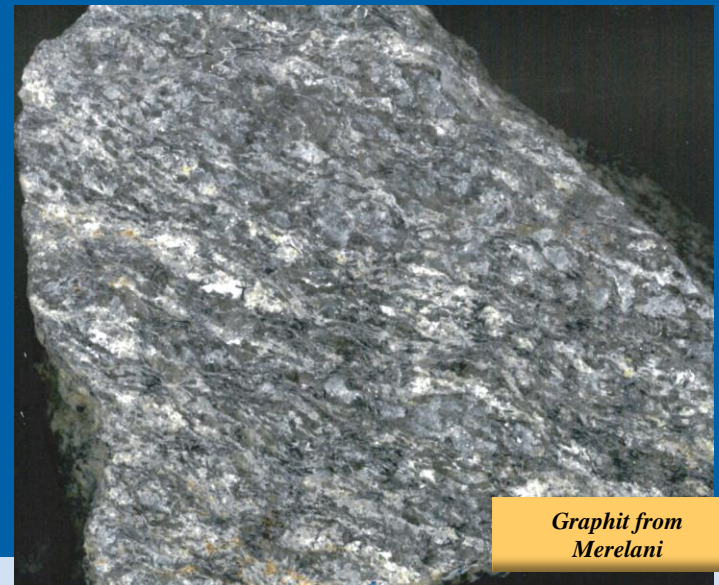
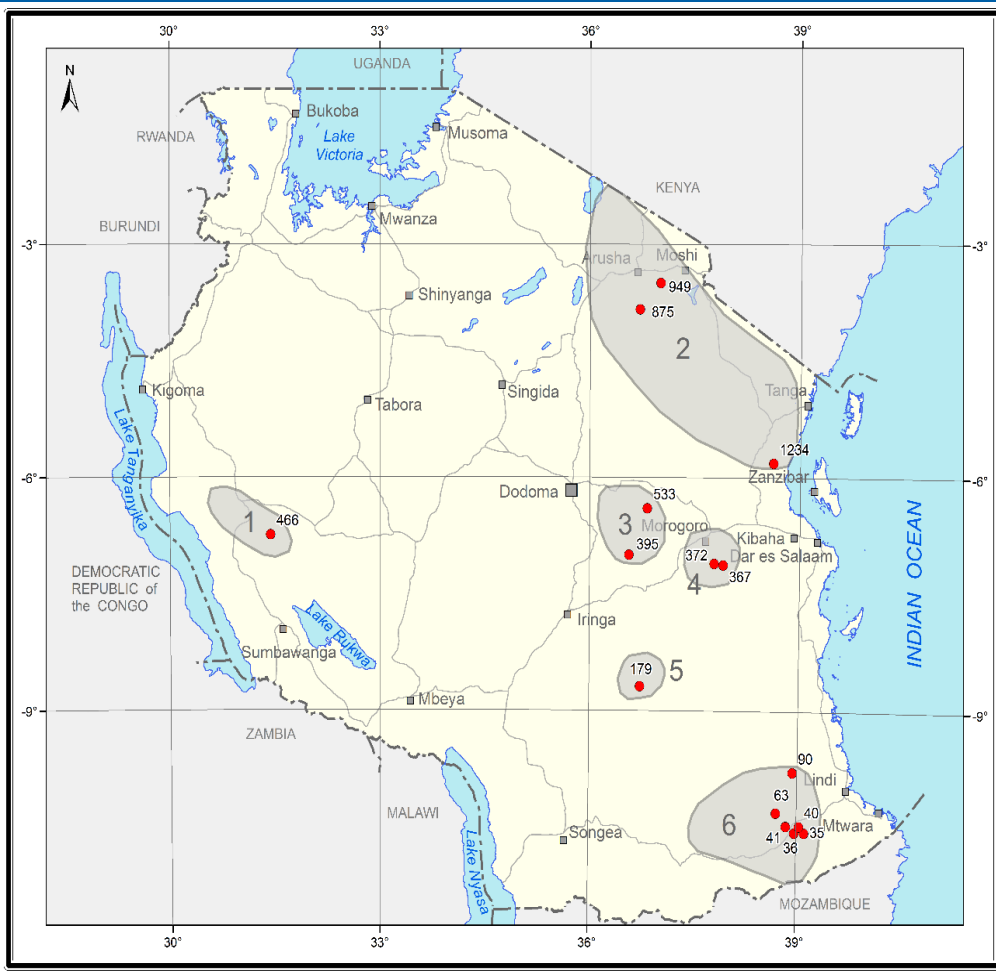


*Small-scale Mining
Muhuvesi River*

- High quality stones (Tanzanite, Ruby, Garnet, Sapphire, Amethyst, Emerald, Aquamarin, Beryll, Spinel, Tourmalin...)
- In Mozambique Belt metamorphics
- Exclusively small scale mining

Mineral Potential of Tanzania: Graphite

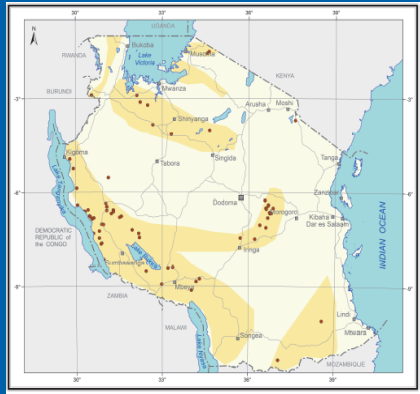
- Mainly in Granulite-Gneiss-rocks
- World class deposits:
- Merelani-Arusha: 7,6 Mt ore @ 11,2 % graphite, proven reserves,
- Epanko with “large flake graphite“, 14,9 Mt ore @ 10.5 % graphite
- In exploration: Mahenge, Nachingwea
- Current development: Kibarran resources



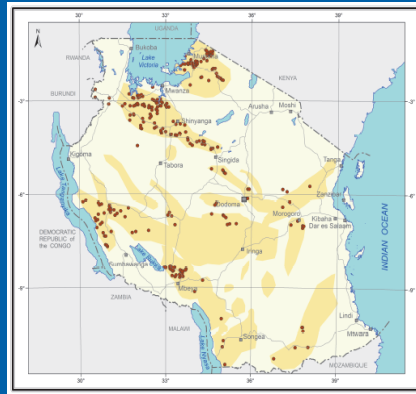
Graphit from Merelani

Mineral Maps for Mining Sector Development

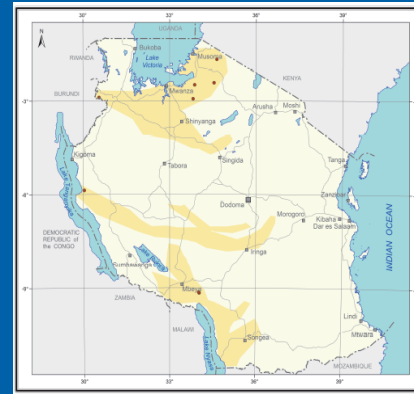
Copper



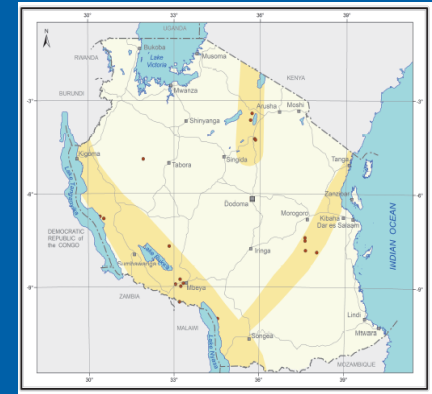
Gold



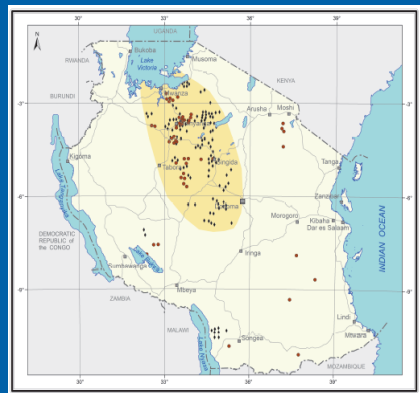
PGM



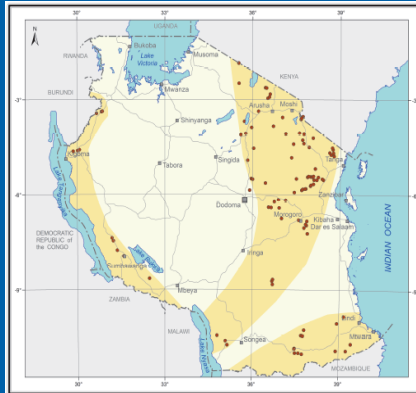
REE



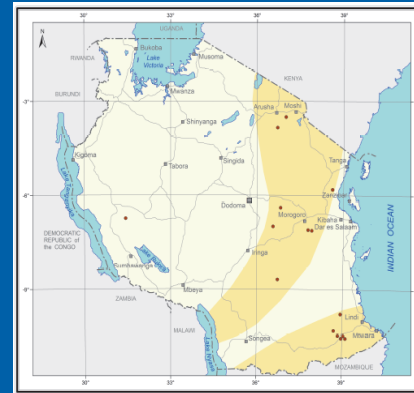
Diamond



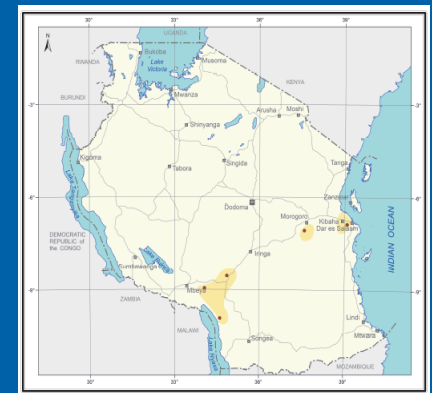
Gemstones



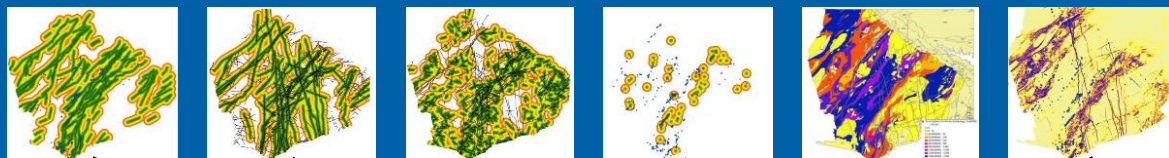
Graphite



Kaolin



Artificial Intelligence helps with Data Processing

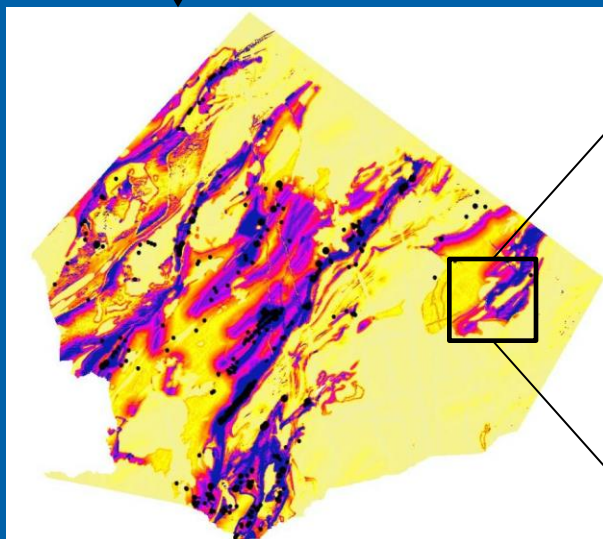


Input Data

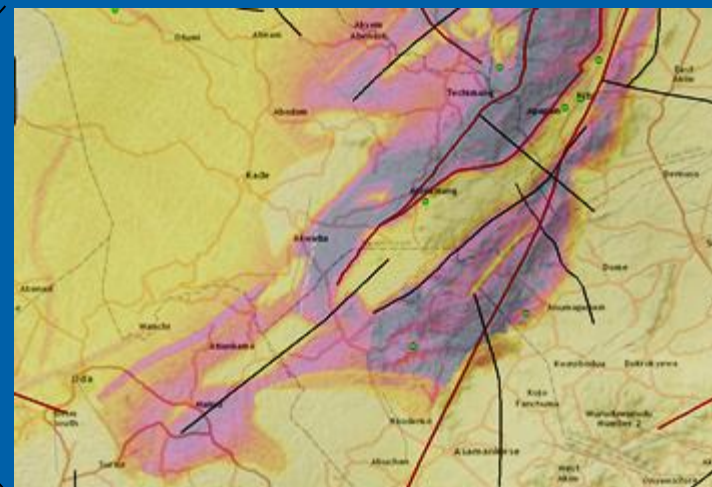
- Large faults
- Striking direction
- Junctions
- Small faults
- Geology
- Airborne magnetics

Gold Potential Map of SW-Ghana

Gold Potential in Hard Rocks

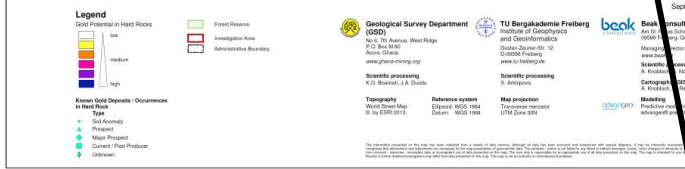
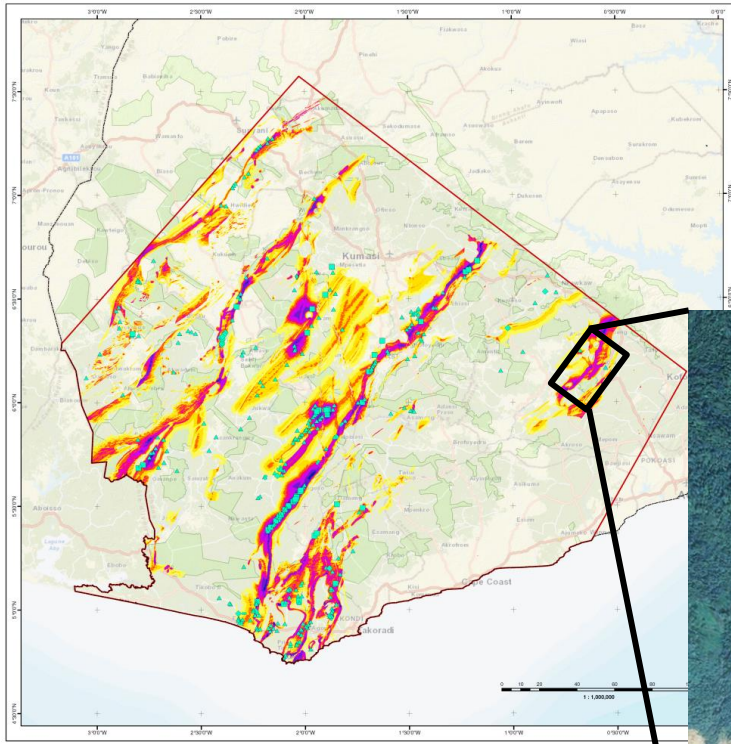


Detail Map: Kibi Belt Area



Example: High Resolution Mineral Potential Map

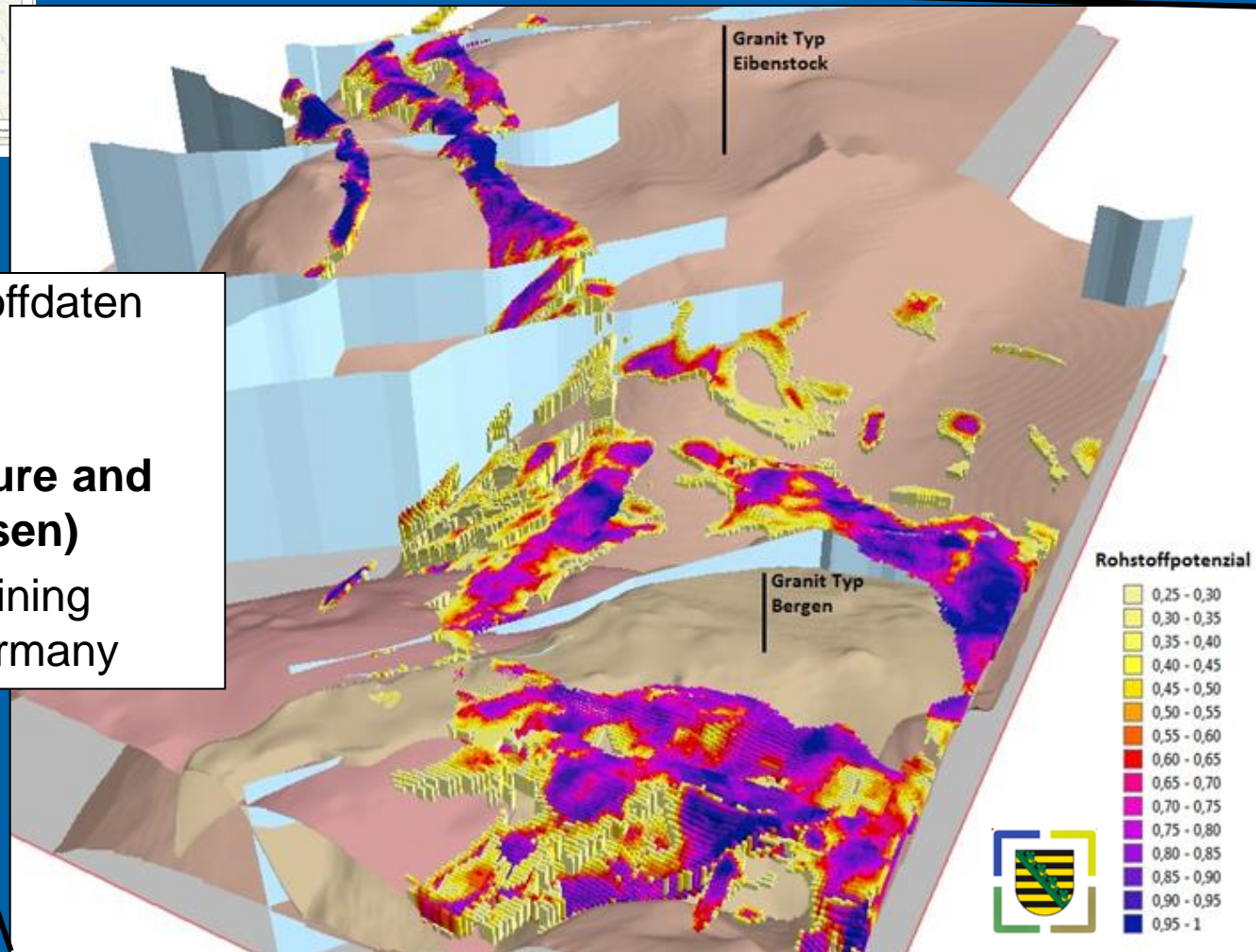
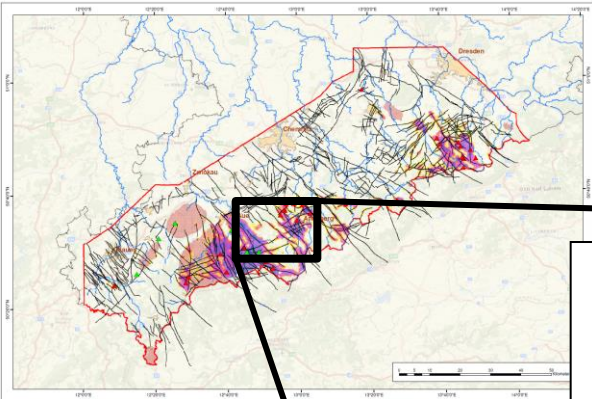
GOLD POTENTIAL MAP OF SW - GHANA
Hard Rock Gold Mineralisations
Scale 1 : 1,000,000



- Exploration targeting
- Protect undiscovered resources
- Land use planning:
 - Housing, Infrastructure
 - Water
 - Agriculture



Example: 3D Mineral Potential Models

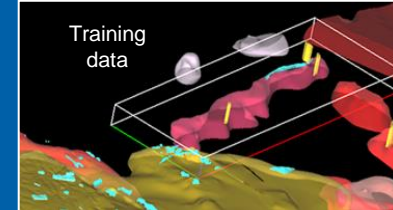
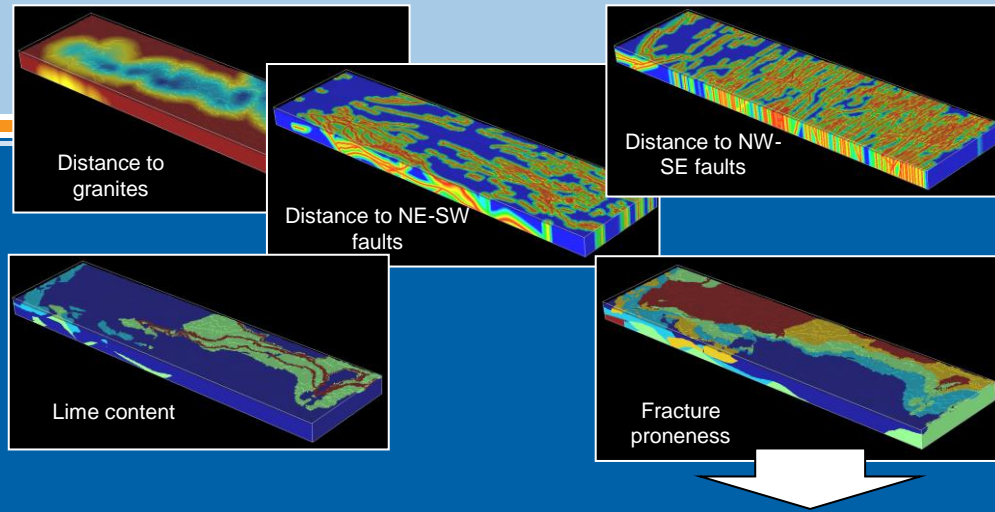


Project **ROHSA** (Rohstoffdaten Sachsen)

Saxon State Office for Environment, Agriculture and Geology (LfULG Sachsen)

Aim: Rehabilitation of Mining Activities in Saxony/ Germany

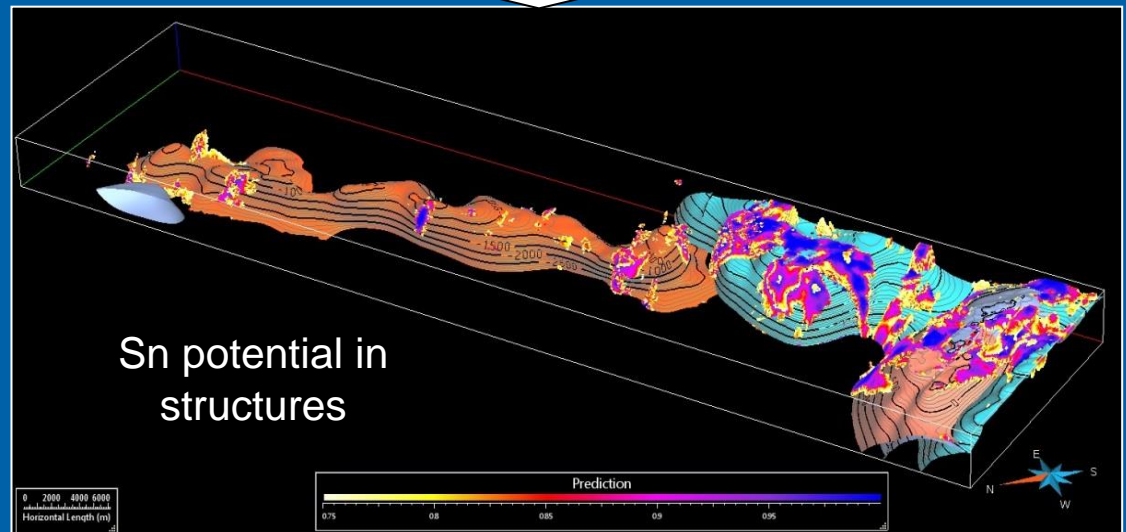
Sn potential above concealed intrusives



3D advangeo®
Prediction Software

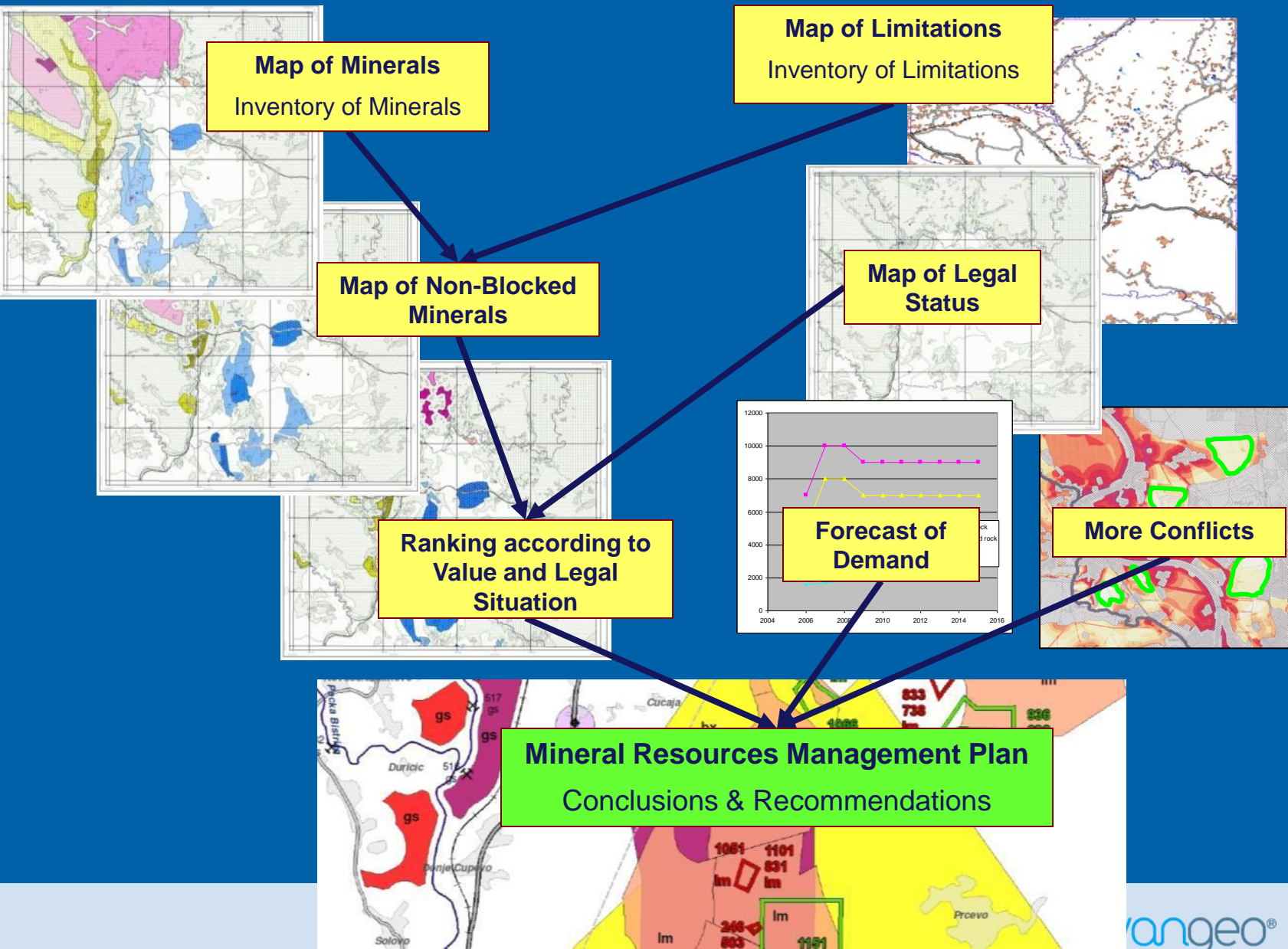
Consideration of real 3D properties derived from the geological model.

Sn skarn and Sn vein potential modelled by using ANN.



Base Data provided by Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie

Example: Governmental Maps - Identification of Mineable Resources



Governmental Maps guide Exploration and Exploitation

Kosovo Mineral Resources Management Plan

Scale 1 : 50,000

Rahovec / Orahovac NW

K 34-54 A

Legend

Mining Protection Zones

- Priority mining area
- Reserved mining area
- Additional resource area
- Prospective area
- Mining protection zone commodity

Nature Protection Zones

- Nature park protection zone
- Nature reservation protection zone
- Nature monument protection zone
- Nature monument heritage
- Nature monument heritage

Water Protection Zones

- Water protection zone
- Spring, mineral and thermal water

Historical Monuments Protection Zones

- Historical monument and main made natural heritage
- Historical monument and main made natural heritage

Mining Related Geohazards

- Objects > 10,000 m³
 - Tailing
 - Mining work / waste dump
 - Open pit
 - Underground mining work
 - Medical mining work
 - Plant / metallurgical facility
- Objects < 10,000 m³
 - Mining work / waste dump
 - Underground mining work
 - Medical mining work

Geology (simplified)

- Quaternary sediments
- Paleogene - Neogene sedimentary rocks
- Paleogene - Neogene magmatic rocks
- Mesozoic sedimentary rocks and minorly metamorphic rocks
- Mesozoic magmatic rocks
- Permian - Triassic sedimentary rocks and metamorphic rocks
- Permian - Triassic magmatic rocks
- Paleozoic metamorphic rocks
- Paleozoic magmatic rocks
- Paleozoic metamorphic rocks

Kosovo Quarry Plan (KQP)

- Border of working area of KQP

The spatial distribution and boundaries of the Mining Protection Zones of construction materials are based on the delineated construction material types and their locations from the Kosovo Quarry Plan (KQP) 1:50,000 by IGMR (2005).

This information was prepared by the authors based on the best available data and information. Although all data have been carefully checked, the authors do not accept any liability for errors or omissions. The authors do not accept any liability for errors or omissions. The authors do not accept any liability for errors or omissions. The authors do not accept any liability for errors or omissions.

Licences

- (data captured until 28.07.2009)
 - Exploration licence, current
 - Exploration licence, approved by Board
 - Region: no No. Licence No. Commodity
 - Exploration licence, current
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Exploitation Sites

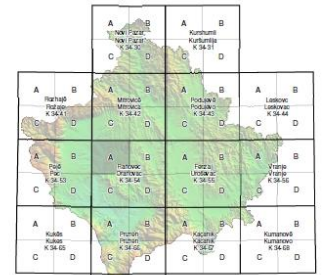
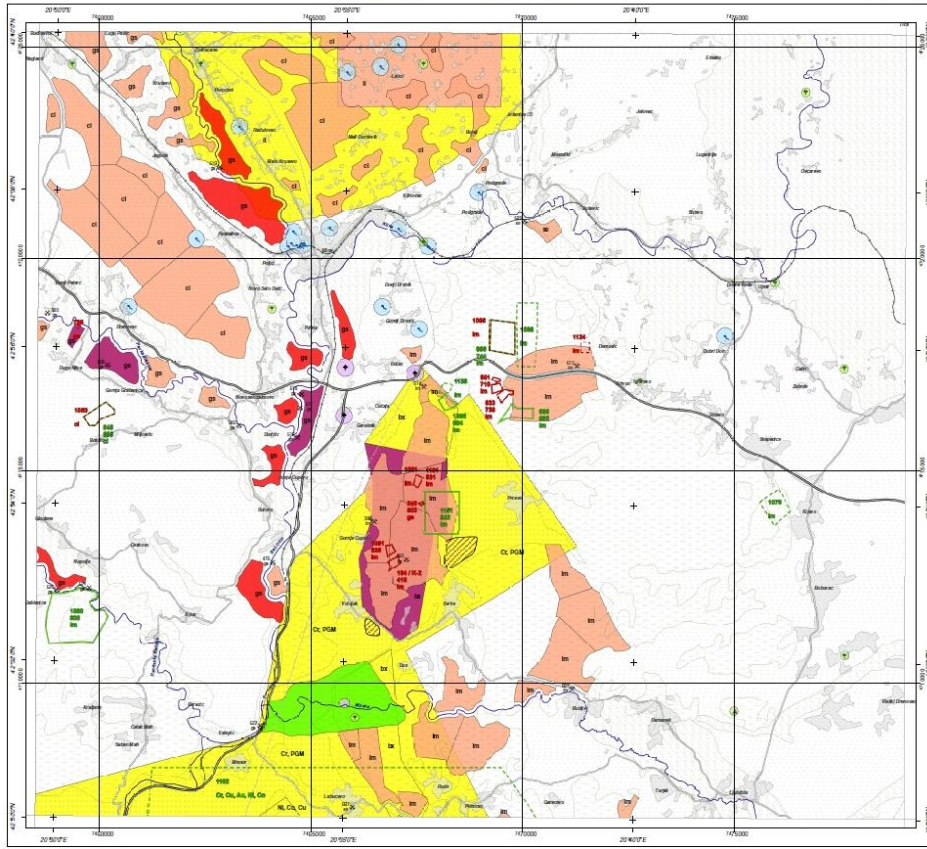
- (data captured until 28.07.2009)
 - Mining active
 - Exploitation site number, commodity
 - Mining inactive
 - Exploitation site number, commodity

Commodity

- Carbonate hard rock: do (dolomite), in (limestone), ma (marble)
- Ceramic and refractory minerals: as (alabaster), br (bariumite), bk (barite), kb (kaolinite), mg (magnesium)
- Chemical minerals: or (quartz)
- Ferrous metals: Cu, Co, Fe, Mn, Ni, Pb
- Light metals: Al (aluminum), Ga (gallium) and Zn (zinc)
- Non-ferrous metals: Cu, Pb, Sn, Zn
- Phosphorus metals: Ag, Au, PGM
- Rare metals: As, Hg, Sb
- Silicate hard rock (sandstone), or (sandstone), ch (chert), da (dolomite), di (diatomite), do (dolomite), ga (gallium), in (limestone), ka (kaolinite), kb (kaolinite), mg (magnesium), ni (nickel), or (quartzite), pa (perlite), pe (pyrite), ps (pyroxene), sh (shale), sk (skarn), st (staurolite), ta (tantalum), te (tellurium), ti (titanium), ur (uranium), va (vanadium), vb (vanadinite), vt (vermiculite), w (wolframite), zn (zinc)

Topography

- Construction area (city, village, etc.)
- Water reservoir
- Administrative border
- River
- Main road
- Regional road
- Highway, planned
- Railway
- Power line (cables above 10kV)
- Pipeline
- Public building or facility
- Antenna tower



Kosovo Mineral Resources Management Plan

Scale 1 : 50,000

Rahovec / Orahovac NW - K 34-54 A

December 2009

Independence Commission for Mines and Minerals
Komisioni i Pavarur për Miniera dhe Minera
Nezavisna Komisija za Rudnike i Minirak

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Geology (Simplified)
Based on: Canada
Geological Survey
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Map projection
Reference system
ESPAK UTM
Datum: ETRS 1989

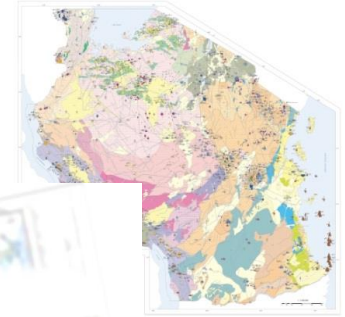
Conclusions

- Mining Sector development & investment attraction need a knowledge base
- IMS are living systems
- IMS are a national task
- Data availability is the key
- Value added products help with decision making & investment attraction
- Governmental maps shall guide mining sector development

GEOLOGICAL SURVEY OF TANZANIA



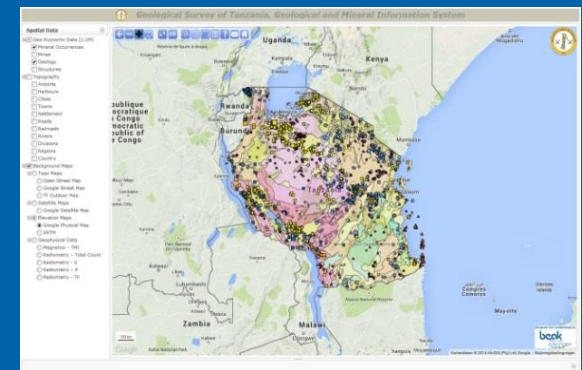
EXPLANATORY NOTES FOR THE
MINEROGENIC MAP OF TANZANIA



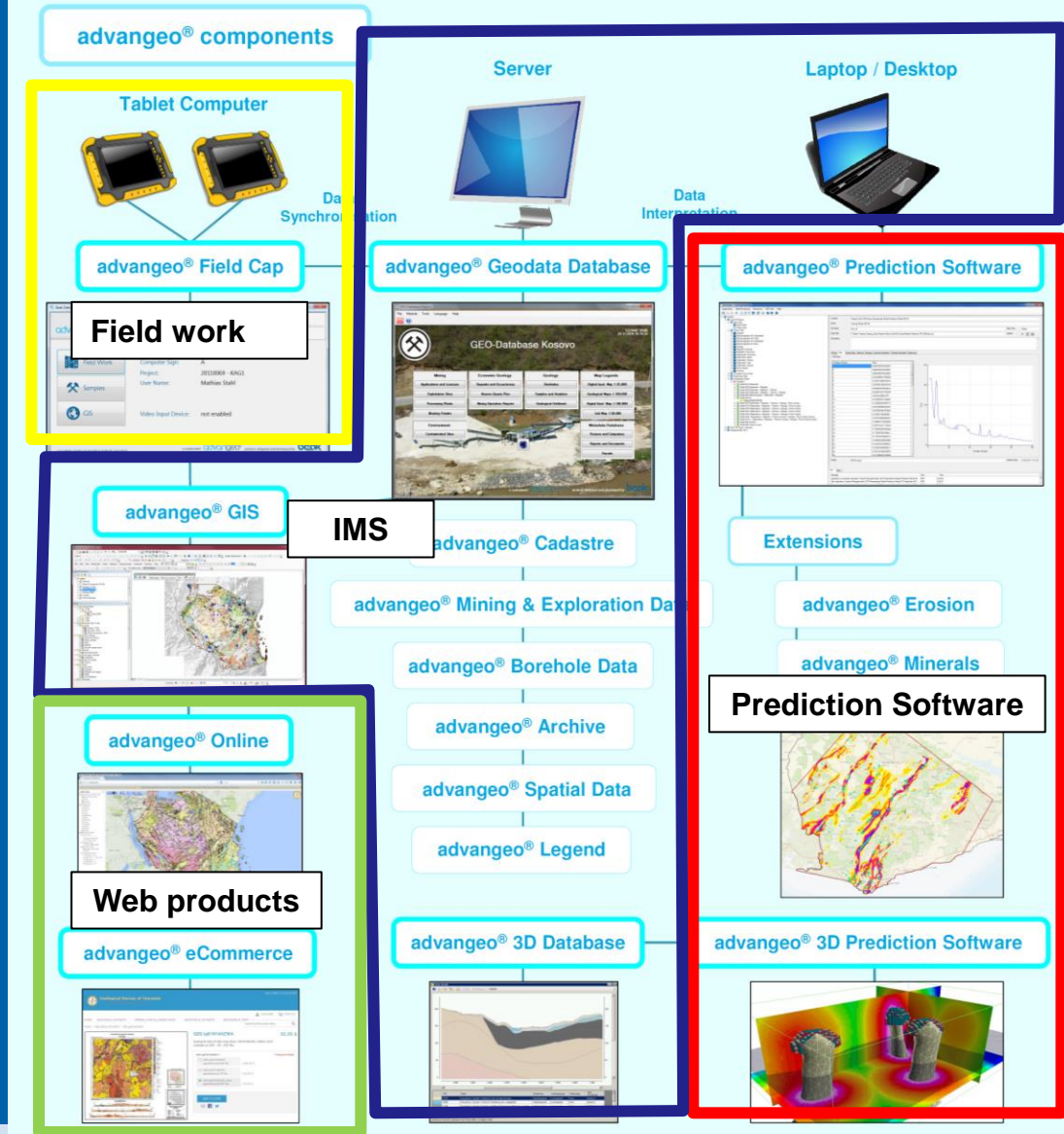
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Thank You !

We thank our colleagues and partners from:

Geological Survey of Tanzania

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Geological Survey of Namibia

Minirena, Rwanda

Department of Geological Survey and Mines, Uganda

Independent Commission for Mines and Minerals, Kosovo

Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie



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