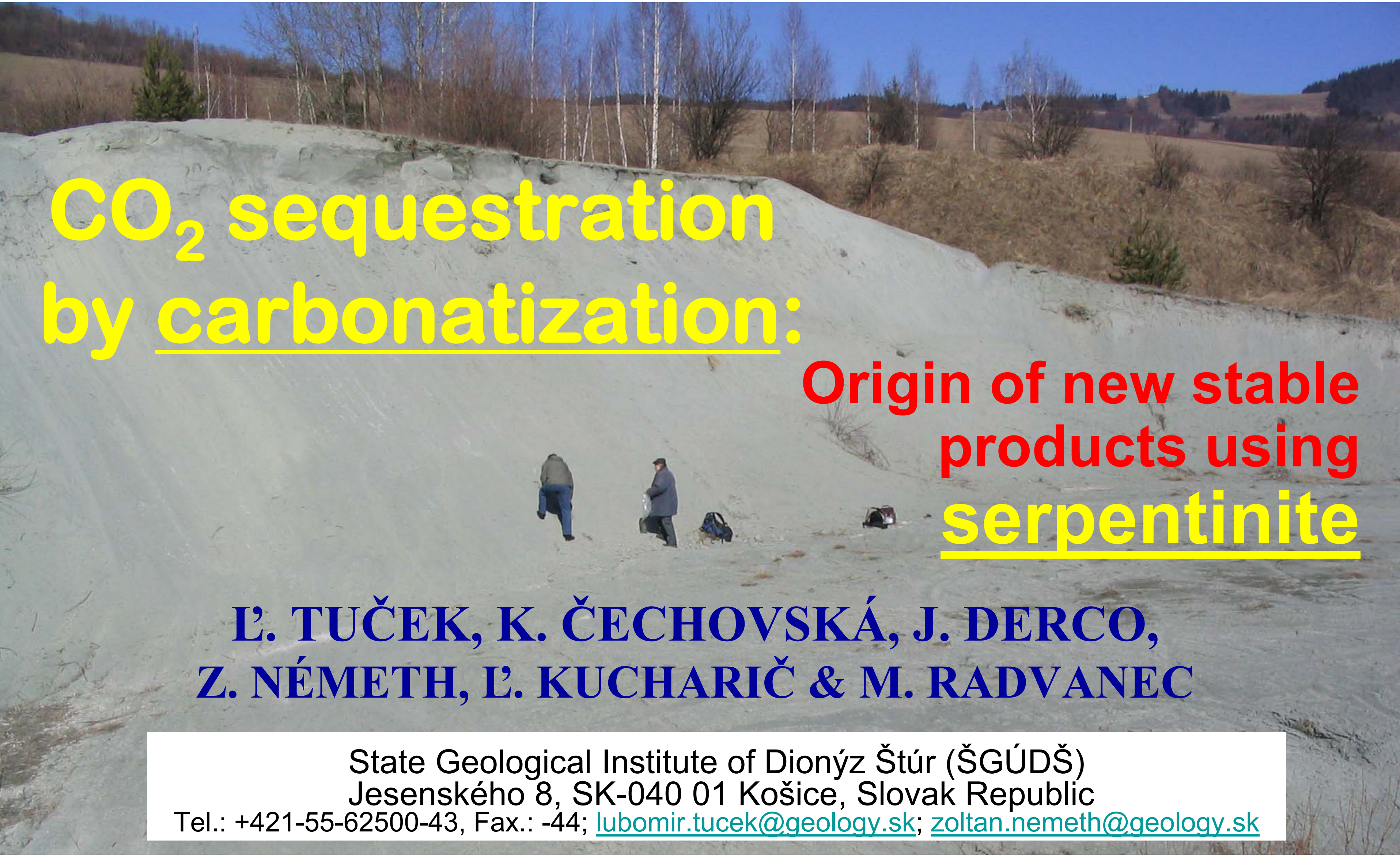

CO_2 sequestration by carbonatization:

Origin of new stable products using serpentinite

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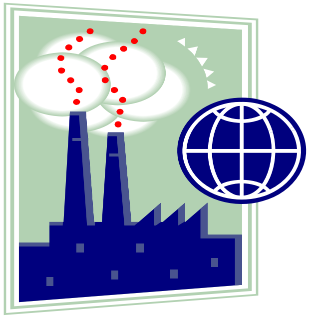
Mineral sequestration

1. Theory

QUALITY of ATMOSPHERE – GRADUAL DETERIORATION

by extensive **release of CO_2** into atmosphere



Main producers of CO_2 in Slovakia (183 producers; limits for 2008 41.261 mil. t.)**:**

1. **Electrical and heating industries**
   (e.g. electrical plant in Eastern Slovakia 5.36 mil. t. in 2008)
2. **Metallurgical industry and steelworks**
   (11.4 mil. t. in 2008)
3. **Industry where the carbonate-bearing raw material is decomposed by heat (limekilns, magnesite dressing plants, cement factories)**
4. **Traffic (mainly automobile transport)**
   (2.45 mil. t. in 2008 - production of petrol)
5. **Combustion of waste**

Definition of CO_2 sequestration :

1. catching
2. deposition
3. storing

} **CARBON DIOXIDE**

CO_2 sequestration:

- **physical method (e.g. geological storing)**
- **biological method (e.g. reforestation)**
- **chemical method (e.g. mineral sequestration)**

Catching of CO_2 = its removal

- from combustion gas
- from technological gas or atmosphere

Obtaining of high purity CO_2 (above 98 %), which can be:

- used
- converted
- stored

Separation of CO_2 from:

- nitrogen oxides (NO_x)
- sulphur oxides (SO_x)
- carbon oxide (CO)
- oxygen (O_2)
- water vapour (H_2O)
- other gass compounds (methane, hydrosulphide)
- solid particles

can be done by numerous methods and ways

CO_2 sequestration by carbonatization - safe method of liquidation of industrial CO_2

Simplified principle of carbonatization - exothermic reaction:

$$CaO + CO_2 = CaCO_3 + 179\ \text{kJ/mol}$$

$$MgO + CO_2 = MgCO_3 + 118\ \text{kJ/mol}$$

Final result of reactions →

solid and stable products - carbonates

Mineral carbonatization:

- direct method (single-phase method)
- indirect method (two-phase method)

Direct method:

Reacting mineral components directly enter into the reaction with CO_2

Indirect method:

mineral (reacting) components are extracted from mineral matrix and consequently react with CO_2

Natural conditions –

mineral carbonatization (especially direct) represents

very slow process

To **accelerate reactions:**

- inevitable technological **optimalization of all factors**, influencing the reaction kinetics

Modification of entering mineral compounds –

- grain-size,
- thermic,
- chemical,
- physical–mechanical or their combination.

General factors, influencing to reaction rate and forming of final products:

- mineral and chemical composition of entering rocks (activity of their components, purity of gass regarding CO_2)
- state of entering components, their mutual ratio
- temperature (T)
- pressure (p) CO_2
- reaction time – time of mutual activity of phases with CO_2
- grain-size, porosity and activity of specific surface of material
- modification of entering components (chemical, thermic, ...)
- reaction conditions – static or dynamic
- pH of reaction environment
- type of additives, reagents,...
- density, resp. viscosity of reacting suspension

Advantages of mineral sequestration of CO_2:

- CO_2 is firmly tied on qualitatively new and stable products
- Prepared products - carbonates are safe for environment
- Reactions with CO_2 resulting in carbonate origin are exothermic
- Liquidation (change) on final products occurs in relatively short time

  (1 hour till 2 days)
- Carbonates can be deposited and stored unlimitedly long time
- Finances for expensive monitoring are saved
- Waste (CO_2) reacts with other (harmful) waste (e.g. serpentinite) and useful matter originates (protection of environment)
- New mineral compounds can be used in various industrial branches (anorganic filling agents – plastics, colours, ...)

Mineral sequestration

2. Results of experiments

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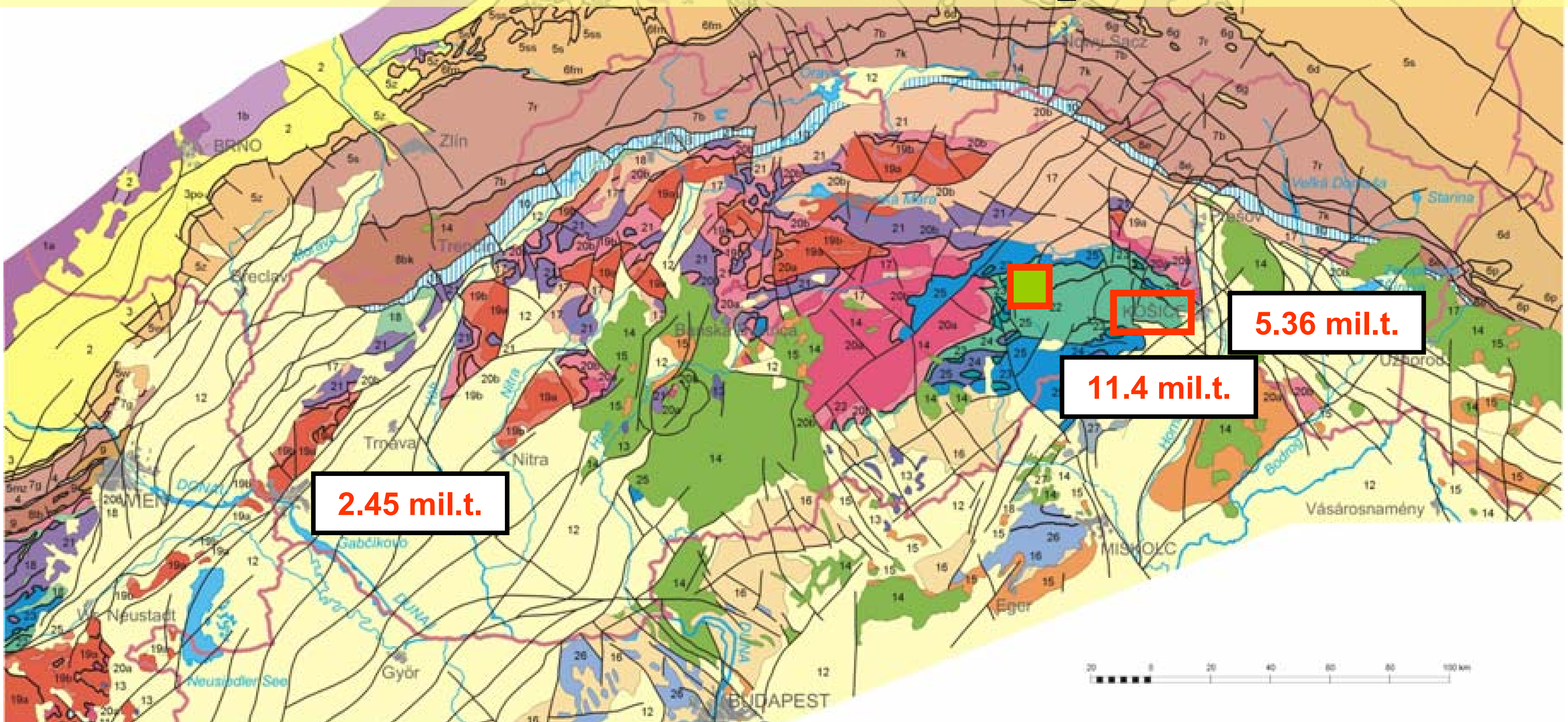
Research in ŠGÚDŠ Bratislava is based on the project "Quantitative parameters of selected geological structures appropriate for CO_2 storage"



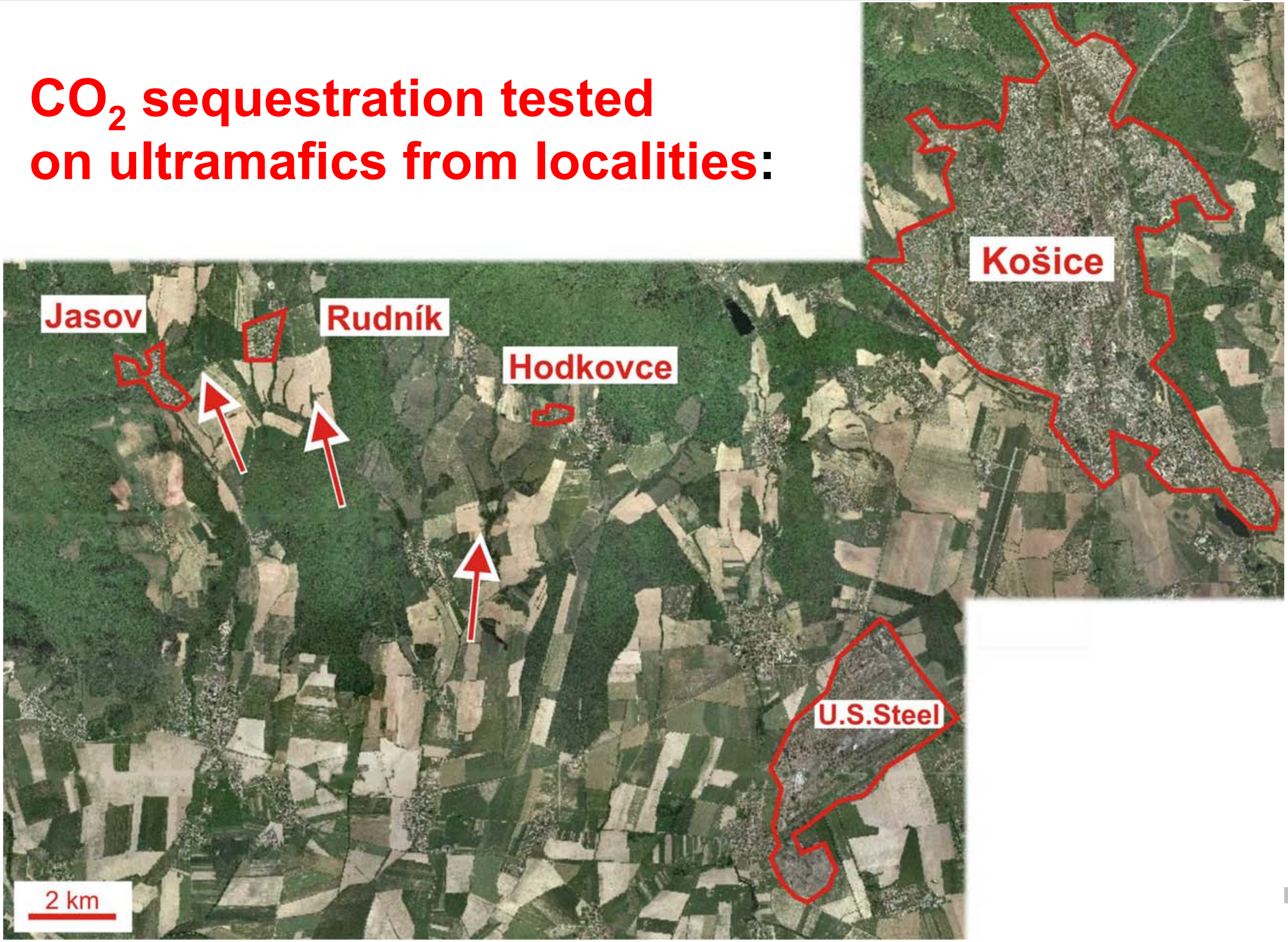
The **CO_2 sequestration** by carbonatization at certain p-T conditions:

$$Mg_3Si_2O_5(OH)_4 + 3CO_2 = \mathbf{3MgCO_3} + 2SiO_2 + 2H_2O$$

minerals of serpentine group (mainly chrysotile) + CO_2

=> nesquehonite, hydromagnesite => **magnesite**

CO_2 sequestration tested on ultramafics from localities:




Jasov
100m


Rudník
150m


Hodkovce
Novačany
200m

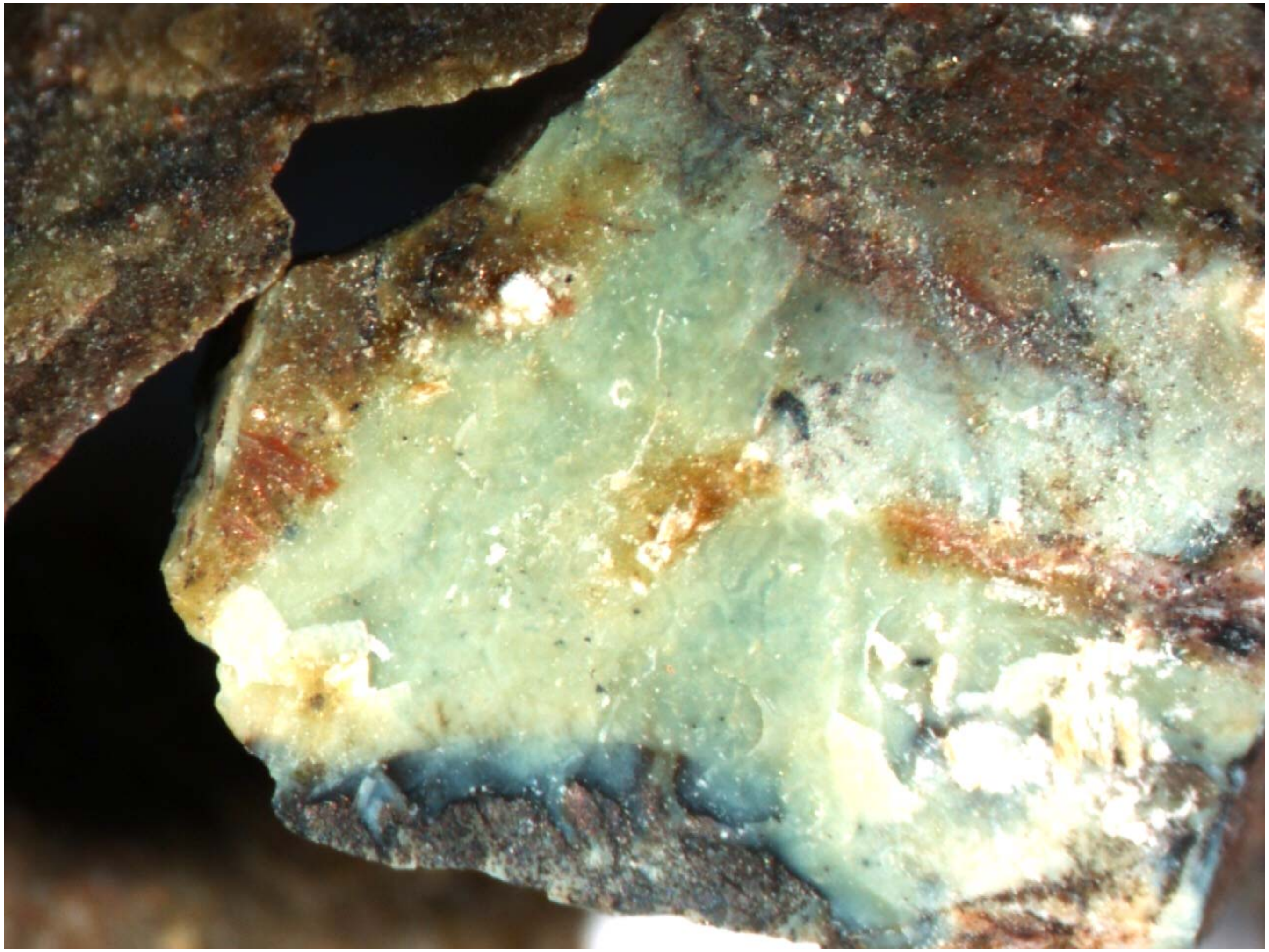
Pretreatment of samples: drying, refining, homogenization, quartering and sorting

Homogeneous parts of samples:
X-ray diffraction analyses, chemical analyses, DTA-TGA, microprobe analyses

Hodkovce 2 – crushed stone (granularity beneath 1 mm)

Hodkovce 2 – detail of crushed stone beneath 1 mm

Hodkovce 2 – serpentinite fragment



Hodkovce 2 – crushed stone after thermal processing

Sample from locality HODKOVCE 2

Chemical composition:

SiO_2	= 40.01 %
Al_2O_3	= 0.77 %
Fe_2O_3	= 8.04 %
FeO	= 0.11 %
CaO	= 0.24 %
MgO	= 36.73 %
TiO_2	= 0.05 %
Cr_2O_3	= 0.334 %
MnO	= 0.07 %
Na_2O	= 0.01 %
K_2O	= 0.02 %
P_2O_5	= 0.01 %
Loss.ign.	= 13.44 %

Mineral composition:

Serpentine minerals	= 80.3 %
olivine + pyroxene	= 9.9 %
magnetite (maghemite)	= 8.9 %
calcite	= 0.4 %
chromite	= 0.5 %
Sum	=100.0 %

Pressure, temperature and time constraints of reactions aimed to formation of new solid mineral forms by means of rocks from studied locaties and gaseous CO_2:

Pressure CO_2	**= 0,1 - 0,3 MPa**
Temperature	**= 22 - 200 °C**
Reaction time	**= 5 - 20 hours**
Crystallization time	**= 4 - 24 hodín**

Results of reactions → products with solid chemical bounds of CO_2 on:

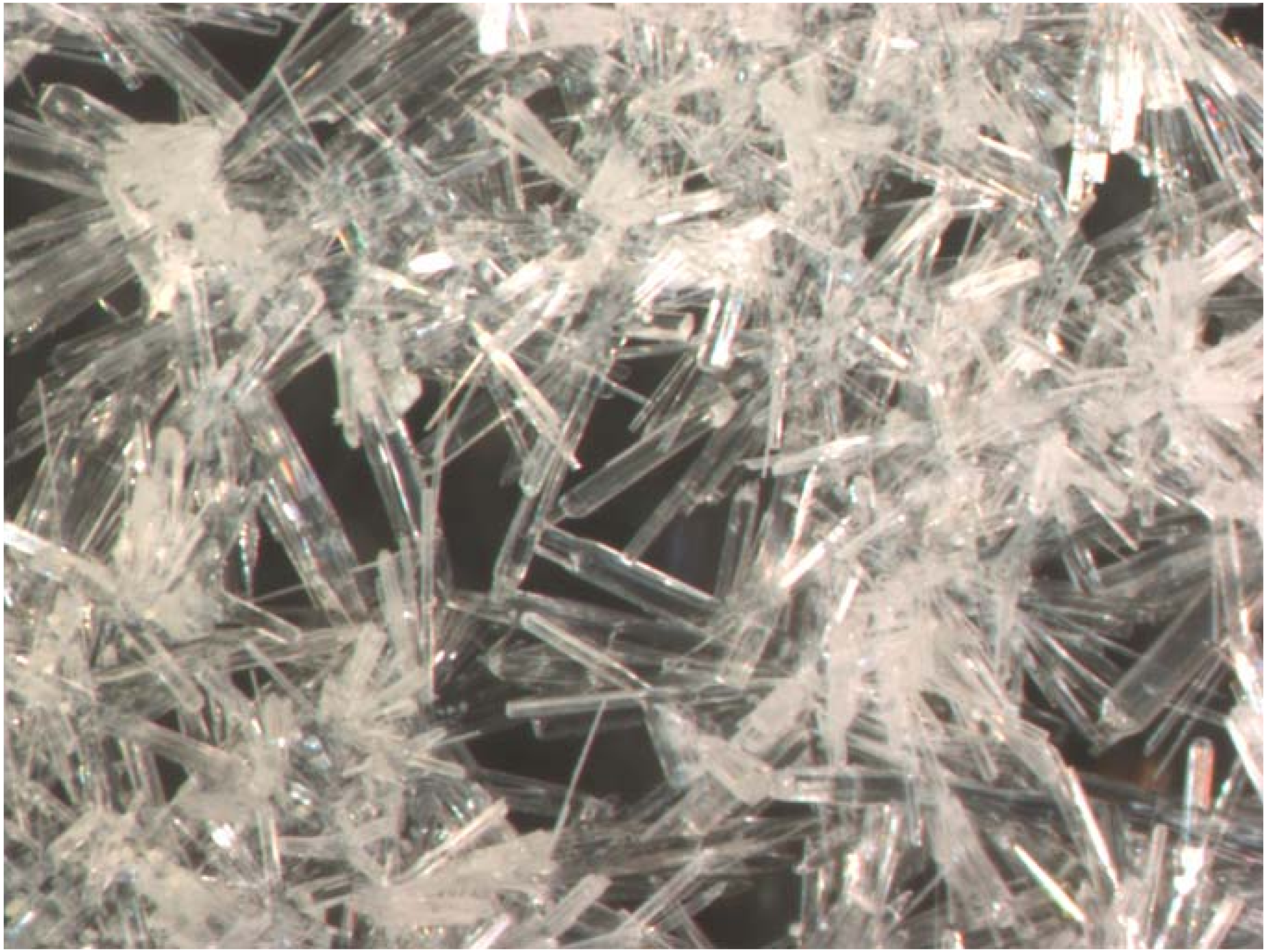
- ❑ solid, transitional phases:
  - ➢ amorphous phase of Mg – Si
  - ➢ amorphous phase of Si

- ❑ solid, new products:

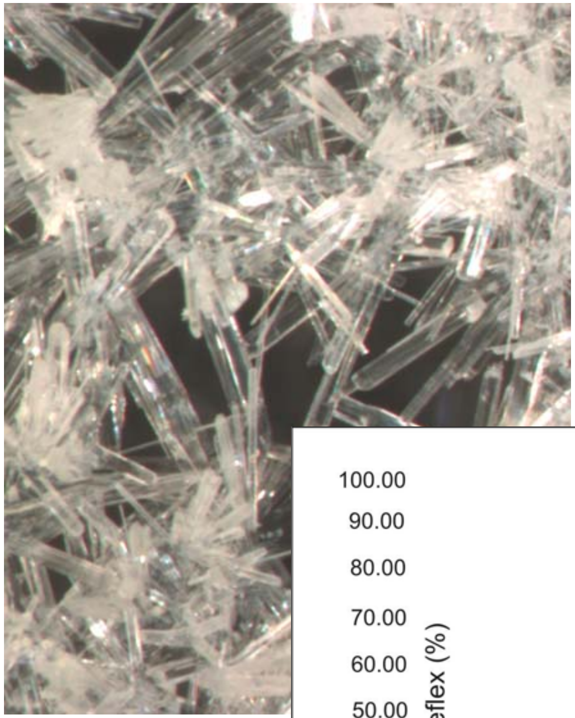
nesquehonite	- $Mg(HCO_3)(OH) \cdot 2H_2O$
hydromagnesite	- $Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$
barringtonite	- $MgCO_3 \cdot 2H_2O$
dypingite	- $Mg_5(CO_3)_4(OH)_2 \cdot 5H_2O$

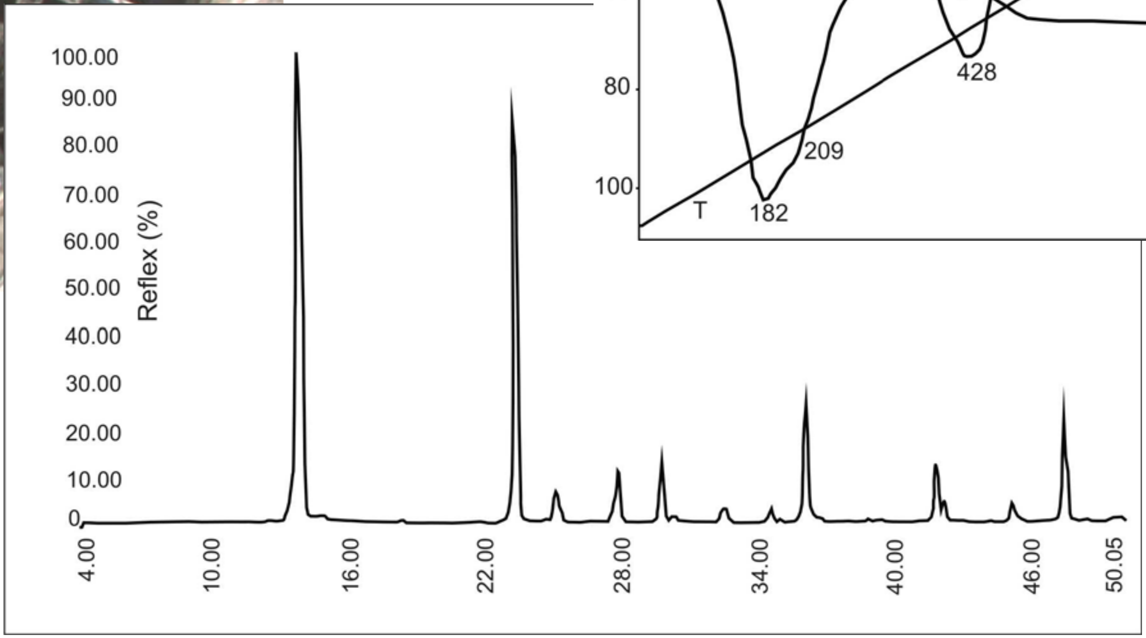
Hodkovce 2 - nesquehonite

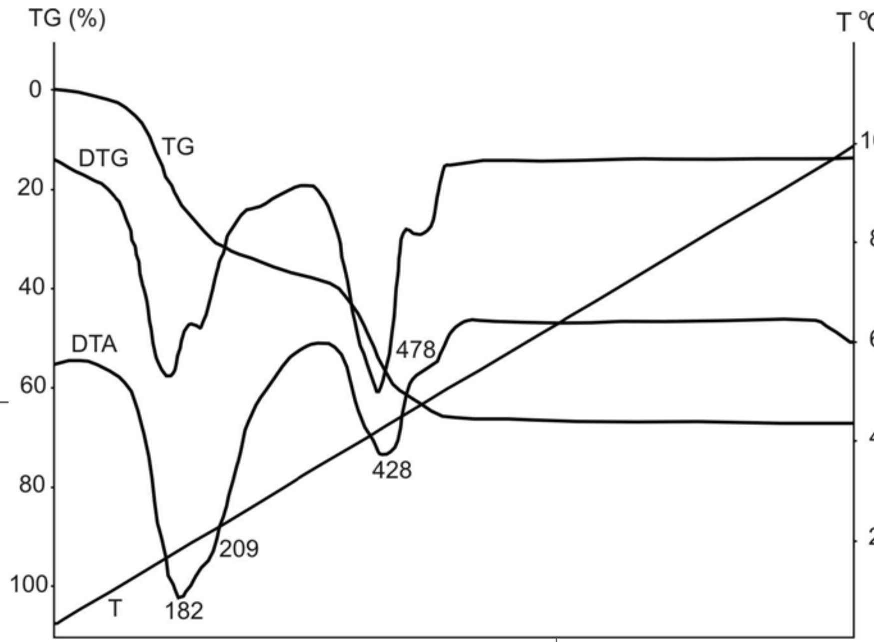
Hodkovce 2 – magnified detail of nesquehonite



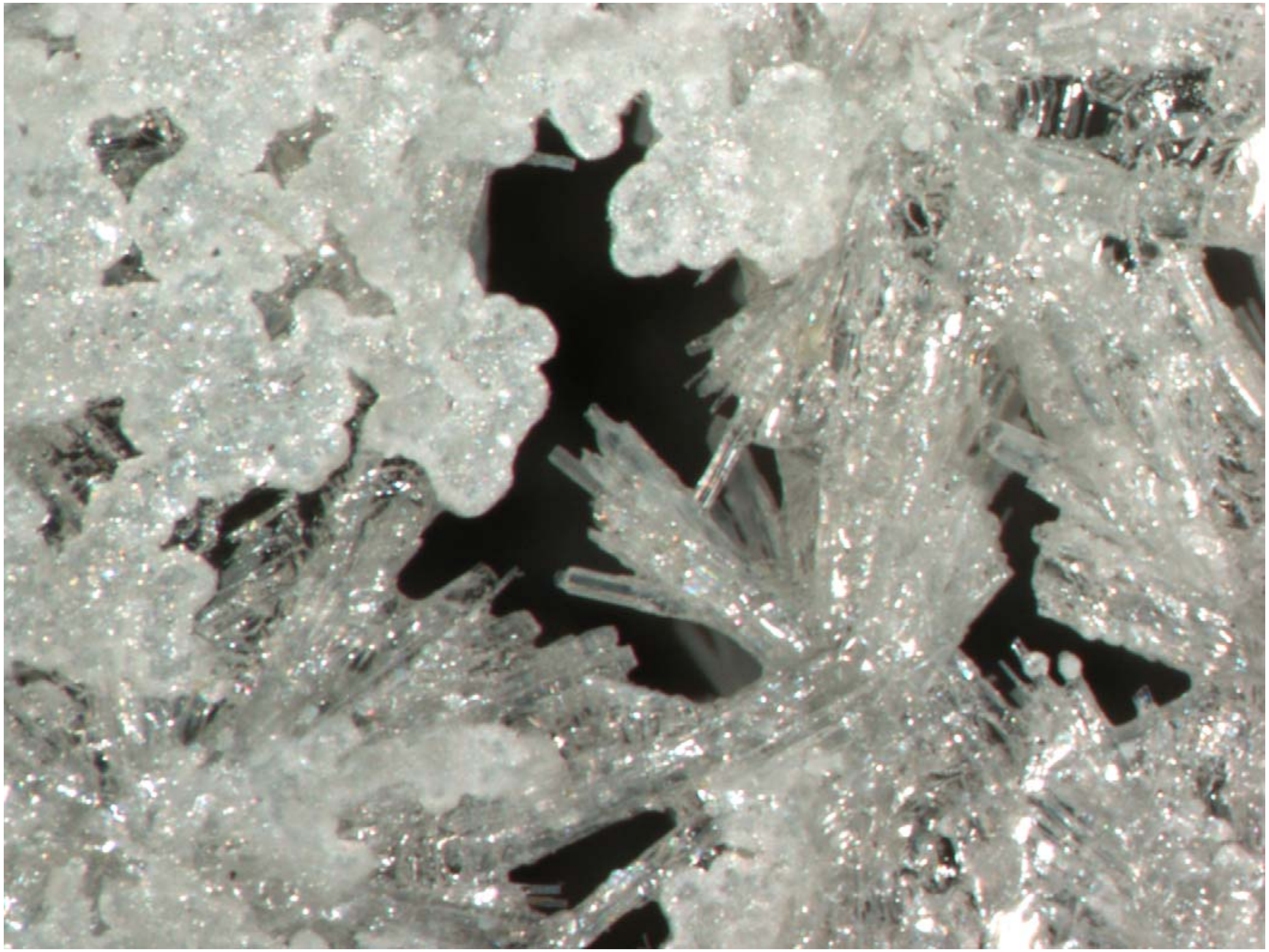
Hodkovce 2 – magnified detail of nesquehonite





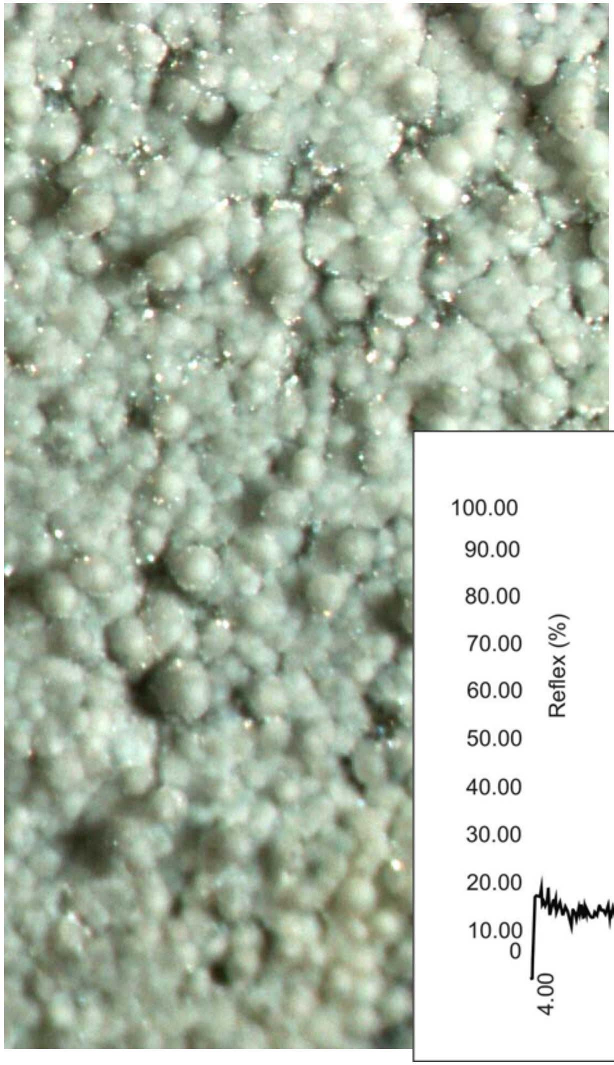


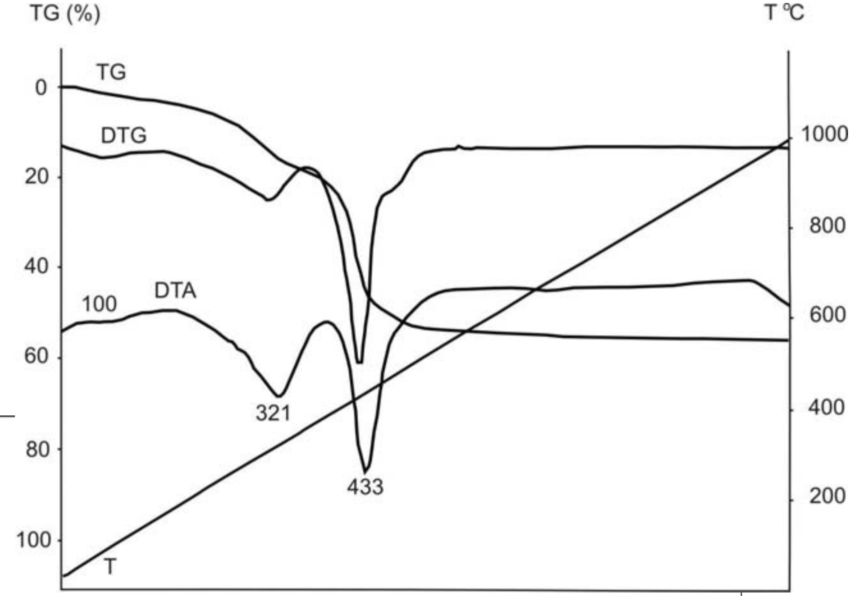
Hodkovce 2 – detail of nesquehonite + hydromagnesite

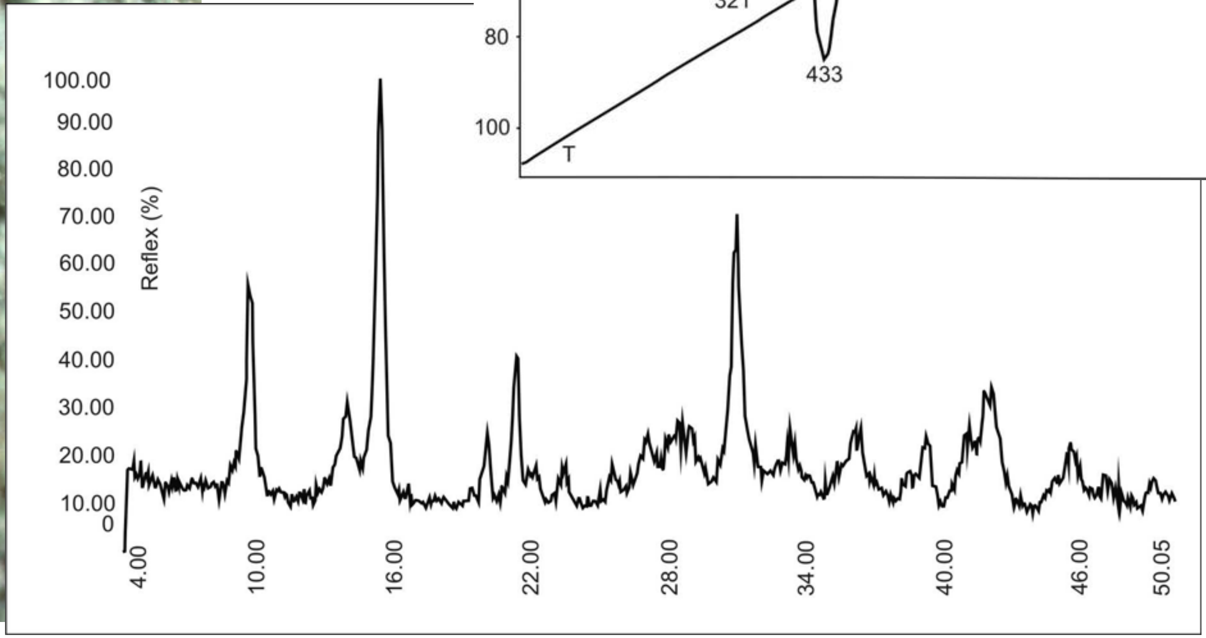


Hodkovce 2 - hydromagnesite

Hodkovce 2 - hydromagnesite





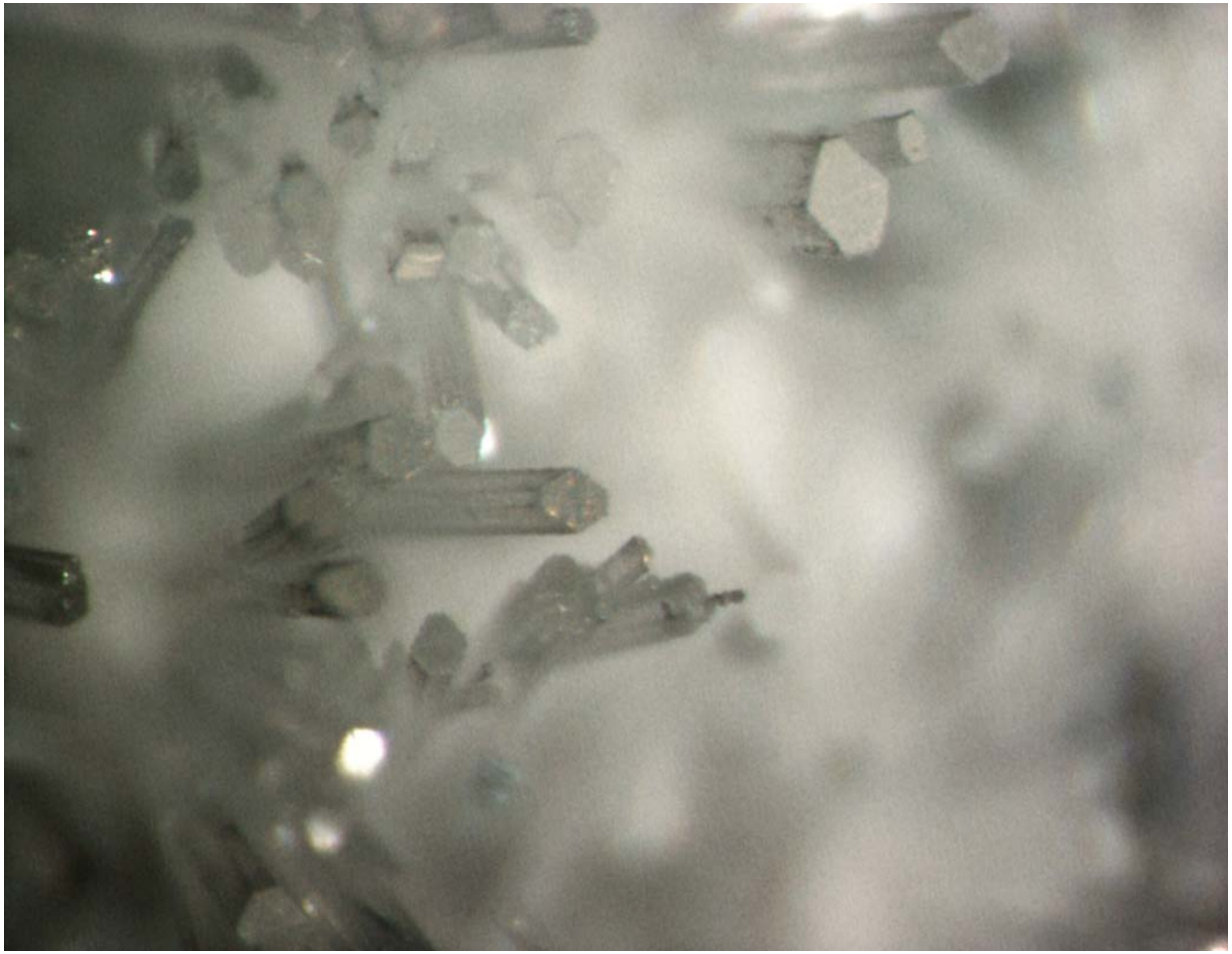


Jasov 1 - nesquehonite

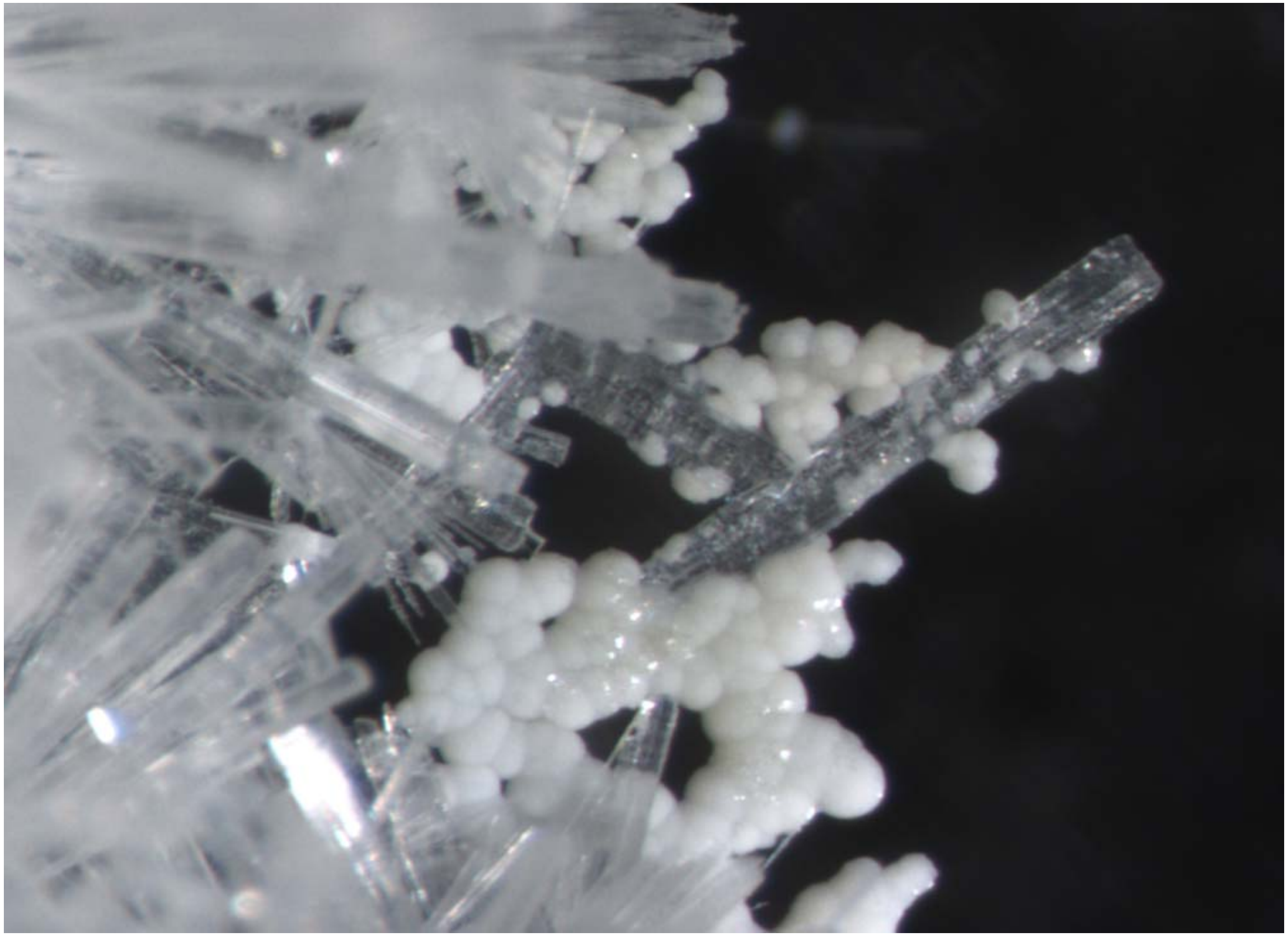
Jasov 1 – detail of nesquehonite

Rudník 2 – detail of nesquehonite

Rudník 2 – detail of nesquehonite

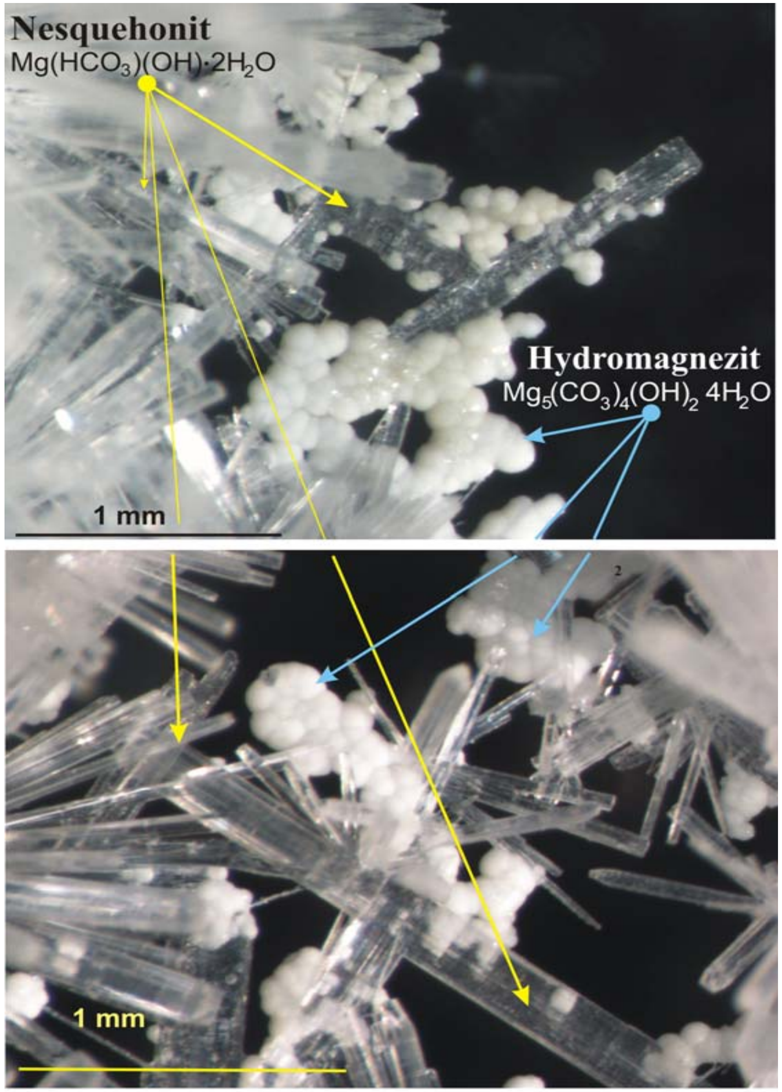


Rudník 2 – detail of nesquehonite + hydromagnesite



Komárovce 1-11 - nesquehonite

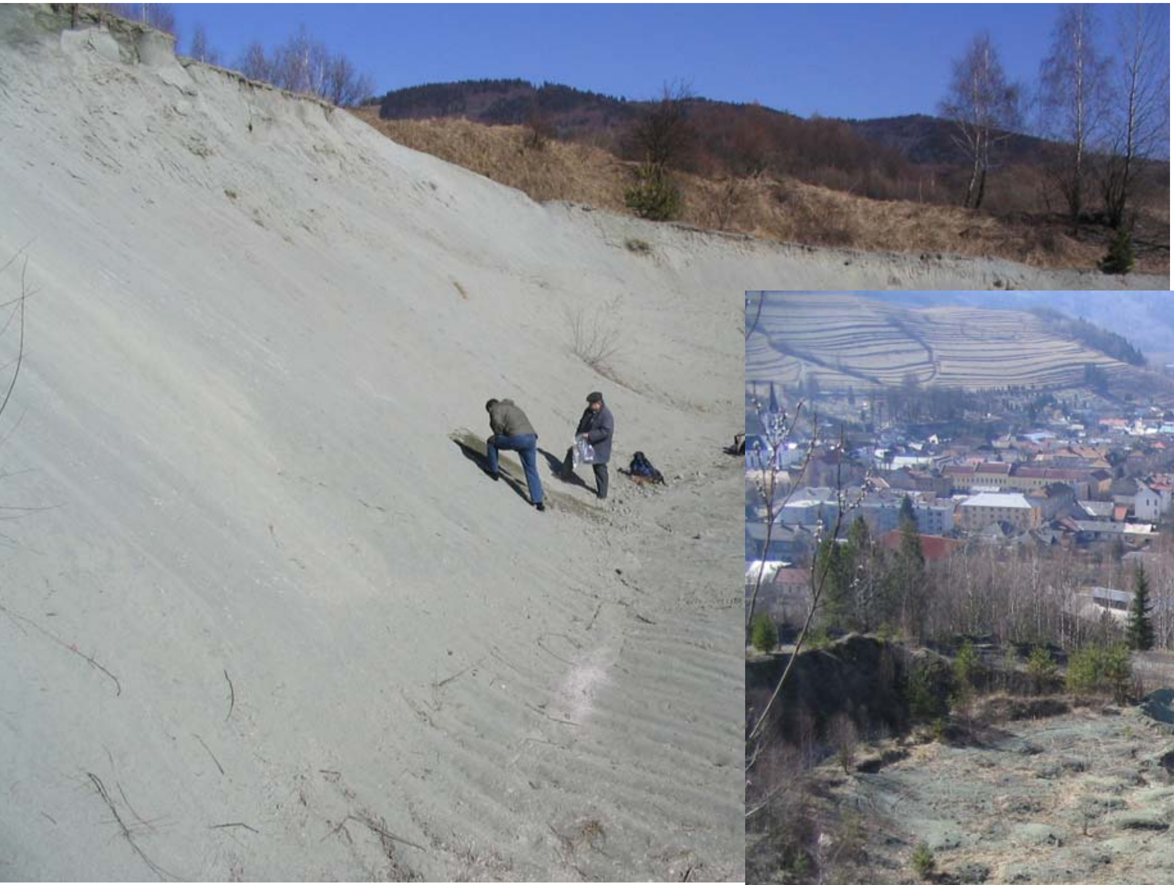
Komárovce 1-11 - detail of nesquehonite



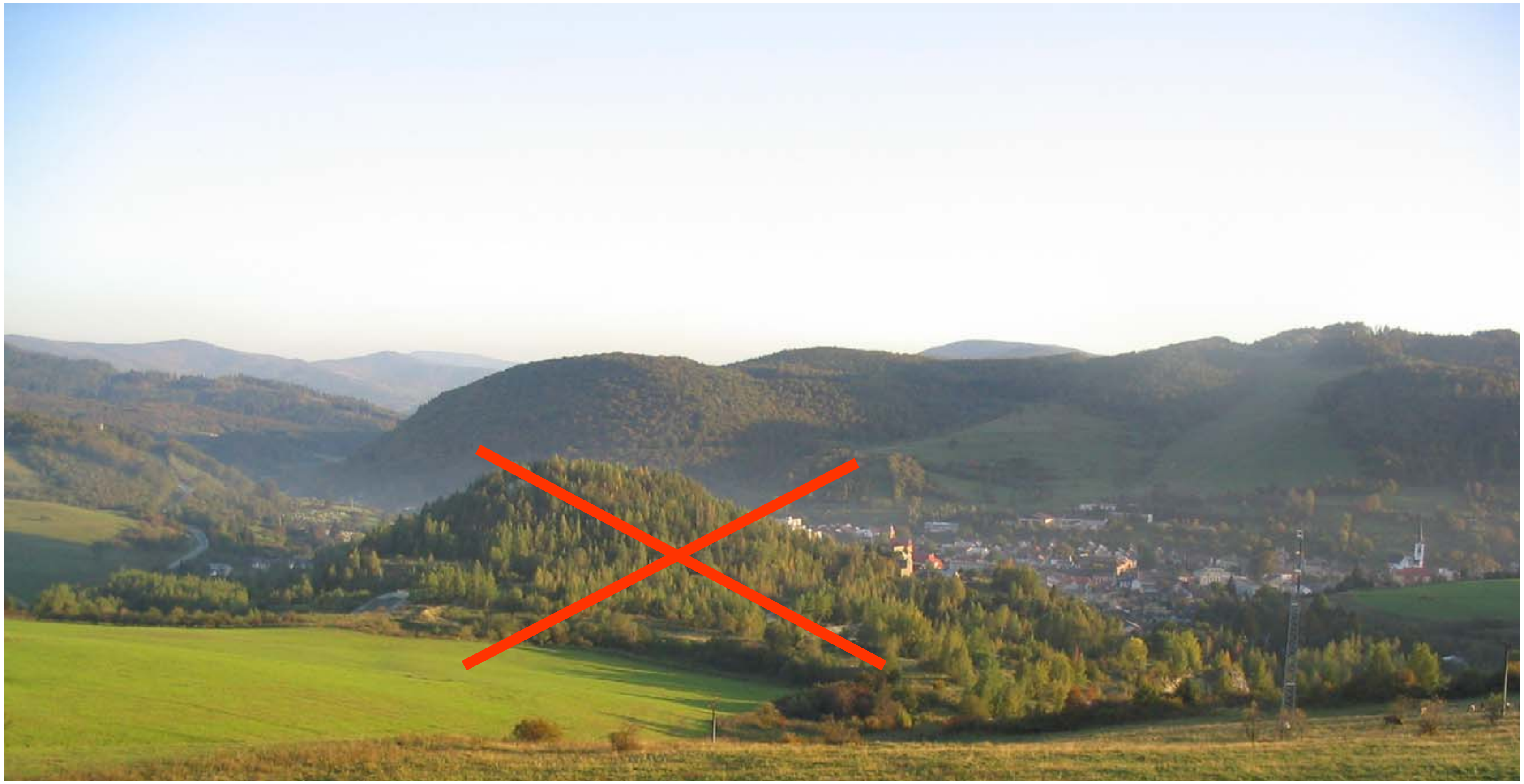
Nesquehonit a **hydromagnezit**, synteticky pripravené minerály pôsobením CO na serpentinit z lokality Rudnik. Vzorka RU - 2 - C.

Rudník 2 – nesquehonite and hydromagnesite

Dobšiná – former exploitation of chrysotile asbestos from ultramafics



Dobšiná – CO_2 sequestration => removal of environmental load



ŠGÚDŠ - ATNS Applied Technology of Industrial Minerals

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May the workshop CO_2 Capture and Storage starts **new and vivid collaboration of scientists leading to final goal – protecting the Earth against climate changes**