Clay minerals and industrial minerals – characterisation and use

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Clay minerals as indicator of geological processes

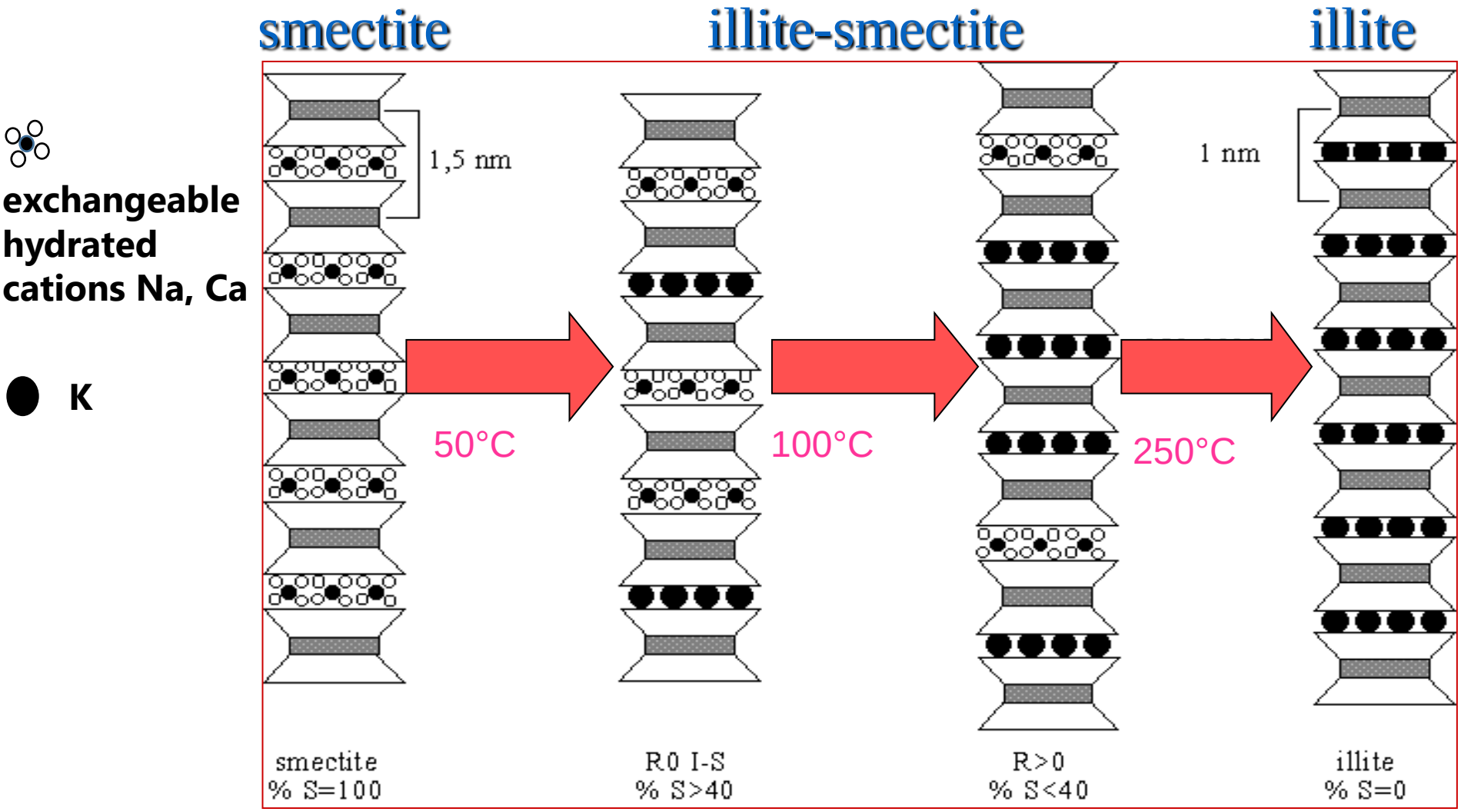
Paleotempeture

Paleoenvironment

Paleoclimate

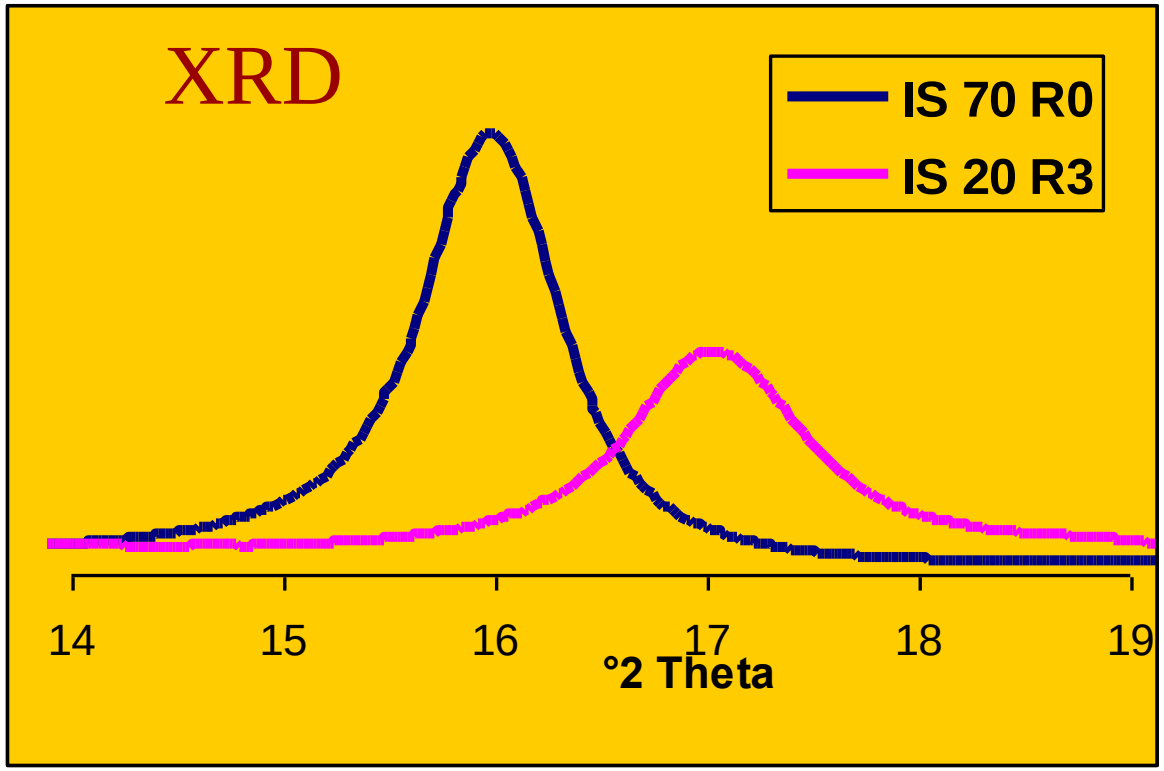
Paleohistory

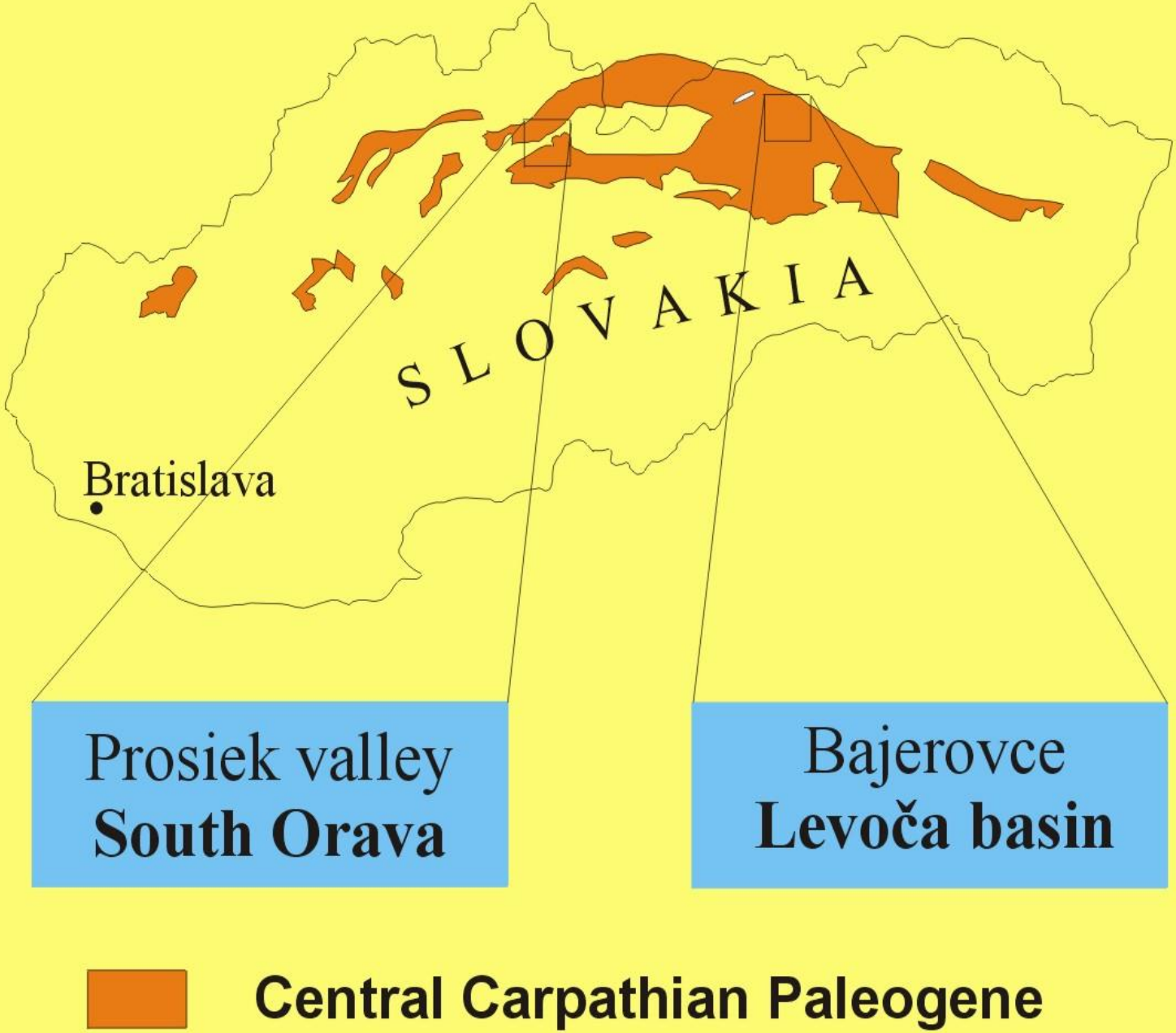
Transformation smectite to illite Paleothermometer (diagenesis – very low metamorphism; hydrothermal alteration)



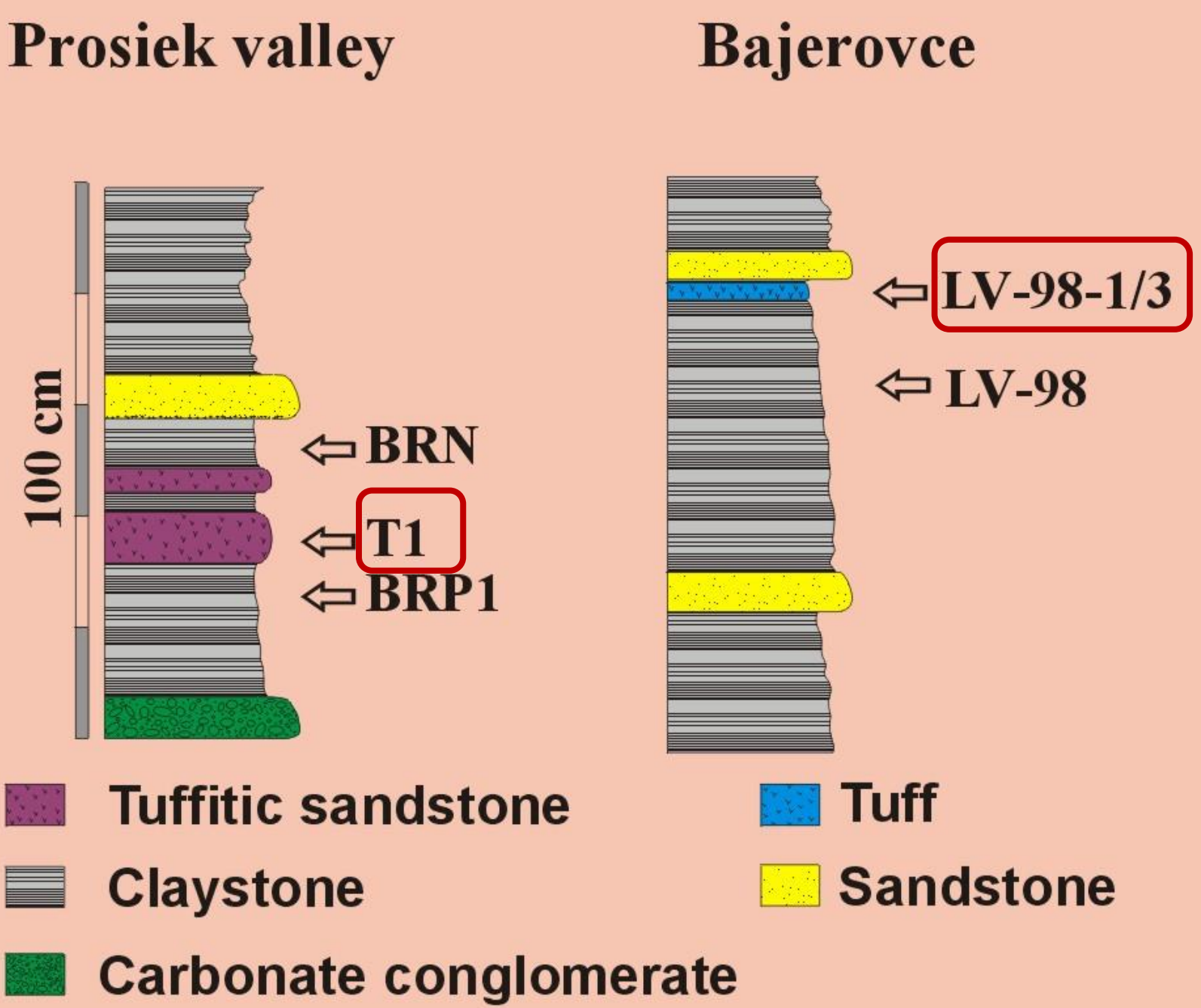
Expandability (%)

The amount of interlayers in the mixed-layered crystals, which are capable of reversibly absorbing water cations, resp. organic molecules and thus change d-spacing



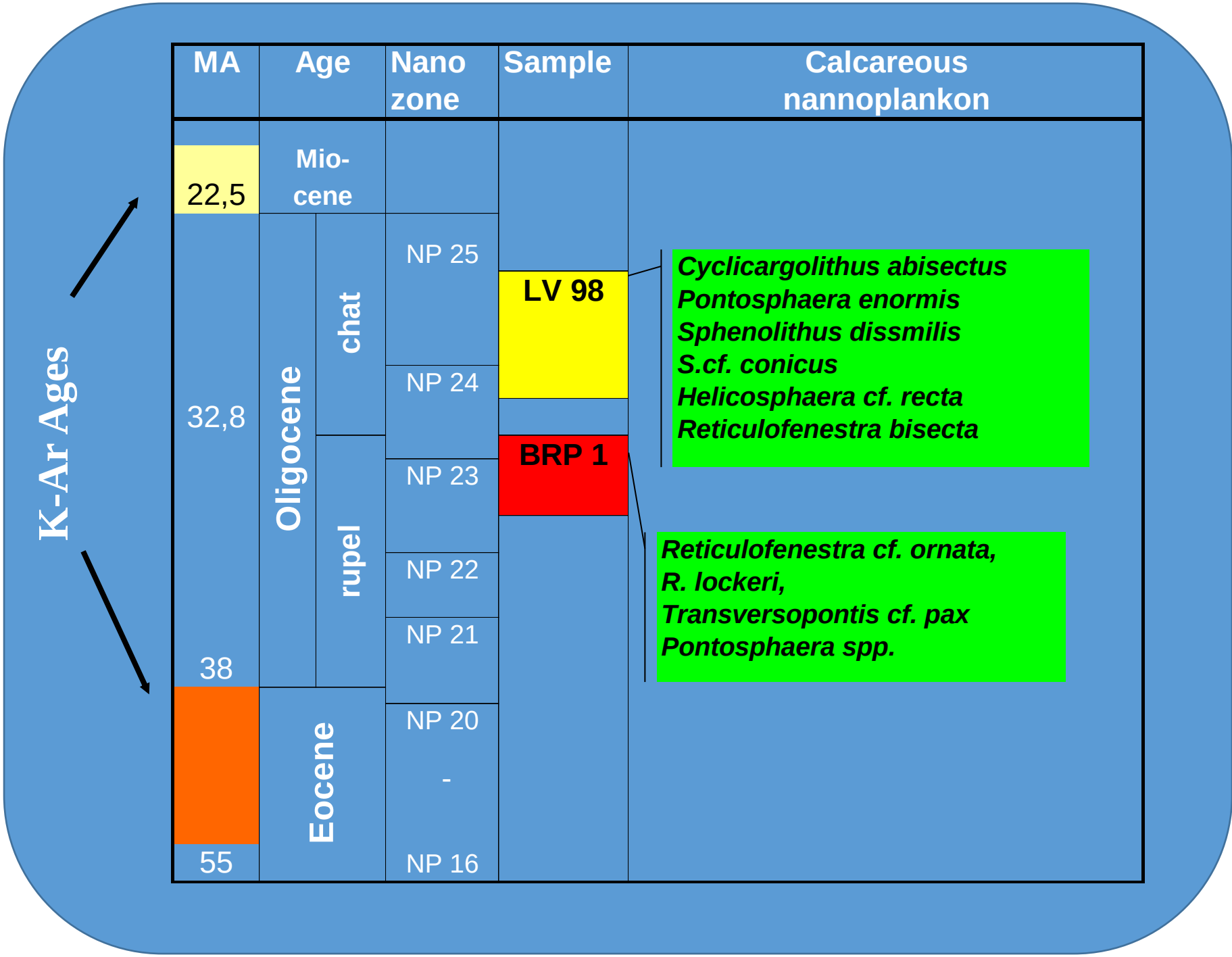


Uhlík et al., 2002 Mineralia Slovaca 34, 85-92


Prosiek valley
Bajerovce
100 cm
BRN
T1
BRP1
LV-98-1/3
LV-98
Tuffitic sandstone
Claystone
Carbonate conglomerate
Tuff
Sandstone

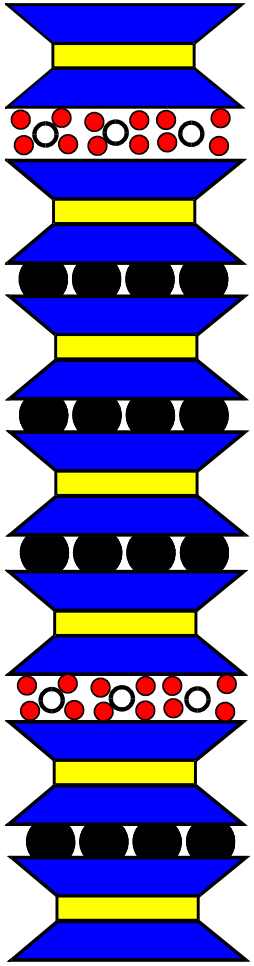
K-Ar dating

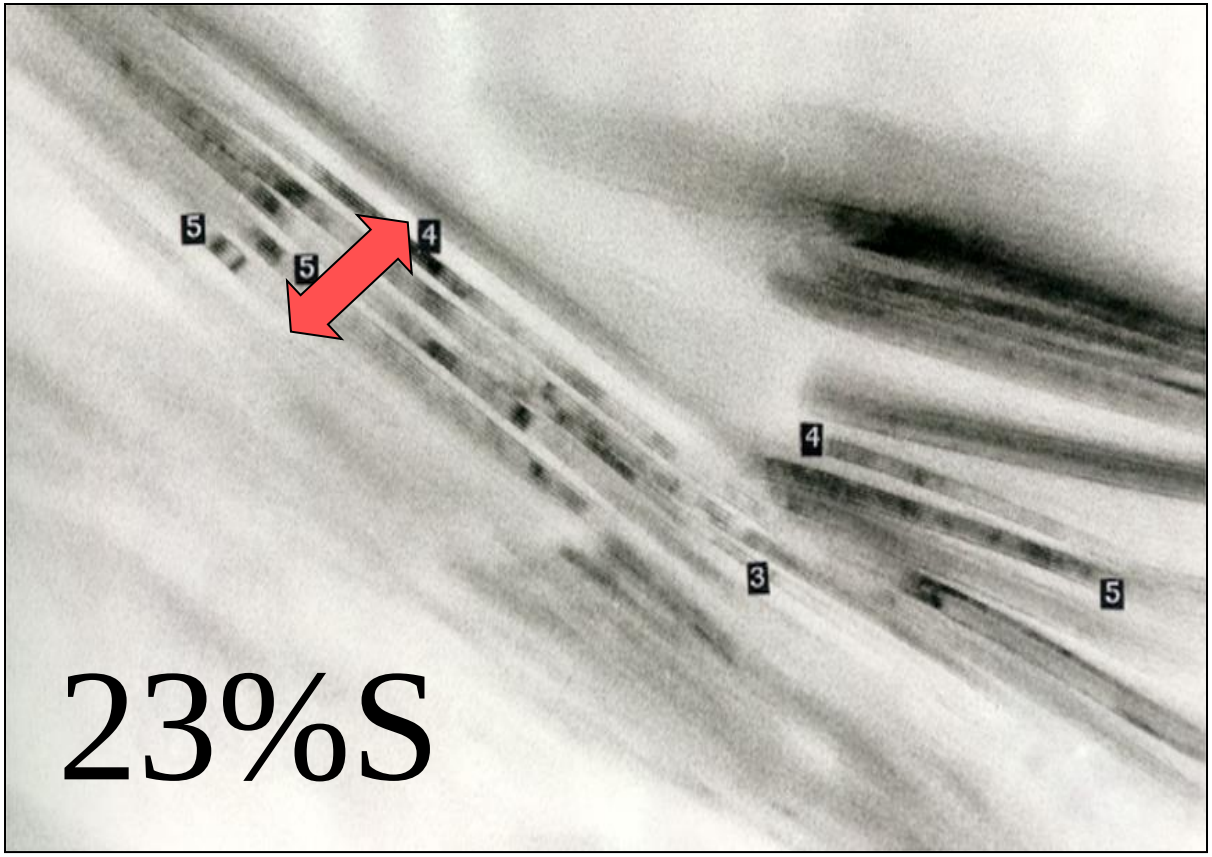
	? 😐 T1 Prosiek Valley	☺ LV 98 1/3 Bajerovce
< 0.02 μm	-	22.5 ± 2.5 Ma
0.02-0.05μm	-	22.3 ± 2.2 Ma
< 0.2 μm	41.2 ± 5.0 Ma	-
0.2 - 2 μm	52.0 ± 8.7 Ma	22.4 ± 1.7 Ma


MA
Age
Nano zone
Sample
Calcareous nannoplankon
K-Ar Ages
22,5
Mio-cene
32,8
Oligocene
chat
rupel
38
Eocene
55
NP 25
NP 24
NP 23
NP 22
NP 21
NP 20
-
NP 16
LV 98
BRP 1
Cyclicargolithus abisectus
Pontosphaera enormis
Sphenolithus dissmilis
S.cf. conicus
Helicosphaera cf. recta
Reticulofenestra bisecta
Reticulofenestra cf. ornata,
R. lockeri,
Transversopontis cf. pax
Pontosphaera spp.

Expandabilita

$$\%S_{max} = 1/T_{mean} * 100\ \%$$

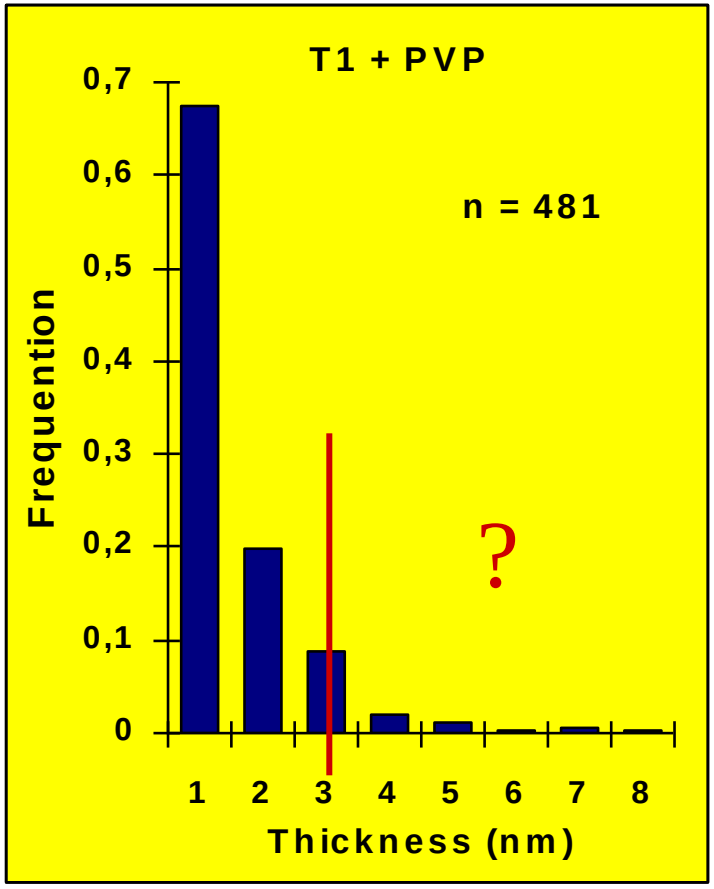


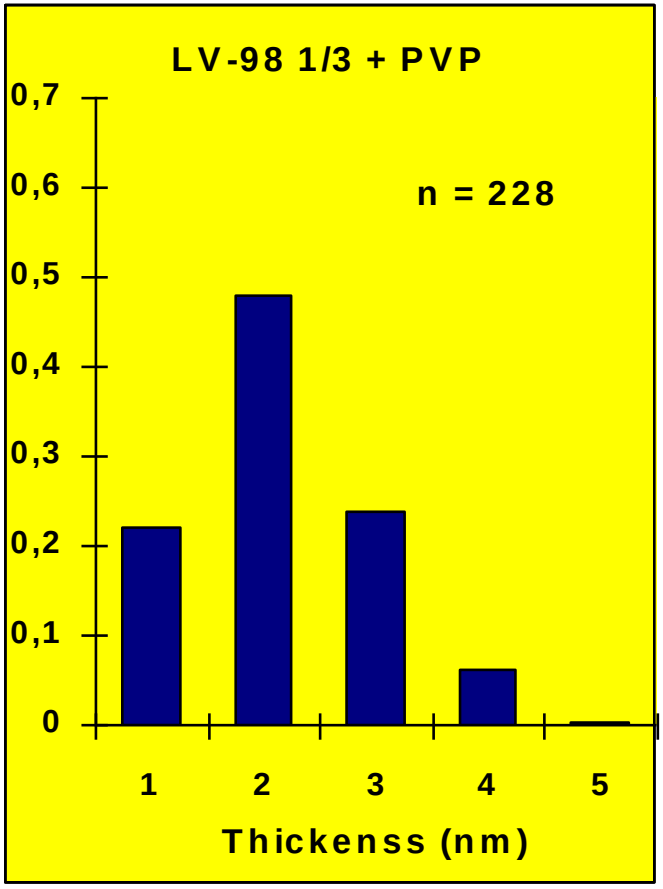


TEM (HRTEM) + PVP

HRTEM-PVP technique

Prosiek Valley **Bajerovce**

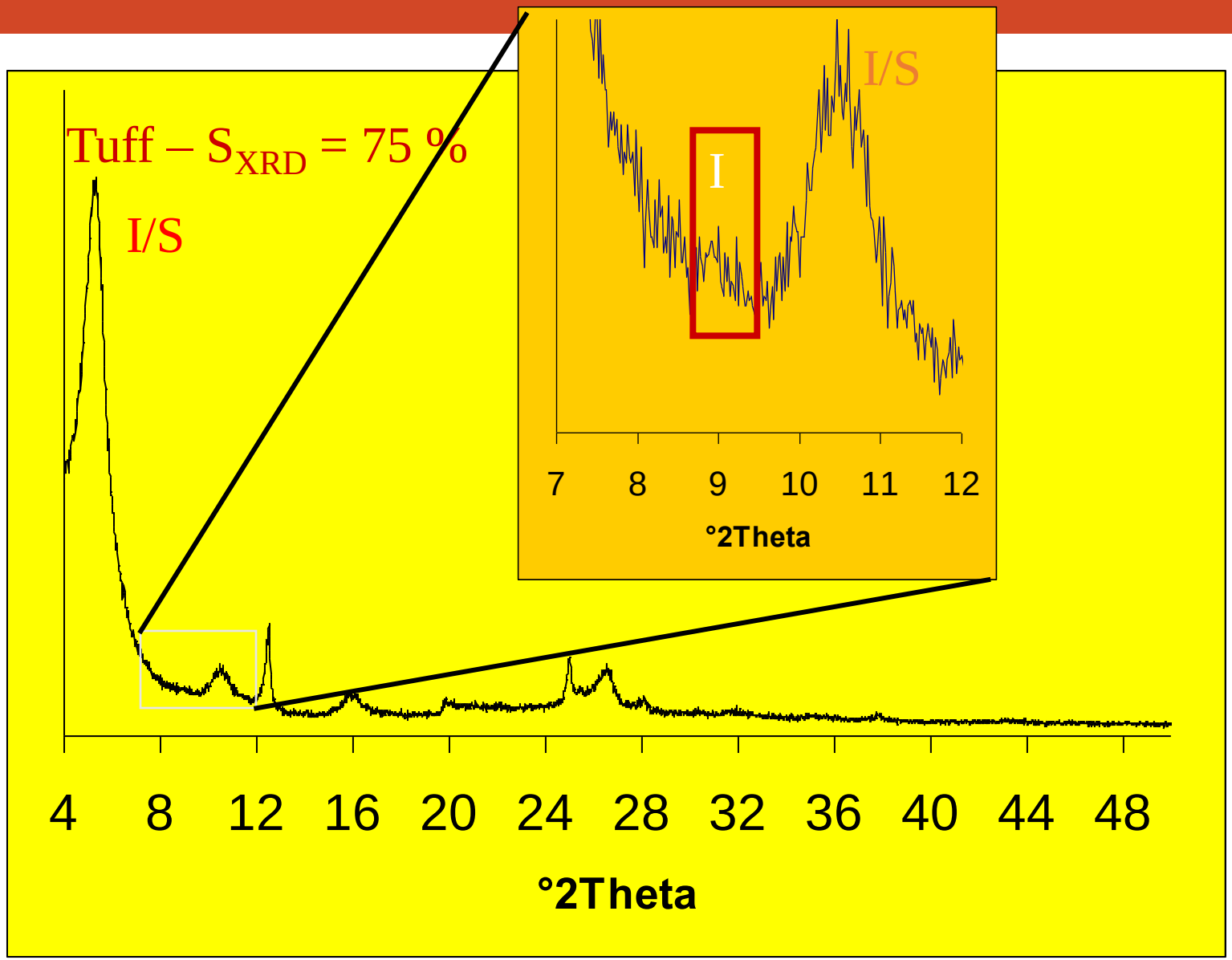




S_{XRD} = 75 %
S_{PVP} = 65 %

S_{XRD} = 44 %
S_{PVP} = 46 %

Prosiek Valley – XRD (<2μm; EG)



Interpretation: Bajerovce

Biostratigraphic age
25 – 30 Ma

>

Isotope age
22.3 – 22.5 Ma

Volcaniclastic sample without presence of detrital illite (HRTEM, XRD)

⇩

☺ K-Ar data are considered as period of maximal temperature connected with maximum burial of studied samples.

Interpretation: Bajerovce

S_{XRD} = 44% → **120 to 140°C**

Assuming constant geothermal gradient, illitization age is period of maximal temperature connected with maximal burial of studied samples. The thickness of missing overburden from 3 to 4.6 km was estimated for the Bajerovce area. These results indicate a continuity of subsidence of studied area also during the early Miocene.

Uhlík et al., 2002 Mineralia Slovaca 34, 85-92

Very low metamorphose

Hydrothermal alteration

Very low expandability

(<5%S)

Index „crystalinity“

(**illite,** chlorite...)

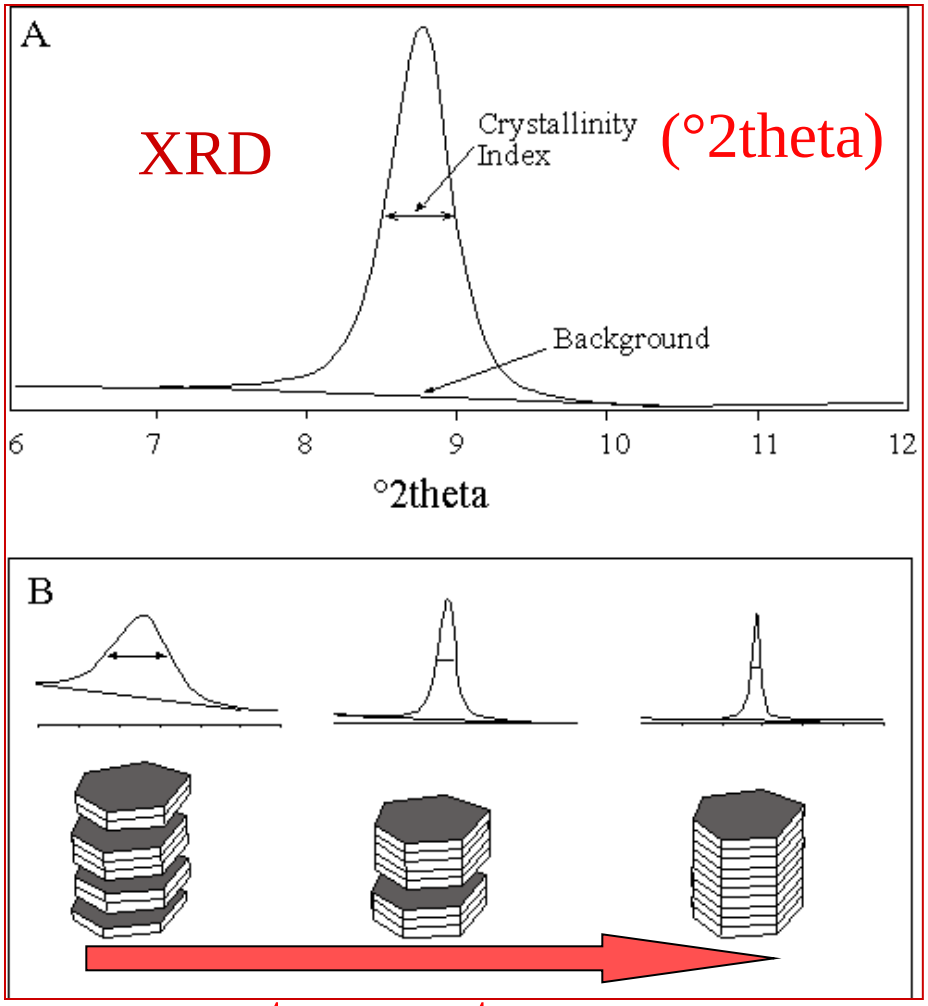
Physical nature:

particle thickness growth!!!

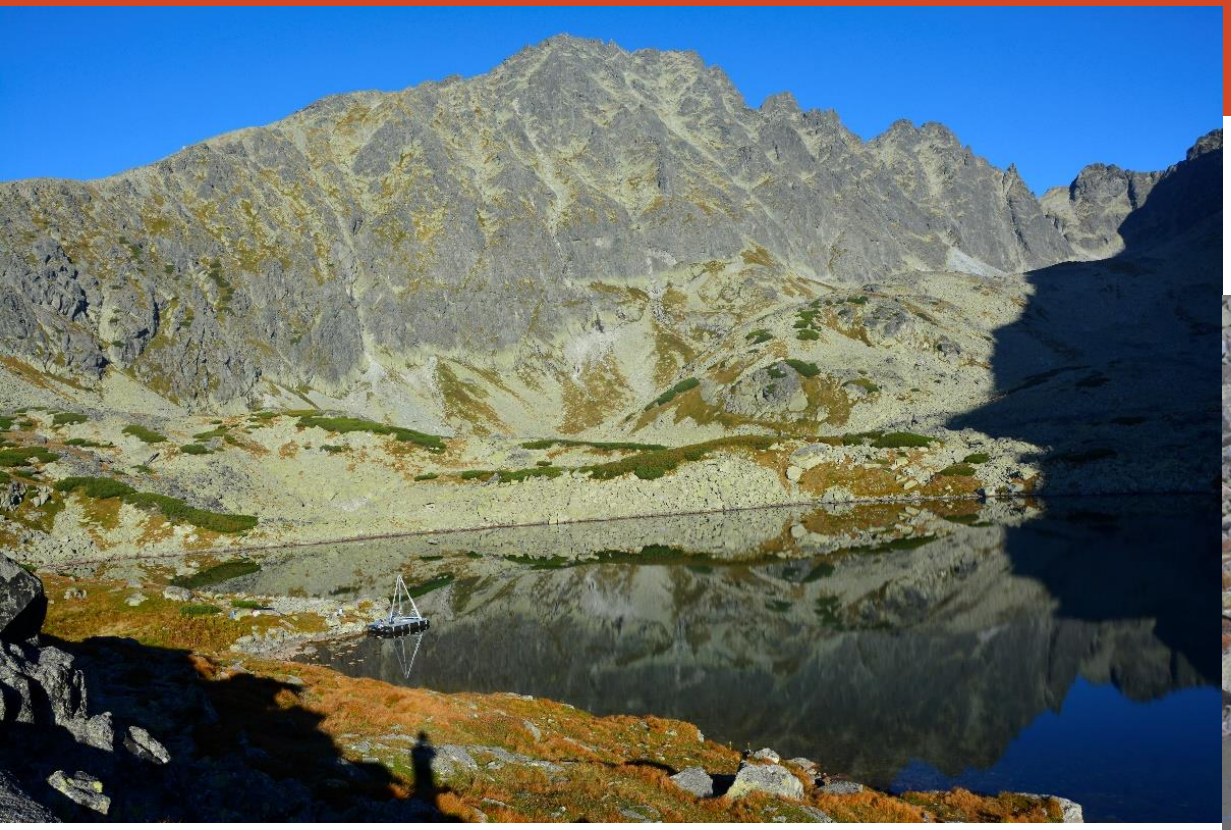
(T_{mean})

Estimation of temperatures:

200-400°C



Paleolimnology (glacial lakes)



- APVV-15-0292

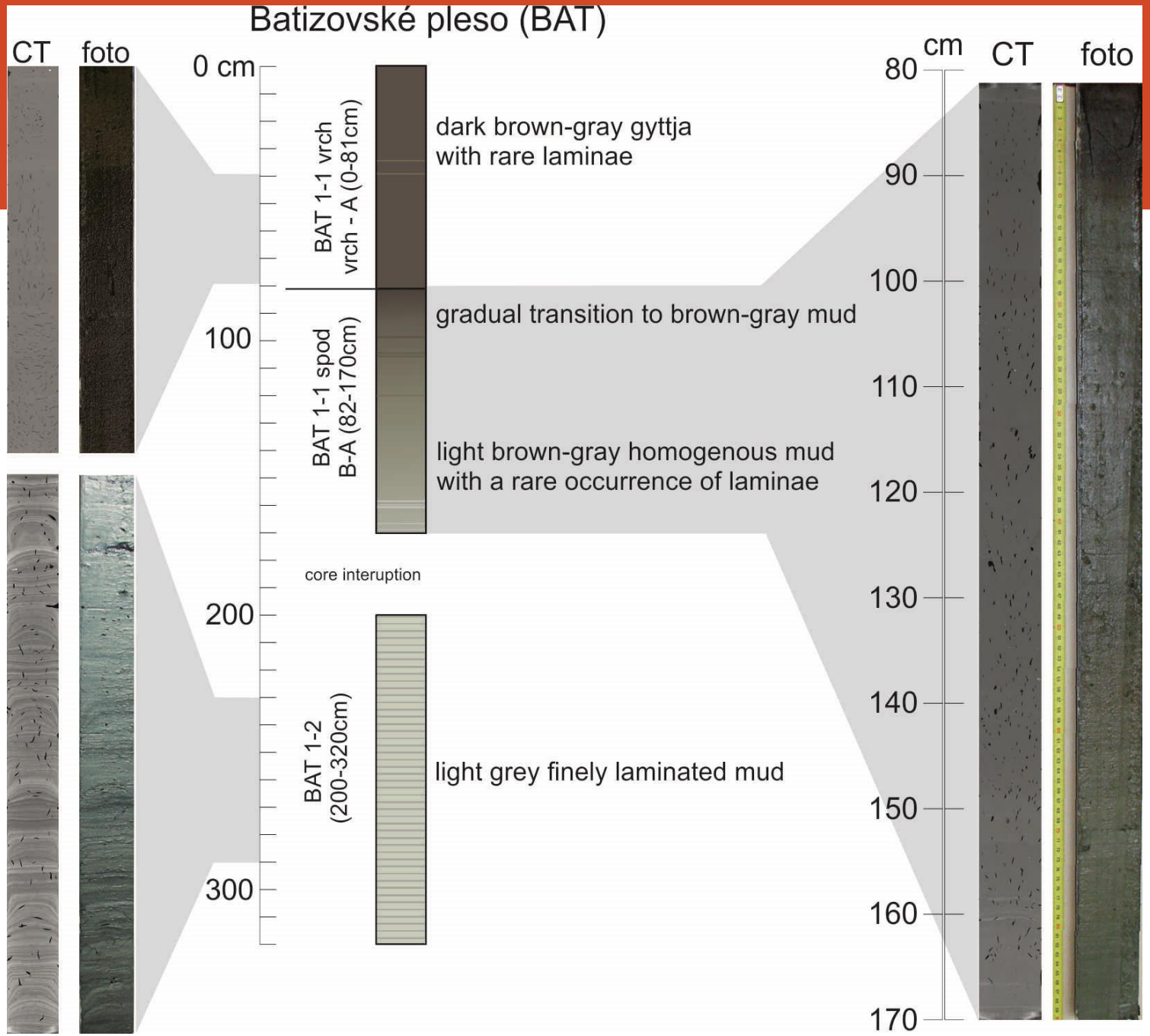
http://www.geo.sav.sk/en/depovyt-apvv-15-0292/

- Core length: 2 m, Core diameter: 60 mm
- Drilling: using mechanical rollers and hammers
- Paleolimnological swimming platform allows a sampling of lake sediments and examination of their paleontological record
- Sediment suitability for drilling: clay to medium-grained sand
- More: www.geol.sav.sk/files/Paleolimnolab. pdf

Dhavamani et al., 2022 Catena 209, 105787

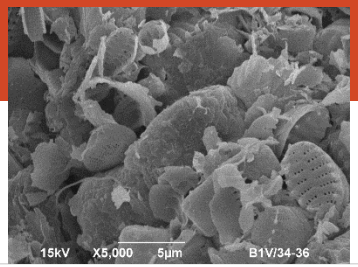
gyttja

gray laminated glacial silt



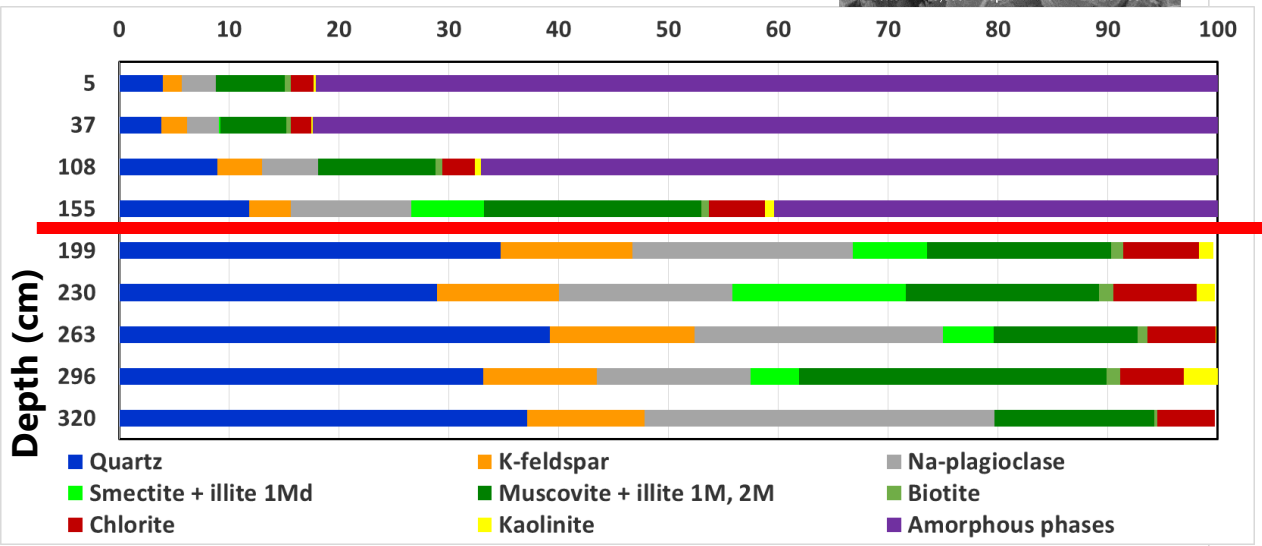
Pipík et al., in prep.

Batizovské pleso, 1884 m n.m.

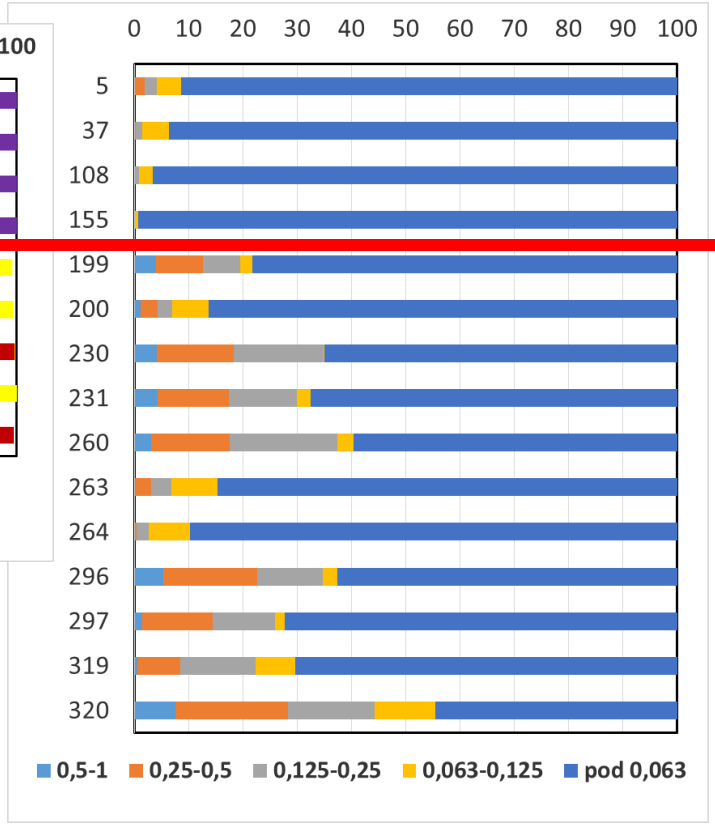


gyttja

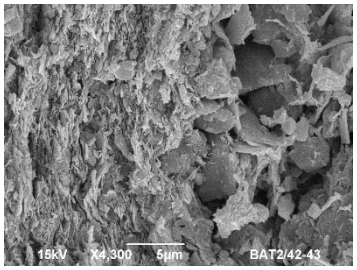
XRD



Grain size distribution



gray laminated glacial silt



Uhlík et al., 2020 Mente et Maleo, 5, 1, 39; Pipík et al., in prep.

Industrial minerals

Characterisation

Use

Bentonite, clays, diatomite, kaolin, magnesite, perlite, talc, zeolite and others

Perlite (project APVV-0339-12, 2013-2018)

Genesis - Jastrabá, Lehôtka pod Brehmi

Lexa et al., 2021: Geologica Carpathica, 72(3), 253–281

Properties - Water, Porosity

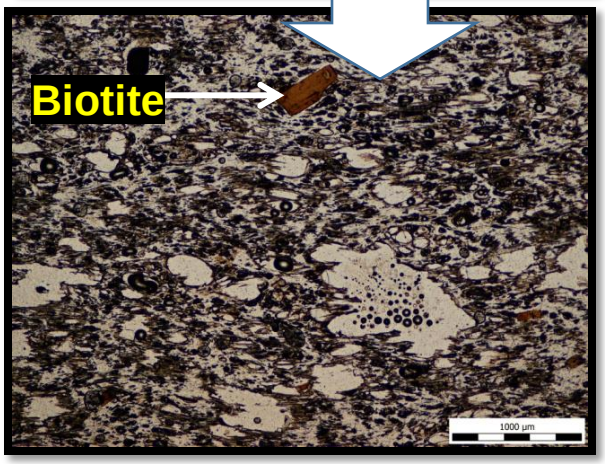
Pálková et al., 2020: Spectrochimica Acta Part A, 240, 118517

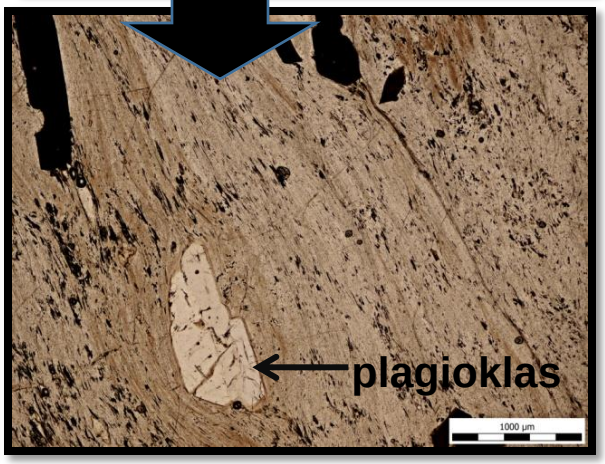
Varga et al., 2019: Monatshefte für Chemie, 150, 6, 1025-1040

Use - expansion

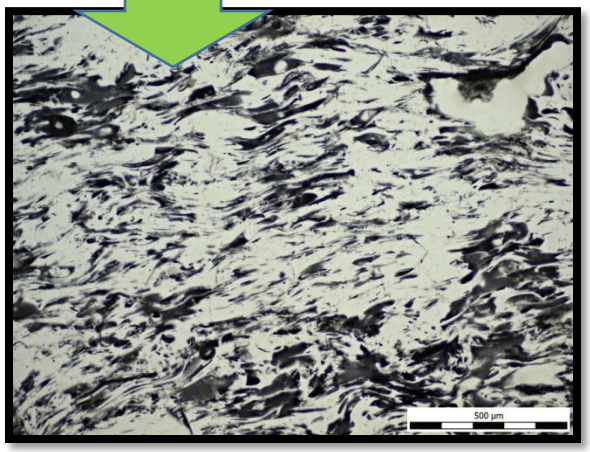
Two types of perlite

Lehôtka pod Brehmi





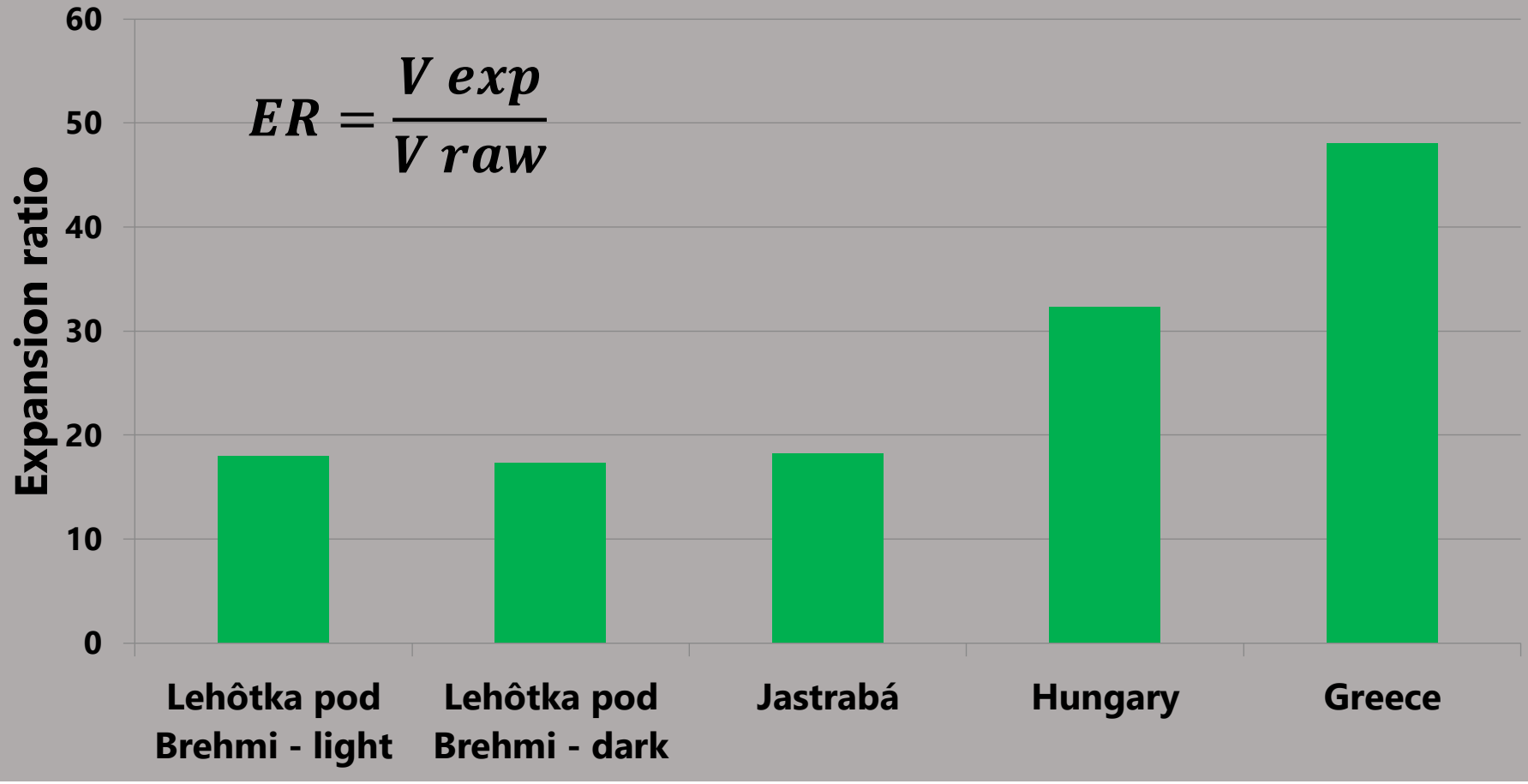
Jastrabá



Expansion process, horizontal furnace, Zrenjanin, Serbia

Experimental expansion in laboratory furnace

$$ER = \frac{V\ exp}{V\ raw}$$



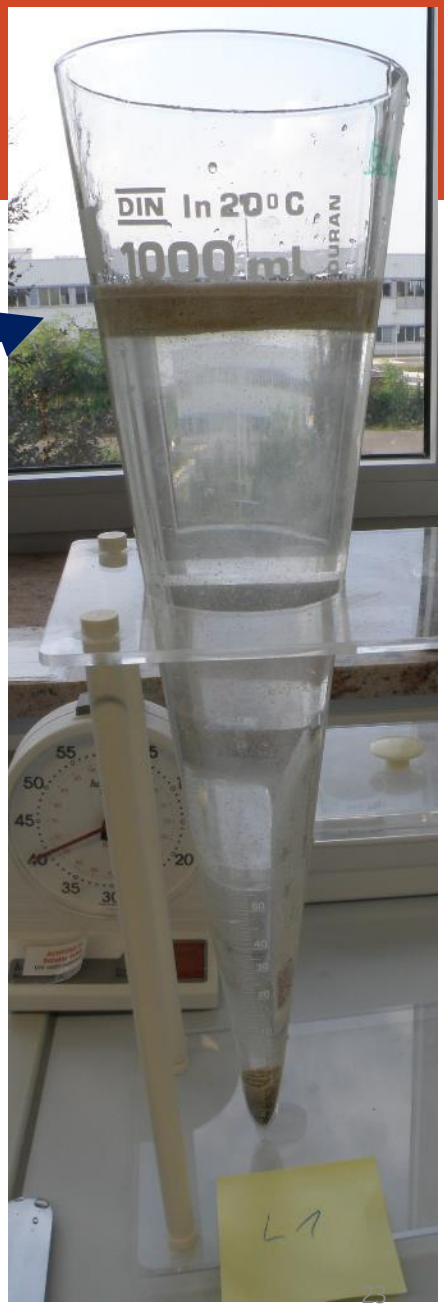
expansion ratio is between 17 and 20

Imhoff cone test procedure

100 ml expanded perlite to 1 L of water

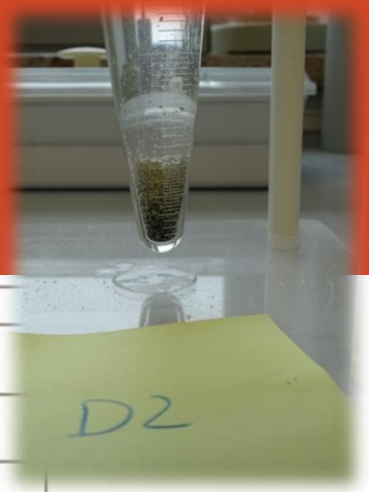
to mix

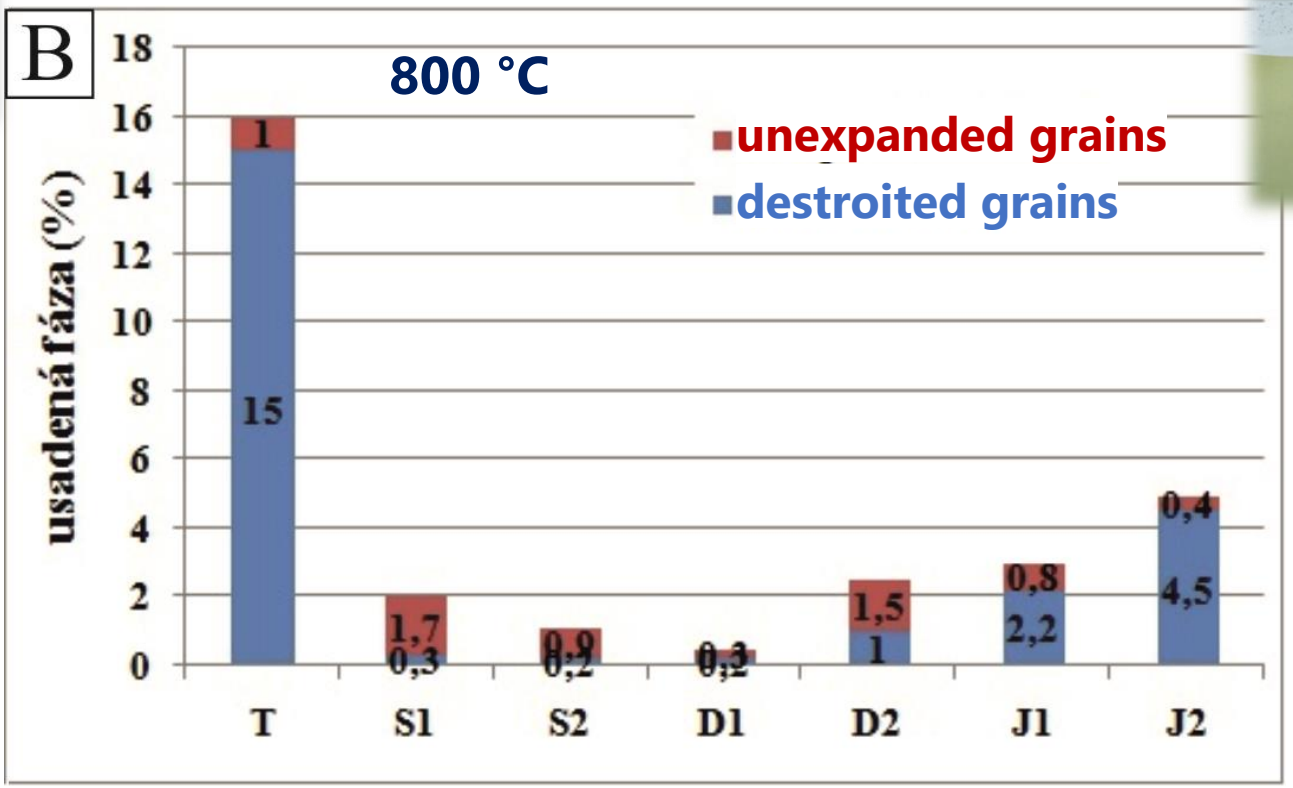
after 2 hours of settling to record of volume of unexpanded or destroyed particles



Perlite expansion

Imhoff test





Samples:

T – Trachilas, Greece, **S** – gray type Lehôtka pod Brehmi, **D** – dark type Lehôtka pod Brehmi, **J** – Jastrabá

fractions: **1**- 0,16-0,3 mm; **2** – 0,3-0,6 mm

Comparison of world and Slovak perlites

Expansion			Mechanical stability		
Slovak perlites	<	**World perlites**	**Slovak perlites**	>	**World perlites**

WHY ?

gas bubble

melt

superposition of shells

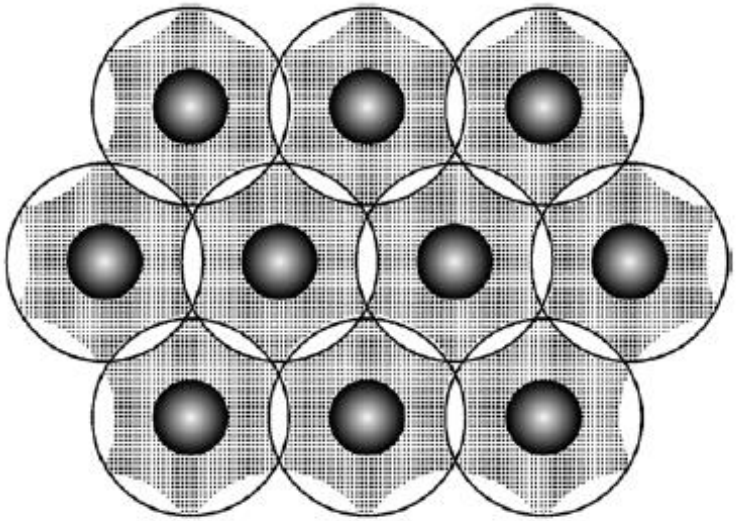
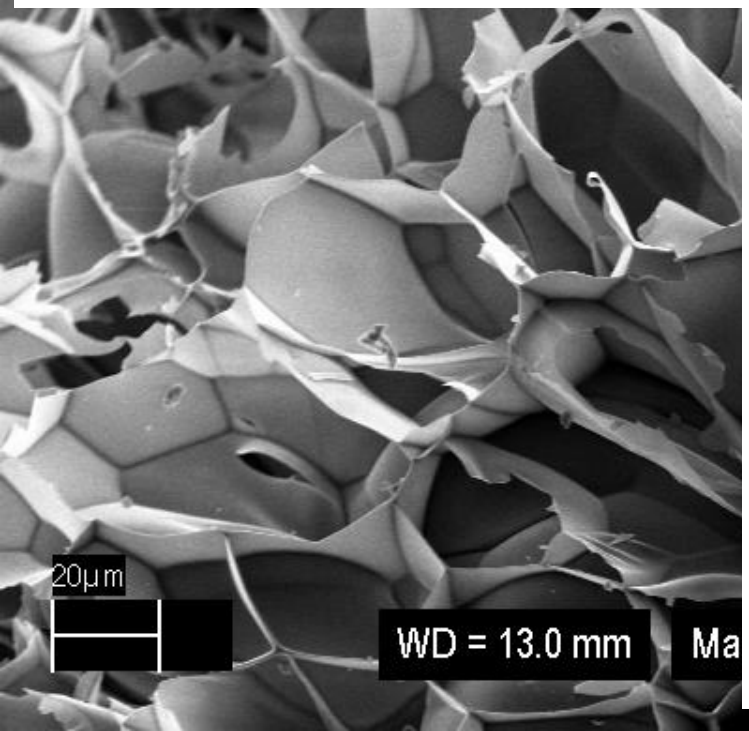


Figure 1 Cellular foam model.

Expanded perlite



Zähringer et al. 2008

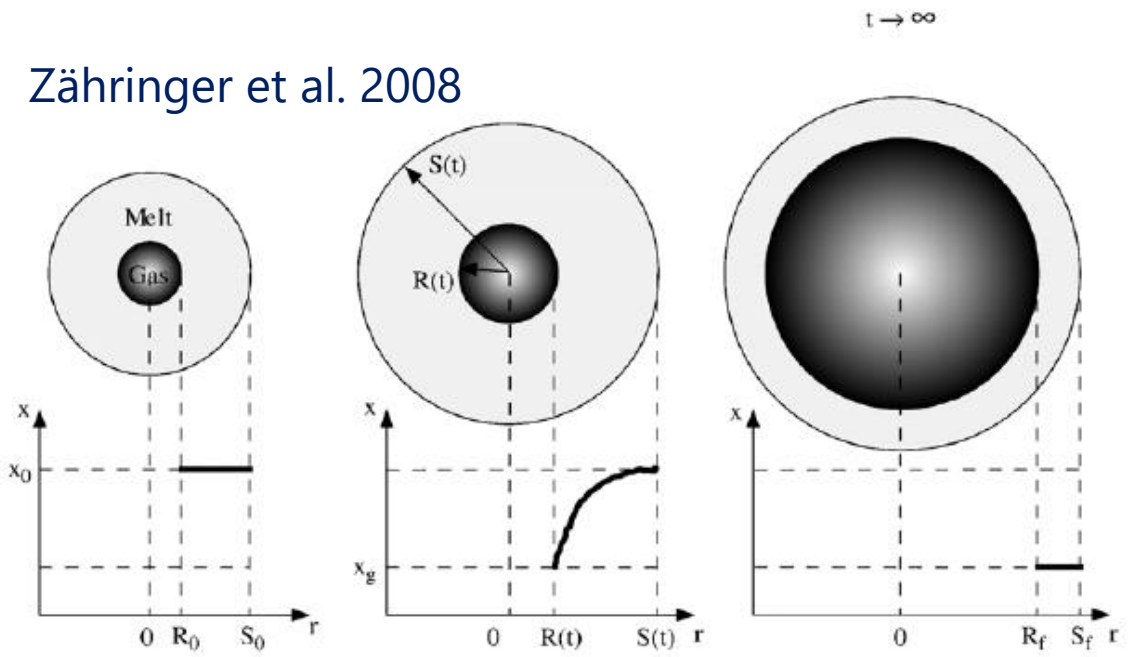


Figure 2 Bubble growth in a finite melt volume.

Statistical parameters of whole rock major element composition of perlites from the Lehôtka pod Brehmi and Jastrabá deposits (wt % recalculated to 100 % dry)

Oxide	SiO_2	TiO_2	Al_2O_3	Fe ox	MnO	MgO	CaO	Na_2O	K_2O	H_2O*
Lehôtka pod Brehmi deposit										
Number	51	51	51	51	51	51	51	51	51	51
Minimum	72.81	0.135	13.37	1.329	0.041	0.197	1.169	2.24	4.83	3.00
Maximum	75.14	0.333	14.37	3.065	0.094	0.468	1.815	3.08	5.93	4.90
Median	74.15	0.213	13.75	1.809	0.042	0.332	1.425	2.52	5.64	3.60
Average	74.13	0.215	13.76	1.874	0.047	0.337	1.418	2.54	5.62	3.72
Std. deviation	0.55	0.035	0.21	0.332	0.012	0.069	0.136	0.18	0.20	0.44
Jastrabá deposit										
Number	22	22	22	22	22	22	22	22	22	22
Minimum	73.84	0.083	13.10	1.230	0.042	0.104	0.951	1.81	4.99	3.60
Maximum	76.95	0.249	15.29	1.812	0.074	0.385	1.486	2.95	5.73	6.00
Median	76.31	0.085	13.46	1.390	0.063	0.137	0.989	2.03	5.41	5.20
Average	76.13	0.101	13.61	1.434	0.061	0.159	1.020	2.08	5.38	5.15
Std. deviation	0.73	0.037	0.49	0.160	0.007	0.059	0.115	0.25	0.17	0.58

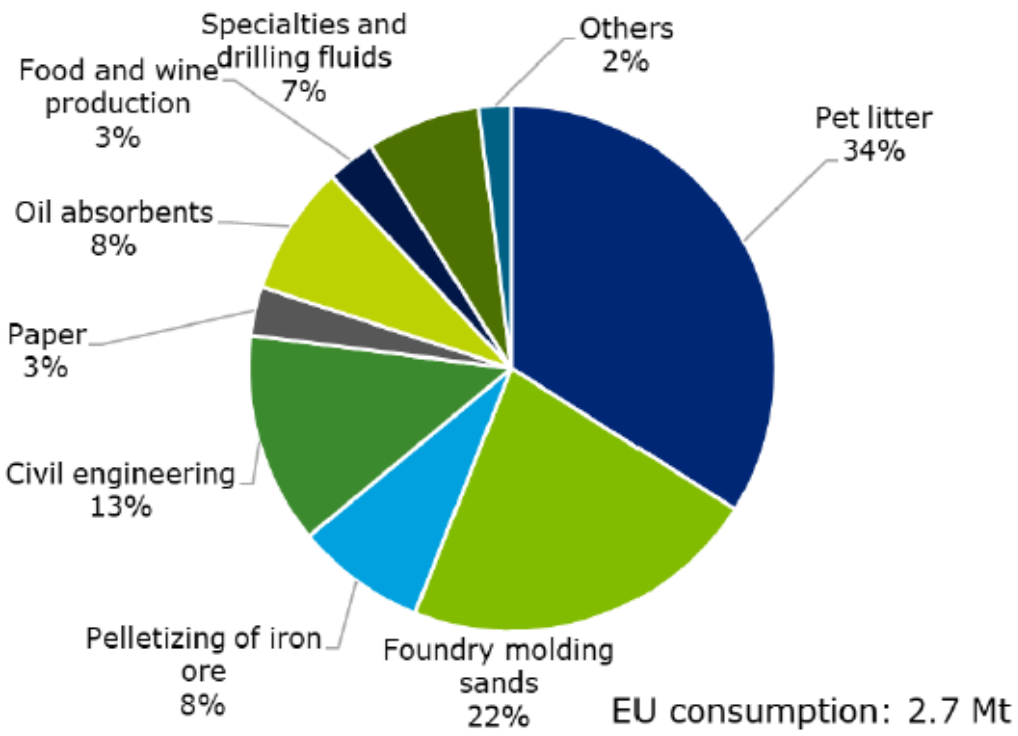
* water content = LOI, presence of other constituents in the LOI is negligible

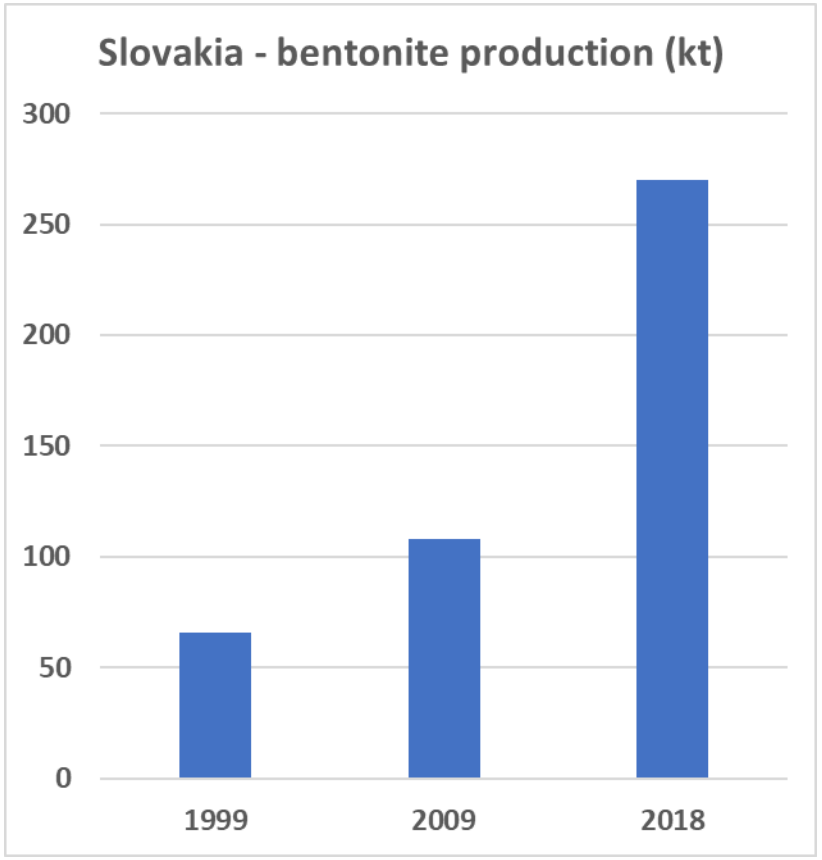
	K_2O/Na_2O	loosely bound H_2O (0-250°C)	strongly bound H_2O (550-950°C)
Slovak perlites	**2-2,5**	**45-60 %**	**1-7 %**
Varga et al., 2019			
Foreign perlites	**0,7-1,4**	**18-50 %**	**6-23%**
Roulia et al., 2006, J Mater Sci			

BENTONITE

Slovak bentonite production:
~ 10th in the world (1.6%)
~ 5th in Europe, (6%)
Reserves in Slovakia: ~ 57 Mt

EU consumption 2012 -2016

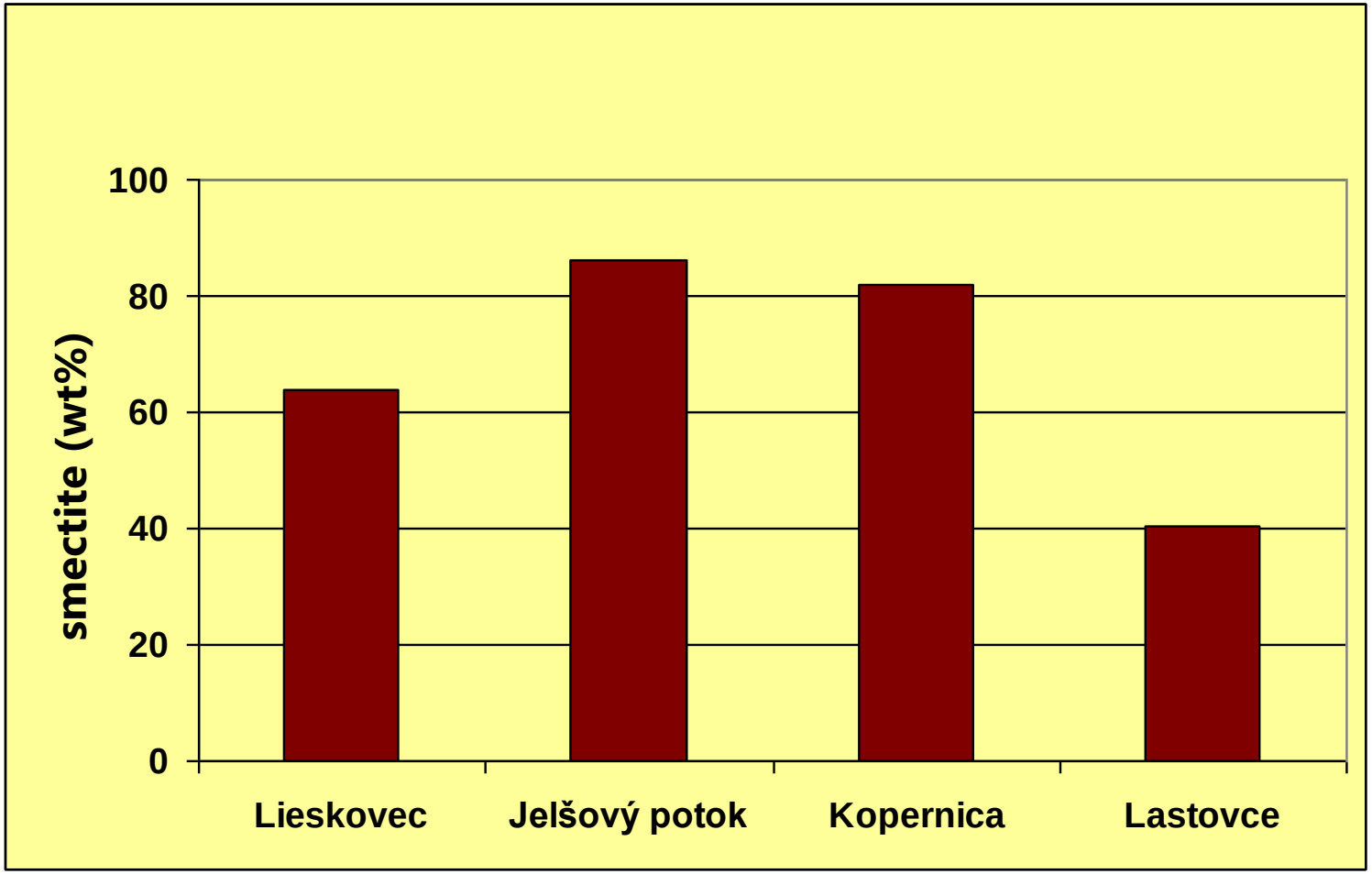




EC, 2020; USGS, 2020; Šoltés et al., 2020

Bentonite quality increase with amount of smectite

XRD



Poľana | Kremnica Mt. | ESNB

Challenge For Slovak Bentonite production

APVV-20-0175

- Good quality bentonite

vs

- Low added value of exported bentonites
  - raw bentonite
  - cat litter

- the average price of exported bentonite was **54 EUR/t**
- the average price of imported bentonite was **308 EUR/t**

- **to optimize the application of Slovak bentonites to increase their added value**

The average prices are from ŠOLTÉS et al., 2020

Introductory seminar and field trip (July 14-16, 2021)

Introductory seminar and field trip (July 14-16, 2021)

Partners:

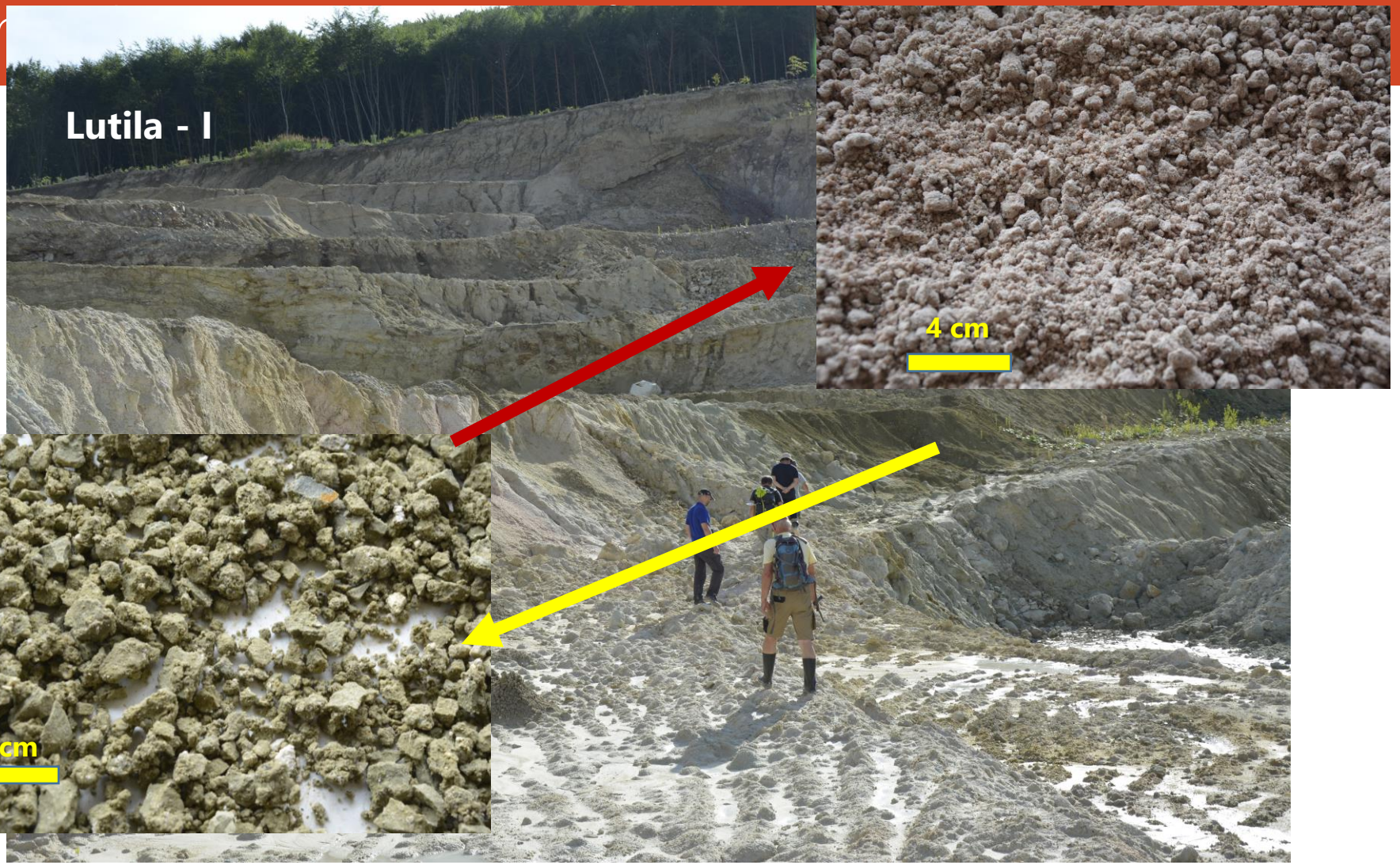
-The Earth Science Institute of the Slovak Academy of Sciences

-Institute of Inorganic Chemistry of the Slovak Academy of Sciences

-Department of Geotechnics, Faculty of Civil Engineering, Slovak University of Technology in Bratislava

User of project results:

REGOS, s.r.o.


Lutila - I
4 cm
4 cm

collaboration
is fun

Thank you for attention