Carbon isotope stratigraphy of the Mesozoic carbonate sedimentary sequences

Otília Lintnerová

Uhlíková izotopová stratigrafia mezozoických karbonátových sekvencii.

Seminár Katedry mineralógie, petrológie a ložiskovej geológie – november 2021.

Carbon isotope interpretation for stratigraphy

C - basic biogenic element : biogenic fractionation of stable C-isotope composition (resp. ratio $\delta^{13}C$) due to „metabolic activity“: preferred uptake of the light C isotope (biogenic element H, O, N, S... – potentially preferred distribution of the H,N, O S isotopes - „vital effect“)

Fig. 1 : Global carbon cycle

Major carbon reservoirs: oceans – atmosphere and biogenic reservoirs (organic mater production). The $\delta^{13}C$ of carbonate rocks : „cross connection“ of organic and mineral carbon (carbonates and fossil fuels).

Fig. 2. The δ^{13} C results interpretation

- biogenic and un-biogenic origin of major part of carbon in samples/ rocks (organic vs. Inorganic origin, organic matter production, accumulation, transformation etc.)

(e.g. CH_4 bacterial vs. catagenic natural gas, in-organic and volcanic gas etc.)

- bioproduction of marine and terrestrial realms and „biota“ evolution - **significant biotic turnover** (paleogeographic, paleoclimatic and paleoecologic indicators)

C- isotopoes in stratigraphy : life and sedimentary conditions **changes** in „well defined“ sedimentary record - interpretation base as **integrated** data (facies analyse, biostratigraphy, magnetostratigraphy etc.)

The $\delta^{13}C$ changes in time - e. g. oceans and continents re-formation, connected with massive volcanic activity, oxic- and anoxic conditions – ocean anoxic events, global climatic changes and response of local carbonate systems to global ones. $\delta^{13}C$ - wide correlation of sedimentary sequences

Conditions of the carbonate mineral transformation in beds (diagenetic, metamorphic processes etc. - **together with $\delta^{18}O$** - selected and specific sample material – tests, cements etc.)

Fig. 1

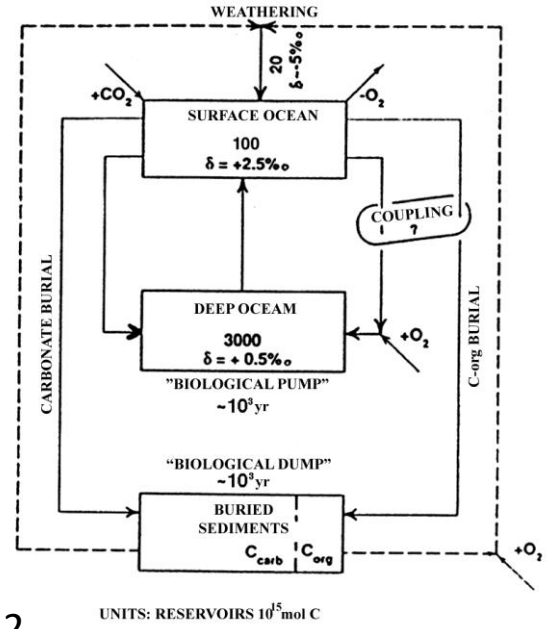
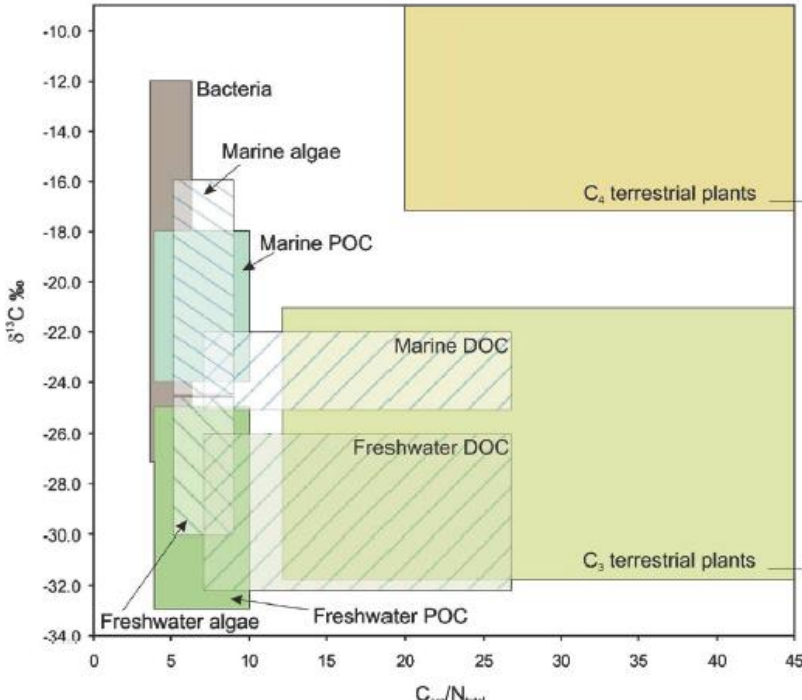


Fig. 2.



Current projects

VEGA : 2/0013/20 : Chronology of global events in Tethyan and Parathethyan basins of the Western Carpathians infered from evolution and life environments of fossil planktonic organisms.

Planktonic organisms are known as a most sensitive components of marine and oceanic ecosystems in the present time and geological history. Therefore, they belong to principal zonal microfossils, which have been used to compile the geological time scale. Bio-events in evolution of planktonic fossils (foraminifera, nannoplankton, tintinids, etc.) are correlable with stratigraphic boundaries of Mesozoic systems (J/K, K/T), periods (P/E, O/M), stages (Apt/Alb, Cen/Tur, Lut/Bar), biozones, magnetozones, isotope curves, orbital cycles, etc. Besides of crucial importance for biostratigraphy, the plankton is considered as a highly sensitive biotic proxy for climate, CO2 level, productivity, eustatic changes, dissolved oxygen, circulation, isolation and others. The project is intended to identify of planktonic bio events in the Western Carpathian sections, their correlation with phylogenic features, international stratotypes and global paleoenvironmental changes of the Tethyan and Paratethyan basins.

APVV-20-0079 – do 2021- 2024 – Sedimentary archives of boundary events, paleoenvironments and global changes in Tethyan and Paratethyan basins of the Western Carpathians

Sedimentary archives preserve a time-stratigraphic boundaries and records of evolutionary development, life environments, climatic conditions and the Earth global changes. The project is focused to integrated research and multiproxy analysis of stratigraphic sections of the Western Carpathians. The first objective of project will be to provide the data for determination of stratigraphic boundaries and their time-scale calibration with international stratotype sections GSSP. The most usefull for dating of marine sediments are planktonic organisms, which provide a bioevents for global correlation of stratigraphic stage boundaries, biozones, magnetochrons, isotope curves, orbital cycles, etc. Beside of crucial importance for stratigraphy, the fossil microorganisms also provide a sensitive proxy for climatic conditions, CO2 content, eustatic sea level, oxygen concentration, circulation, isolation, and another paleoenvironmental changes. Terrestrial environments will be analyzed in term of mammalian biostratigraphy, vertebrate paleoecology and paleovegetation. The aim of the project will be identification of stratigraphic boundary events at reference sections of the Mesozoic and Cenozoic formations of the Western Carpathians, and their correlation with geologic time scale and global changes of paleoenvironments in Tethyan and Paratethyan basins.

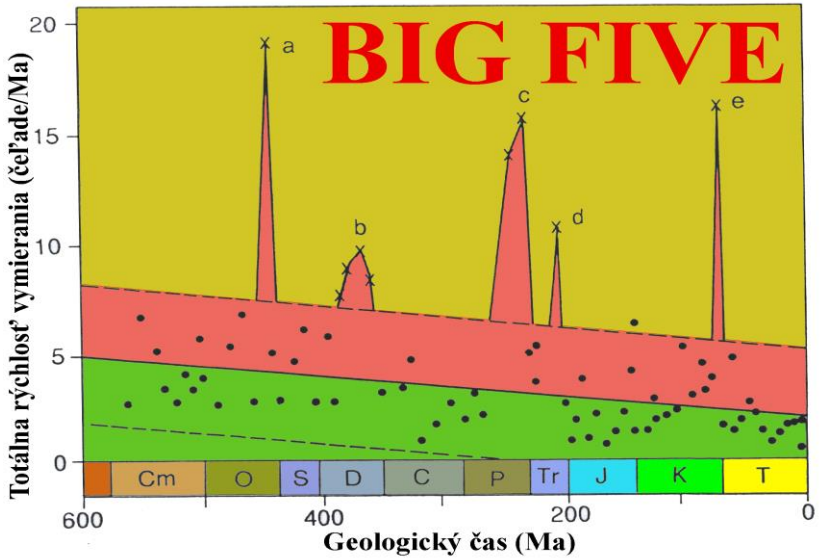
Dr. Ján Soták, Slovak Academy of Science., prof. D. Reháková – Dep. Geology and Paleontology

GLOBAL NATURE OF TRIASSIC /JURASSIC BOUNDARY EVENTS
(IGCP project – revision TJB systems)

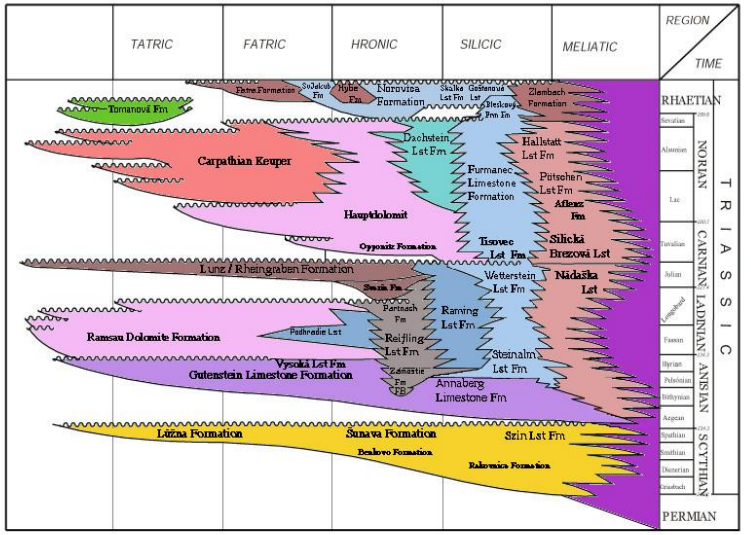
Western Carpathians : Biostratigraphy vs. Integrated stratigraphic method (geochemical and mineralogical study)

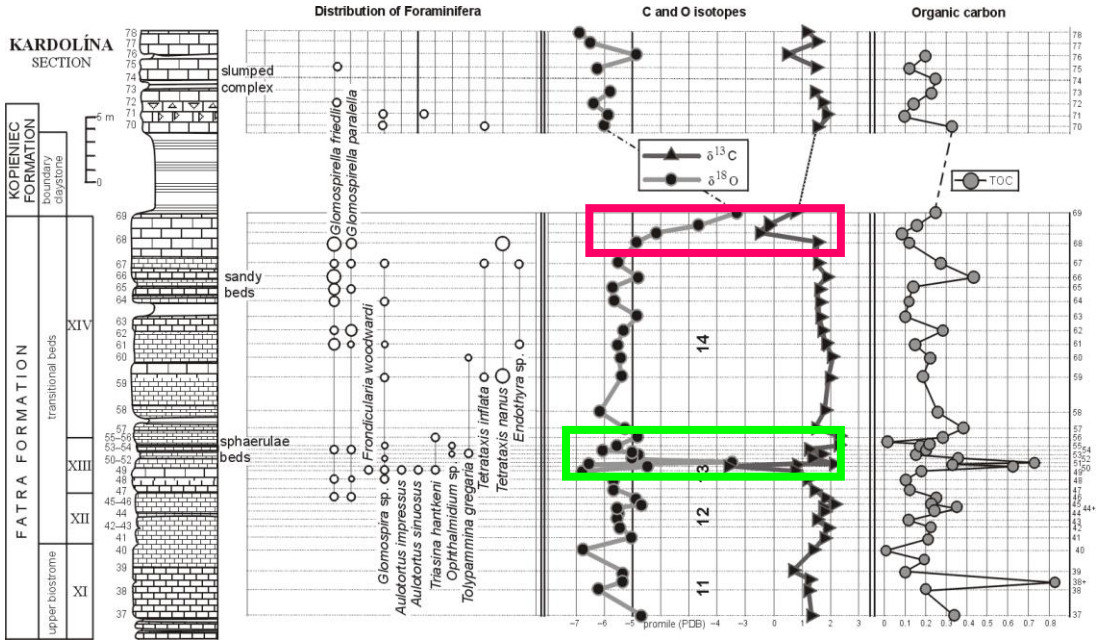
1. Incomplete sedimentary records
2. Shortness of index fossils (cephalopods, conodont, etc.)
3. Negative C $^{13}\delta$ event (and others stratigraphically important geo-chemical signals)

Familly mass-extinction /Ma



- the mass extinction in marine realm at the end of the Triassic - one of the five largest ones in the Phanerozoic (Hallam 1990)
in several groups of animals, the end-Triassic extinction was as crude as the end-Cretaceous one (Raup and Sepkoski 1988)
Global mass extinction:
- two abundant and diverse mega fossil group – ammonites and bivalves
several groups, that survived the end –Palaeozoic mass extinction: conodonts, murchosoniaceans, gastropods, corals have died
- marine micro-organisms – ostracods, dinoflagellates, foraminifera (?)
terrestrial realm: plant record is less affected by mass extinction than marine invertebrate record
- difficult question to answer:
catastrophic event or gradual decline in diversity ??



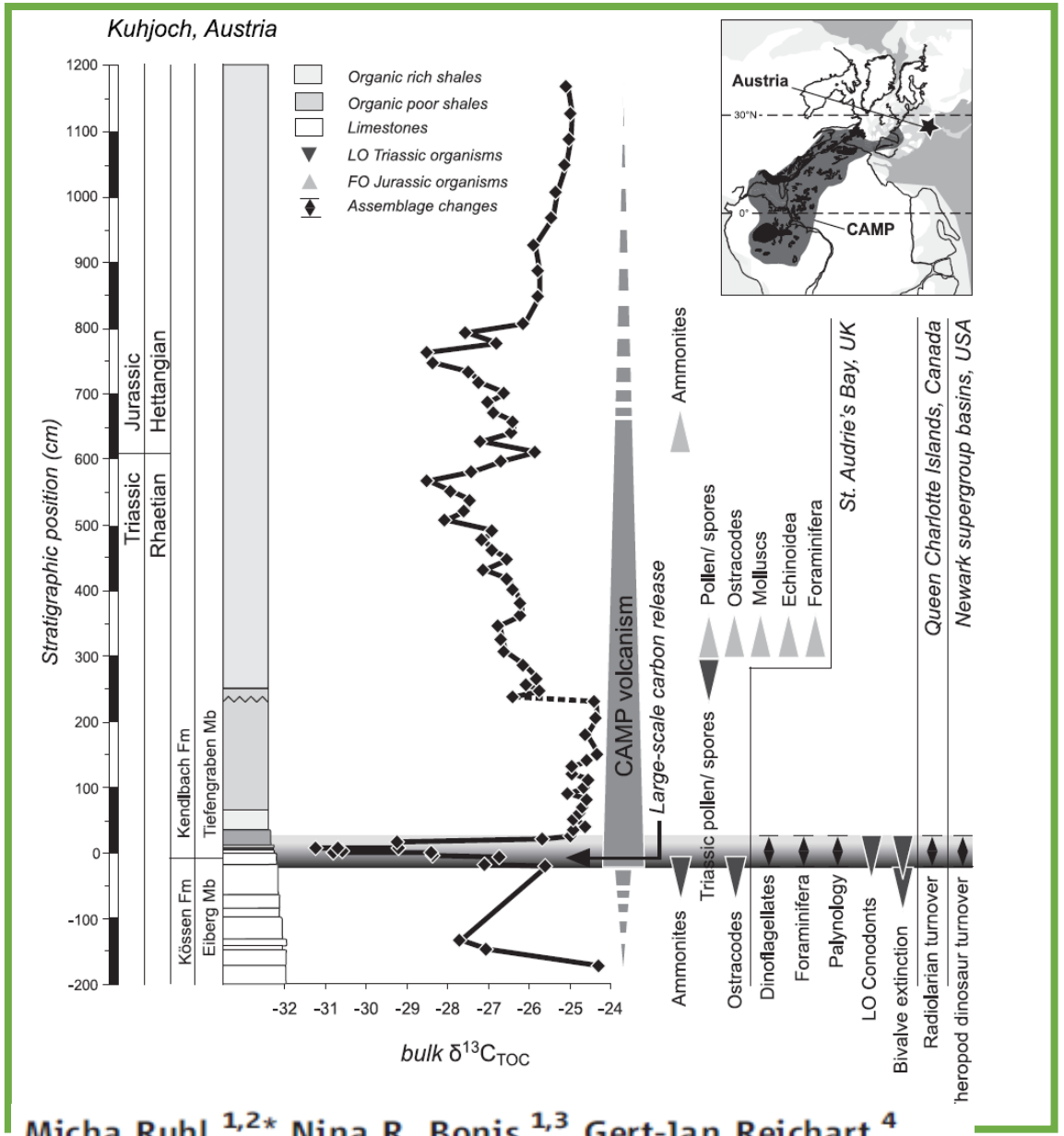


- Measurement of carbon isotope composition is widely applied to provide information on the carbonate deposition and/or on global **C cycle perturbation**.
- The uppermost Triassic is marked by a **pronounced negative excursion near the system boundary that is linked to significant biotic turnover.**

ETME, ~201.6 million years ago

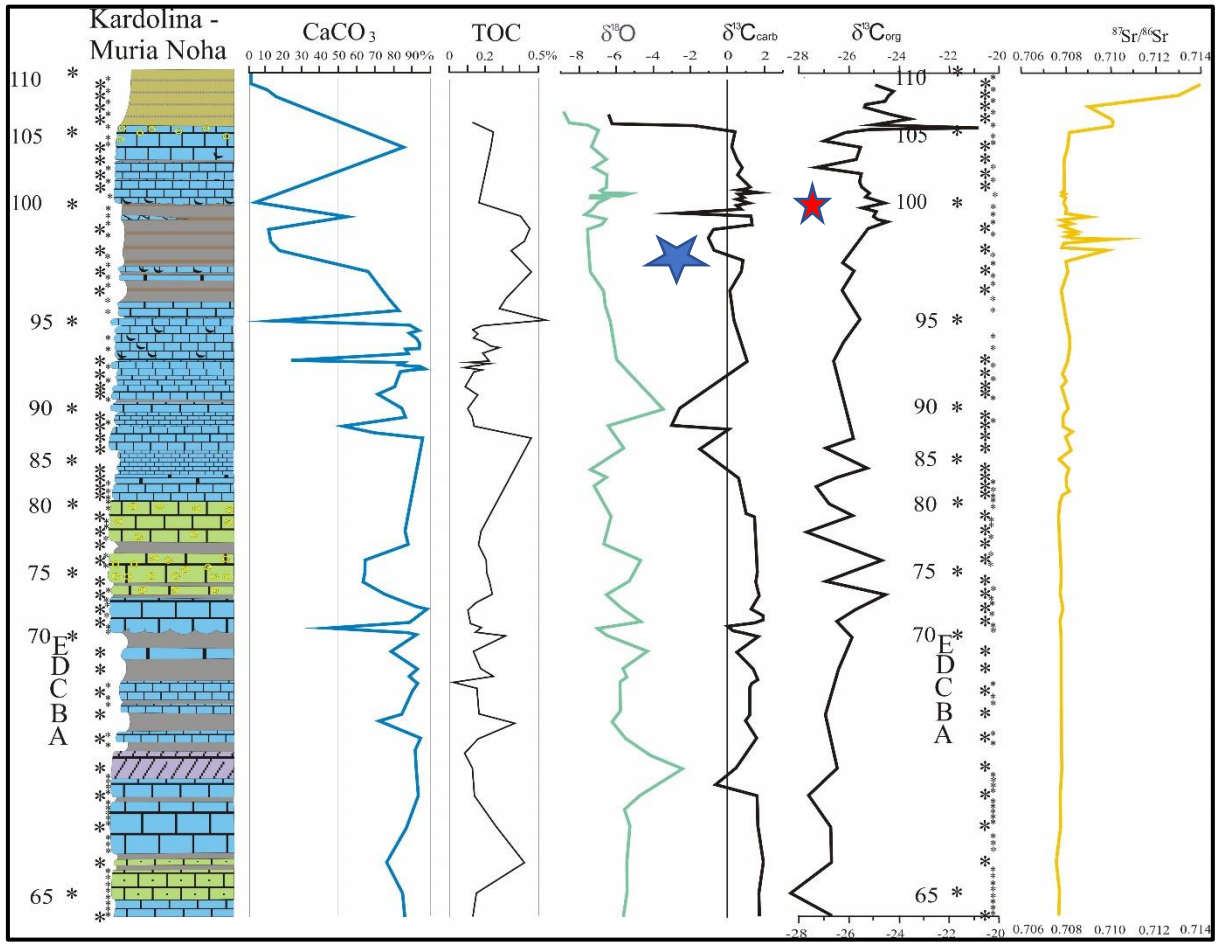
www.sciencemag.org **SCIENCE** VOL 333 22 JULY 2011

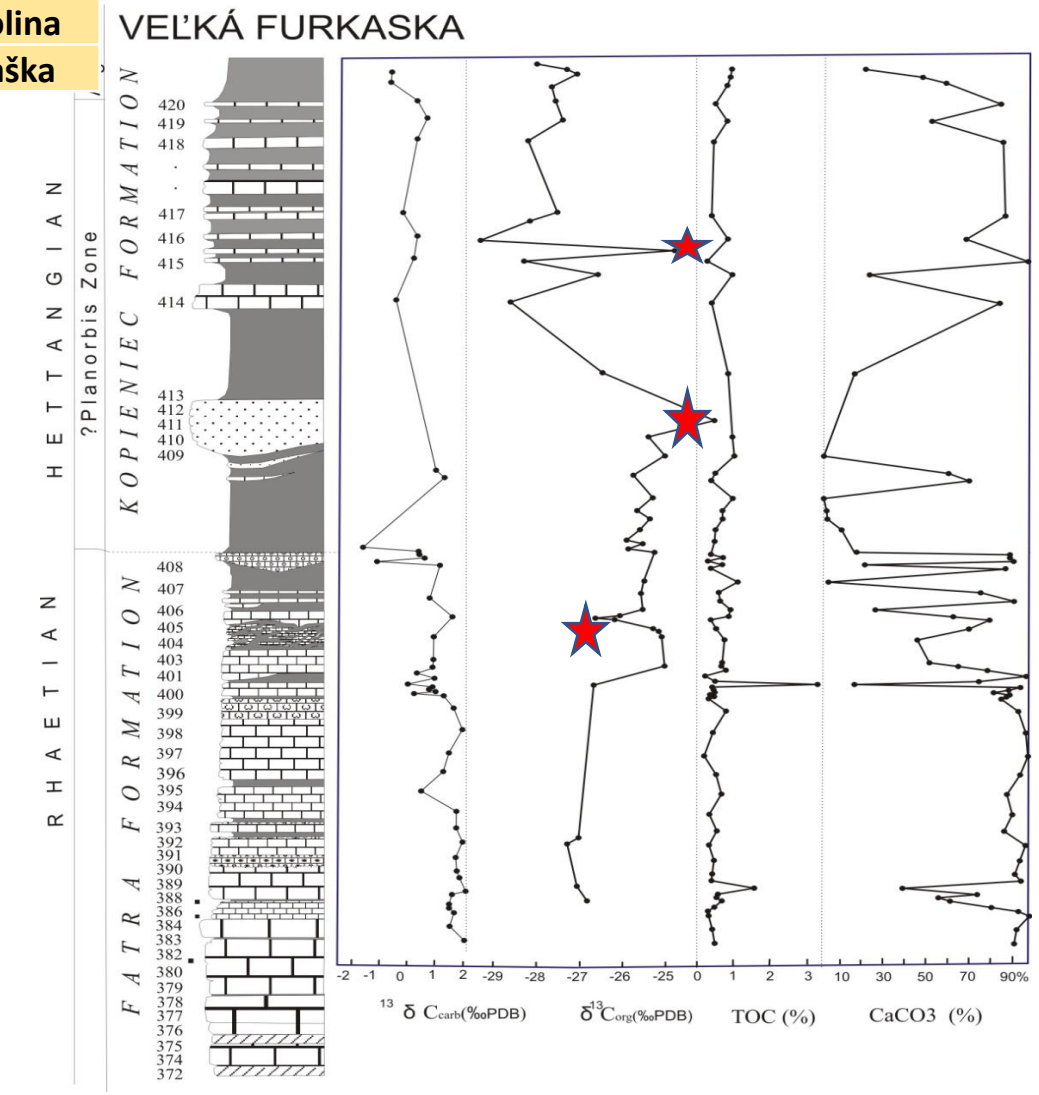
Stratotype - „gold point“



Micha Ruhl,[1,2*] Nina R. Bonis,[1,3] Gert-Jan Reichart,[4] Jaap S. Sinninghe Damsté,[4,5] Wolfram M. Kürschner[1,6]

Sections	Fatra Fm.	Boundary interval	Fatra Fm.	Boundary interval	
$\hat{o}^{13}C_{org}$ (‰)	Rozsah	Rozsah	Rozsah	Rozsah	TOC (%)
Kardolina	-24.64 to -28.33	- 27.3 to - 20.81	0.1 to 0.5	0.16 to 0.68	Kardolina
Furkaška	- 27.10 to -27.8	- 29.36 to - 24.78	0.1 to 0.4	1.24 to 2.89	Furkaška





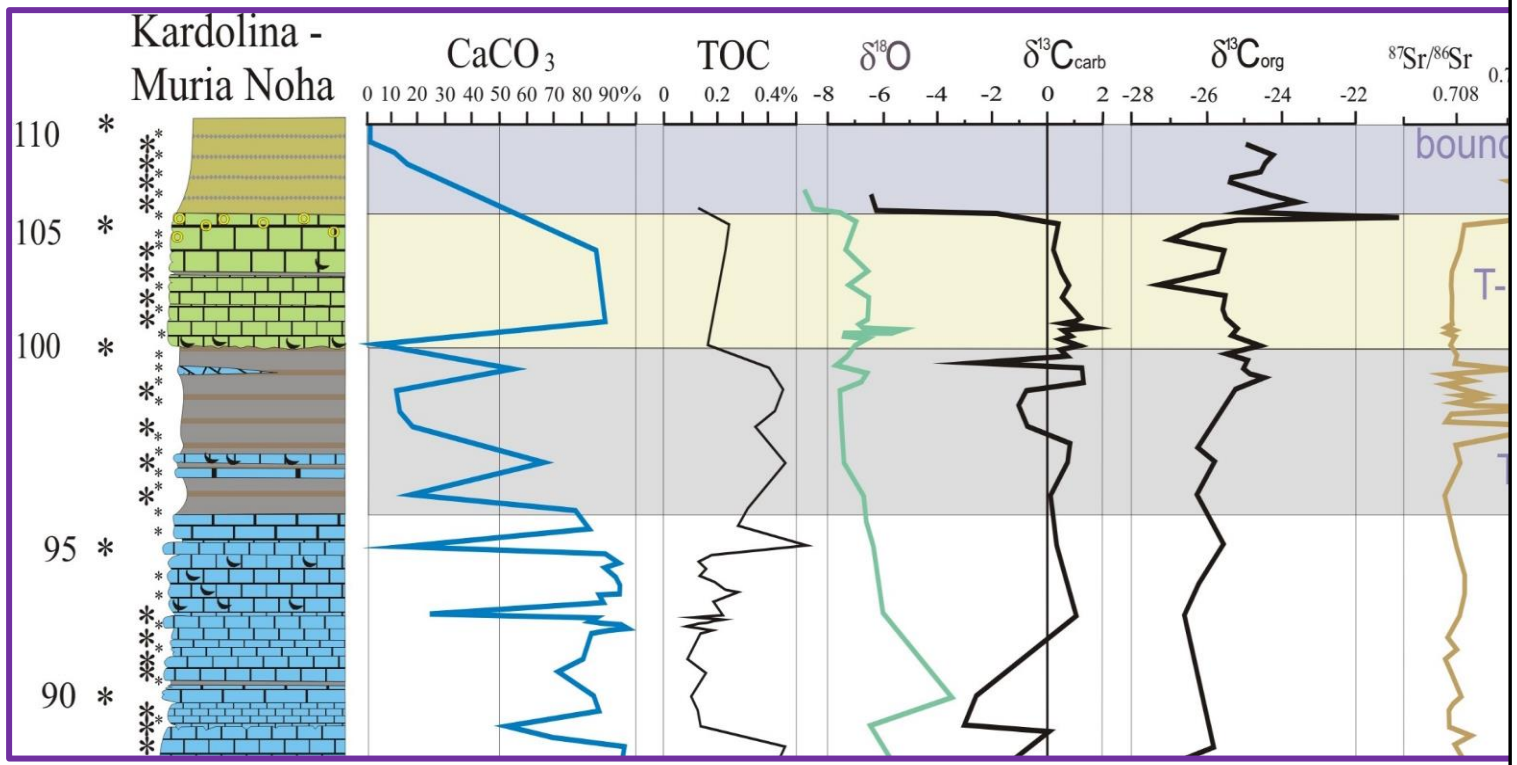
Vďačný M., Michalík J. ,Lintnerová O. 2019 : Tectonic discrimination of siliciclastic sedimentary record of the northern Tethyan margin at the end of the Triassic

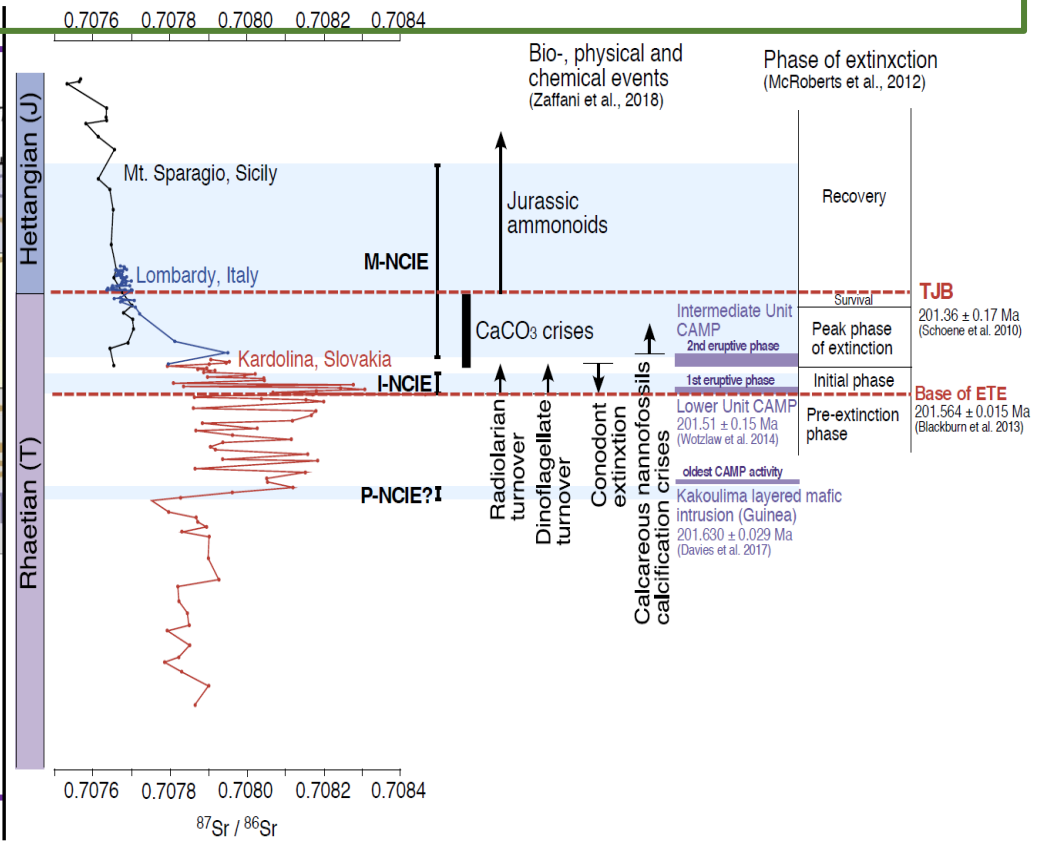
Lintnerová, O. - Michalík, J. - Uhlík, P. - Soták, J.- Weissová, Z. 2013: : Latest Triassic climate humidification and kaolinite formation (Western Carpathians, Tatric Unit of the Tatra Mts.)

Triassic-Jurassic Boundary beds: bio-stratigraphy : microfossils extinction level(s) vs. $\delta^{13}C_{org}$

Causes of the $\delta^{13}C$ excursions at the T/J systems boundary remain **under investigation**. **Suggested mechanisms e**xplaining perturbed global C cycle and accelerated biotic extinction :

- Out-gassing during volcanic activity
- Changes in productivity
- Greenhouse climate and ocean anoxia
- Seafloor methane releases





Chemical analyses of rock : provennce and tectonic interpretation

Intesity of weathering vs detrital mineral transport

Cretaceous Research 118 (2021) 104659

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Jurassic – Cretaceous boundary record in Carpathian sedimentary sequences

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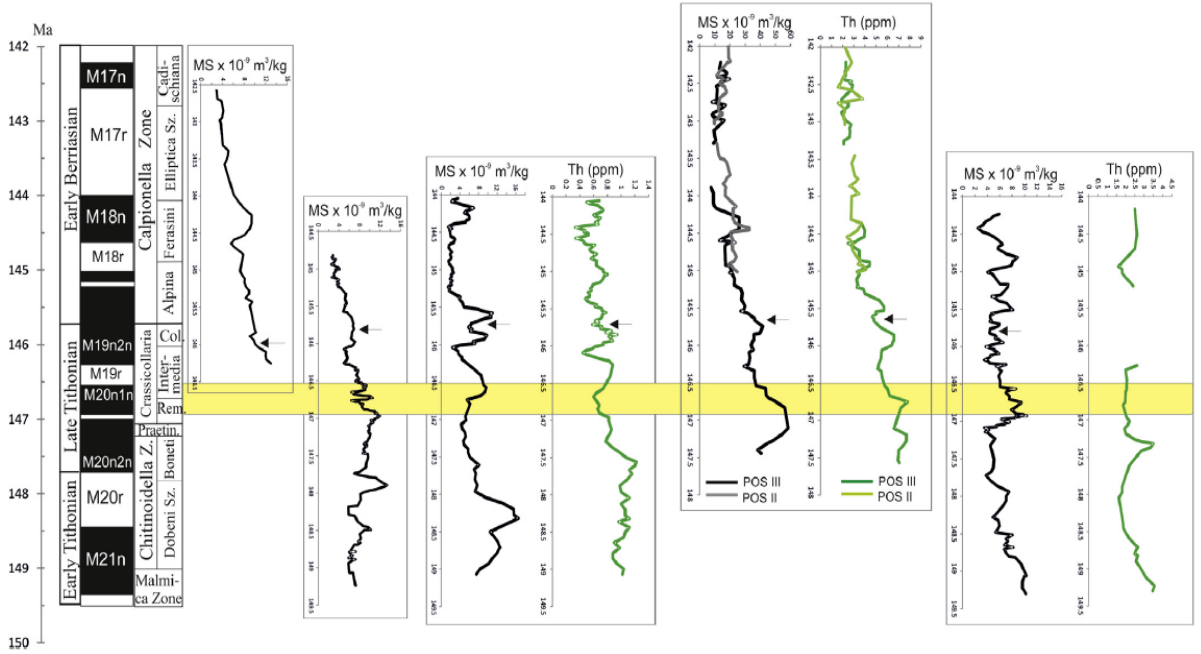


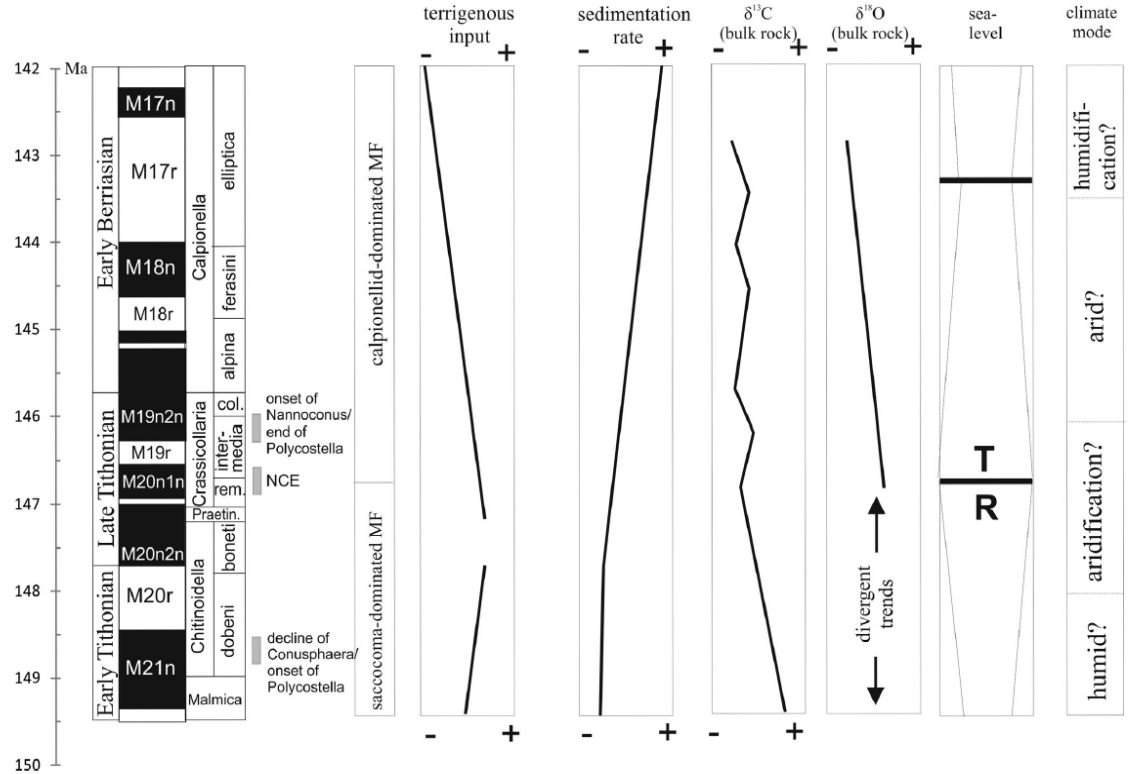
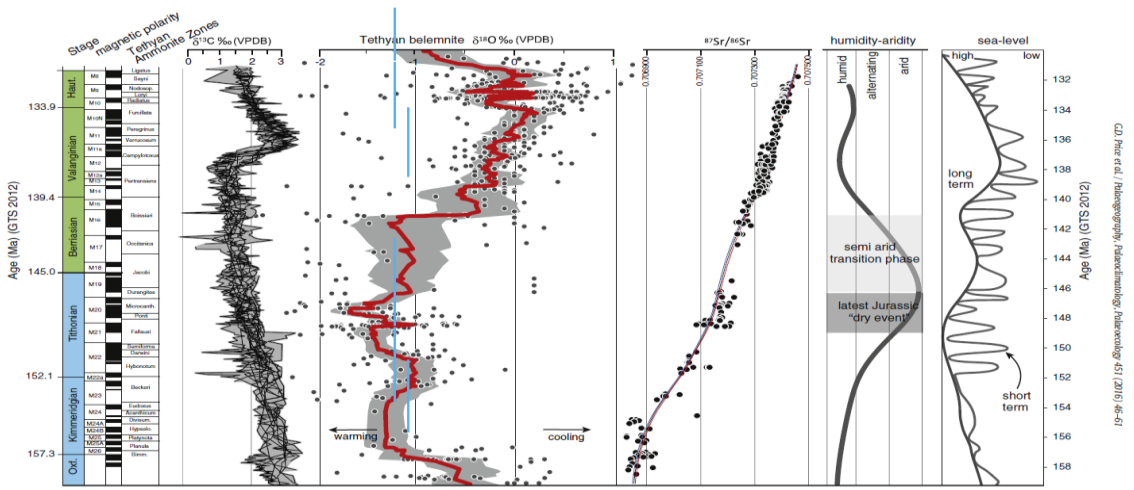
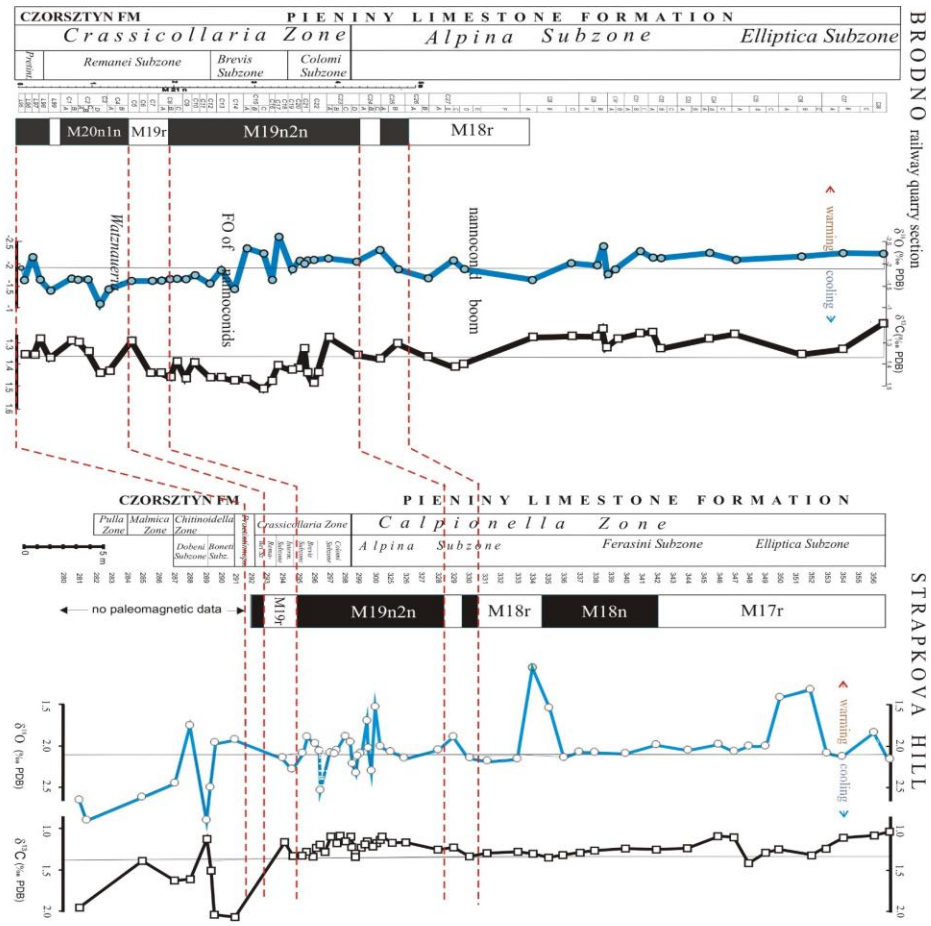
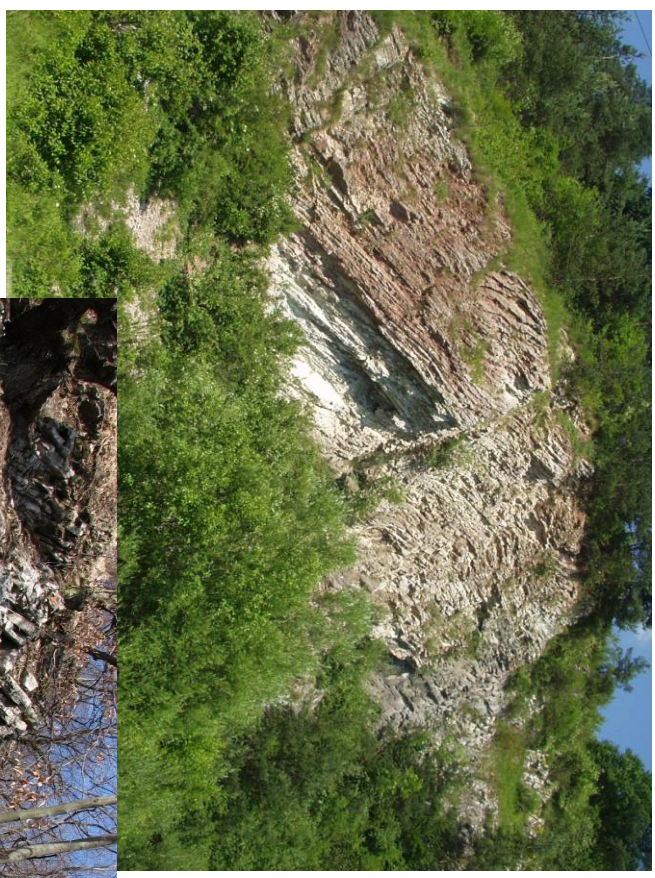


Fig. 12. Summary of palaeoenvironmental events in the Tithonian – Lower Berriasian of the PKB and Central West Carpathians: nannofossil events (Tremolada et al., 2006; Michalik et al., 2009, 2016), microfacies, terrigenous input, sedimentation rate, synthetic $\delta^{13}C$ and $\delta^{18}O$ trends (this study), sea-level (Hardenbol et al., 1998) and climatic changes (after Price et al., 2016).




BRODNO railway quarry section
CZORSZTYN FM
PIENINY LIMESTONE FORMATION
Crassicollaria Zone
Alpina Subzone
Elliptica Subzone
Praetul.
Remanei Subzone
Brevis Subzone
Colomi Subzone
M20n1n
M19r
M19n2n
M18r
Watznaueria
FO of nannoconids
nannoconid boom
warming
cooling
δ18O (‰ PDB)
δ13C (‰ PDB)
STRAPKOVA HILL
CZORSZTYN FM
PIENINY LIMESTONE FORMATION
Pulla Zone
Malmica Zone
Chitinoidella Zone
Crassicollaria Zone
Calpionella Zone
Alpina Subzone
Ferasini Subzone
Elliptica Subzone
Dobeni Subzone
Boneti Subz.
no paleomagnetic data
M19r
M19n2n
M18r
M18n
M17r



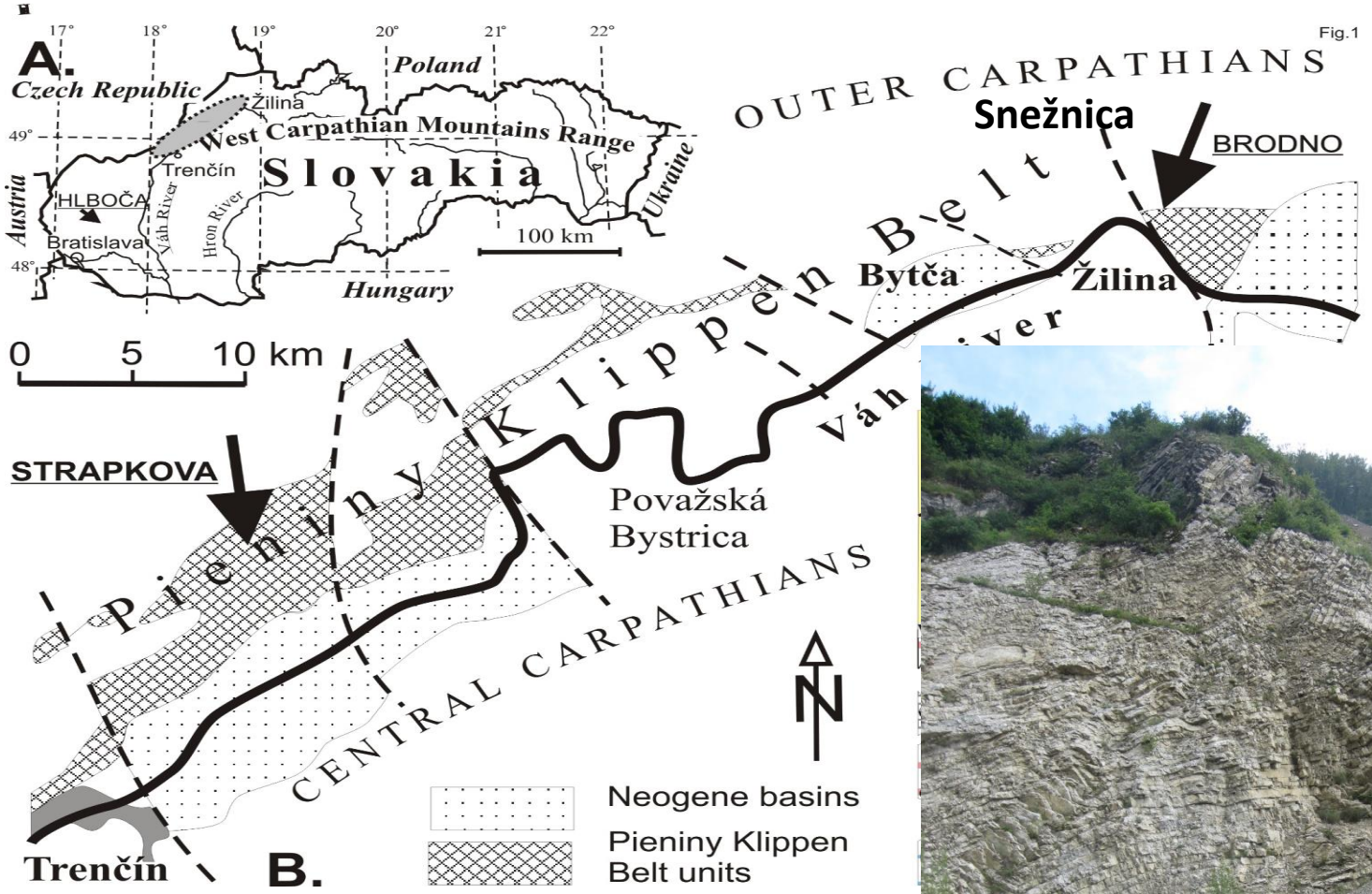
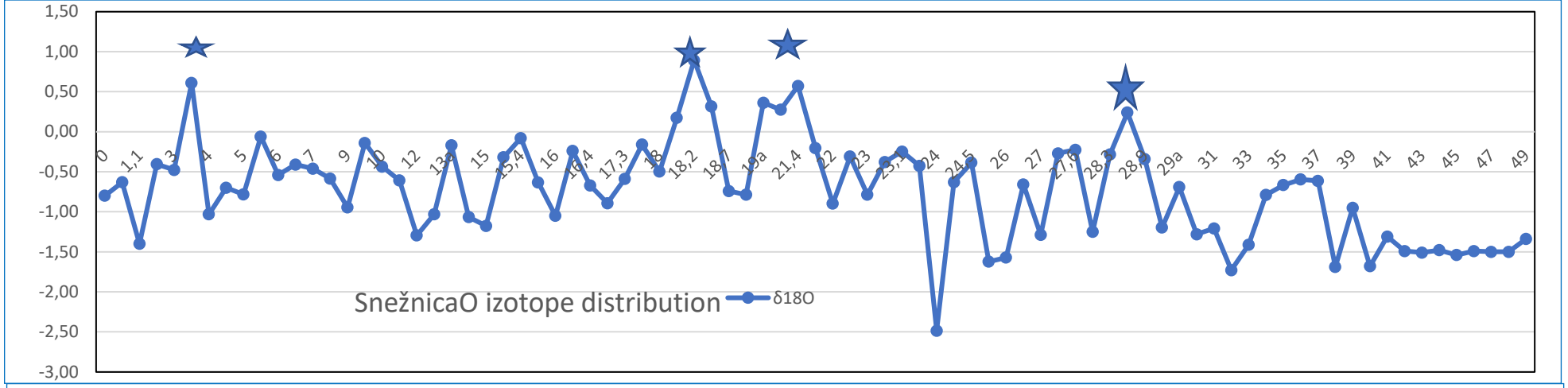
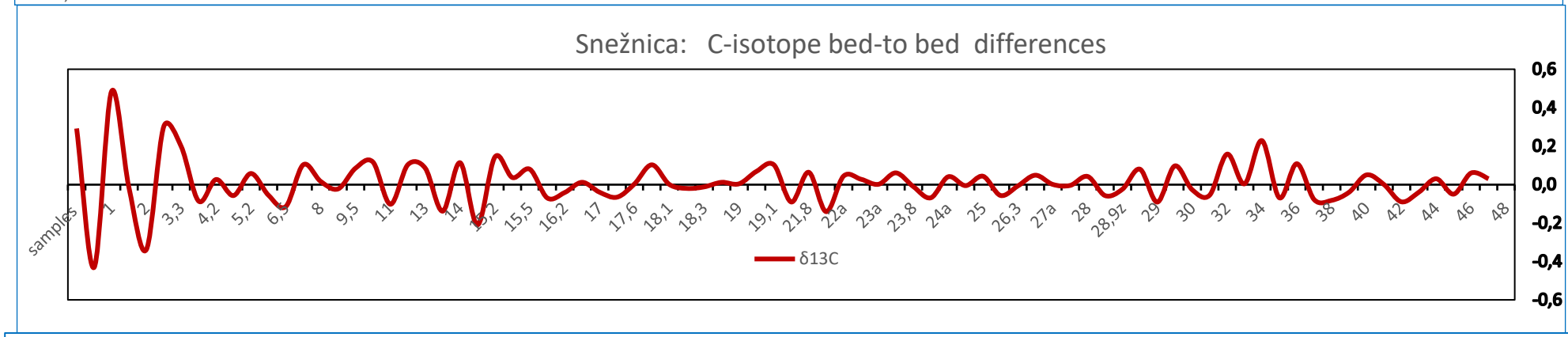


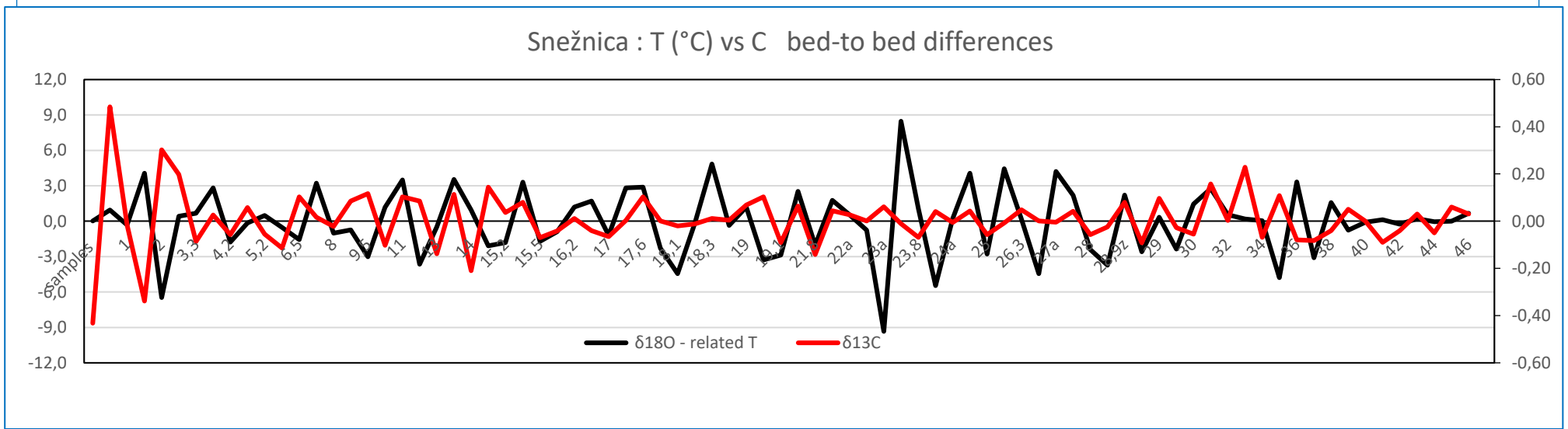
Fig.1
A.
17°
18°
19°
20°
21°
22°
Poland
Czech Republic
Žilina
West Carpathian Mountains Range
49°
Trenčín
Slovakia
Austria
HLBOČA
Váh River
Hron River
Ukraine
Bratislava
100 km
48°
Hungary
0 5 10 km
OUTER CARPATHIANS
Snežnica
BRODNO
Pieniny Klippen Belt
Bytča
Žilina
Váh River
STRAPKOVA
Považská Bystrica
CENTRAL CARPATHIANS
N
Trenčín
B.
Neogene basins
Pieniny Klippen Belt units


21/06/2016


21/06/2016





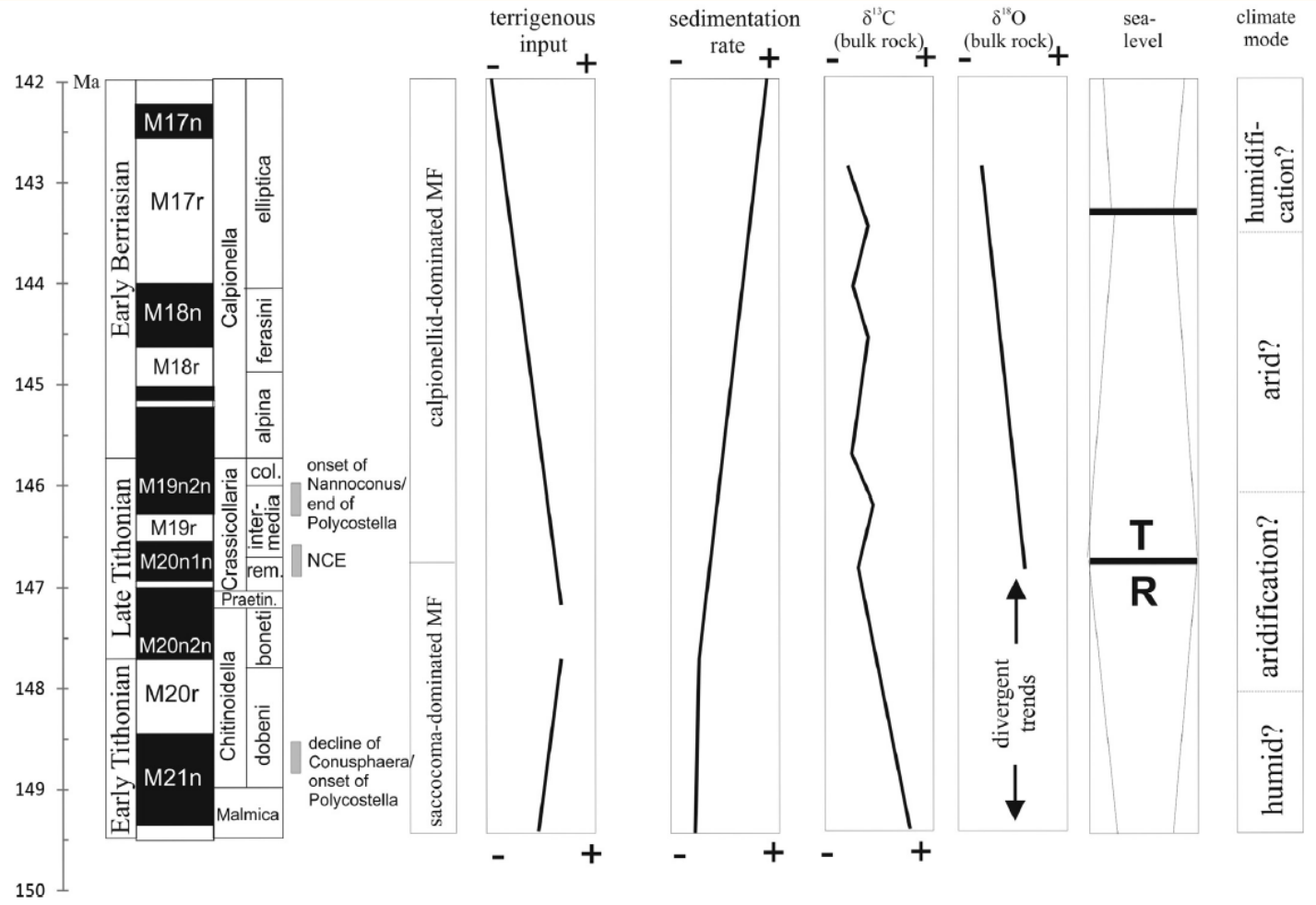


Stars : Shifts of $\delta^{18}O$ composition could be also influenced by meteoric water (released as groundwater from aquifers to basins during eustatic sea level drop in „ greenhause climate mode and/or short time eustatic fluctuations.

new „plankton“ distribution - quantitative data

SNEŽNICA	Samples	$\delta^{13}C$ ‰	$\delta^{18}O$ ‰			Temperature °C		
		rang	rang	$\Delta^{18}O$ ‰	average	rang	Δ T°C	average
Calpionella Ferasini 32-39	8	+0.98 to +1.41	-0.22 to -1.29	1.07	- 1.12*	14.3 to 19.3	5.0	16.56
Calpionella Alpina 31-27	11	+1.32 to +1.42	-0,20 to - 1.29	1.09	- 0,71	10.7 to 17.3	6,6	14.76
Calpionella - Alpina J/K -27	3	+1.36 to +1.41	-1.29 to -0.23	1.6	- 0.59	12.7 to17.3	4.6	14.27
Crassicullaria zona 26 -16	**24)**	**+1.32 to +1.58**						
Crassicollaria Colomi 26-21	14	+1.32 to +1.48	- 2.49 to +0.572	3.8	-0.84	9.4 to 22.8	13.4	14.83
Crassicollaria Intermedia 19-16	10	+1.45 to + 1.58	-1.05 to +0.89	1.94	- 0.19	8.1 to 16.2	8,1	12.58
Chitionella , Malmica 15.5-1	16	+1.39 to +1.78	-0.40 to -1.18	0.78	- 0.72	13.4 to 17.3	3.9	14.94

BRODNO		$\delta^{13}C$ (‰ PDB)	$\delta^{18}O$ (‰ PDB)		T (°C)		
Stratigraphy Michalík et al 2009		rang	rang	average	rang	Δ T°C.	average
Calpionella alpina (C26-C39)	17	+1.20 to +1.42	-2.42 to -1.59	-2.0	18.5 to 22.1	4.5	20.5
Calpionella alpina (C24-C25) J/K	4	+1.28 to +1.39	- 2.39 to -1.76	-2.03	19.3 to 21.6	2.3	20.4
Crassicullaria -Colomi (C17 to C24							
Crassiullaria - Brevis (C12 to c-16)	25	+1.30 to +1.53	-2.27 to -1.26	-1.60	17.1 to 21.6	4.5	19.1
Crassiullaria - Remanei (L99 + C+-C11)							
Chitionidela (dobeni+boneti) Malmica (L57-L75)	22	+1,28 to +1,72	-2.15 to -1.16	-1.66	16.7 to 20.9	4.3	18.8



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the Snežnica Section :
New record of magnetostratigraphic scale
(record in the picture is only „preliminary scale“)

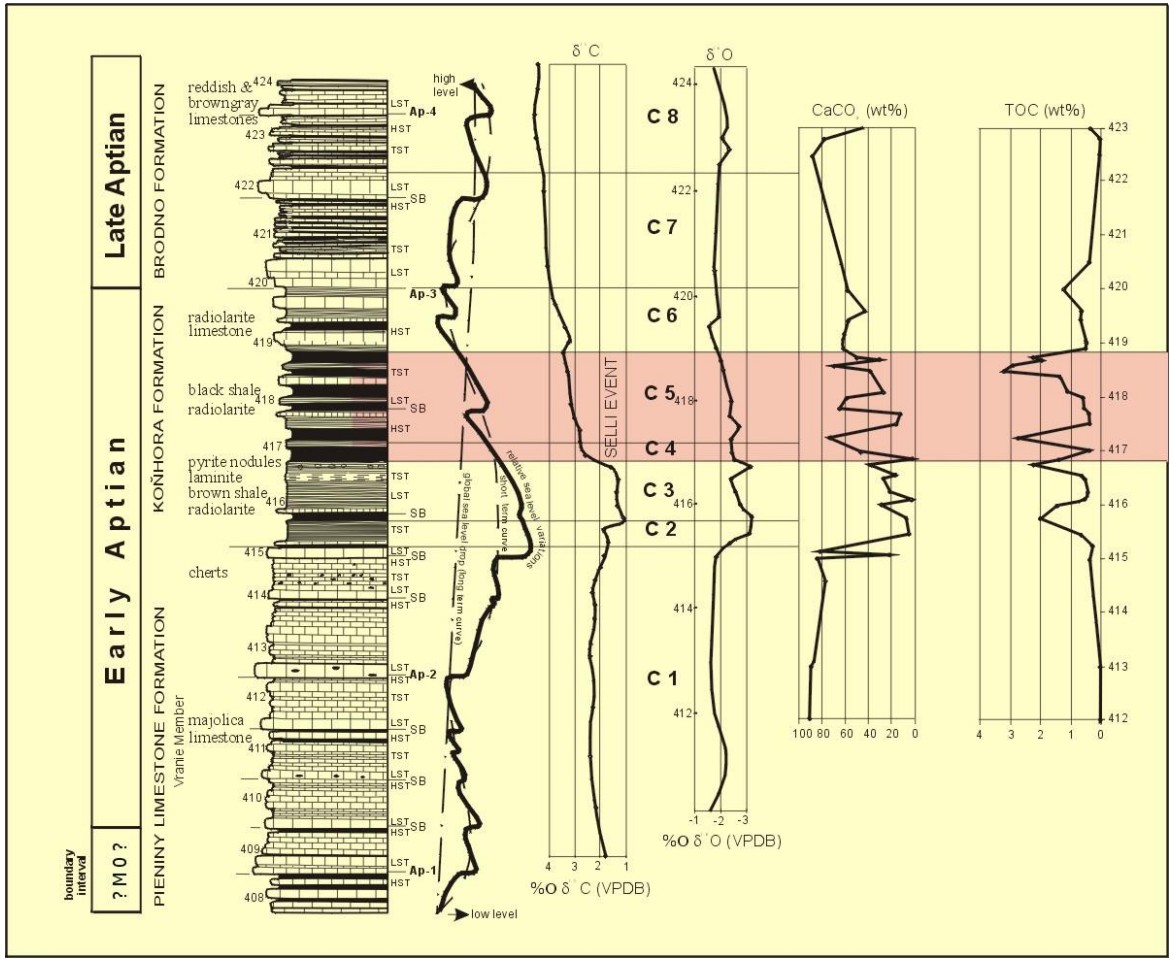
Clay minerlas - kaolinite
- paleoclimatic indicator
- (potentialy selection of the special samples ??)

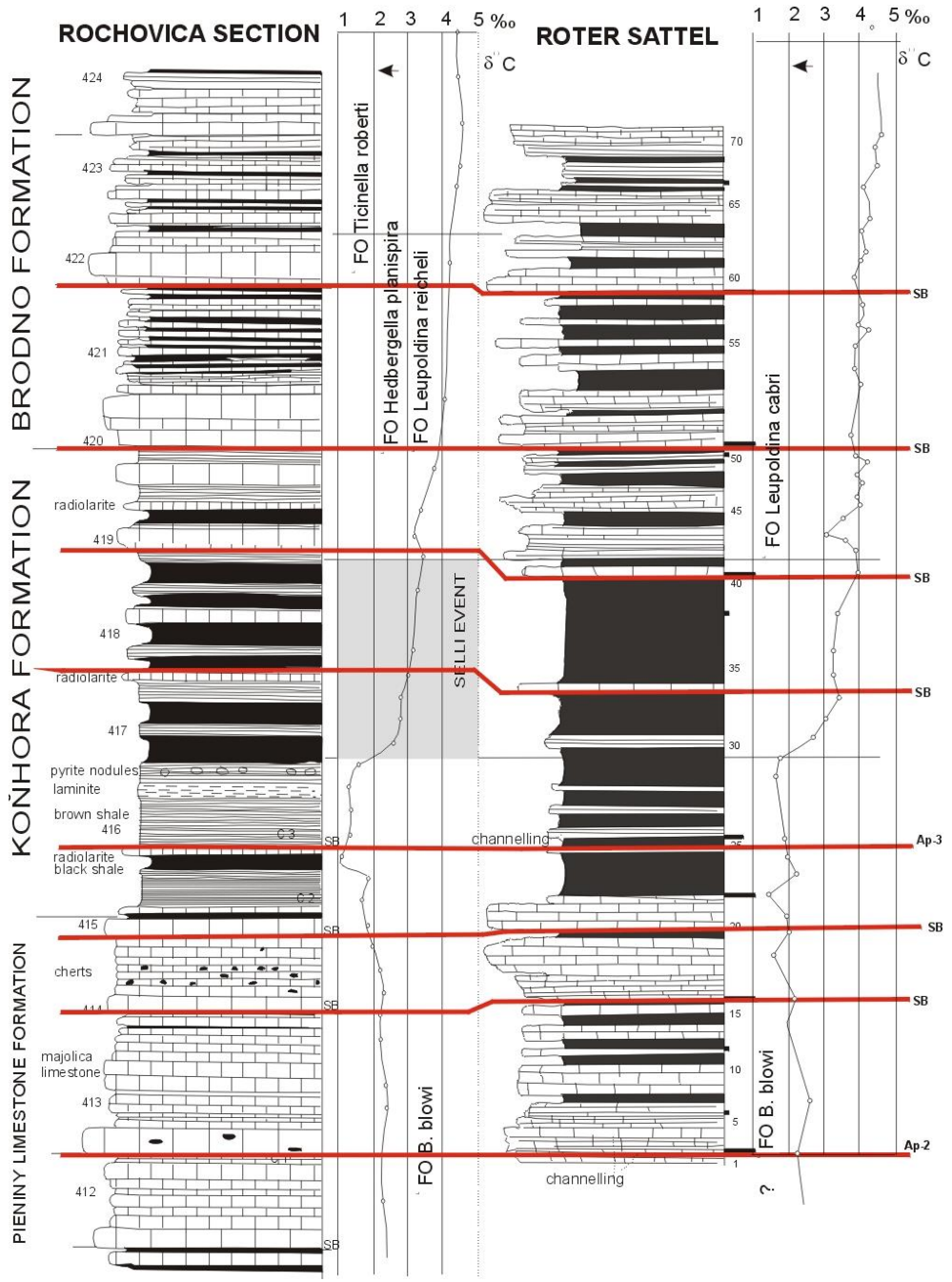
XIVth Jurassica Conference
&
Workshop of the ICS Berriasian Group

(2019 – in Vienna)

Earth Science Institute, Slovak Academy of Sciences
& Faculty of Natural Sciences, Comenius University

Regional correlation

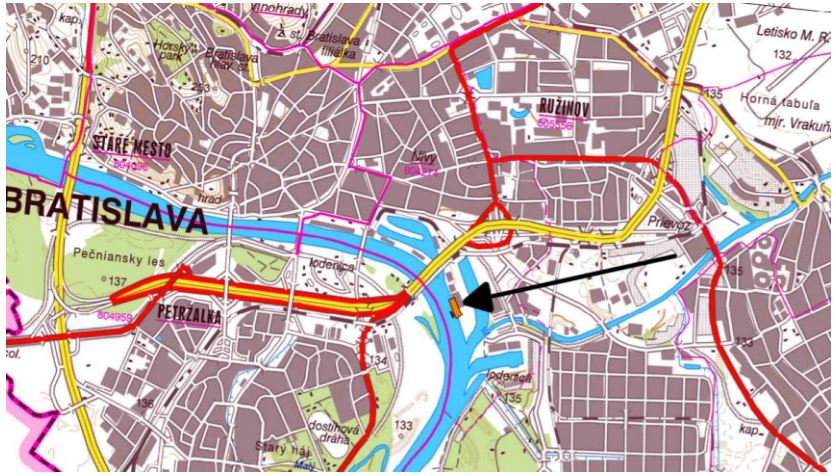




Mineral Material research
APVV - Bentonites - doc. P. Uhlík
VEGA : Effect of mineralogy, chemistry and surface properties of technological types of perlites on quality of expanded perlites and reduction in accumulation of fine perlite by-product by its conversion into zeolites and their environmental application. M. Osacký –

Environmental risk of the ore mining

- Texbook : e- version, in Slovak



Fossil fuels geology courses

- Hot topic : Natural gas : green vs. blue gas , natural gas taxonomy etc.