NATIONAL SCIENCE CENTRE POLAND

LPSs along Dnieper

UMCS MARIA CURIE-SKŁODOWSKA UNIVERSITY IN LUBLIN

НАЦІОНАЛЬНА АКАДЕМІЯ НАУК УКРАЇНИ 1918

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Loess chromaticity as an environmental change recorder: spectrophotometric study of aeolian dust and its role in paleoclimate studies

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EGU General Assembly 2024

EGU General Assembly 2024
Vienna, Austria & Online | 14–19 April 2024
Thu, 18 Apr, 11:09–11:11 (CEST) PICO spot 5 | PICO5.13

„Typical” loess colours:

„Redness”

Lightness

„Yellowness”

L*	a*	b*
90.557	-0.612	17.011

pale yellow

5Y 8/2

Approximate sRGB:

237, 228, 195

bright, lightly saturated brown with a distinct yellow tone

L*	a*	b*
80.888	2.902	13.732

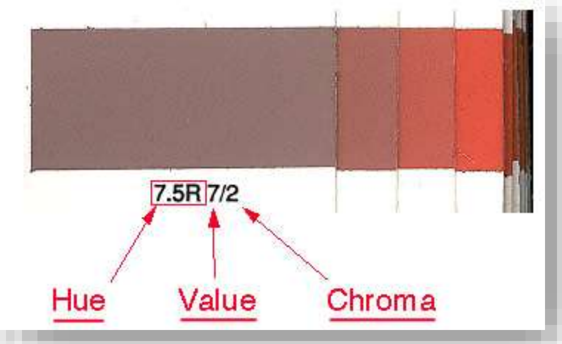
very pale brown

10YR 8/2

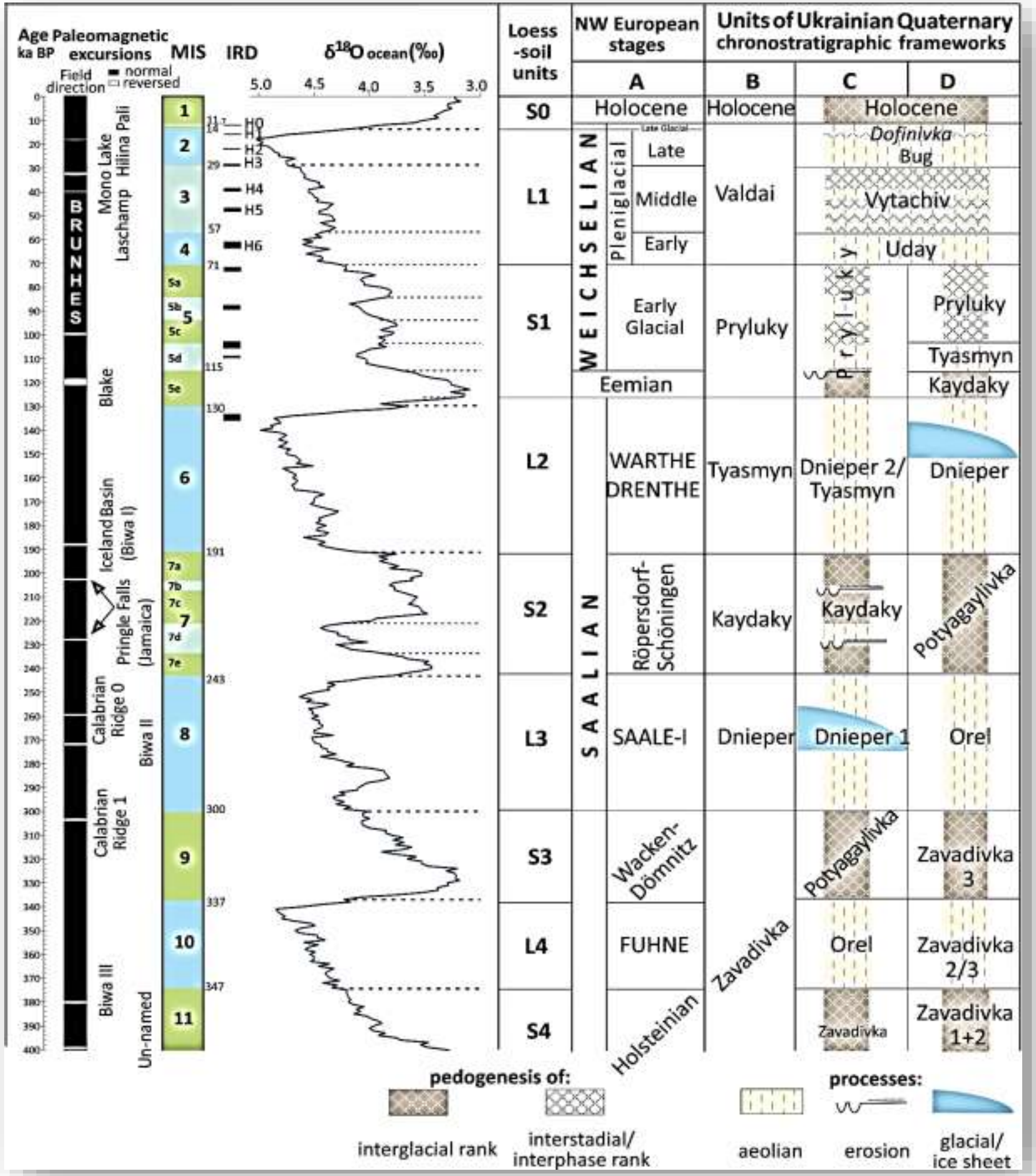
Approximate sRGB:

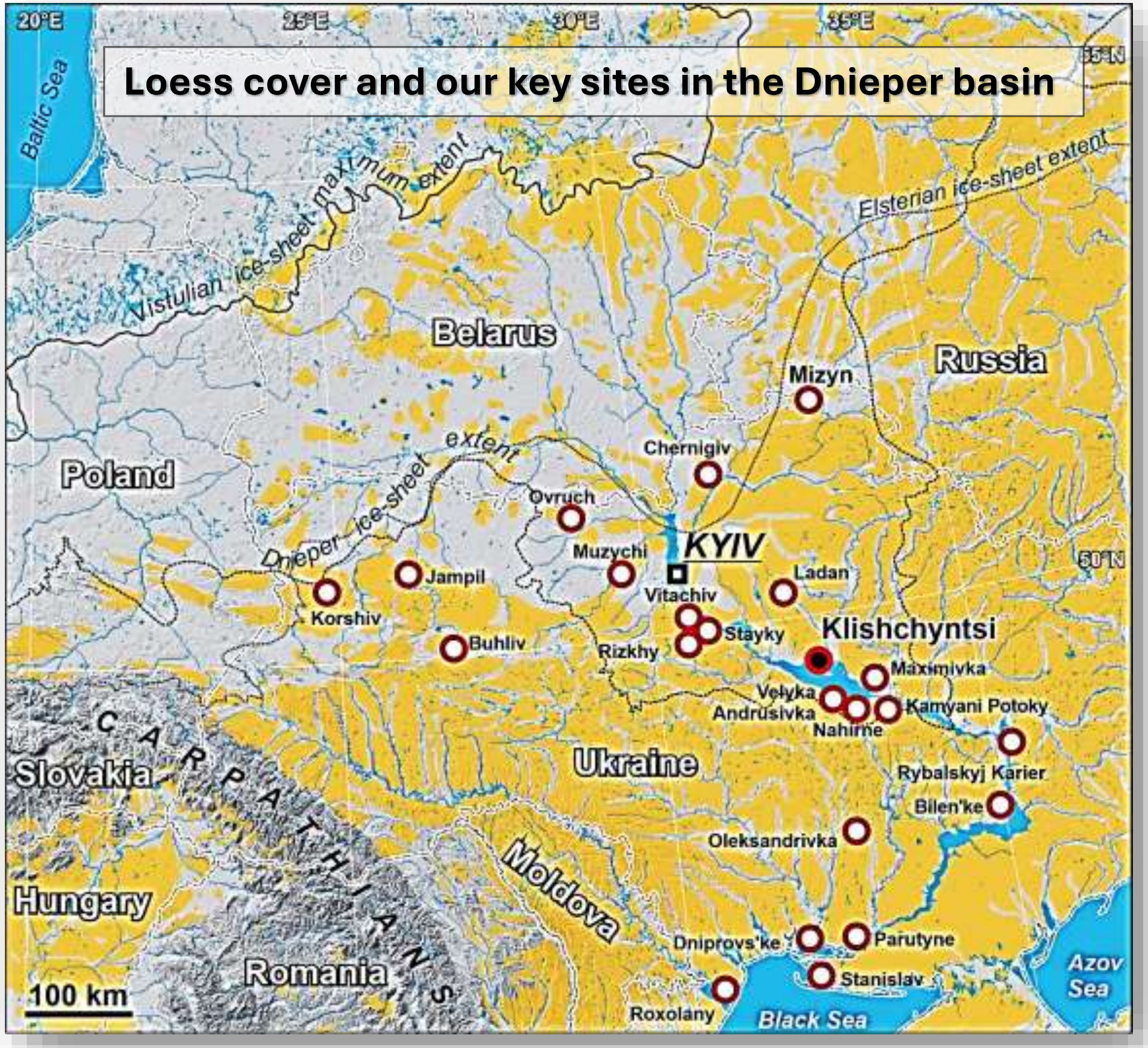
214, 198, 175

light, slightly saturated brown with a distinct red tone

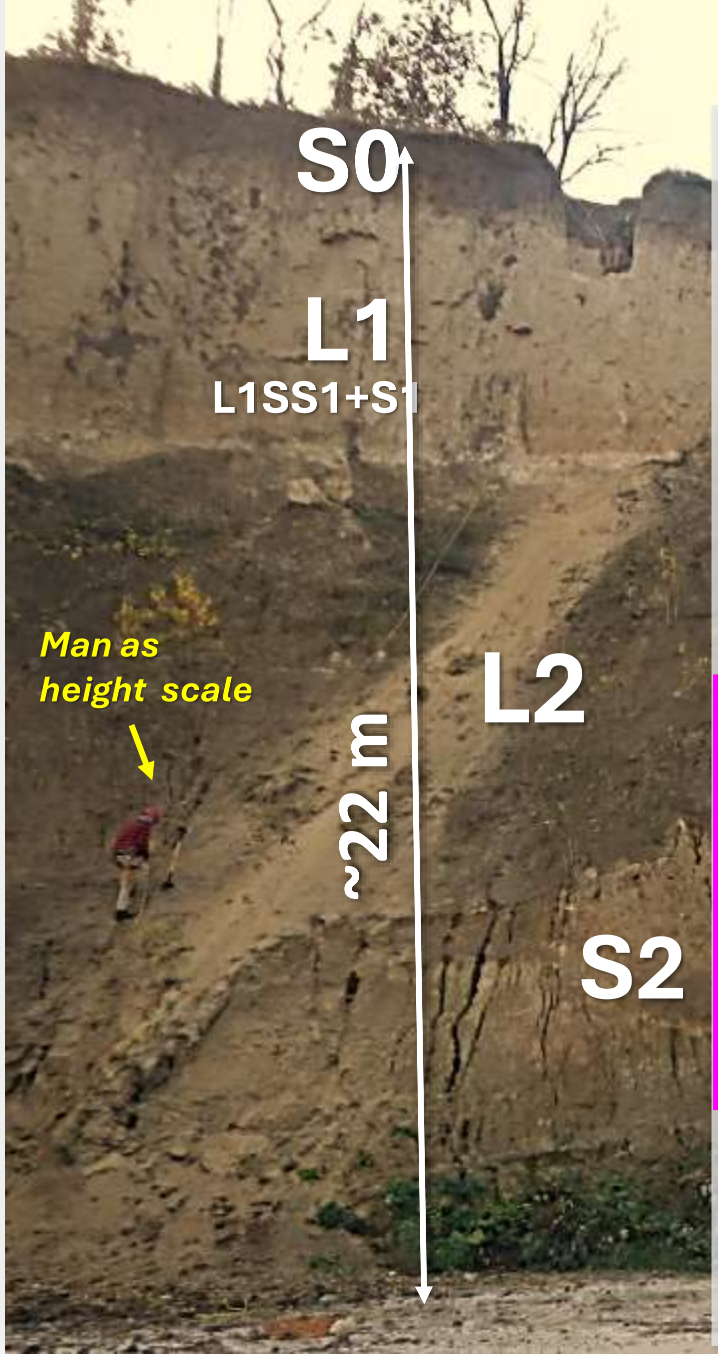


Pleistocene stratigraphy of Ukraine





Field and laboratory investigations



The following laboratory measurements were used:

Field mapping and sampling of sections

- Interval: 5 cm (high resolution!)

Grain size analyses:

- Particle measurement: 0.01 – 2000 μm
- Fractions (and subfractions)
- Granulometric indices: mean grain size, skewness, kurtosis, GSI, U ratio
- Heat map: 100 logarithmic classes in terms of %

Spectrophotometric analyses:

- L* - lightness (black vs. white)
- a* - redness (green vs. red)
- b* - yellowness (blue vs. yellow)
- Redness index
- RGB colors + tuning (Rmax)
- digital Munsell colour

Chemical analyses (ACME, Canada):

- 44 major elements,
- 20 trace elements,
- 14 rare earth elements
- 46 geochemical indices

Others:

OSL and 14-C datings, AMS, magnetic susceptibility, biome reconstruction and thermo-humidity parameters based on paleobotanical materials, small mammals

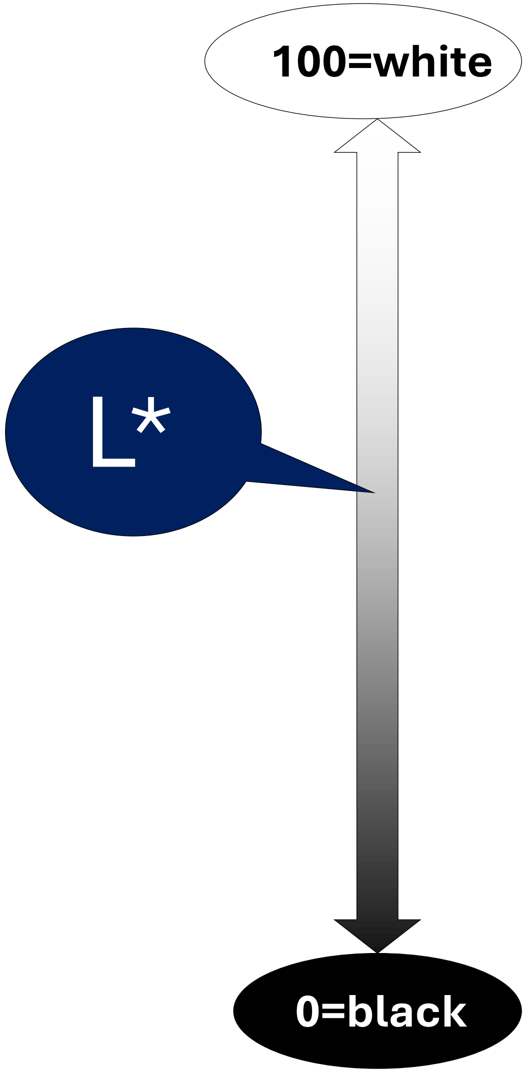
Laboratory spectrophotometric measurements:

- ✓8 mm measurement aperture in the shape of a circle
- ✓Operating principle: emission of a light beam followed by the measurement of light reflected by a system of detectors
- ✓Wavelength range: 400 – 700 nm (resolution every 10 nm)
- ✓Compact size
- ✓Wireless operation
- ✓Fast measurement: about 1 second
- ✓Digital archiving of measurement results

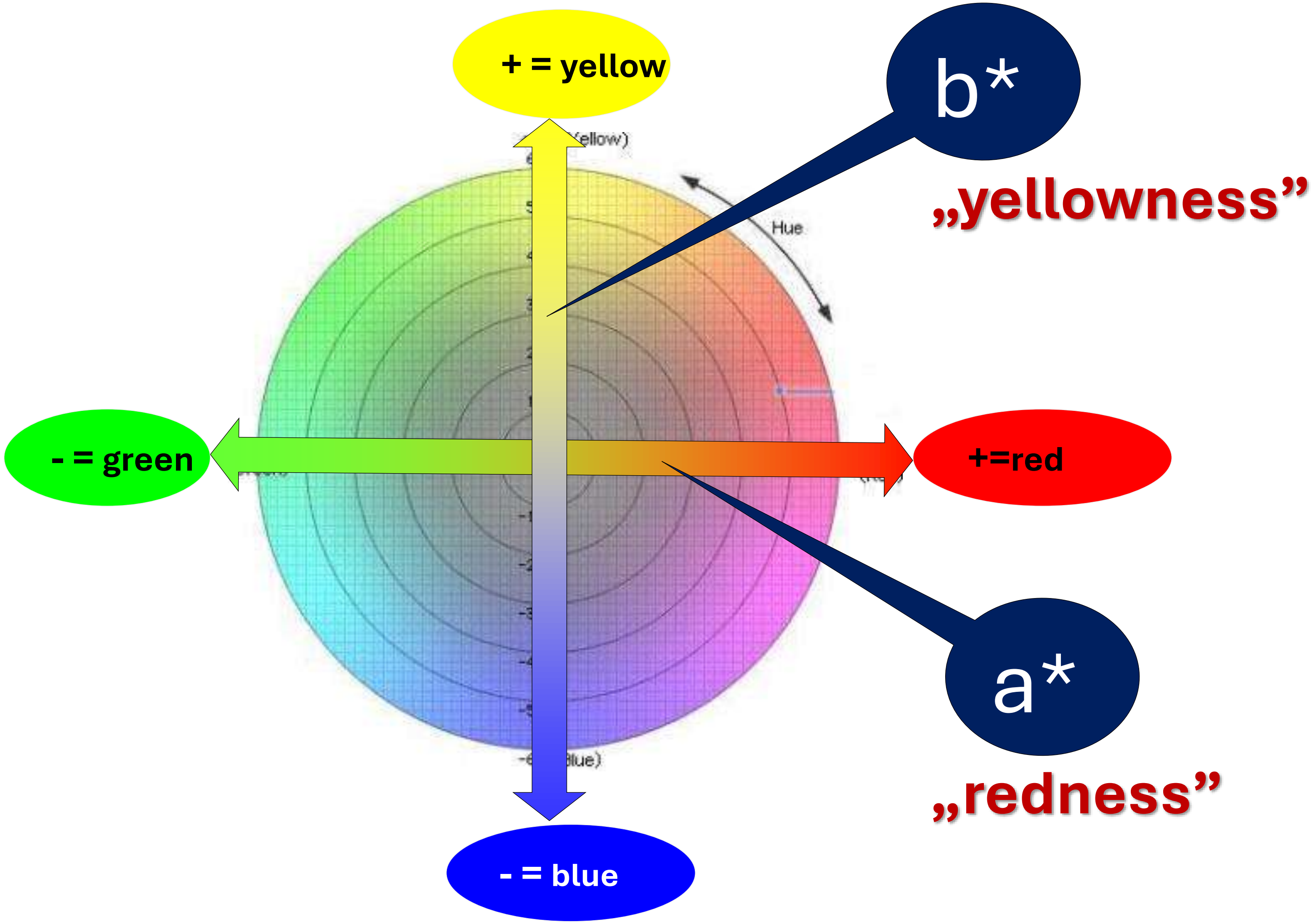
	A	B	C	D	E	F	G	H	I	
1	głębokość	Name	Test Mode	Light/Deg	L*	a*	b*	a do b	DL*	Da*
2	0,1	CH_001	SCI	D65/10°	57,01	3,6	10,29	5,54033	0,03	
3	0,2	CH_002	SCI	D65/10°	60	4,4	12,92	4,643963	3,02	
4	0,3	CH_003	SCI	D65/10°	62,91	5,12	15,09	4,168986	5,93	
5	0,4	CH_004	SCI	D65/10°	64,82	5,5	16,58	3,90953	7,84	
6	0,5	CH_005	SCI	D65/10°	65,85	5,24	16,52	3,986077	8,87	
7	0,6	CH_006	SCI	D65/10°	66,54	4,8	16,1	4,132919	9,57	
8	0,7	CH_007	SCI	D65/10°	66,69	4,6	15,58	4,280488	9,71	

Spectrophotometry – a measurement technique that involves the quantitative measurement of the transmission or reflection of light (visible) by a sample.

„Lightness (luminance)"



Coordinate system L*a*b*



Redness index RILAB-BT

according to Barrón and Torrent (1986):

$$RI_{LAB-BT} = \frac{a* \left((a*)^2 + (b*)^2 \right)^{0.5} . 10^{10}}{b* . L*^6}$$

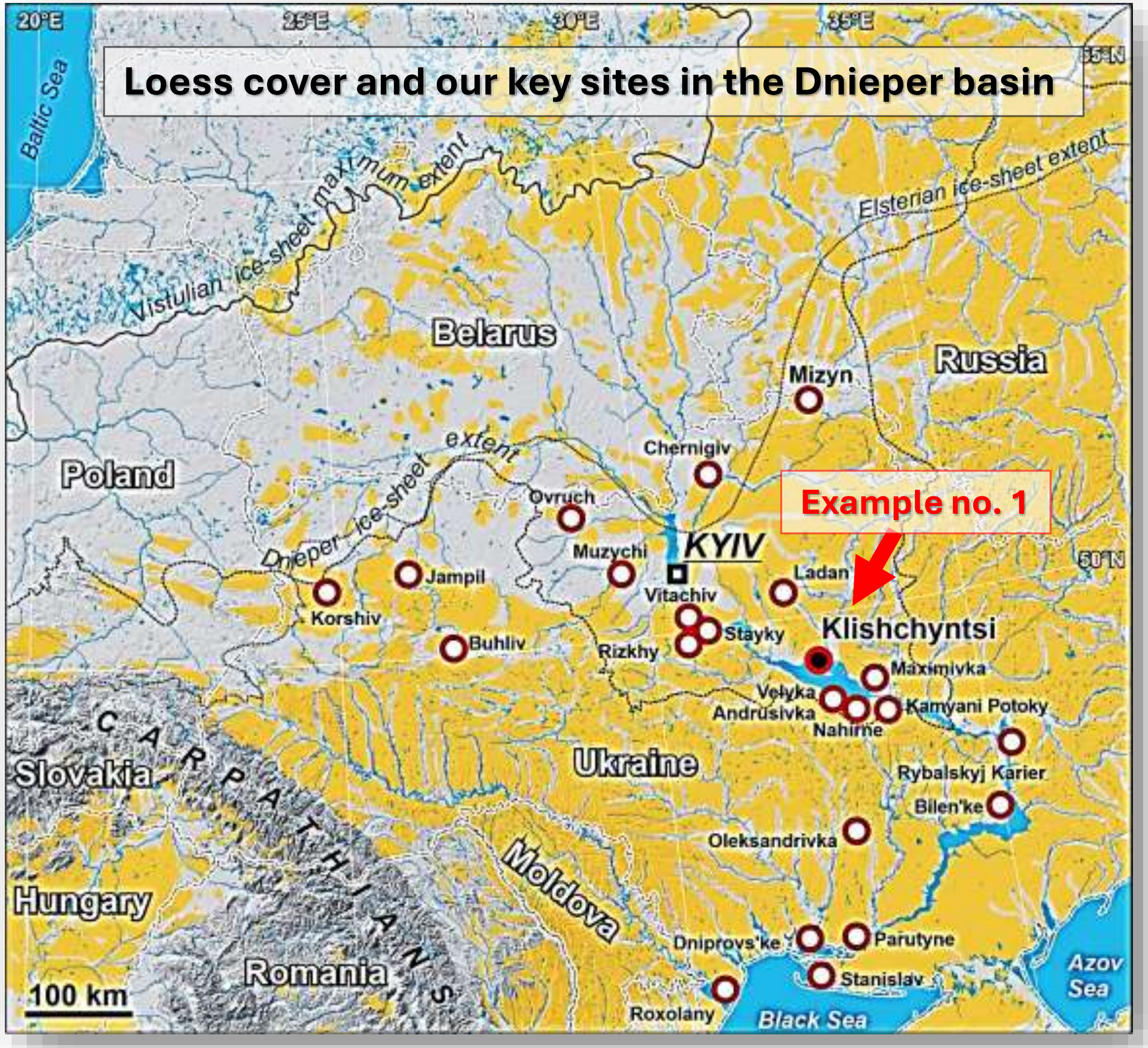
Korshiv_2018_marzec2021 - Excel

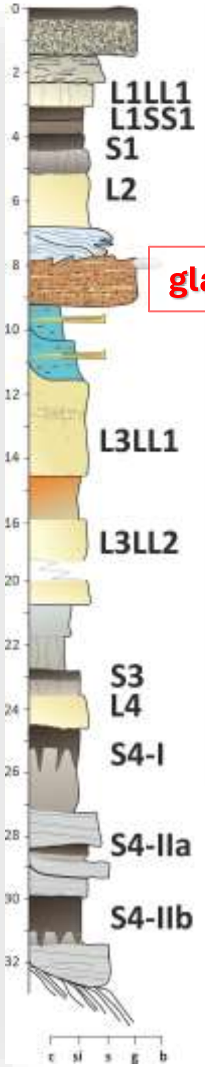
I9 =POTĘGA(H9;0,5)

Głębokość	Name	L*	a*	b*	a do potegi 2	b do potegi 2	suma potęg	suma potęg do potęgi 0,5	razy a	razy 10 do potęgi 10	L do 6	b razy L6	wynik
5	Korshiv_001	53,24	2,55	7,55	6,5025	57,0025	63,505	7,969002447	20,32096	2,0321E+11	22773421316	1,71939E+11	1,181868
10	Korshiv_002	51,25	2,56	7,06	6,5536	49,8436	56,3972	7,509806922	19,22511	1,92251E+11	18120209660	1,27929E+11	1,502799
15	Korshiv_003	57,83	2,84	9,23	8,0656	85,1929	93,2585	9,657044061	27,42601	2,7426E+11	37404095212	3,4524E+11	0,794405
20	Korshiv_004	59,12	2,93	9,76	8,5849	95,2576	103,8425	10,19031403	29,85762	2,98576E+11	42697903595	4,16732E+11	0,716471
25	Korshiv_005	63,27	2,97	10,92	8,8209	119,2464	128,0673	11,31668238	33,61055	3,36105E+11	64148574022	7,00502E+11	0,479806
30	Korshiv_006	62,45	3,03	10,88	9,1809	118,3744	127,5553	11,29403825	34,22094	3,42209E+11	59319114075	6,45392E+11	0,530235
35	Korshiv_007	63,84	3,14	11,39	9,8596	129,7321	139,5917	11,81489314	37,09876	3,70988E+11	67695105601	7,71047E+11	0,481148
40	Korshiv_008	61,27	3,17	10,89	10,0489	118,5921	128,641	11,34200159	35,95415	3,59541E+11	52903850446	5,76123E+11	0,624071
45	Korshiv_009	63,21	3,41	12,2	11,6281	148,84	160,4681	12,6676004	43,19652	4,31965E+11	63784439267	7,7817E+11	0,555104
50	Korshiv_010	61,27	3,08	10,84	9,4864	117,5056	126,992	11,26907272	34,70874	3,47087E+11	52903850446	5,73478E+11	0,605233
55	Korshiv_011	63,42	3,2	11,53	10,24	132,9409	143,1809	11,96582216	38,29063	3,82906E+11	65066496999	7,50217E+11	0,510394
60	Korshiv_012	64,82	3,43	12,62	11,7649	159,2644	171,0293	13,0778171	44,85691	4,48569E+11	74174420188	9,36081E+11	0,479199
65	Korshiv_013	63,03	3,38	12,2	11,4244	148,84	160,2644	12,65955765	42,7893	4,27893E+11	62702353587	7,64969E+11	0,55936
70	Korshiv_014	62,38	3,39	11,74	11,4921	137,8276	149,3197	12,21964402	41,42459	4,14246E+11	58921286741	6,91736E+11	0,59885
75	Korshiv_015	64,81	3,42	12,94	11,6964	167,4436	179,14	13,38431918	45,77437	4,57744E+11	74105787835	9,58929E+11	0,477349
80	Korshiv_016	64,88	3,51	12,8	12,3201	163,84	176,1601	13,27253179	46,58659	4,65866E+11	74587327632	9,54718E+11	0,487962
85	Korshiv_017	63,36	3,39	12,23	11,4921	149,5729	161,065	12,69113864	43,02296	4,3023E+11	64698023224	7,91257E+11	0,543729
90	Korshiv_018	66,01	3,96	14,74	15,6816	217,2676	232,9492	15,26267342	60,44019	6,04402E+11	82729118438	1,21943E+12	0,495644
95	Korshiv_019	64,58	3,61	13,2	13,0321	174,24	187,2721	13,68473968	49,40191	4,94019E+11	72541786042	9,57552E+11	0,515919
100	Korshiv_020	65,15	3,6	13,38	12,96	179,0244	191,9844	13,85584353	49,88104	4,9881E+11	76469195343	1,02316E+12	0,48752

Example no. 1

Klishchyntsi site

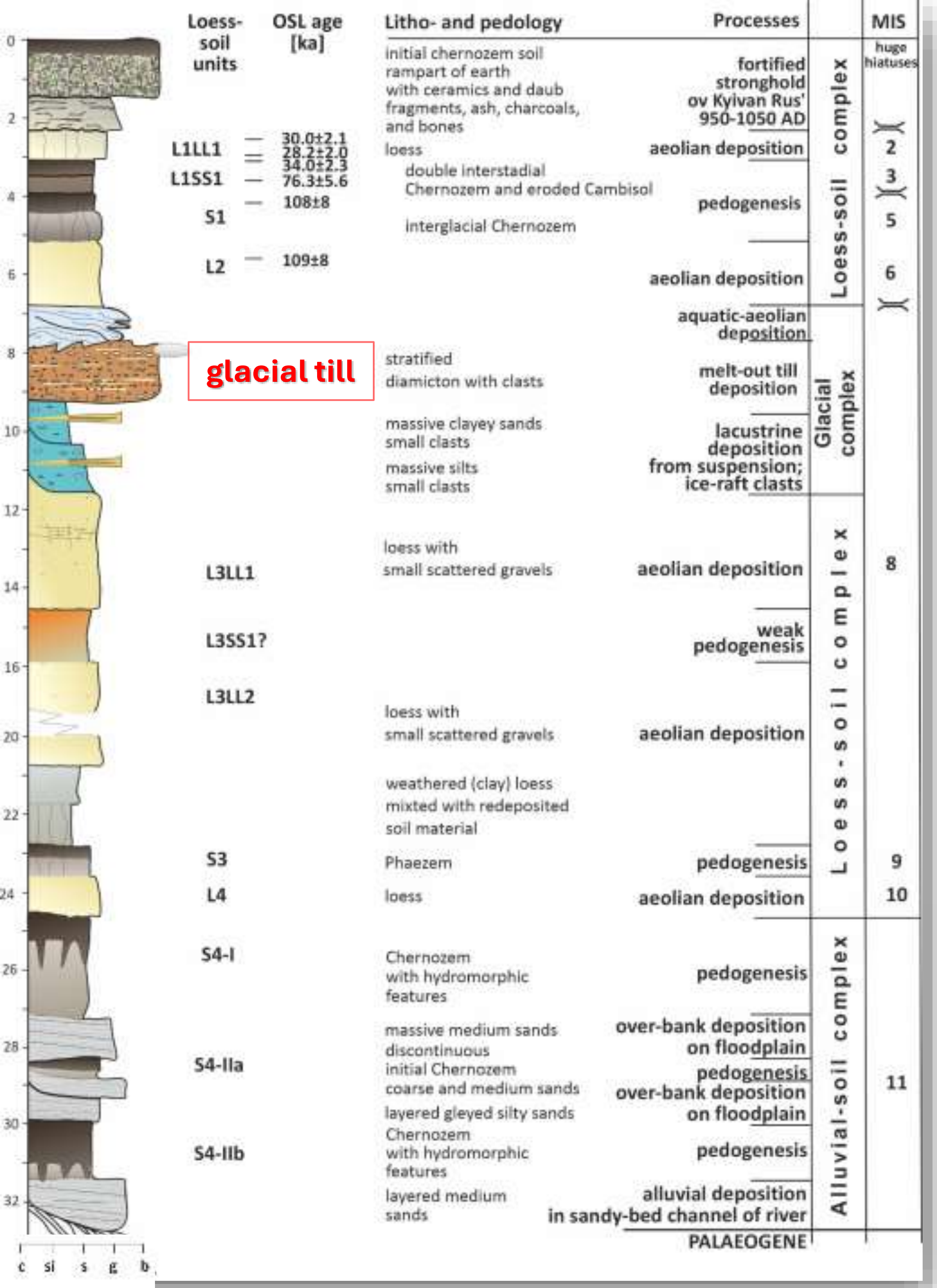


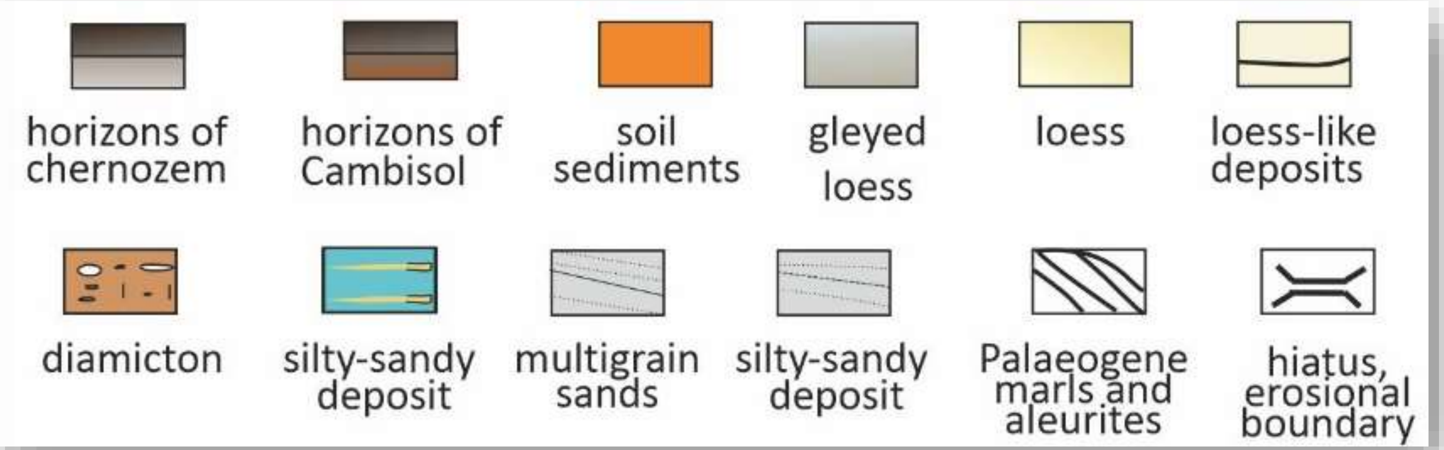


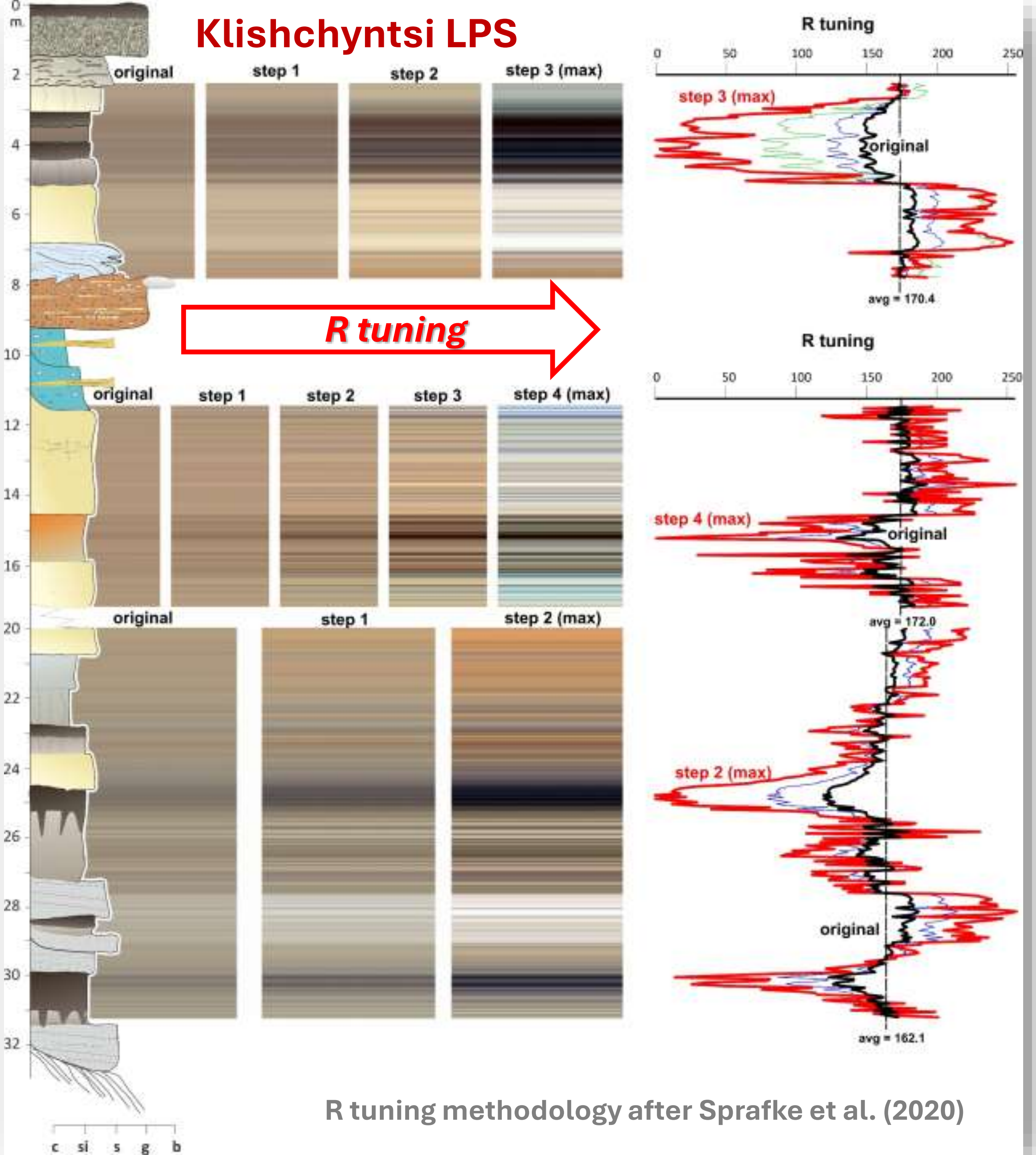
Klishchyntsi section
with loess-palaeosols stratigraphy

Example no. 1

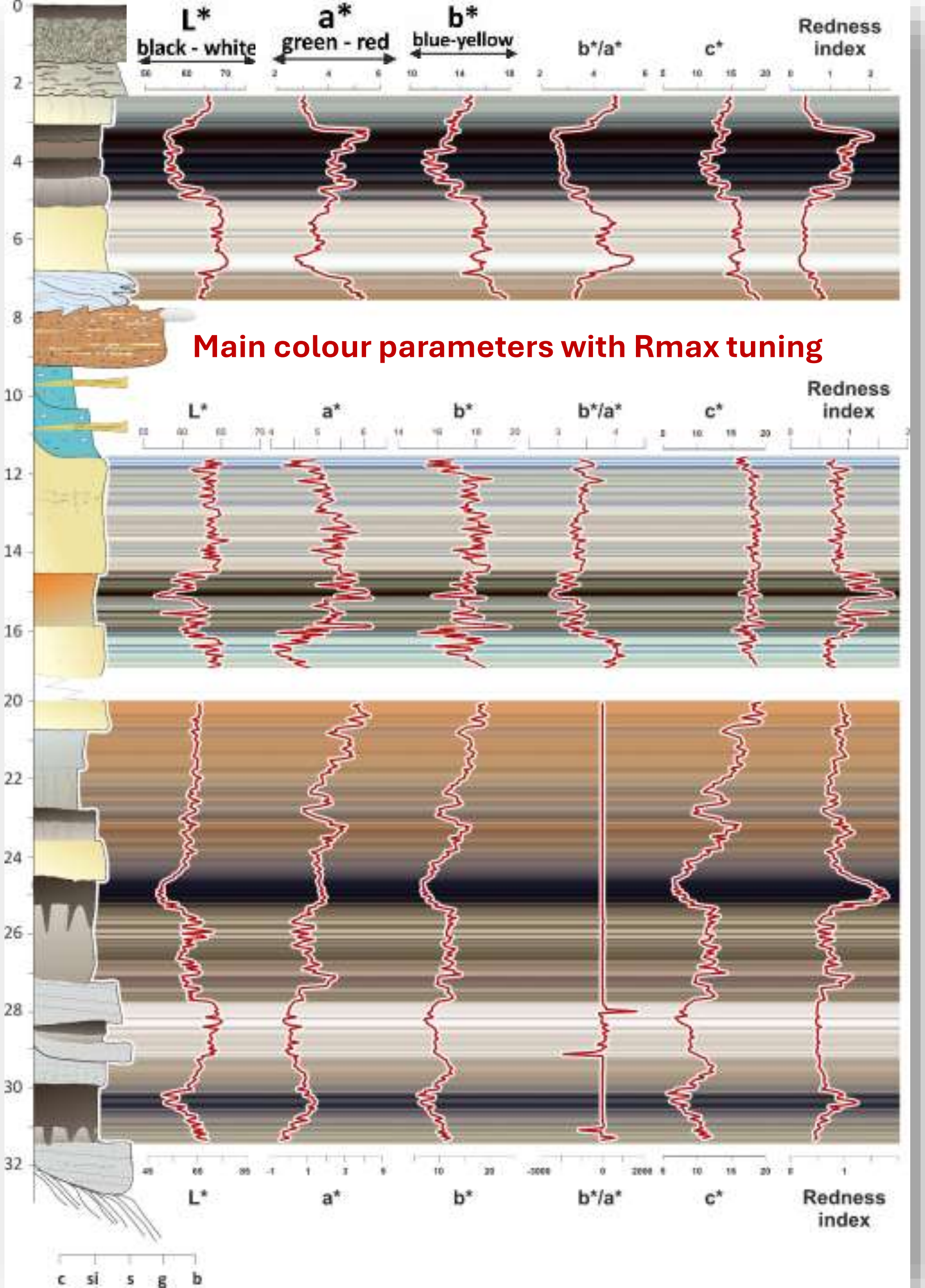
Klishchyntsi LPS – example of our multi-proxy analysis



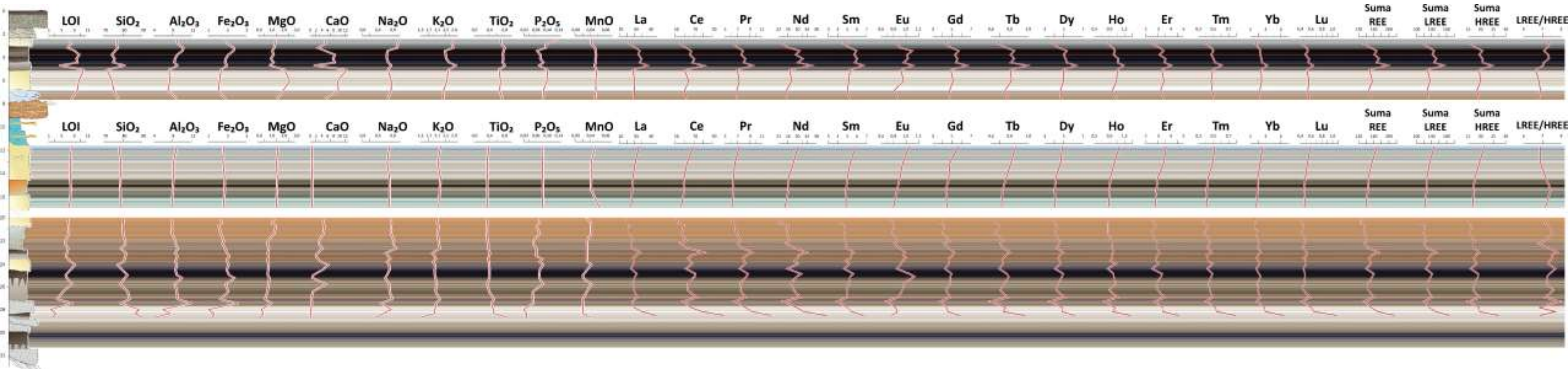




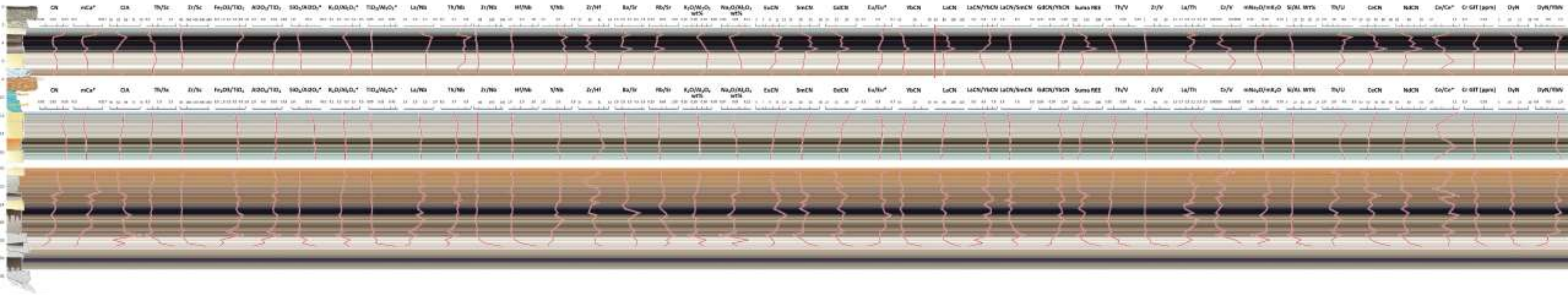
R tuning methodology after Sprafke et al. (2020)



Klishchyntsi LPS – example of our multi-proxy analysis



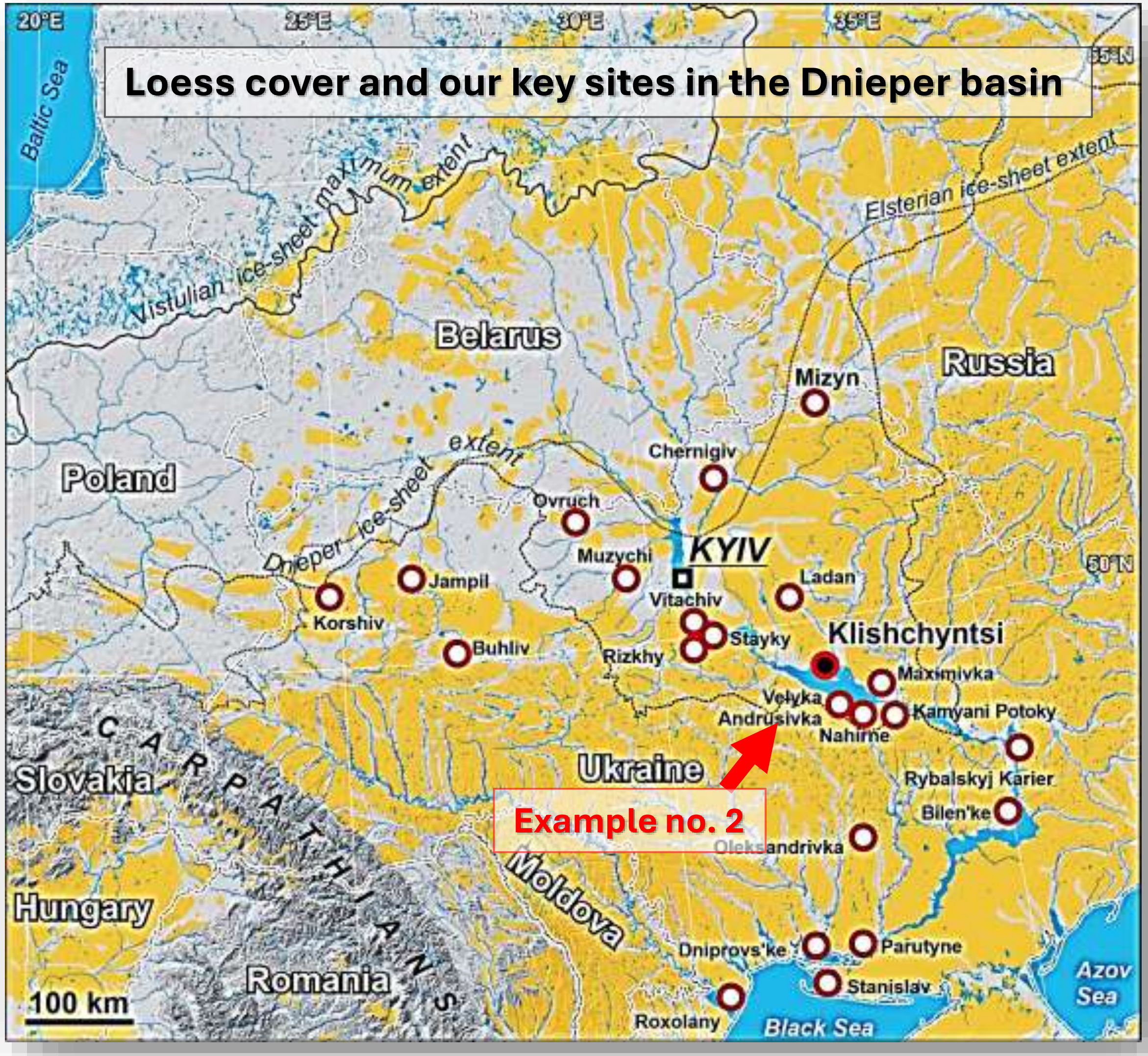
Major elements (100% weight excluding volatiles), rare earth elements (ppm), and basic parameters describing their variability with R max tuning



Geochemical indicators with R max tuning

Example no. 2

Velyka Andrusivka site



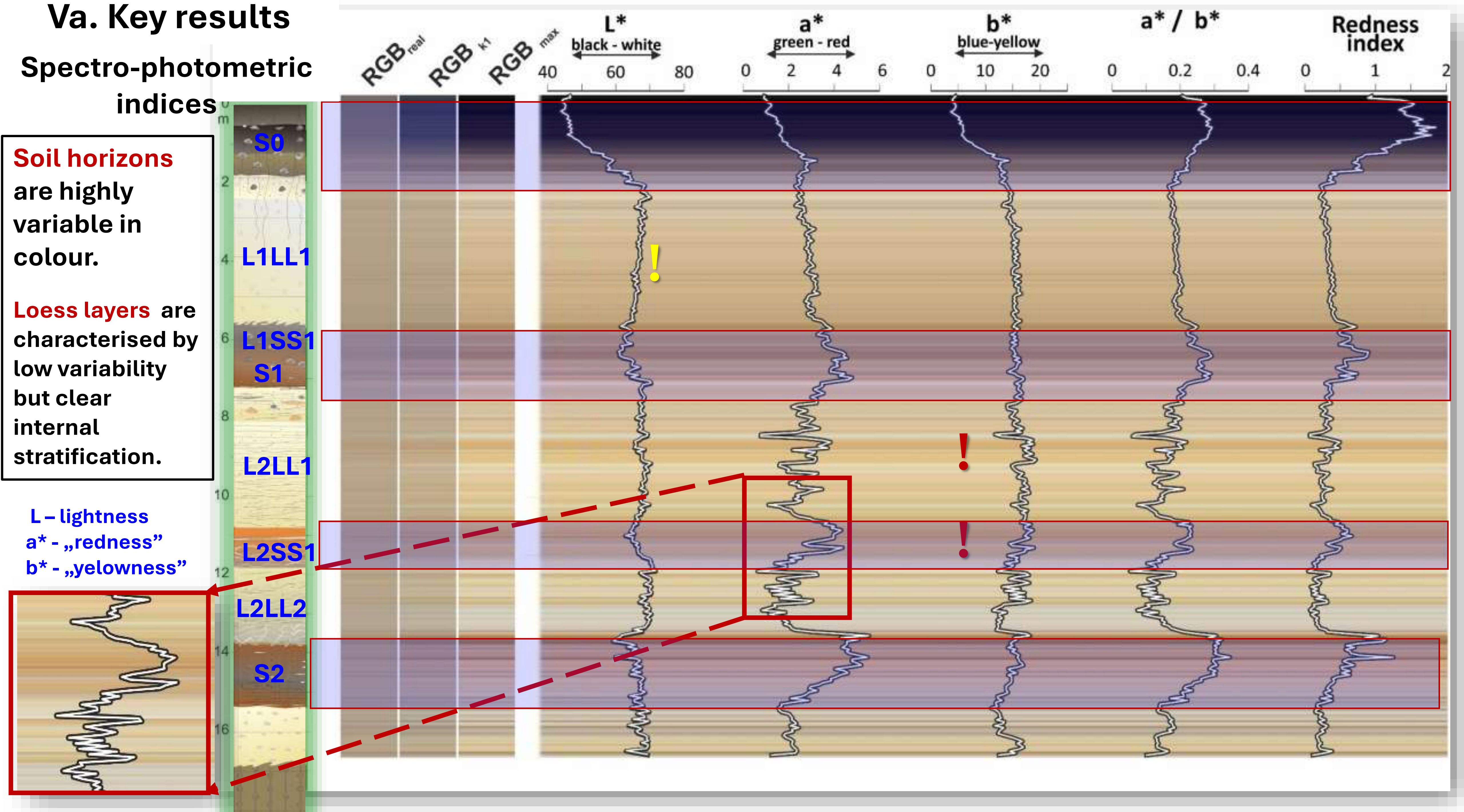
Va. Key results

Spectro-photometric indices

Soil horizons are highly variable in colour.

Loess layers are characterised by low variability but clear internal stratification.

L – lightness
a* - „redness”
b* - „yelowness”



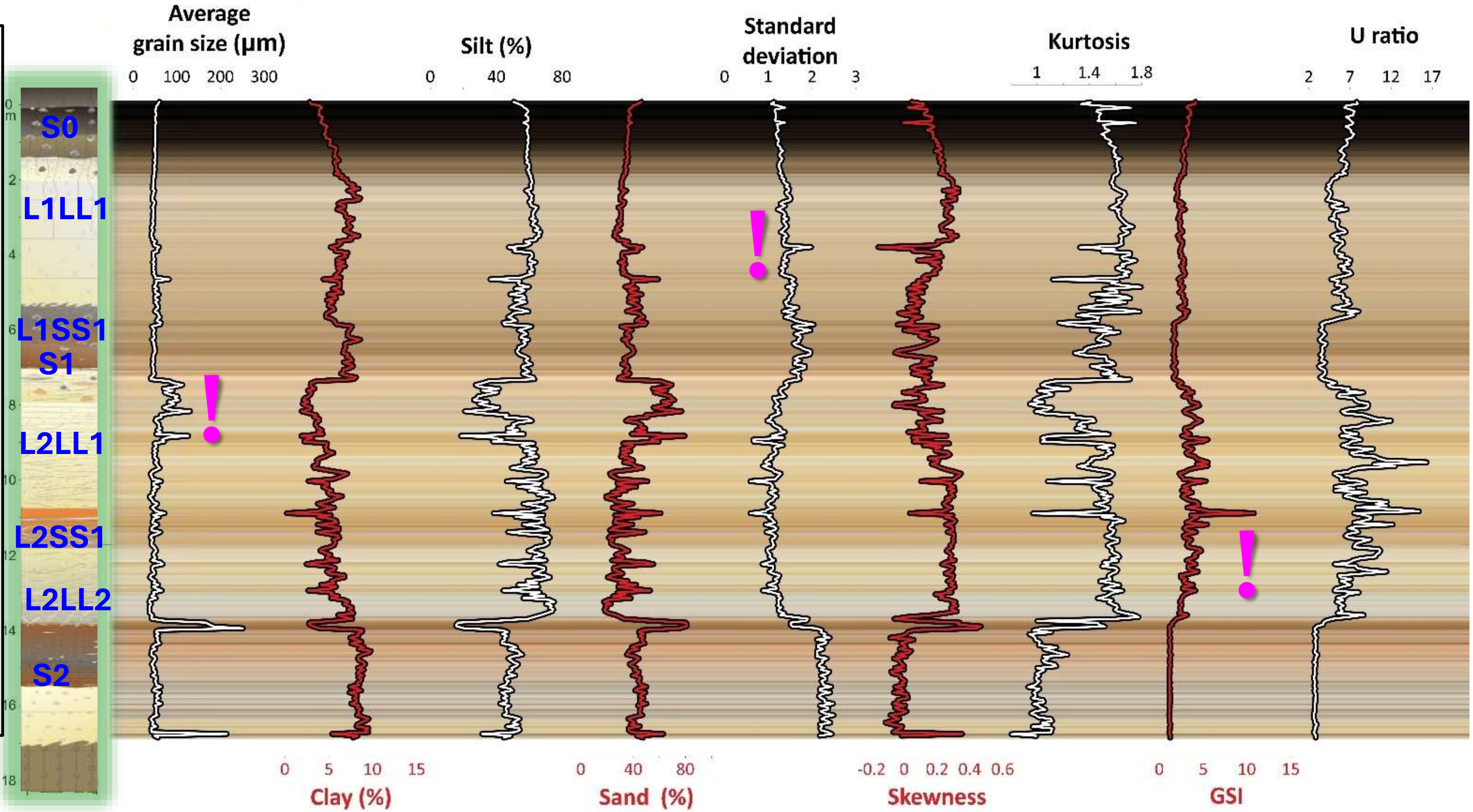
Vb. Key results

Fractions and granulometric indices for the loess-palaeosol sequence

Abrupt changes in all indicators - explicit identification of litho- and pedogenic units

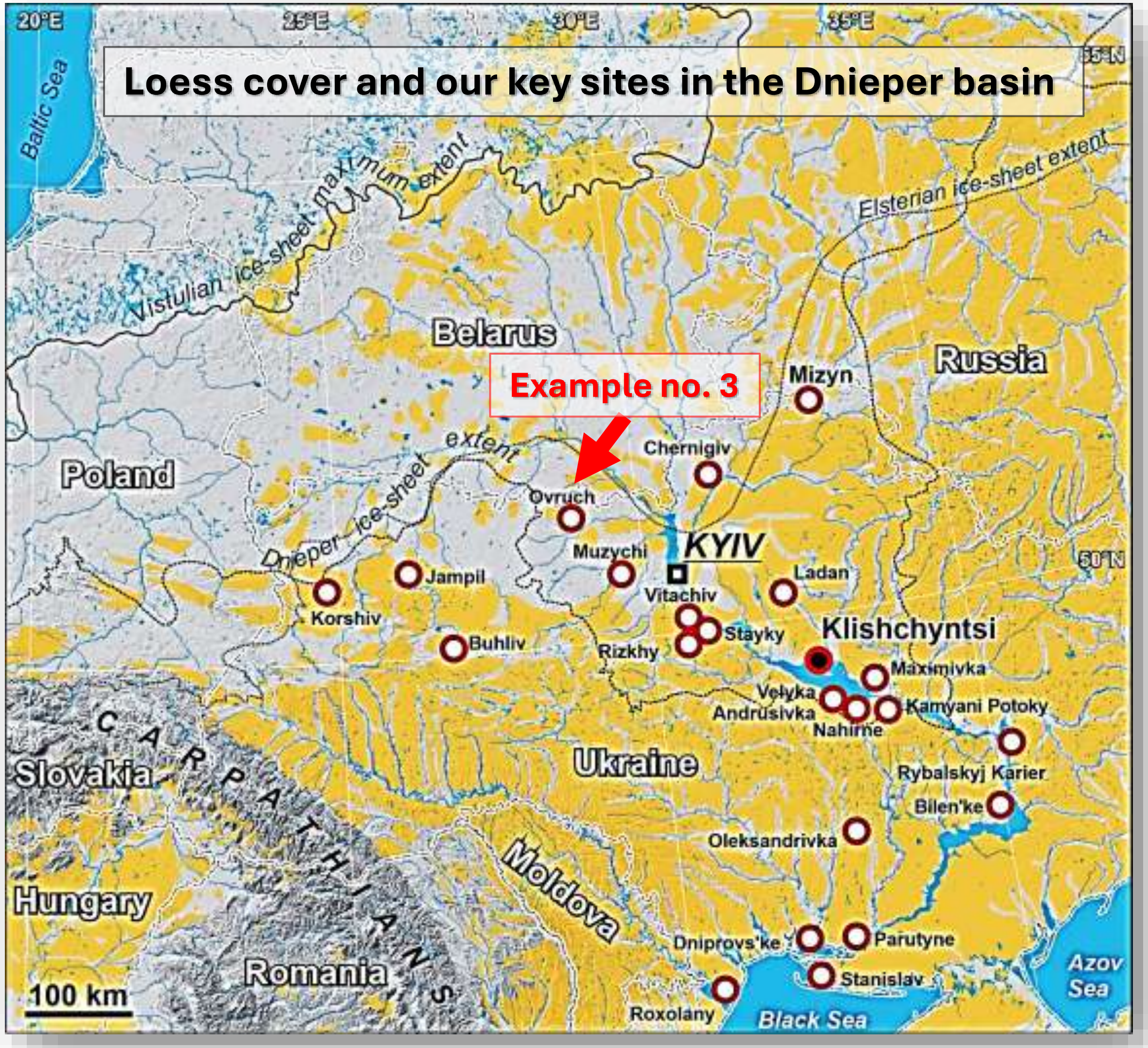
Soil horizons are clear in grain size (and colours).

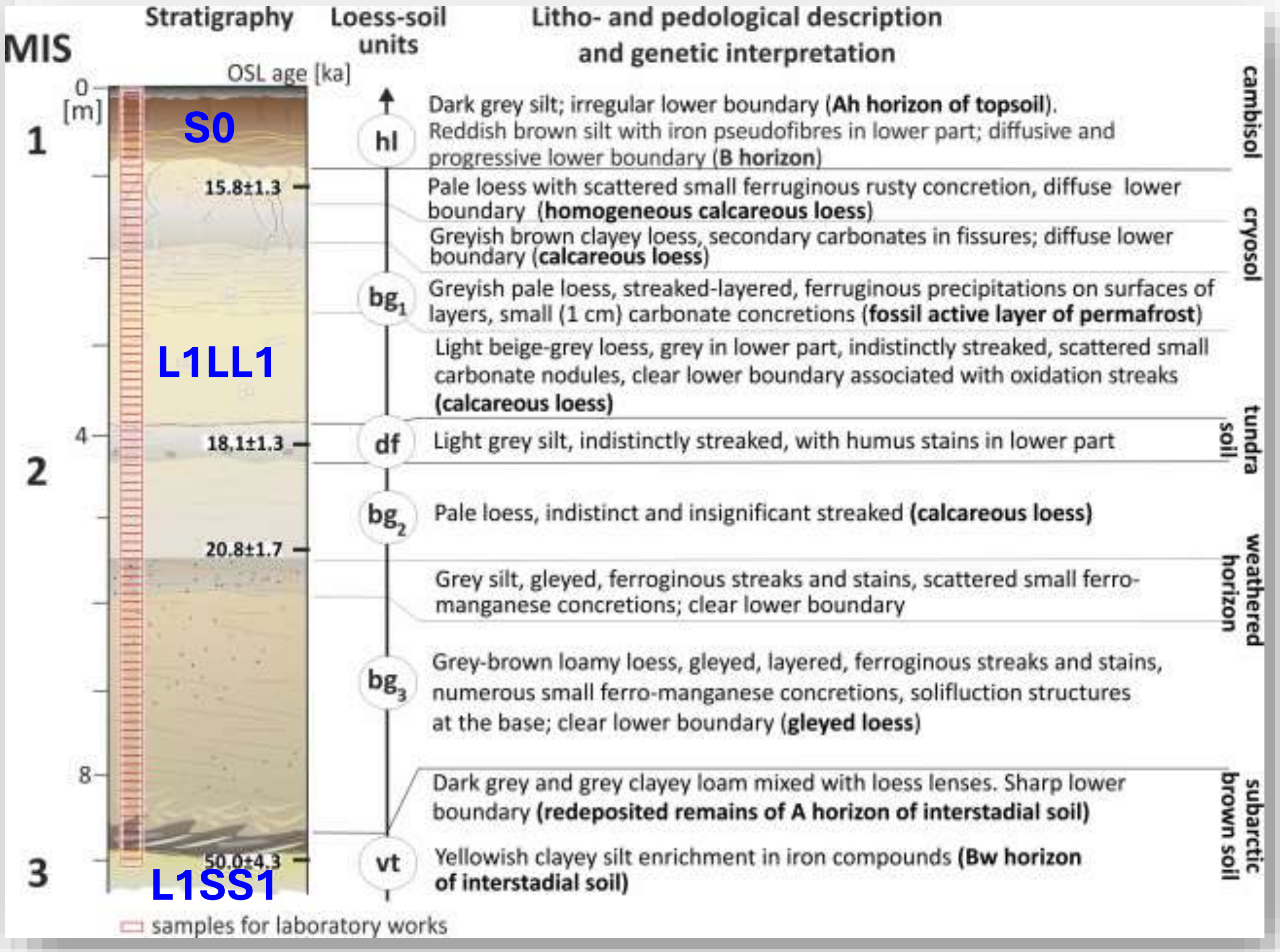
Loess layers show high variability in grain size resulting in division into sub-units.



Example no. 3

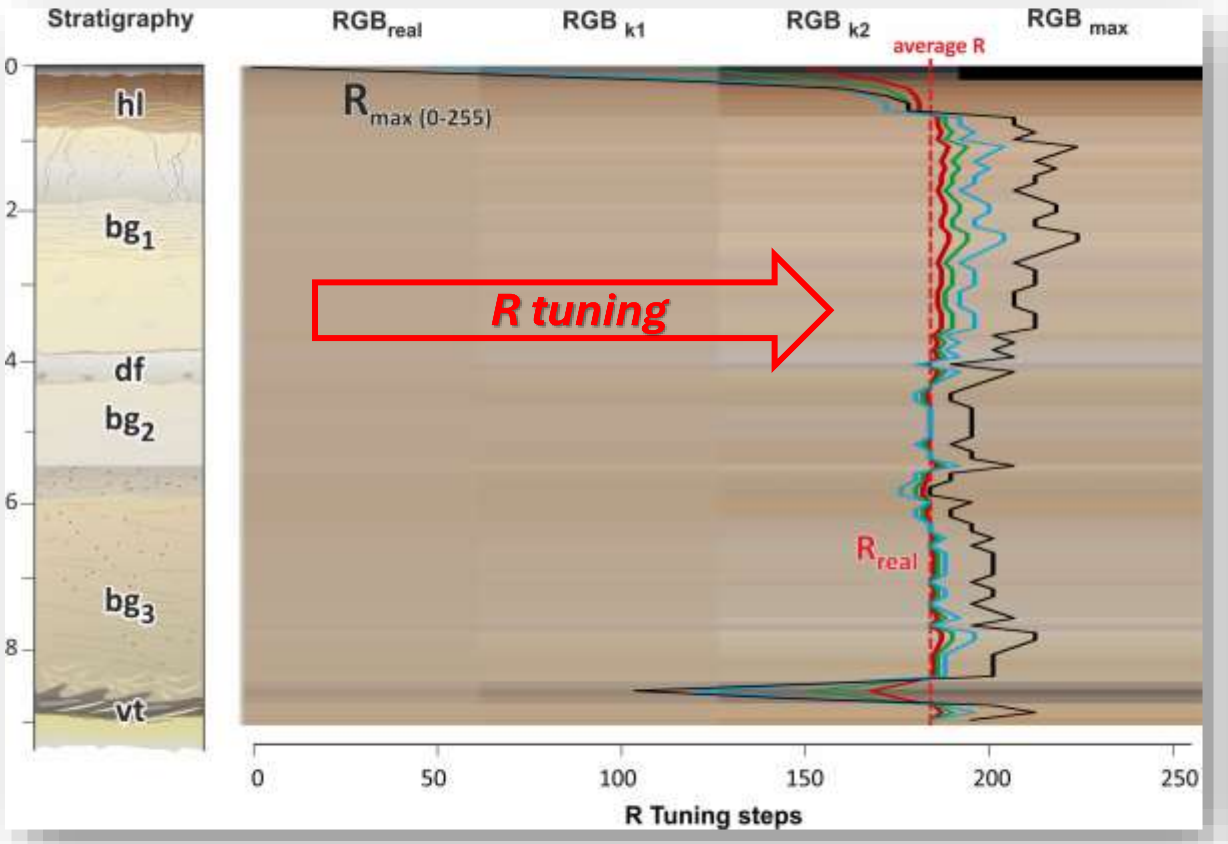
Cherepyn site (Ovruch loess Island)



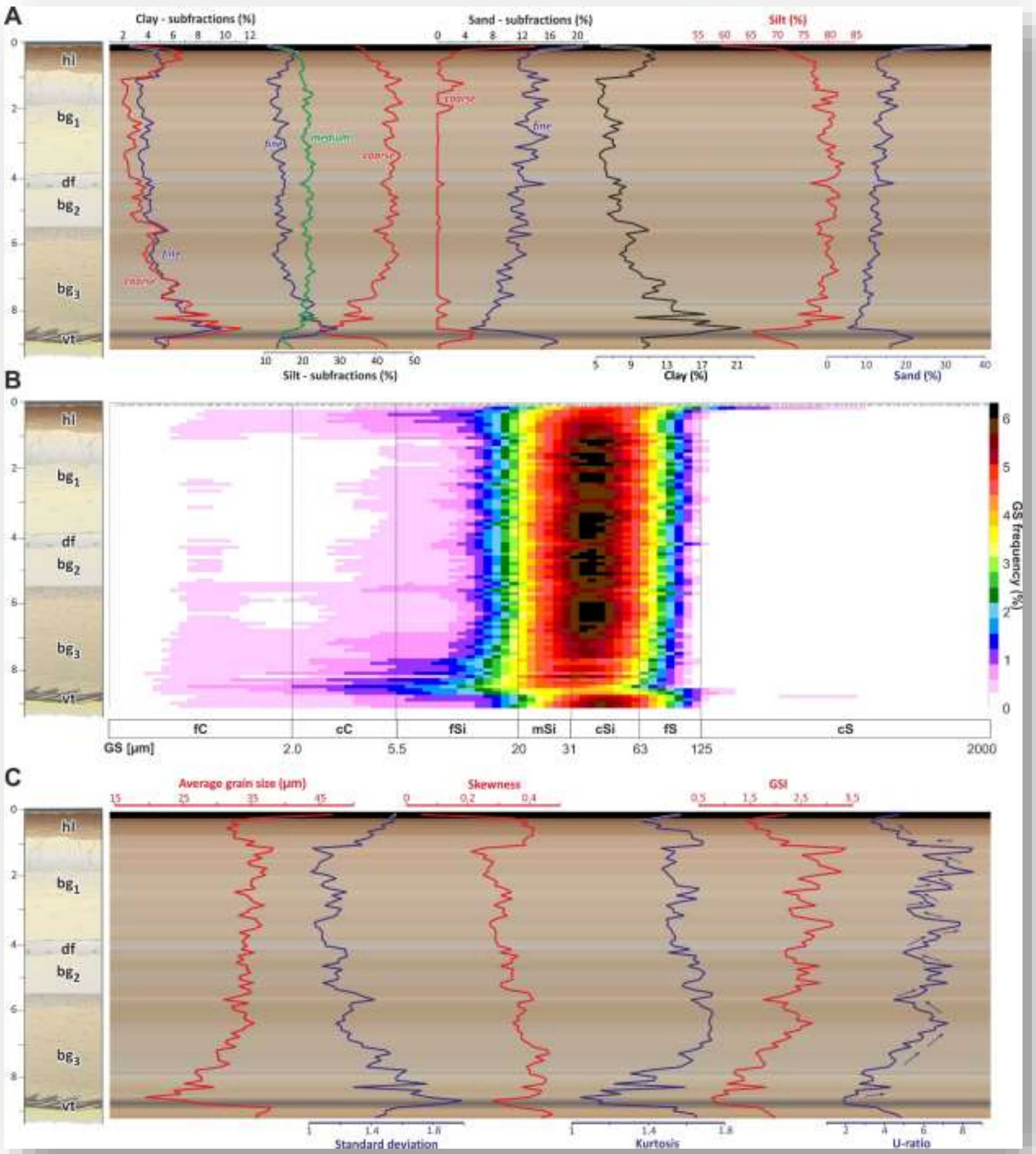


Example no. 3

Cherepyn site

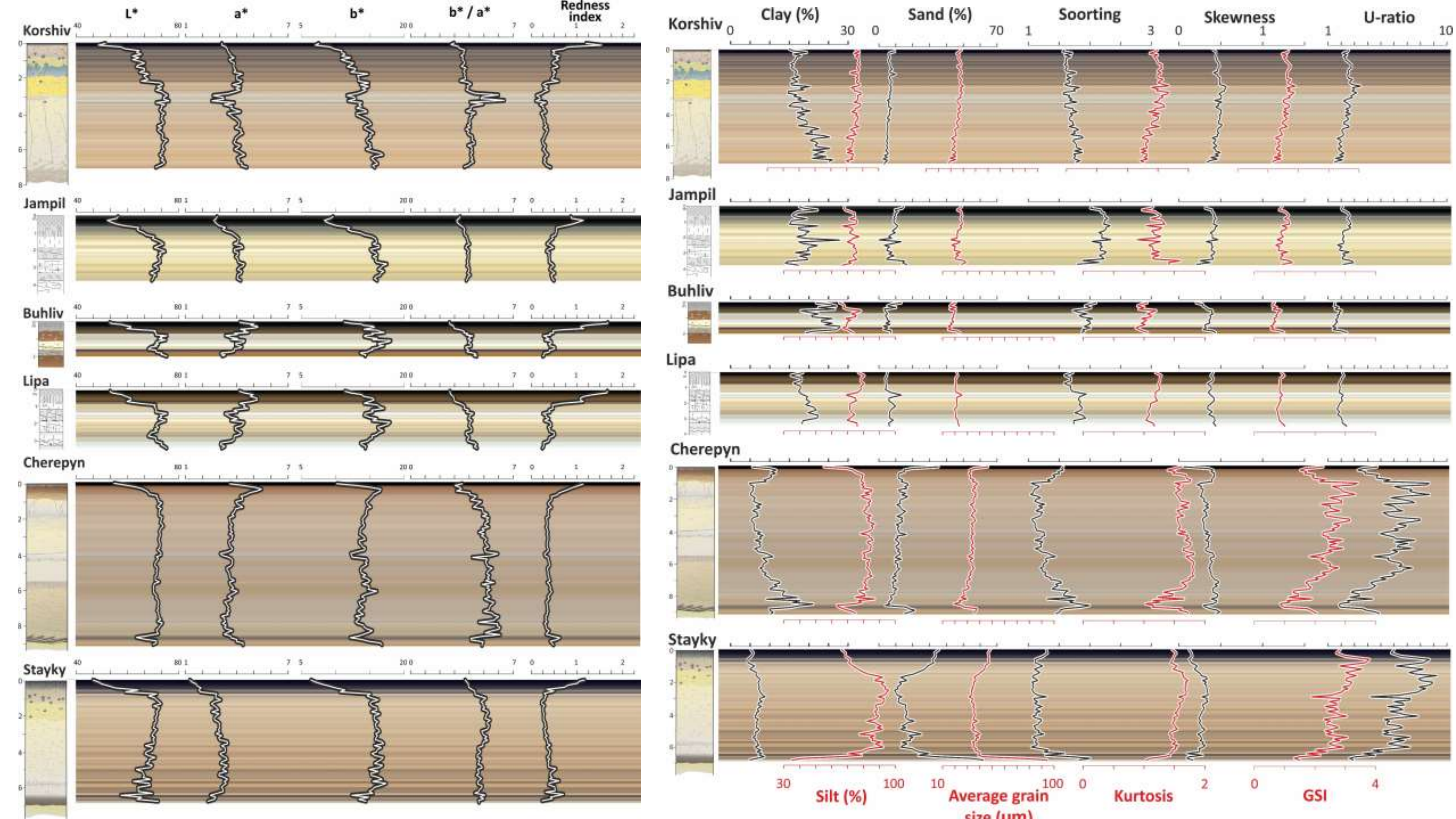


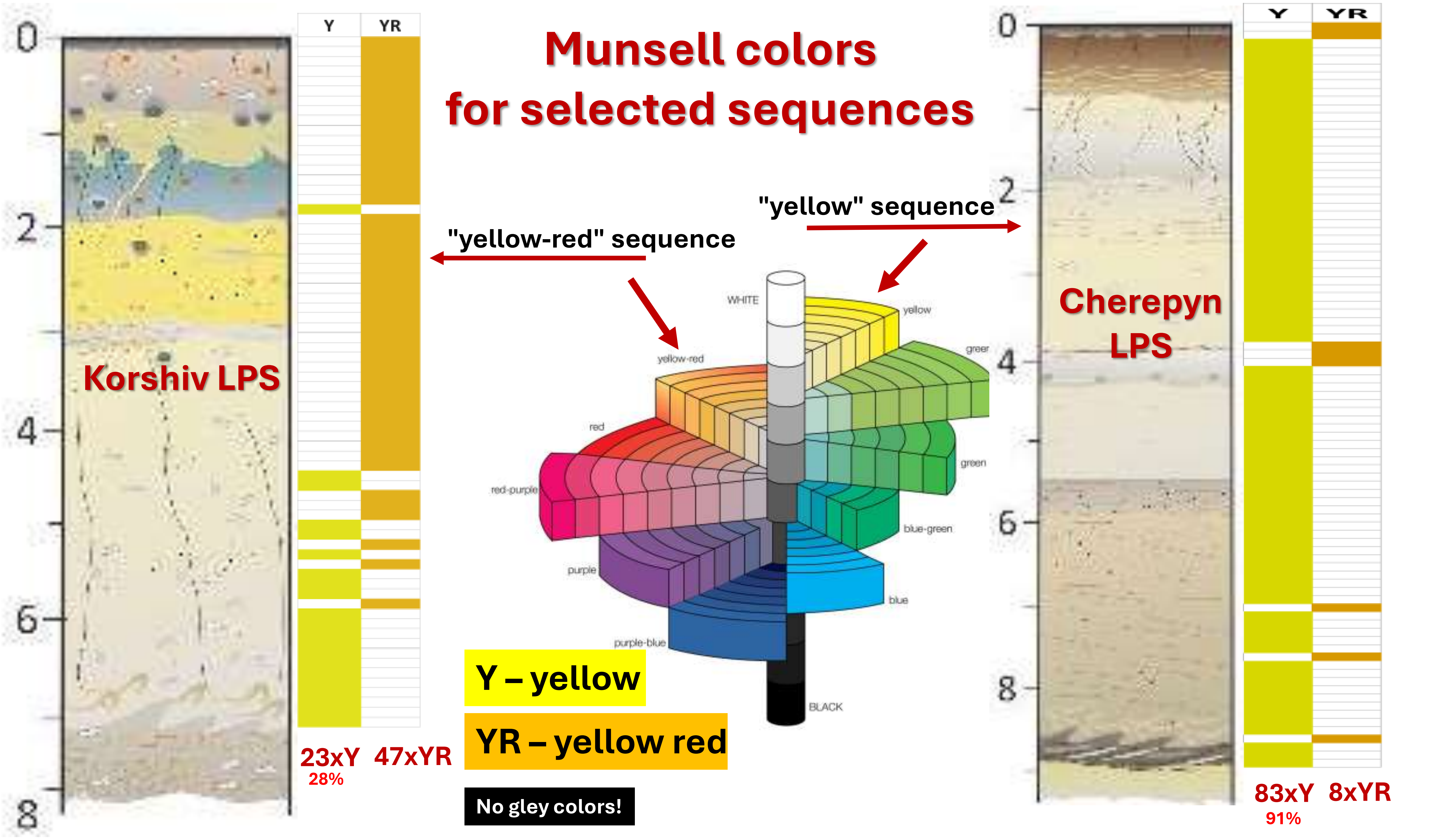
Colour tuning according to R (from real to max)



Main fractions (A), the grain size distribution presented on heat map (B) and granulation indeces with Rmax tuning in the background (C)

Other examples


L*
a*
b*
b* / a*
Redness index
Korshiv
Jampil
Buhliv
Lipa
Cherepyn
Stayky
Clay (%)
Sand (%)
Soorting
Skewness
U-ratio
Silt (%)
Average grain size (μm)
Kurtosis
GSI


Munsell colors
for selected sequences
"yellow-red" sequence
"yellow" sequence
Korshiv LPS
Cherepyn LPS
Y
YR
0
2
4
6
8
23xY
28%
47xYR
83xY
91%
8xYR
WHITE
yellow
green
yellow-red
red
red-purple
purple
purple-blue
blue
blue-green
BLACK
Y – yellow
YR – yellow red
No gley colors!

General conclusions:

- **Enhanced objectivity in colour measurement:** Digital spectrometers improve the objectivity and reliability of soil color analysis over traditional Munsell Soil Colour Chart methods.
- **Detailed chromatic characterization:** Spectrophotometry provides precise measurements of key color parameters, helping to differentiate loess layers and soil horizons based on their unique color profiles.
- **Development of a comparative digital colour record:** A digital color record aligned with the traditional Munsell scale enhances comparison and consistency, bridging traditional and modern soil color analysis methods.
- **Geological and pedogenic insights:** Chromatic data reveal color patterns linked to stratigraphic layers and soil stages, aiding in understanding the area's geological and pedogenic evolution.
- **Detection of subtle geological features:** High-resolution spectrophotometric analysis detects subtle chromatic shifts, revealing hidden erosional features and lithological changes in loess sequences.
- **Correlation with geochemical data:** Variability in color parameters among primary loesses correlates with geochemical data, validating colour as a reliable indicator in geological and soil studies.
- **Dynamic environmental evolution:** Documented color shifts from cold to warm periods illustrate the natural erosion and deposition cycles that shape the landscape.

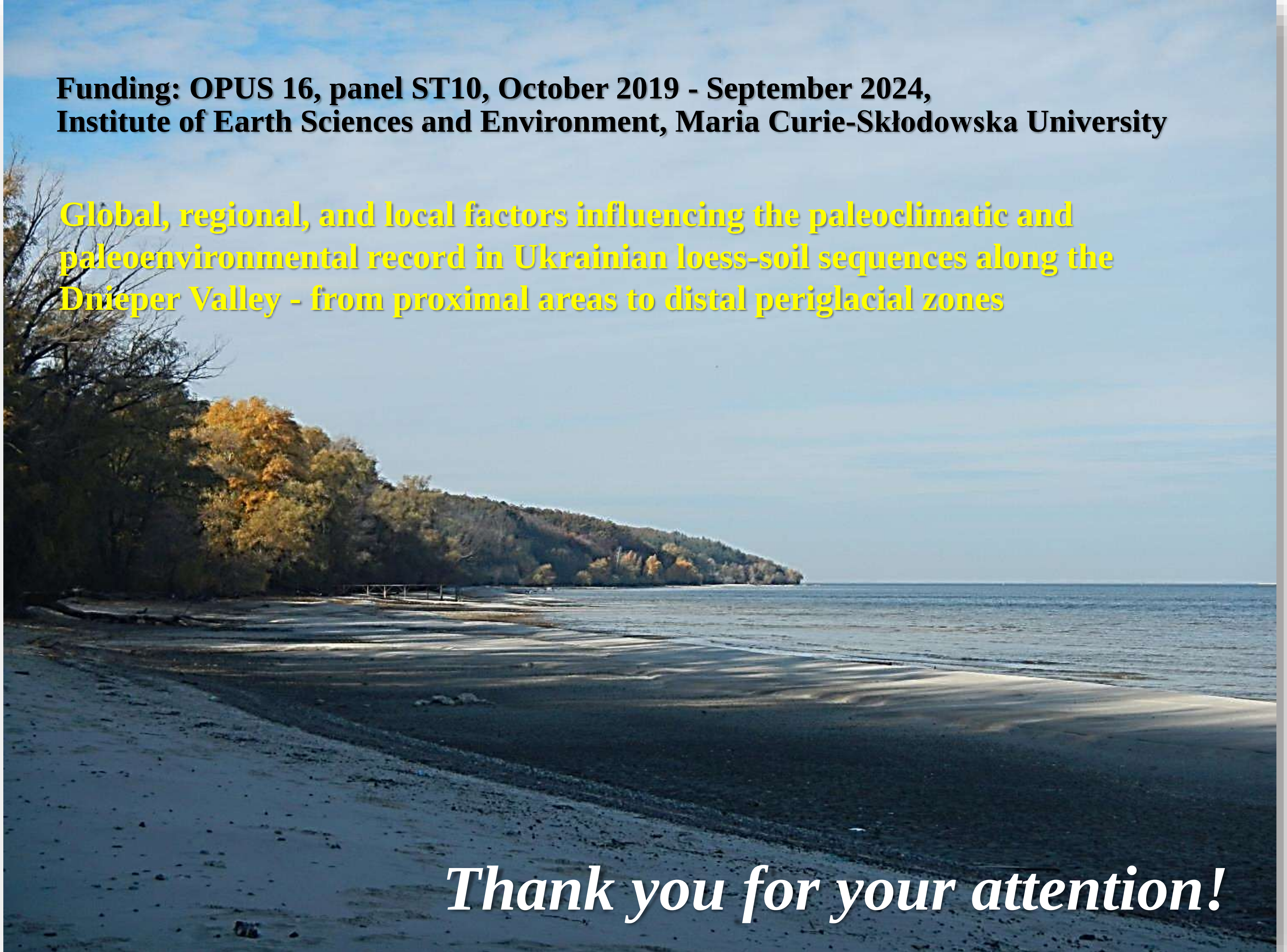
NATIONAL SCIENCE CENTRE POLAND

LPSs along Dnieper

UMCS
MARIA CURIE-SKŁODOWSKA UNIVERSITY IN LUBLIN

НАЦІОНАЛЬНА АКАДЕМІЯ НАУК УКРАЇНИ 1918

80 LAT UMCS



Funding: OPUS 16, panel ST10, October 2019 - September 2024,
Institute of Earth Sciences and Environment, Maria Curie-Skłodowska University

Global, regional, and local factors influencing the paleoclimatic and paleoenvironmental record in Ukrainian loess-soil sequences along the Dnieper Valley - from proximal areas to distal periglacial zones

Thank you for your attention!