Contribution of soil studies to geochemical mapping: The Pedogeochemical Map of the Emilia-Romagna Plain (1:250,000)

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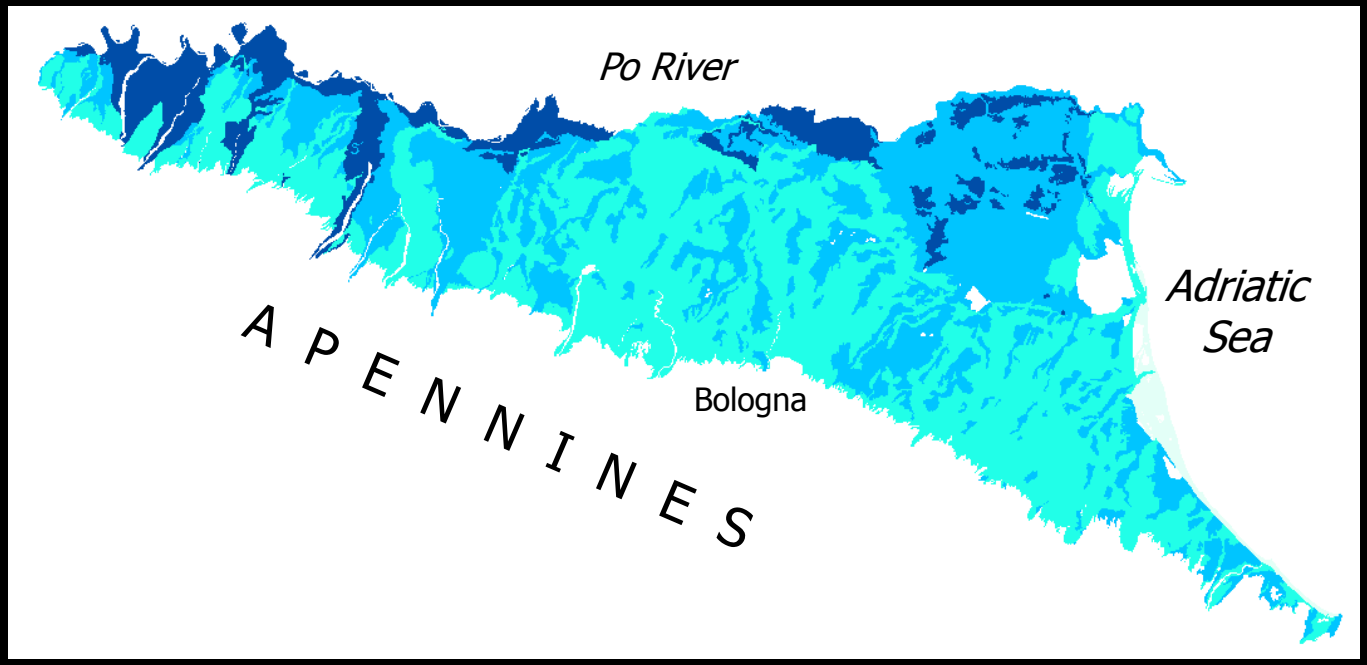
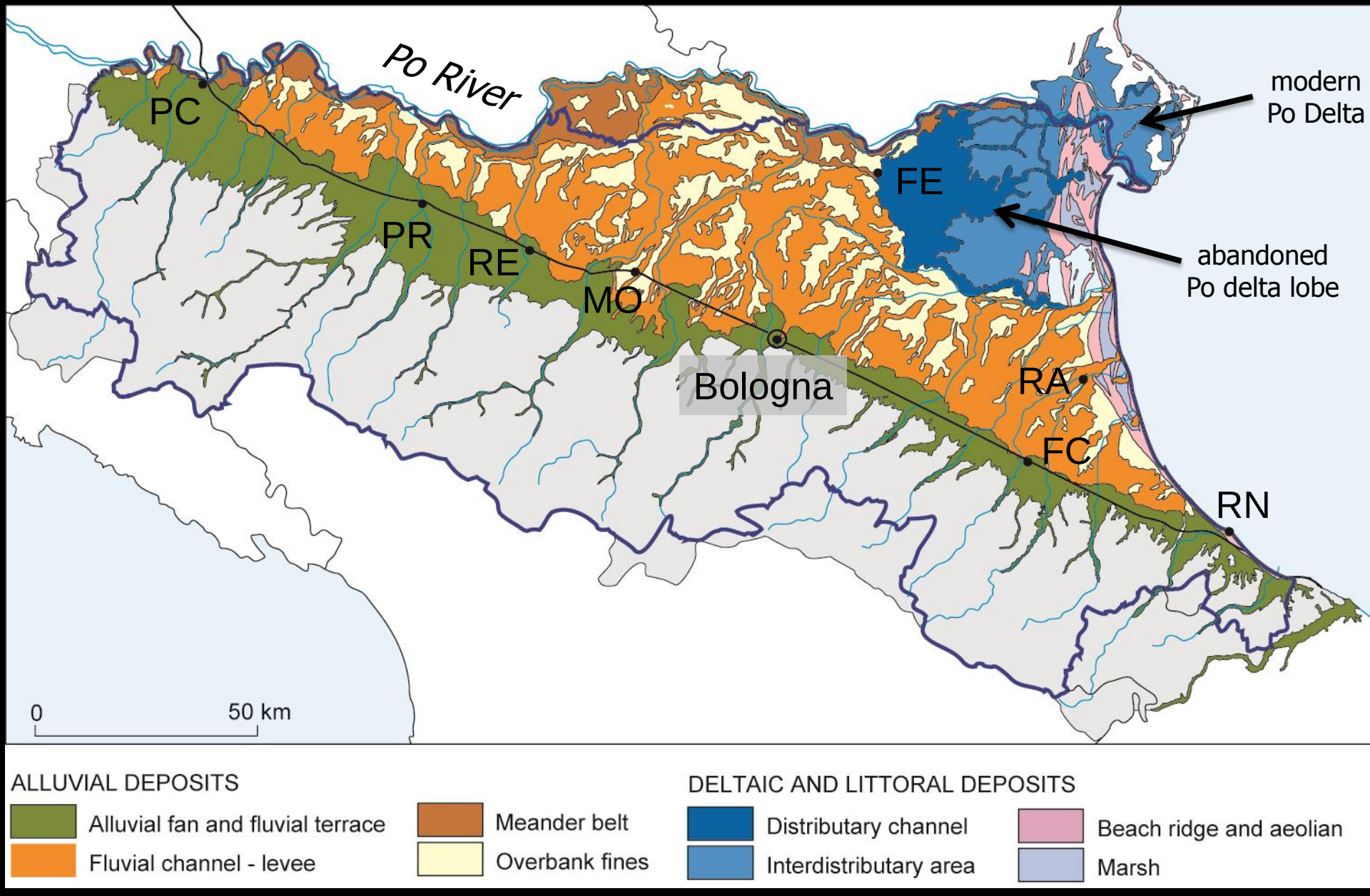
Cr Ni Cu Zn Pb



The Emilia-Romagna alluvial plain: geological setting



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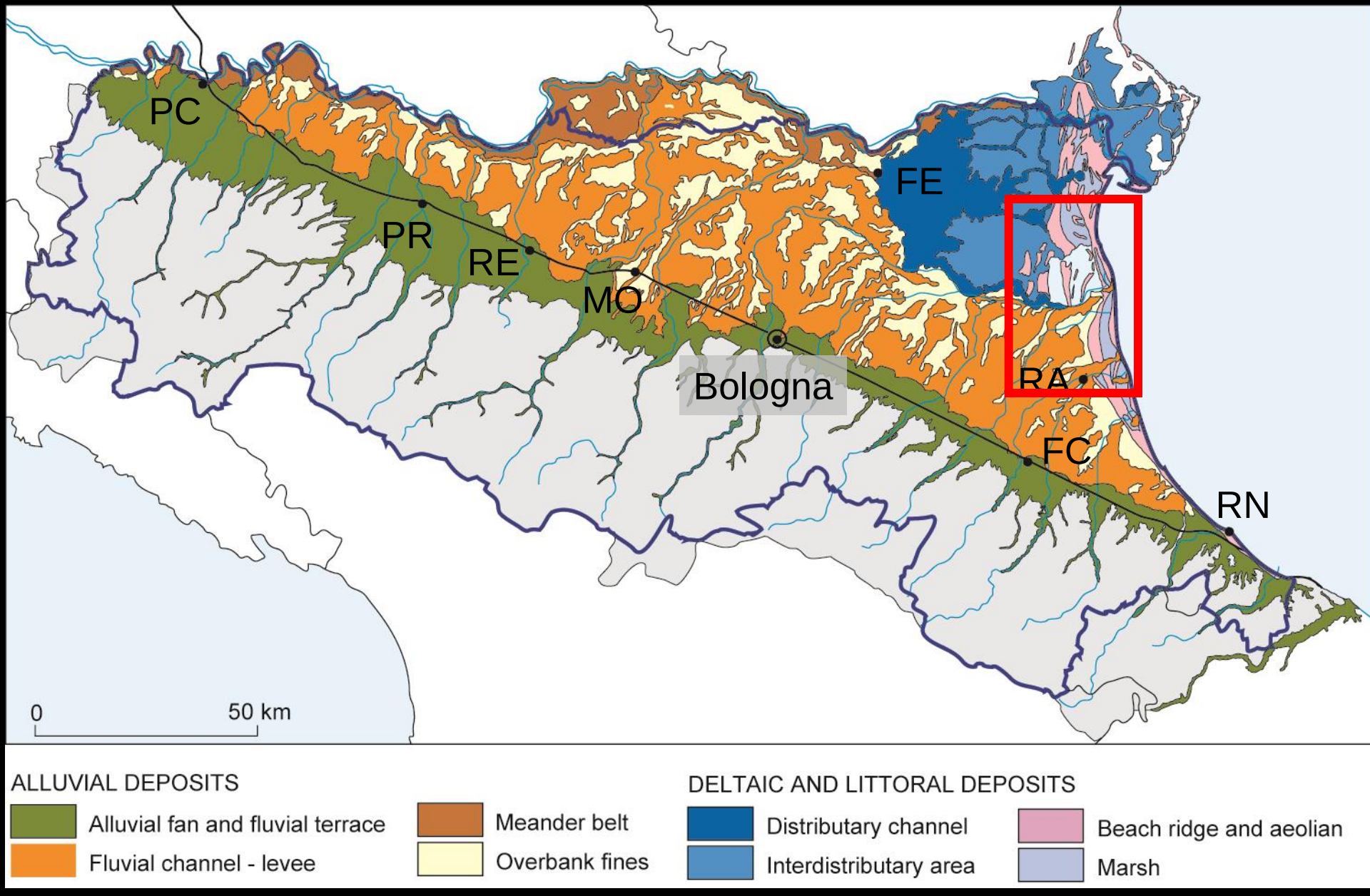
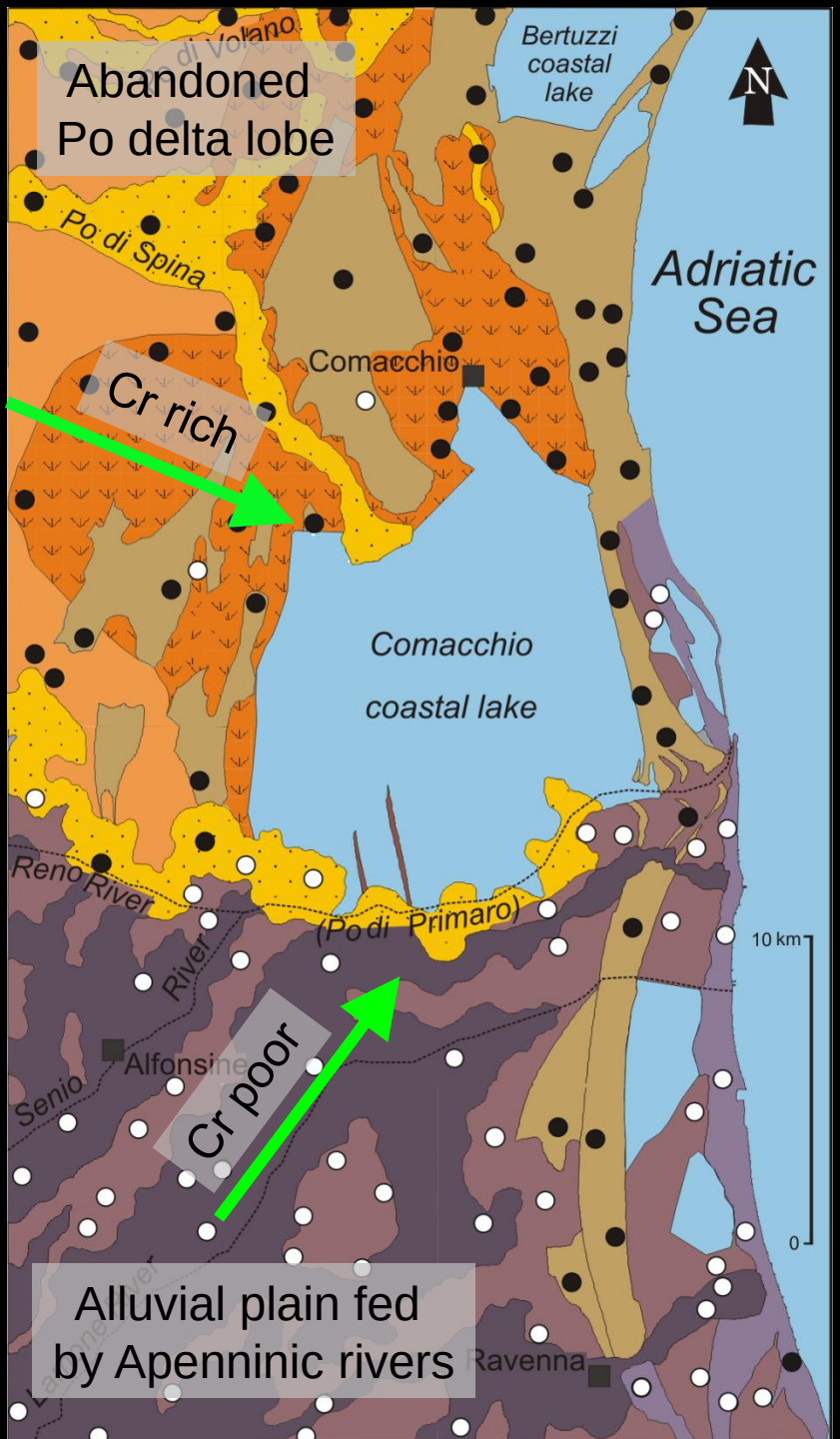


Factors controlling metal distribution - 1

soil type
(alteration, texture, organic matter)

Factors controlling metal distribution - 2

sediment provenance



Cr/Al_2O_3

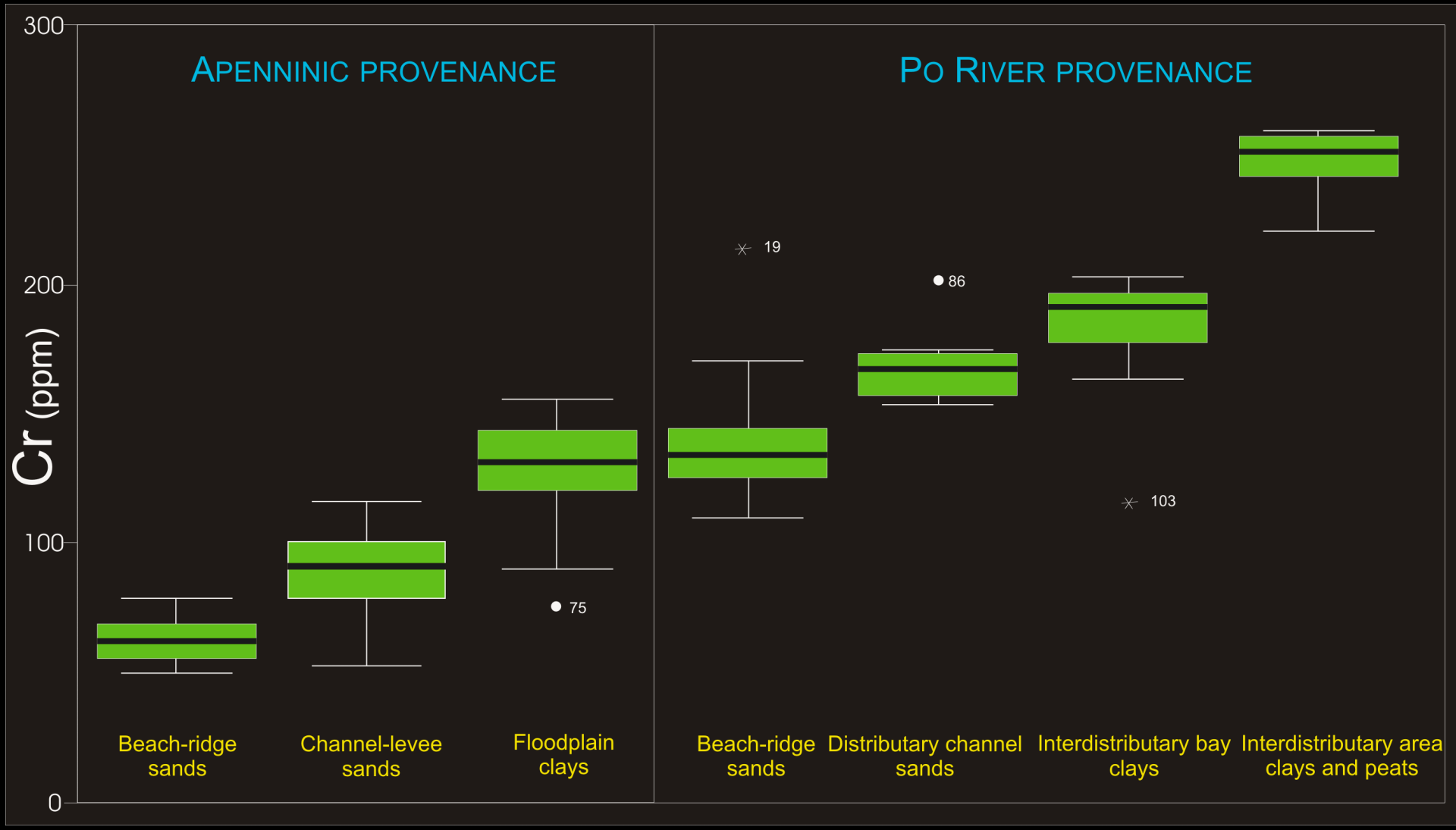
- ○ ⩾ 11.6
- ● < 11.6

- Distributary channel
- Interdistributary area
- Interdistributary bay
- Beach ridge (Po River)
- Channel-Levee
- Floodplain
- Beach ridge (Apennines)

(Amorosi & Sammartino, 2007 - Int. J. Earth Sci.)

Factors controlling metal distribution - 3

grain size (hydraulic sorting)



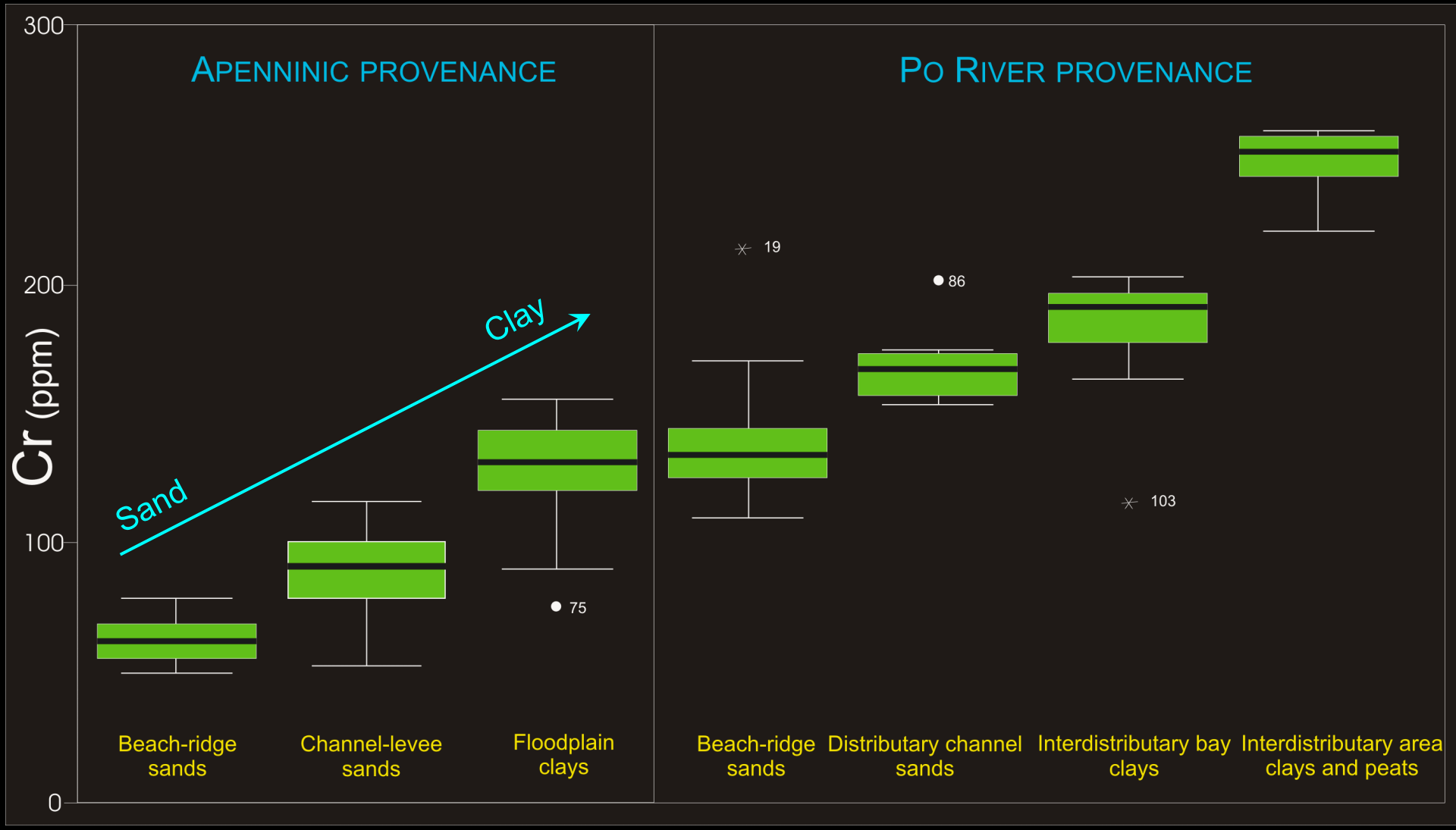
Ophiolite free

Ophiolite bearing

(Amorosi & Sammartino, 2007)

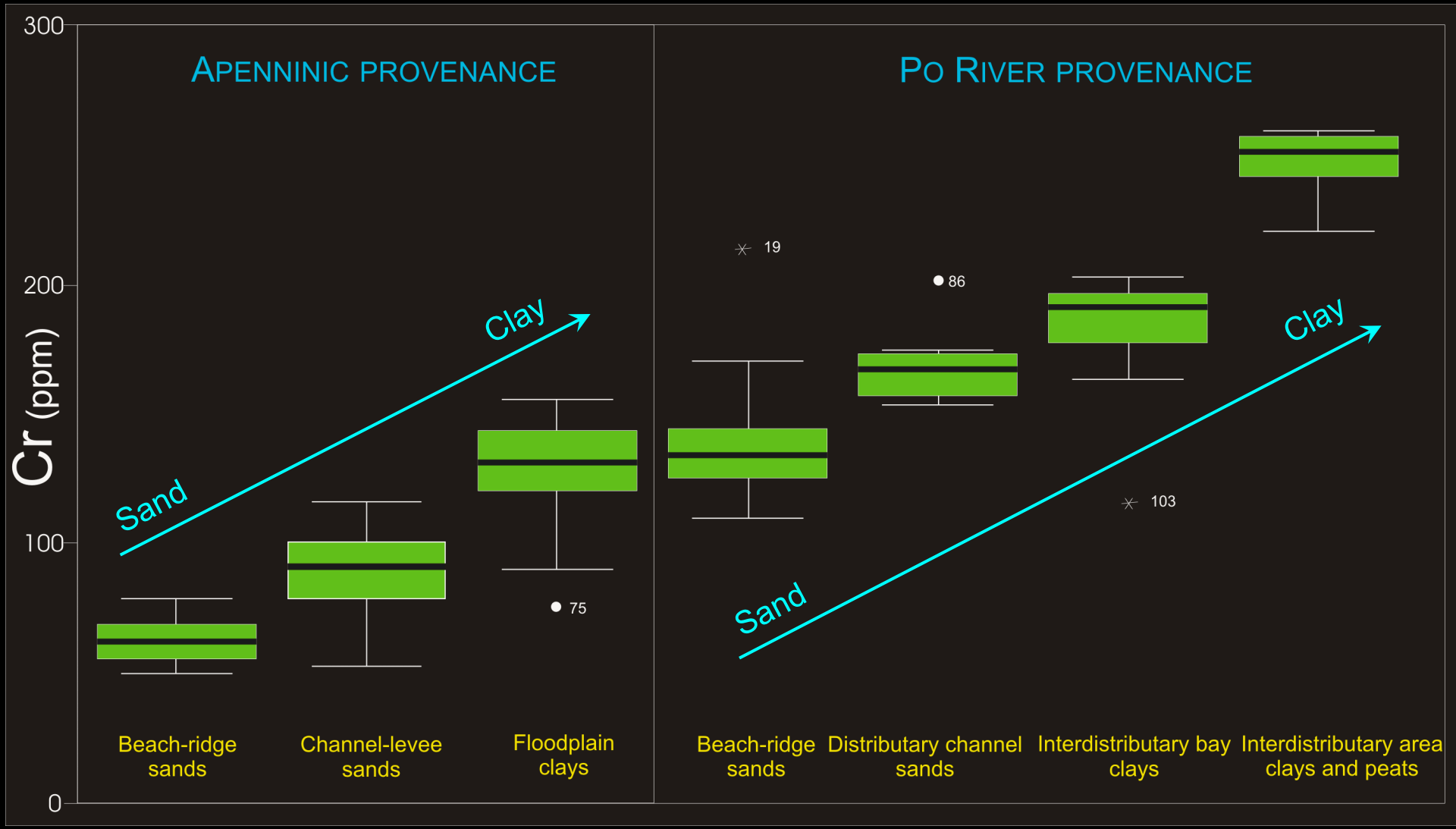
Factors controlling metal distribution - 3

grain size (hydraulic sorting)

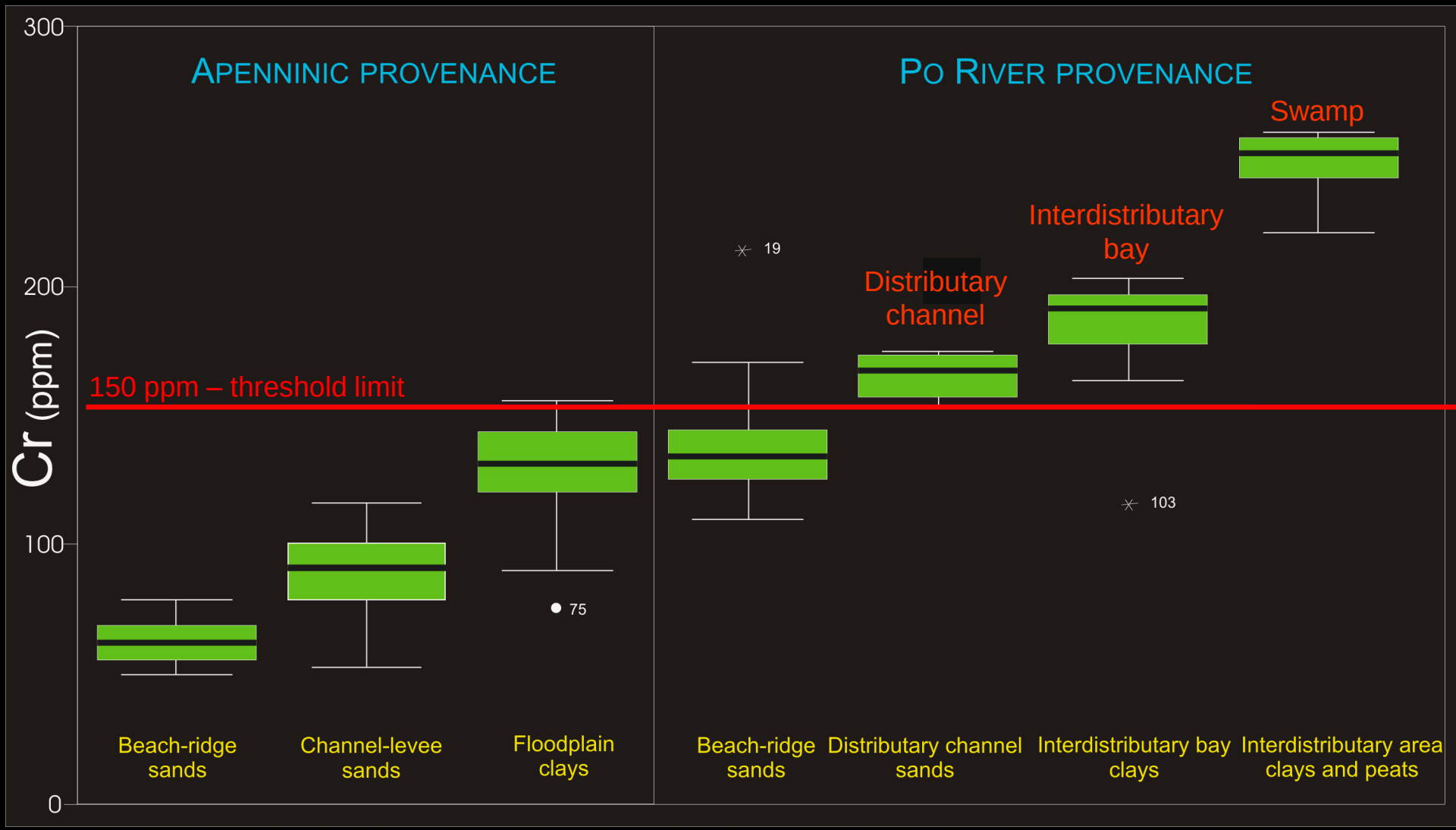


Factors controlling metal distribution - 3

grain size (hydraulic sorting)



Natural metal concentrations may exceed threshold limits



The Pedogeochemical Map of the Emilia-Romagna Plain 1:250000

GENETICAL-FUNCTIONAL SOIL UNITS (UGFs)

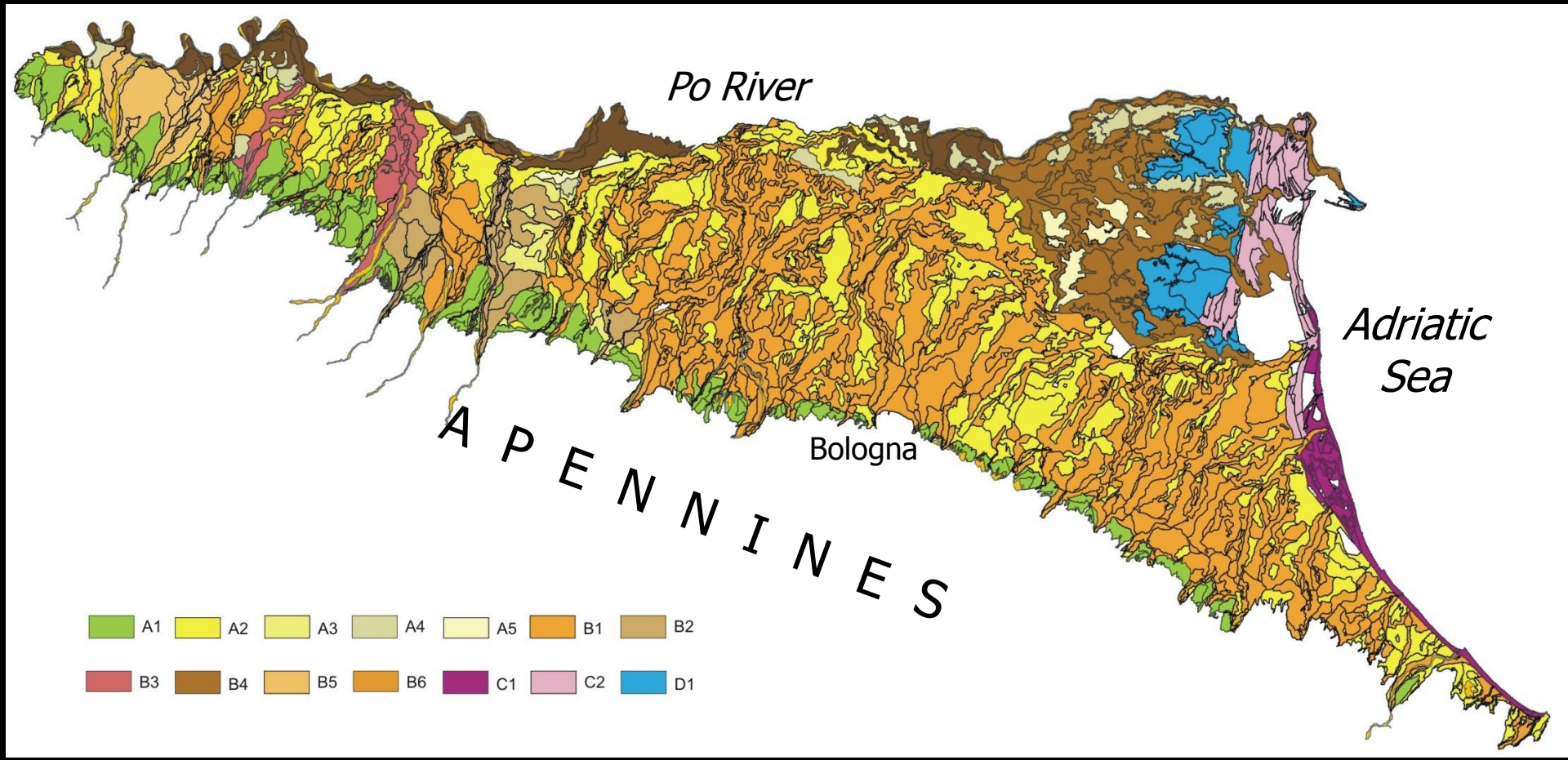
UGFs bear distinctive connotations in terms of

- Soil type
- Sediment provenance
- Depositional environment

UGF	Soil type	Sediment provenance	Depositional environment
A1	Medium- to fine textured, high alteration *Stagnic Luvisols, Vertic Cambisols*	Apenninic catchments Variable ophiolitic supply	Undifferentiated
A2	Fine textured, low to moderate alteration *Vertic Cambisols, Hyposalic Vertisols, Calcic Vertisols*	Apenninic catchments No ophiolitic supply	Floodplain
A3	Fine textured, low to moderate alteration *Vertic Cambisols, Calcic Vertisols, Eutric Vertisols*	Apenninic catchments Moderate ophiolitic supply	Floodplain
A4	Fine textured, low to moderate alteration *Vertic Cambisols, Calcic Vertisols, Hyposalic Vertisols*	Mixed Po / Apenninic High ophiolitic supply	Floodplain
A5	Fine textured, low to moderate alteration *Vertic Cambisols, Gleyic Cambisols, Calcic Vertisols*	Po River	Interdistributary area
B1	Medium- to coarse textured, low to moderate alteration *Calcaric Cambisols, Haplic Calcisols*	Apenninic catchments No ophiolitic supply	Fluvial channel
B2	Medium- to coarse textured, low to moderate alteration *Calcaric Cambisols, Haplic Calcisols*	Apenninic catchments Moderate ophiolitic supply	Fluvial channel
B3	Medium- to coarse textured, low to moderate alteration *Calcaric Cambisols, Haplic Calcisols*	Apenninic catchments Moderate to high ophiolitic supply	Fluvial channel
B4	Medium- to coarse textured, low to moderate alteration *Calcaric Cambisols, Haplic Calcisols*	Po River	Fluvial channel
B5	Medium- to coarse textured, low to moderate alteration *Calcaric Cambisols, Haplic Calcisols*	Apenninic catchments High ophiolitic supply	Fluvial channel
B6	Medium to coarse textured, low to moderate alteration *Calcaric Cambisols, Haplic Calcisols*	Po River	Distributary channel
C1	Coarse textured, low alteration *Calcaric Arenosols*	Apenninic catchments No ophiolitic supply	Beach ridge
C2	Coarse textured, low alteration *Calcaric Arenosols*	Po River	Beach ridge
D1	Organic material *Thionic Histosols, Thionic Fluvisols*	Po River	Interdistributary bay

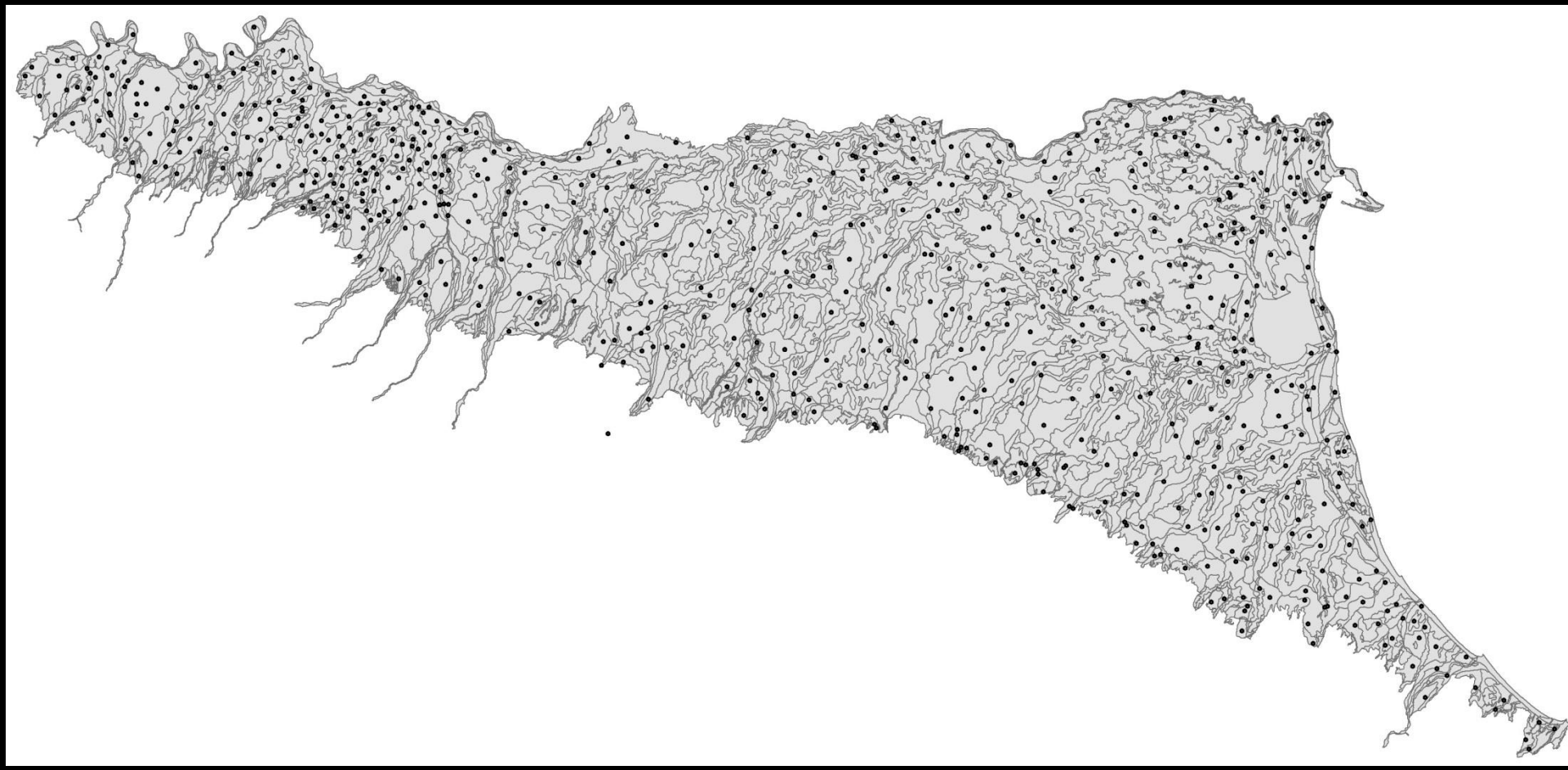
Genetical-functional soil units (UGFs)

Genetical-functional soil map



(from Regione Emilia-Romagna plain soil map 1:50000)

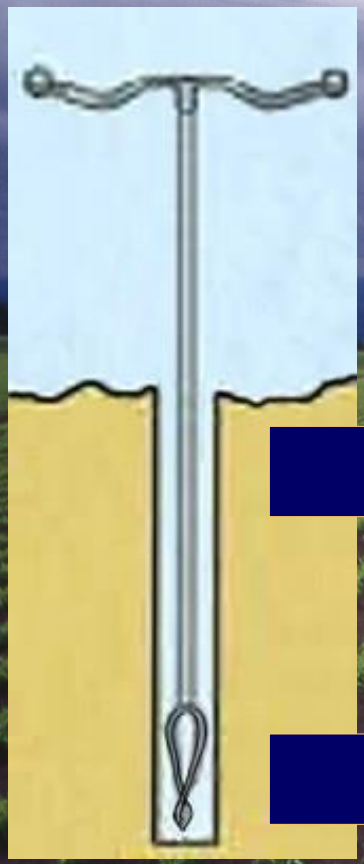
Sampling strategy



700 study sites – 1,400 samples

Materials

Hand drillings

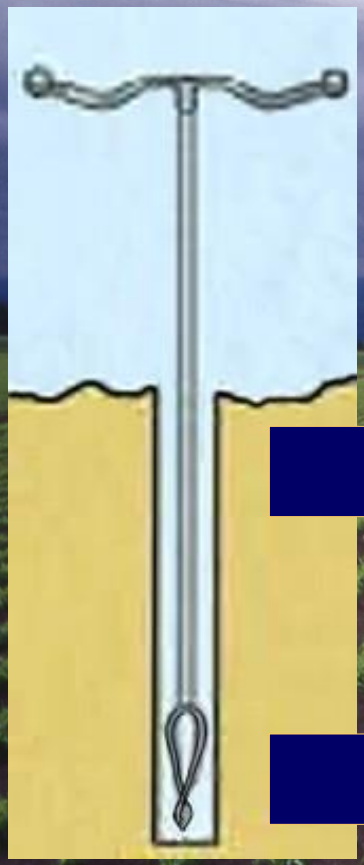


20-30 cm

120-130 cm

Materials

Hand drillings



20-30 cm → ANTHROPOGENIC EFFECT

120-130 cm → BACKGROUND VALUES

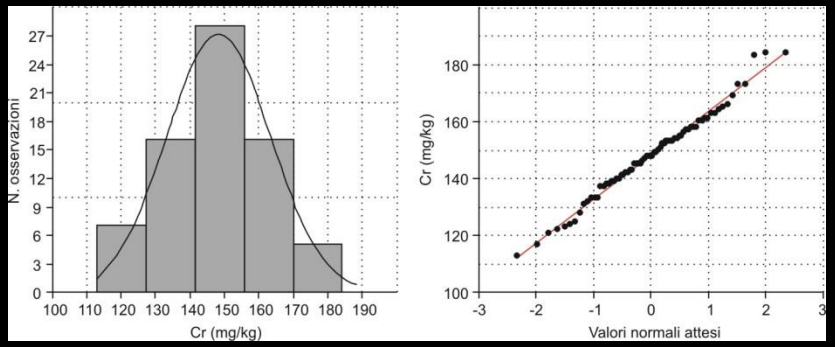
Geochemical analyses were matched with previously published material from cores as deep as 200 m (Amorosi et al., 2002; 2007; 2008)

ANALYTICAL TECHNIQUES

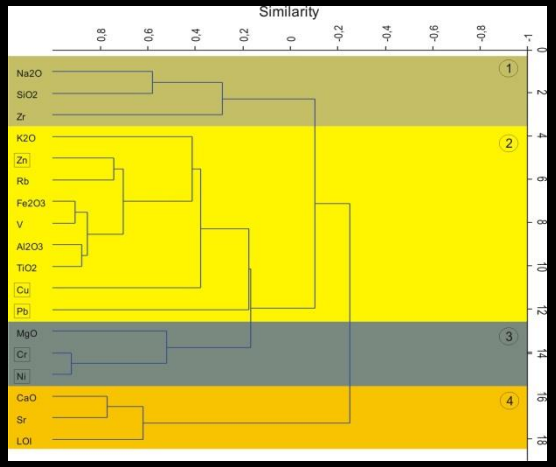
- XRF (Bologna University laboratory)
- ICP-MS following aqua regia digestion

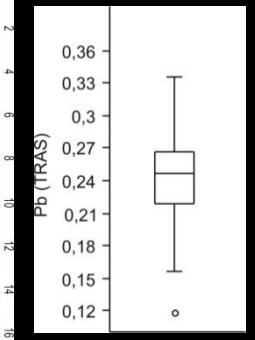
  (Ravenna ARPA laboratory, AlsChemex Vancouver)

STATISTICAL DATA ANALYSIS



- Cluster analysis
- Frequency histograms
- Cumulative frequency curves
- Box-and-whiskers plots

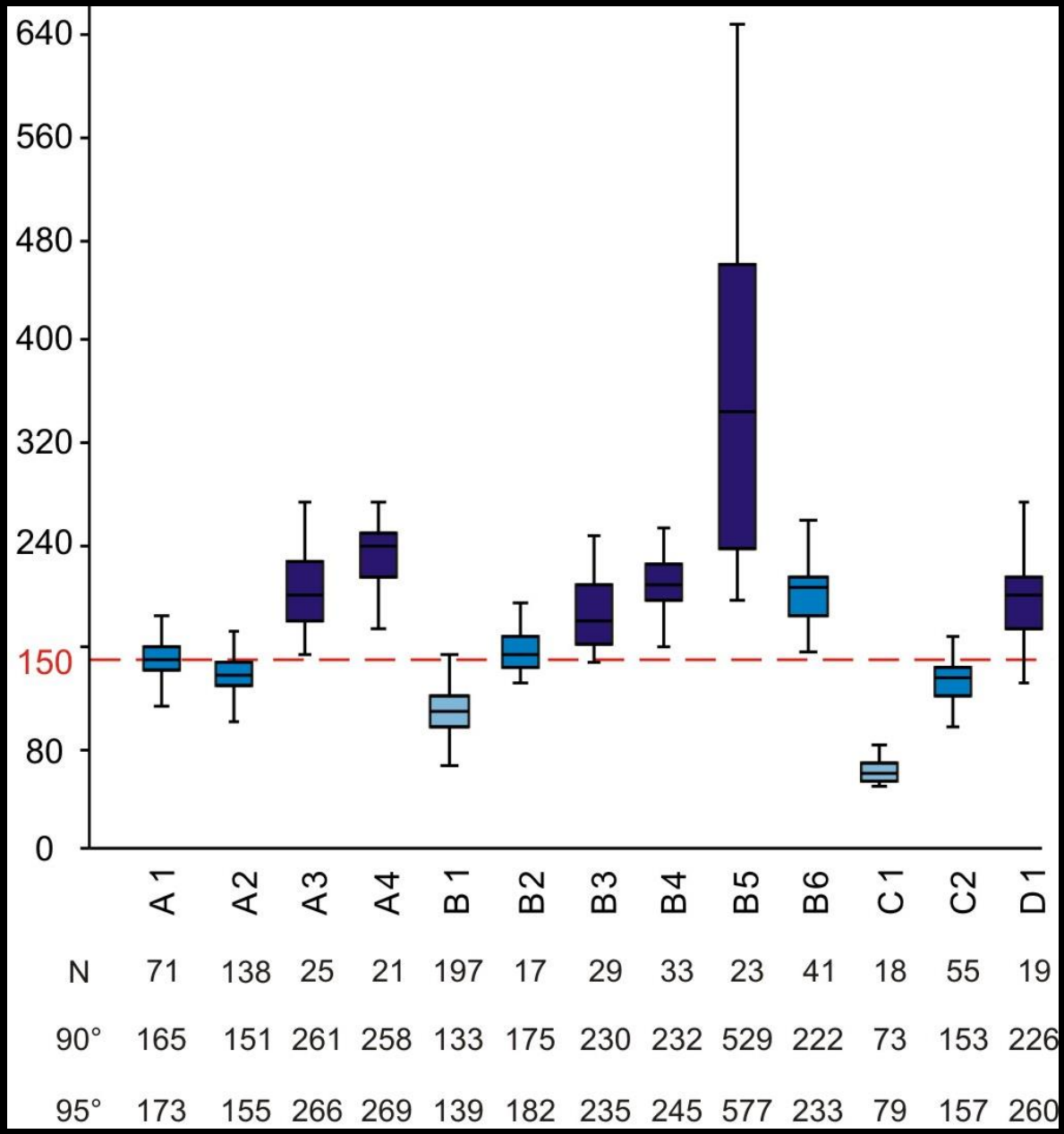




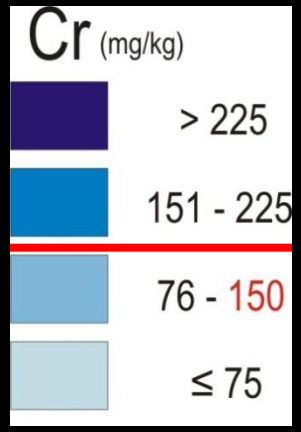
- Kolmogorov-Smirnov test
- Box-Cox transformations

Cr	A1	A2	A3	A4	B1	B2	B3	B4	B5	C1	C2
N	129	72	10	13	185	16	29	23	23	16	28
Min	99	113	152	169	71	130	145	159	196	50	110
Max	162	184	197	249	151	192	244	250	646	79	158
Sum	17316	10666	1711	2693	20225	2472	5379	4792	8352	955	3718
Mean	134,2	148,1	171,1	207,2	109,3	154,5	185,5	208,3	363,1	59,69	132,8
Std. error	1,302	1,782	4,743	6,433	1,209	4,423	5,427	5,115	26,97	2,079	2,281
Variance	218,7	228,6	225	538	270,5	313,1	854,2	601,7	16733	69,16	145,7
Stand. dev	14,79	15,12	15	23,19	16,45	17,69	29,23	24,53	129,4	8,316	12,07
Median	136	148	170	208	109	150	182	210	345	57	132
Skewness	-0,5	0,076	0,265	0,079	0,163	0,461	0,486	-0,231	0,402	0,678	0,186
Kurtosis	-0,529	0,001	-1,366	-1,195	-0,417	-0,865	-1,07	-0,761	-0,863	-0,536	-0,651
Geom. mean	133,4	147,4	170,5	206	108,1	153,6	183,3	206,9	341,2	59,17	132,3

Delineating the pedogeochemical content – Cr

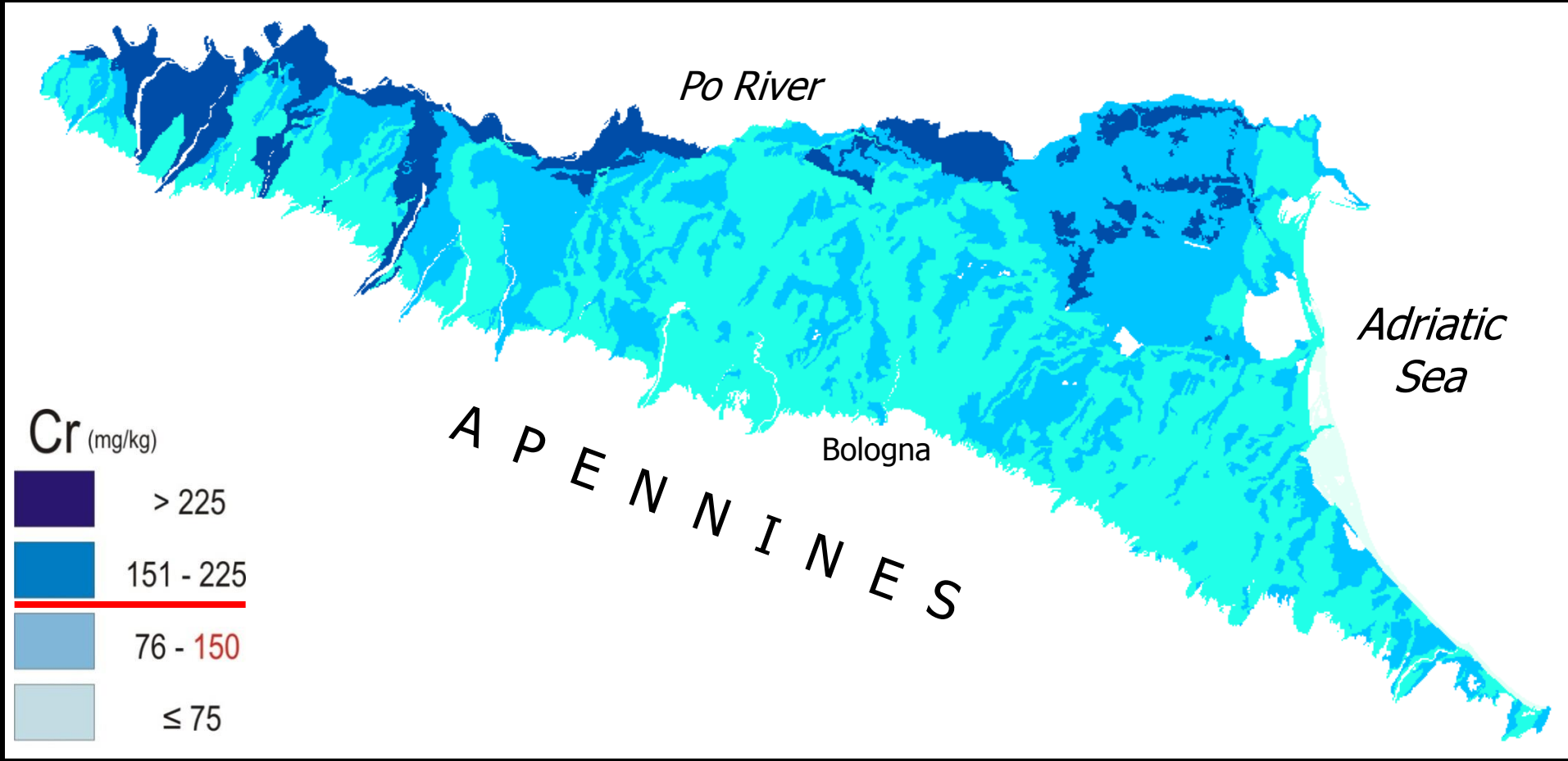


Pedogeochemical content higher than threshold levels



Pedogeochemical Map of the Emilia-Romagna plain

Map of the Pedogeochemical Content



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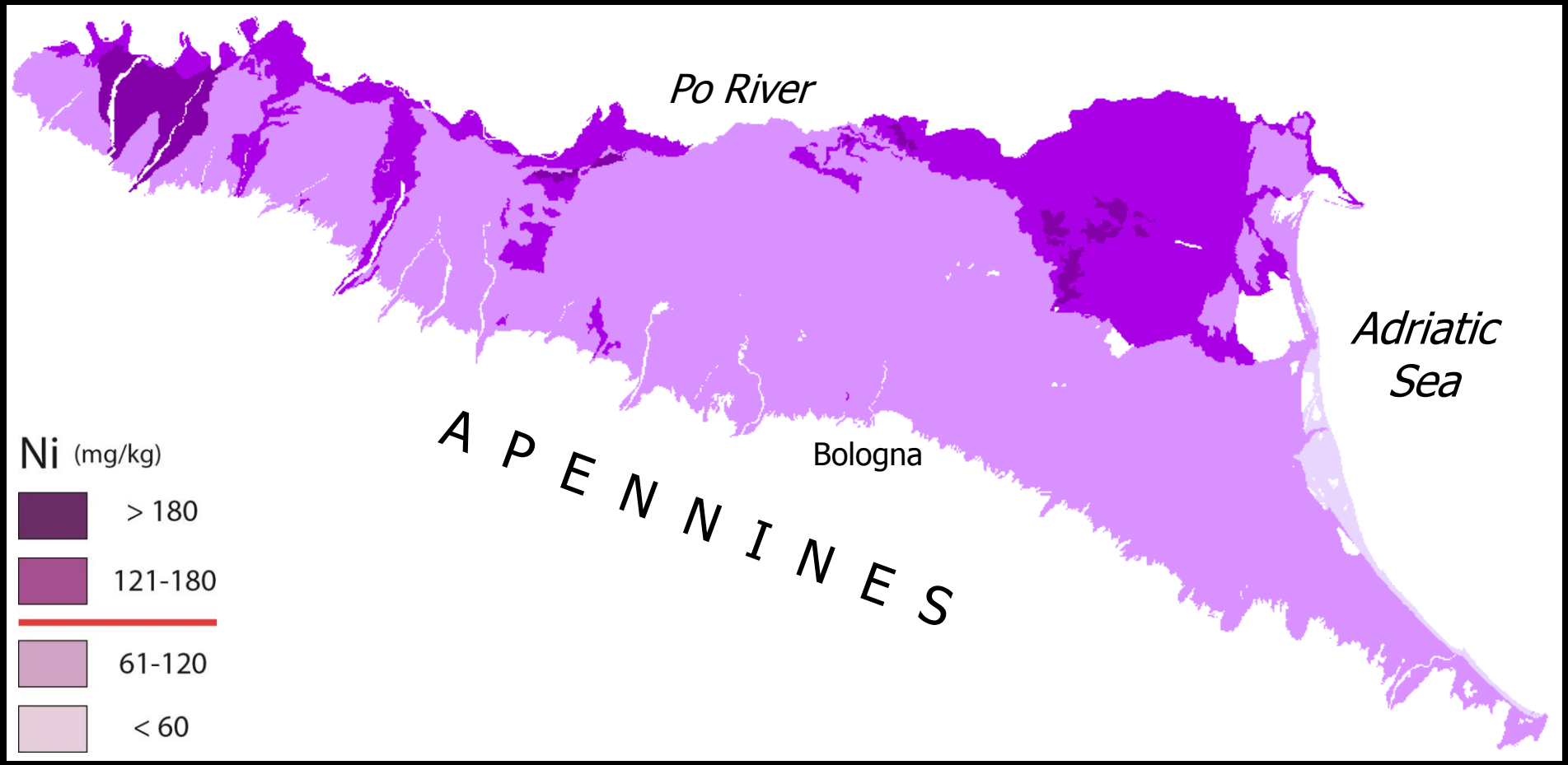

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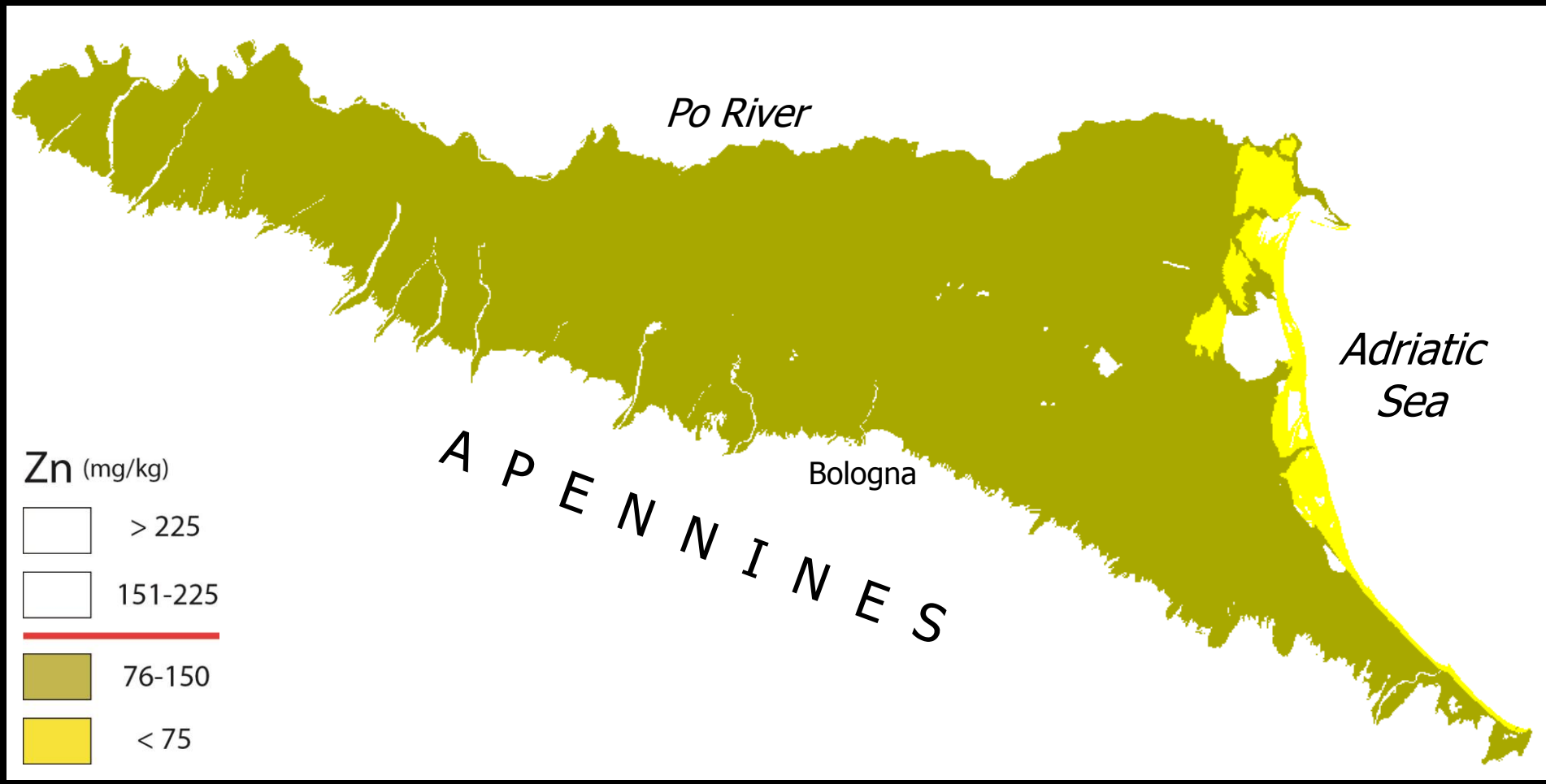

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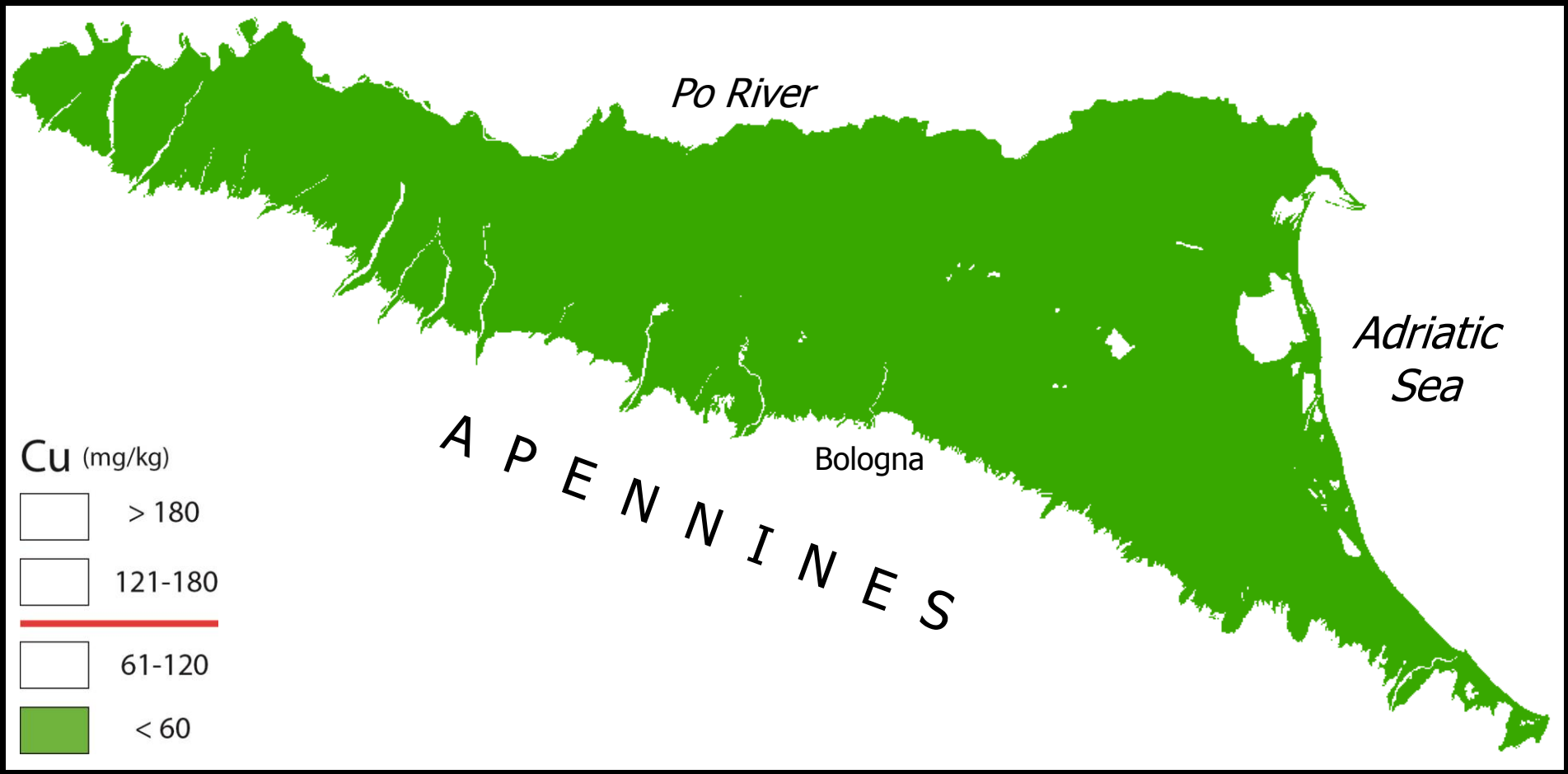

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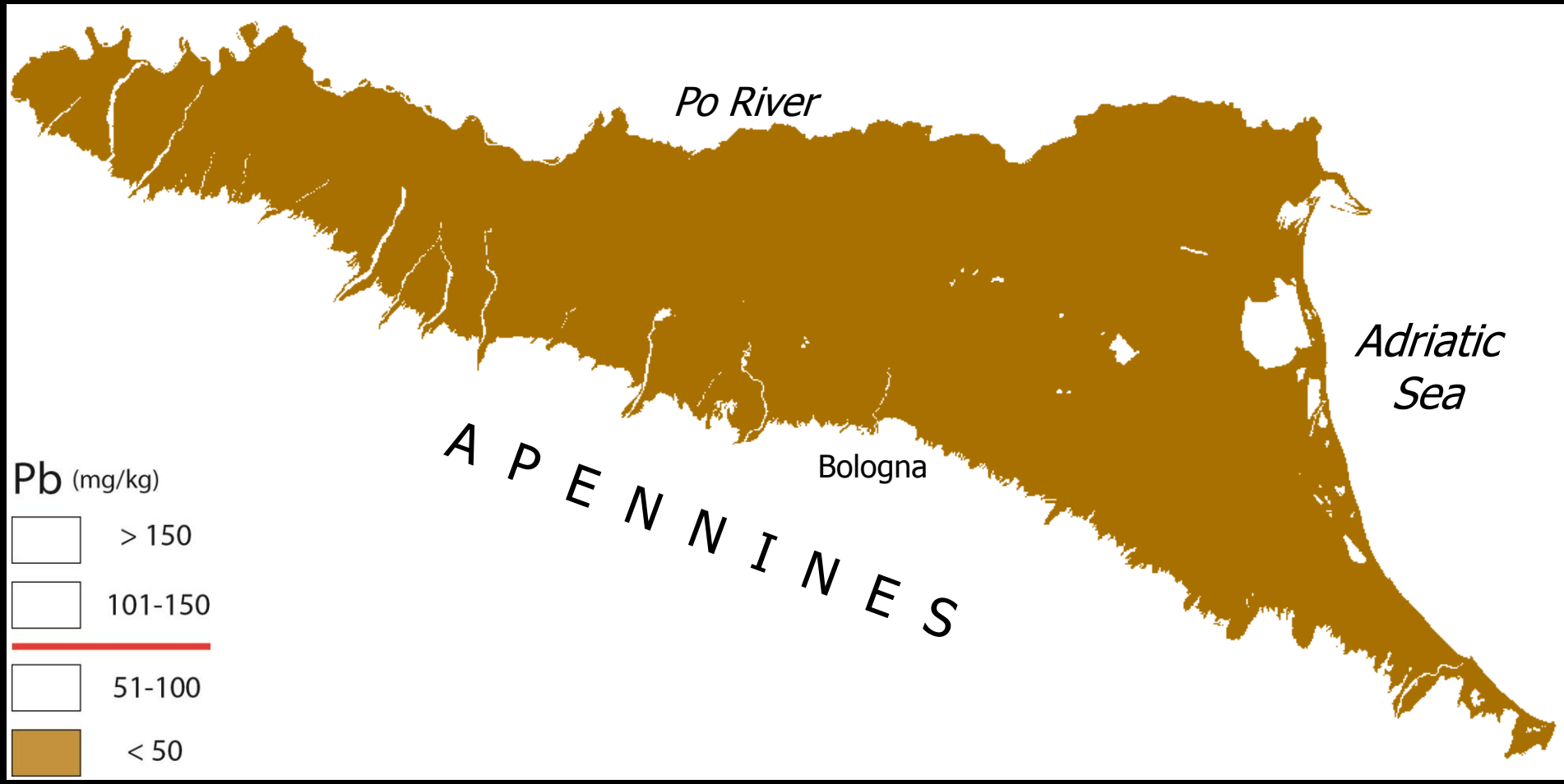
Map of the Pedogeochemical Content



XRF-ICP comparison

Metal percentage obtained following aqua regia digestion and ICP-MS analyses compared with XRF analyses (100 samples)

Cu	100%
Pb	94%
Zn	88%
Ni	81%

(Als Chemex data)

XRF-ICP comparison

Metal percentage obtained following aqua regia digestion and ICP-MS analyses compared with XRF analyses (100 samples)

Cu	100%
Pb	94%
Zn	88%
Ni	81%
Cr	44%

(Als Chemex data)

GEOCHEMICAL ANOMALIES

GEOACCUMULATION INDEX

$$Igeo = - \log_2 C_n / (1{,}5 * B_n)$$

(Muller, 1981)

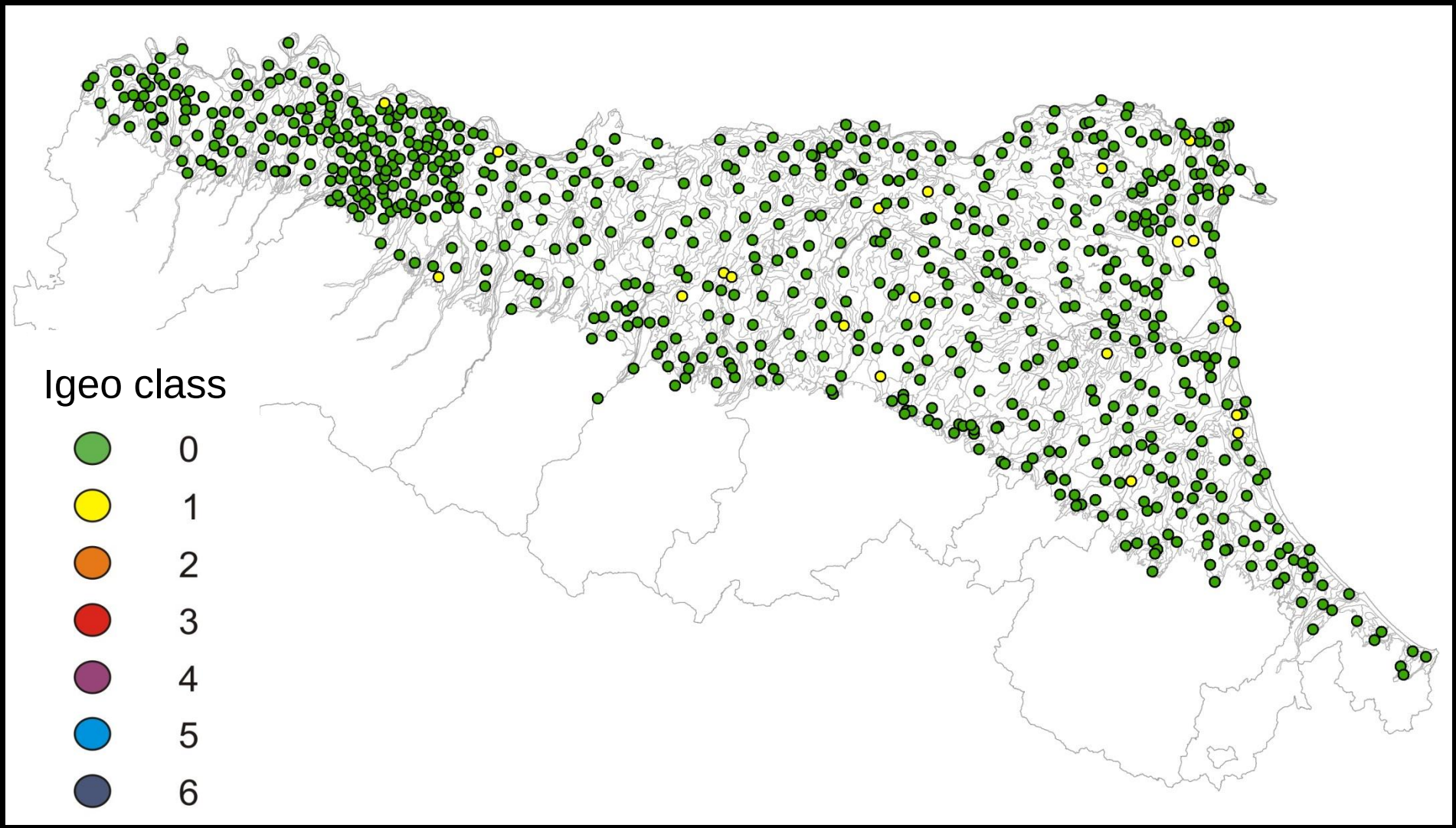
C_n = background value at 120-130 cm depth

B_n = metal concentration at 20-30 cm depth

Cr

Pedogeochemical Map of the Emilia-Romagna plain

Map of the Geochemical Anomalies



Cu

Pedogeochemical Map of the Emilia-Romagna plain

Map of the Geochemical Anomalies