NIOBIUM AND TANTALUM ENRICHMENT IN THE MECSEK HARD COAL FORMATION

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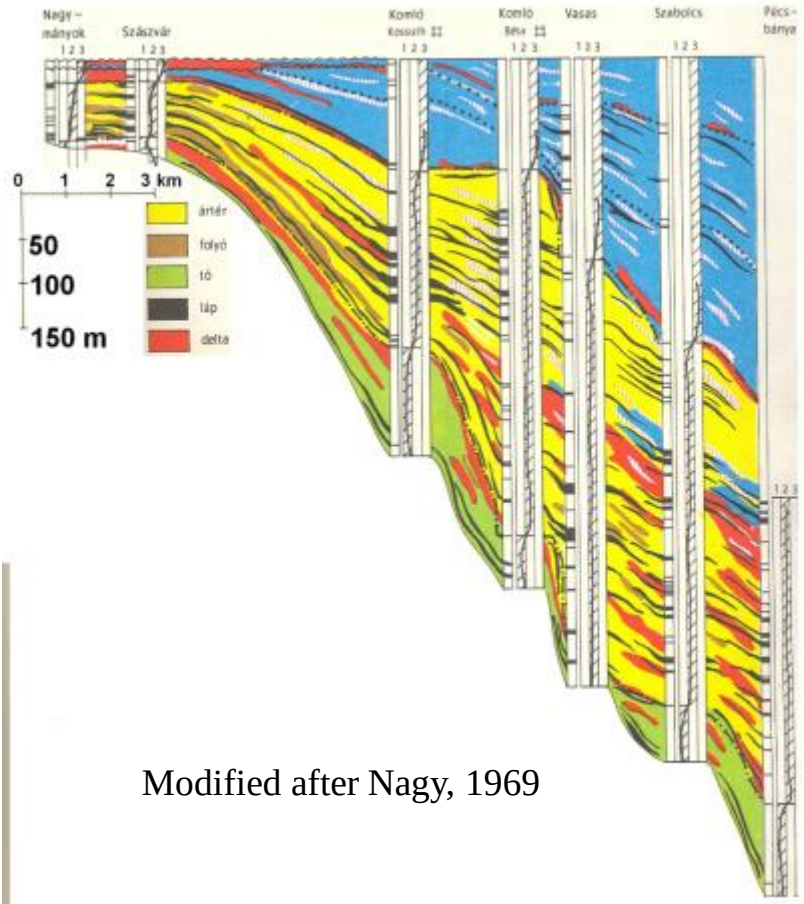
A projekt az Európai Unió támogatásával, az Európai Szociális Alap társfinanszírozásával valósul meg.

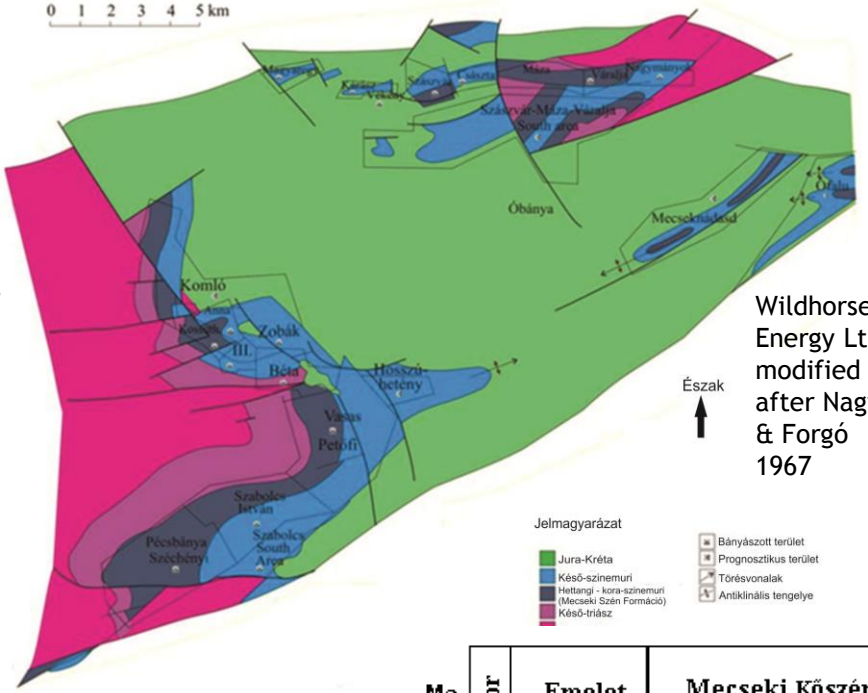
OUTLINE

- Geological background
- Sampling strategy
  1. Pécsszabolcs
  2. Pécs-Vasas
  3. Nagymányok
- Geochemistry
- Comparison of the analyzed areas
- Interpretation of enrichment
- Conclusion

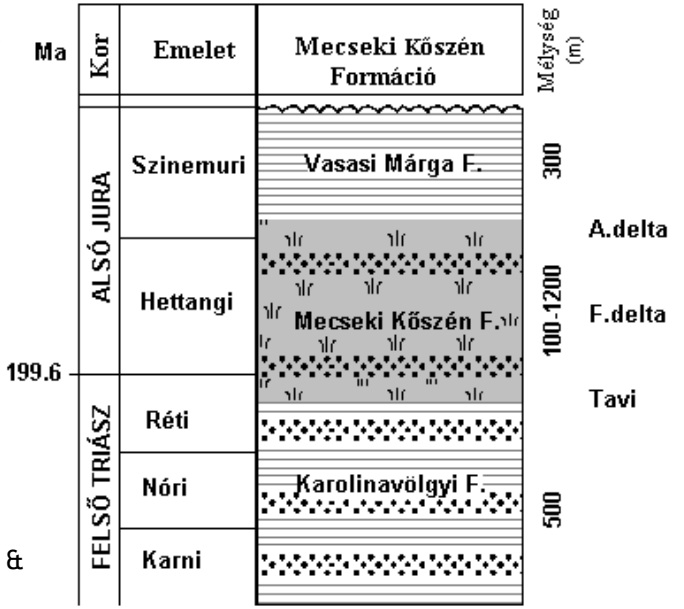
GEOLOGICAL BACKGROUND



Modified after Nagy, 1969

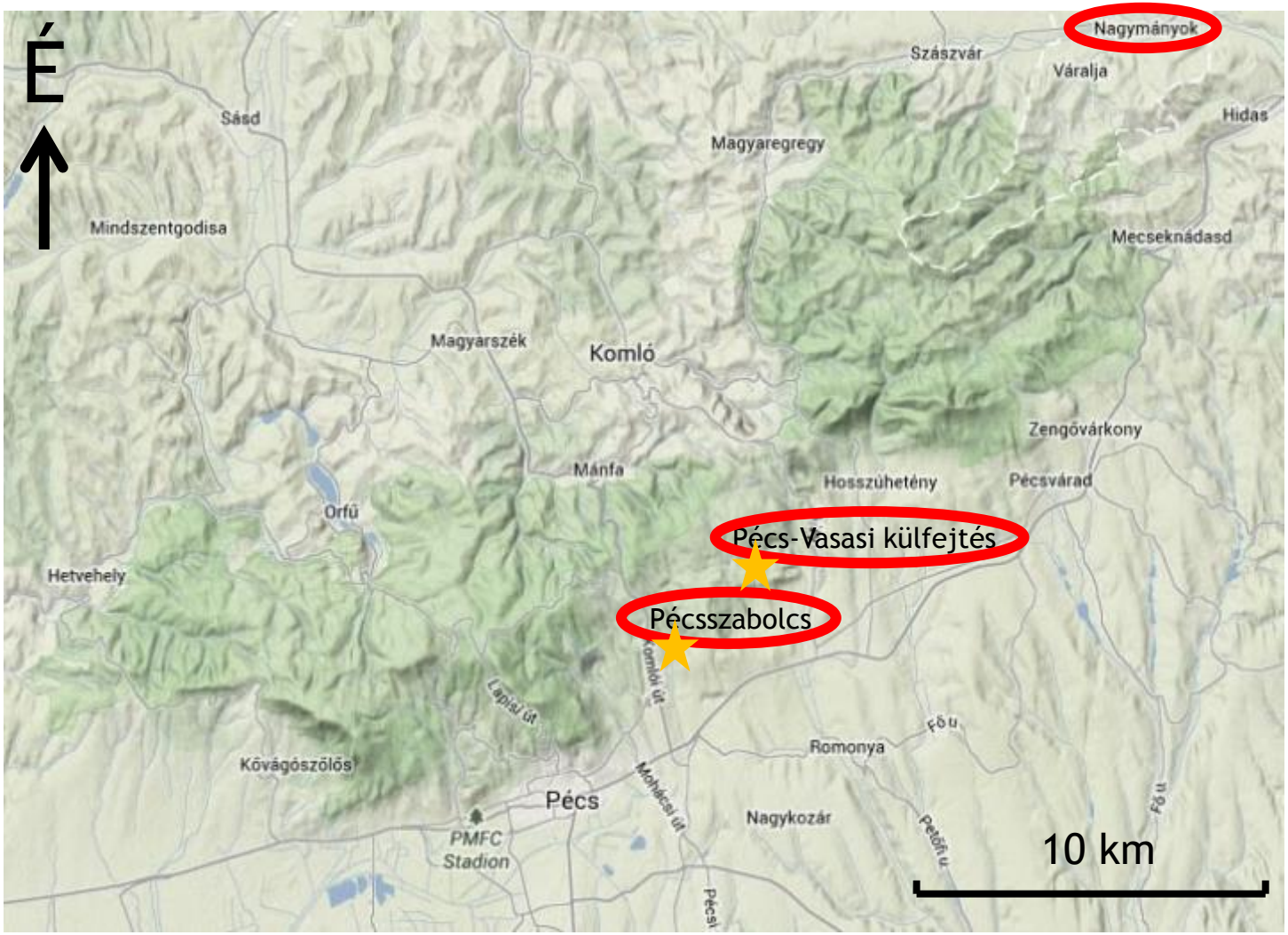


Wildhorse Energy Ltd. modified after Nagy & Forgó 1967



Hámor-Vidó 2014 and Hámor-Vidó & Hámor 2007

SAMPLING STRATEGY



SAMPLING 1. PÉCSSZABOLCS

- Wildhorse Energy UCG Ltd.
- 2 boreholes → 97 samples → 17 composite samples based on similar lithology
  - Coal, 60-90% bright
  - Coal, 10-60% bright
  - Contact samples (inner, outer)
  - Clayey intercalation
  - Sandstone
  - Tuffite
  - Magmatic body

SAMPLING 2. PÉCS-VASAS

- Pannonpower Holding Ltd.
- 16 samples
- Sampled lithotypes:
  - Basalt, metabasalt
  - Coal
  - Natural coke
  - Contact samples
  - Sandstone
  - Pelosiderite

SAMPLING 3. NAGYMÁNYOK

- Calamites Ltd.
- 8 samples from Nagymányok-30. borehole
- Sampled lithotypes:
  - Good and poor quality coal
  - Claystone
  - Samples from the rim of the coal seams

Analitical Methods

- ICP-MS
- ICP-OES
- XRD

GEOCHEMISTRY 1. PÉCSSZABOLCS

Element	World average (Seredin & Finkelman, 2008)			Coal, brightness 60-90%		Coal, brightness <60%		Claystone	
	Upper continental crust (ppm)	Sedimentary rocks (ppm)	Hard coal (ppm)	Average (ppm)	Compared to hard coal world average (enrichment factor)	Average (ppm)	Compared to hard coal world average (enrichment factor)	Average (ppm)	Compared to sedimentary rocks world average (enrichment factor)
Be	3	1.9	2	6.62	*3.31*	8.47	*4.23*	8.2	*4.31*
Co	10	14	6	10.6	*1.77*	13.1	*2.18*	11.58	*0.83*
Ga	17	12	6	24.41	*4.07*	32.4	*5.4*	37.55	*3.13*
Ge	1.6	1.4	2.4	0.27	*0.11*	0.32	*0.13*	0.35	*0.25*
Nb	25	7.6	4	106.13	*26.53*	122	*30.5*	176.25	*23.19*
Sb	0.2	1.2	1	0.87	*0.87*	1.6	*1.6*	1.59	*1.32*
Ta	2.2	1	0.3	6.7	*22.32*	8.35	*27.83*	11.7	*11.7*
W	2	2	0.99	4.47	*4.51*	6.67	*6.73*	6	*3*
Hf	5.8	3.9	1.2	9.07	*7.56*	12.23	*10.19*	17.48	*4.48*
Zr	190	170	36	>289,55	*>8.04*	>433.5	*>12.04*	>326	*>1.92*
ΣRFF	146,3	135,37	60,21	415.44	*6.9*	488.32	*8.11*	540.92	*4*

ΣRFF átlag összes mintán számítva 482,28 ppm

GEOCHEMISTRY 2. PÉCS-VASAS

Element	World average (Seredin & Finkelman, 2008)			Alkaline metabasalt		Coal	
	Upper continental crust (ppm)	Sedimentary rocks (ppm)	Hard coal (ppm)	Average (ppm)	Compared to upper continental crust (enrichment factor)	Average (ppm)	Compared to hard coal world average (enrichment factor)
Be	3	1.9	2	2.47	***0.82***	6.22	***3.11***
Co	10	14	6	40.06	***4.01***	-	-
Ga	17	12	6	18.53	***1.09***	19.01	***3.17***
Ge	1.6	1.4	2.4	0.76	***0.47***	1.19	***0.49***
Nb	25	7.6	4	40.22	***1.61***	51.71	***12.93***
Sb	0.2	1.2	1	0.53	***2.64***	-	-
Ta	2.2	1	0.3	2.4	***1.09***	3.04	***11.33***
W	2	2	0.99	1.19	***0.6***	-	-
Hf	5.8	3.9	1.2	3.13	***0.54***	7.64	***6.36***
Zr	190	170	36	133.52	***0.7***	358.82	***9.97***
ΣRFF	146,3	135,37	60,21	187.52	***1.28***	436.9	***7.26***

ΣRFF átlag összes mintán számítva 264,64 ppm

GEOCHEMISTRY 3. NAGYMÁNYOK

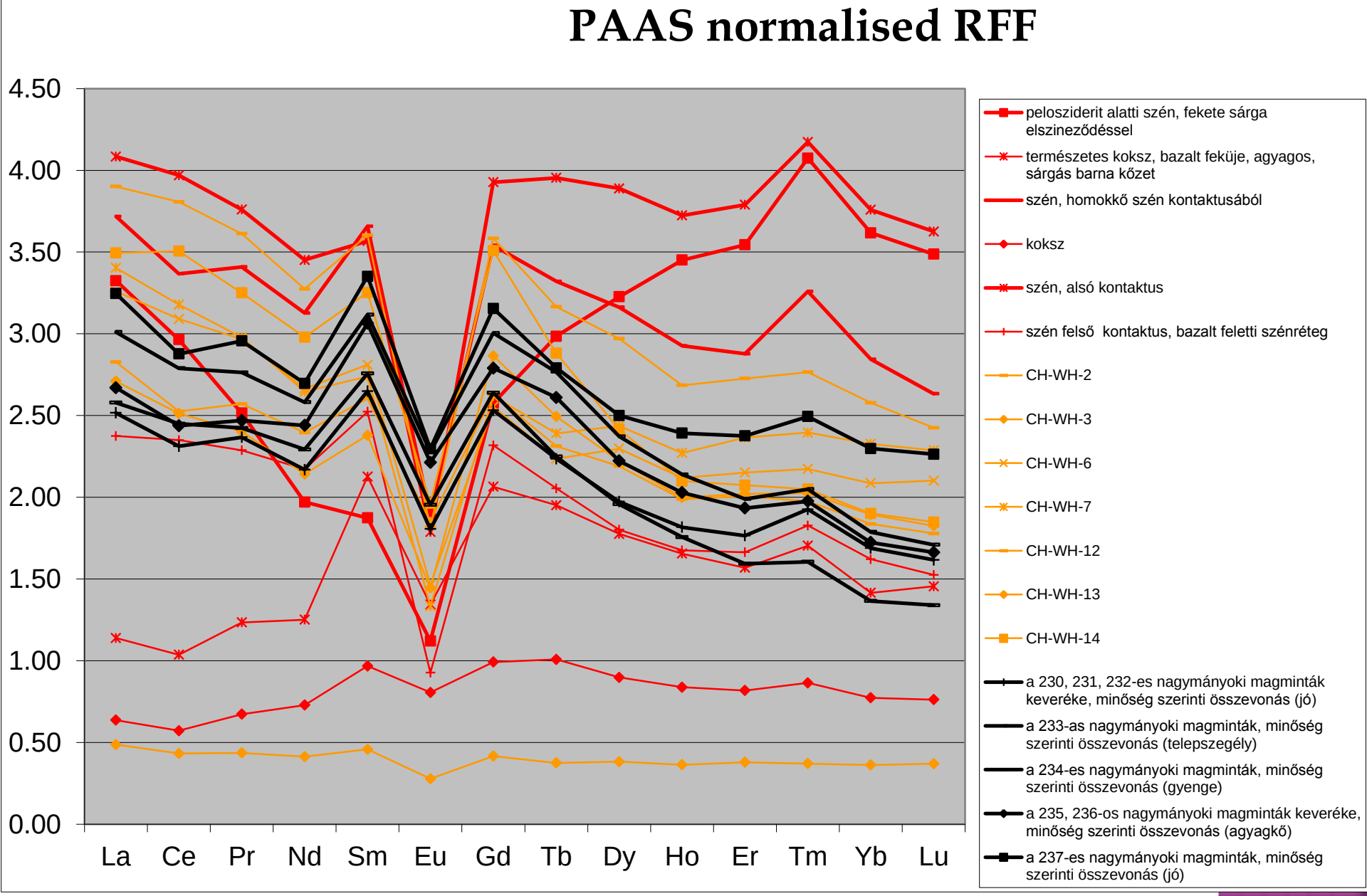
Element	World average (Seredin & Finkelman, 2008)			Hard coal	
	Upper continental crust (ppm)	Sedimentary rocks (ppm)	Hard coal (ppm)	Average (ppm)	Compared to hard coal world average (enrichment factor)
Be	3	1.9	2	8.75	***4.38***
Co	10	14	6	4.69	***0.78***
Ga	17	12	6	15.19	***2.53***
Ge	1.6	1.4	2.4	0.4	***0.17***
Nb	25	7.6	4	51.05	***12.78***
Sb	0.2	1.2	1	0.19	***0.2***
Ta	2.2	1	0.3	3.32	***11.09***
W	2	2	0.99	2.98	***3.01***
Hf	5.8	3.9	1.2	5.04	***4.2***
Zr	190	170	36	294.52	***8.18***
ΣRFF	146,3	135,37	60,21	475.76	***7.9***

ΣRFF átlag összes mintán számítva 475,76 ppm

COMPARISON

Element	Coal average compared to hard coal world average (enrichment factor)		
	Pécsszabolcs	Pécs-Vasas	Nagymányok
Nb	30.5	12.93	12.78
Ta	27.83	11.33	11.09
Hf	10.19	6.36	4.2
Zr	>12.04	9.97	8.18
ΣRFF average - coal	8,11	7,26	7,9
Max. concentration	• Hardcoal, brightness <60% • Claystone on coal contact	Hardcoal	Hardcoal, clayey hardcoal

COMPARISON

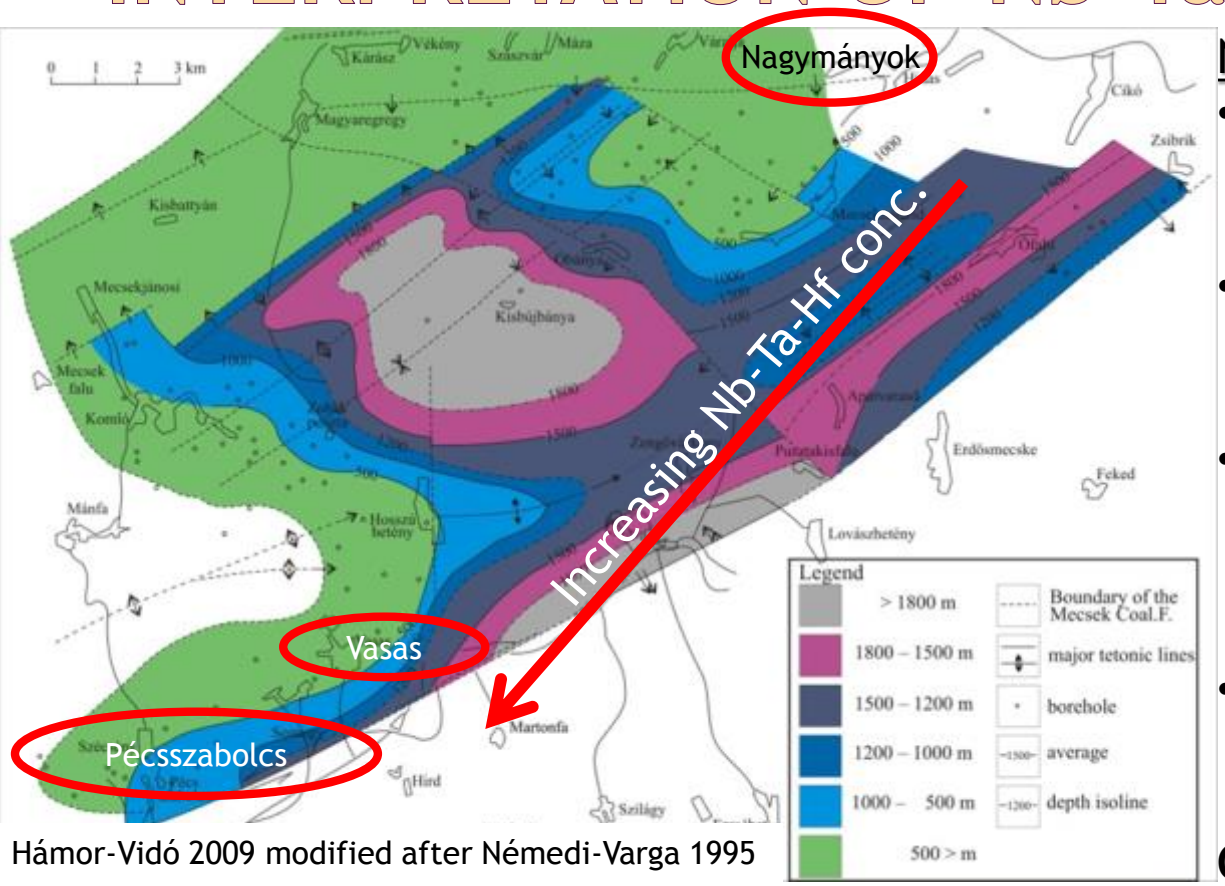

PAAS normalised RFF
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
pelosziderit alatti szén, fekete sárga elszíneződéssel
természetes koksz, bazalt feküje, agyagos, sárgás barna kőzet
szén, homokkő szén kontaktusából
koksz
szén, alsó kontaktus
szén felső kontaktus, bazalt feletti szénréteg
CH-WH-2
CH-WH-3
CH-WH-6
CH-WH-7
CH-WH-12
CH-WH-13
CH-WH-14
a 230, 231, 232-es nagymányoki magminták keveréke, minőség szerinti összevonás (jó)
a 233-as nagymányoki magminták, minőség szerinti összevonás (telepszegély)
a 234-es nagymányoki magminták, minőség szerinti összevonás (gyenge)
a 235, 236-os nagymányoki magminták keveréke, minőség szerinti összevonás (agyagkő)
a 237-es nagymányoki magminták, minőség szerinti összevonás (jó)

INTERPRETATION OF REE

- ∑RFF in natural coke << ∑RFF in coal
- negative Eu anomaly: due to inheritage of granitic provenance area (SEREDIN & FINKELMAN 2008)

- dissolved fine colloids and/or complexes of suspended river-load of meandering rivers (pH=8) → precipitation and adsorption on clays or humic acid in the acidic (pH=6) swamp water (BIRK & WHITE 1991)
  - + underground fluid contribution with lanthanides leached from underlying rocks?

INTERPRETATION OF Nb-Ta-Hf(+Zr?)



Hámor-Vidó 2009 modified after Némedi-Varga 1995

Niobium, Tantalum & Hafnium:

- Highest concentration: hard coal and clayey hard coal
- Concentration increasing toward the SW
- Transportation by fine grain fraction (clay) (PARKER & FLEISCHER 1968)
- Source: Carboniferous granite

Zirconium:

- Source: Carboniferous granite
- CSALAGOVITS & VÍGHNÉ 1969:
  - connected to sand fraction + minor adsorption
  - concentration decreasing toward the SW?

→ necessity of further analysis!

Coal-basins:

- Pécsbánya
- Pécsszabolcs
- Hosszúhetény
- Pécs-Vasas
- Béta
- Komló
- Váralja-South

CONCLUSION

- 3 analyzed area: Pécsszabolcs-Pécs-Vasas-Nagymányok
- Nb-Ta-Hf-Zr enrichment (up to 7-30x)
  - connected to hard coal seams
  - concentration increasing towards SW
  - source: granitic rocks
- REE enrichment (up to 7x)
  - connected to hard coal seams
  - no significant regional differences in distribution
  - negative Eu anomaly represents that REE originated from the weathering of granitic rocks exposed in the Early-Jurassic surrounded the coal basin
  - presumably colloidal transport and precipitation

THANK YOU FOR YOUR ATTENTION!

This work was carried out as part of the TÁMOP-4.2.2.A-11/1/KONV -2012-0005 project in the framework of the New Széchenyi Plan supported by the European Union, cofinanced by the European Social Fund.
The sampling and part of the measurements were supported by Wildhorse UCG Ltd., Pannonpower Ltd. and Calamites Ltd.