

Rare earth minerals in the  
Transdanubian bauxites of  
northwest Hungary (CriticEL project,  
2012-2014)

REBAUX Zagreb, Croatia,

2019.10.12-14

# Introduction: why REE

- Serious increase of the demand of them,
- Difficulties in procuring of them,
- Activities in Criticel project:
  - Gathering the formerly existing data, (mineralogy and geochemistry)
  - Earlier activities:
    - Hungarian State Geological Institute: in te 1960s: areal REE research programme,
    - First Countrywide REE Conference in the University of Heavy Industry , Miskolc, 1972
  - Make a decision: which are the promising areas of Hungary
  - Using modern measuring methodes (ICP-AES, ICP-MS with Li –metaborate digesting, XRD, SEM microprobe with EDX and WDX spectrometers, WDXRF)

# Introduction: Potential sources of REE

- Secondary enrichments in Hungary:
  - Hungarian clayey rocks (Dabu-Dingnan, Aigao analogies )
    - From the weathering of granites, kaolinite rich clays were produced, and they absorbed, or fixated in a stronger way the REE elements.
    - Economically feasible to mine them!
    - Clay deposits, bauxites, red clays,
  - Heavy mineral fraction of waste of sand and gravel mines.
  - Mineral sands: in other countries beside Ti and Zr, REE are mined as well.
  - Úrkút Mn ore deposit.
  - Deep sea clay formations

# Introduction: Potential sources of REE

- Tertiary sources:
  - Red mud :
    - more than 50 million tons in Hungary,
    - all of the REE pass through the alumina extraction process into the waste, and the total REE values are enriched by a factor of two from the original bauxite ore.
  - Coal fly ash : REE, Zr, V, Be, Ge enrichment

# Introduction: the Investigated Areas

- Recsk, Matra Mountains, North East Hungary,
  - Allanite (Ce), monacite (Ce) and because of element replacement: epidote and perovskite.
  - Potential zones: in the skarn
- Mecsek Mountains, South West Hungary,
  - Lantanite-(Ce), ancilite-(Ce), kalcioancilite-(Ce), bastnasite-(Ce), joaquinite-(Ce), cerite-(Ce), eudialite.
  - Potential zones: in the fonolites
- Velence Mountains, North Central Hungary,
  - Connection with the weathered biotite
  - Monacite-(Ce), keralite, xenotime-(Y), apatite, allanite-(Ce), florencite-goyazite,(gathering the mobilised REE)
  - Potential zones: the granites and beforite,
- Bükkszentkereszt, Bükk Mountains, North East Hungary
  - Mn-U-Be anomaly: high REE(HREE), and Y content.
  - In the Phosphatites,
  - In the crystal structure of fluorapatites and clay minerals
  - But: Y is present: xenotime-(Y), pirochlore, eszkinite: (YNbTi(RFF))-oxide
- Úrkút, Transdanubian Central Mountains
  - In the Carbonate ore type REE bearing apatite (with biogenic origin)
  - On the surfaces of clay minerals and Fe-Mn oxides

# Introduction: the Investigated Areas

- Mecsek Mountains, South West Hungary
  - In the coal seams: (more than 500-600 ppm REE, and Nb, Ta, Zr and Hf)
  - Until now: REE carbonates...
- Rudabánya, Rudabánya Mountains, North East Hungary
  - xenotime-(Y)
- Fehérvárcsurgó, Vértes-Velence Mountains, North Central Hungary
  - The sand as glass raw material is containing Fe-Ti oxides and monacite-(Ce)
- Irota-Gadna-Felsővadász, Cserehát, North East Hungary
  - monacite, allanite, REE-carbonates, YNb-oxides
  - In the paleosoic metamorphites and pliocene siliciclastic sediments
- Bauxites of Transdanubian part of Hungary
  - $\Sigma$ REE between 400-800 ppm
  - Zircon, xenotime, monacite and Fe-oxides
  - Economically the exploitation is not feasible, but together with Al it may be.
- (Modified after TÖRÖK, 2014)

For further primary production, directly, Hungarian bauxite reserves (in 2006) ~6 000 000 tons

Place of occurrence,	Area,	Reserve,	Modulus
		(thousand t)	
Bakonyoszlop térsége	Bakonyoszlop, Csesznek, Dudar.	2 500	7,8
Németbánya I-IX. telepek	Németbánya	300	9,9
Németbánya kis lencsék (déli)	Németbánya	200	7,9
Nyirád felhagyott bányák	Nyirád	500	8,5
Nyireskút IV/B	Szóc, Taliándörög.	300	7,5
Óbarok-Vázsonypusztá	Óbarok	195	6,0
Sármás	Bakonyjákó	250	14,0
Gerecse, Vértes	Óbarok, Nagyegyháza.	~1 800	7,2
Táncsics ;	Nyirád	130	8,8

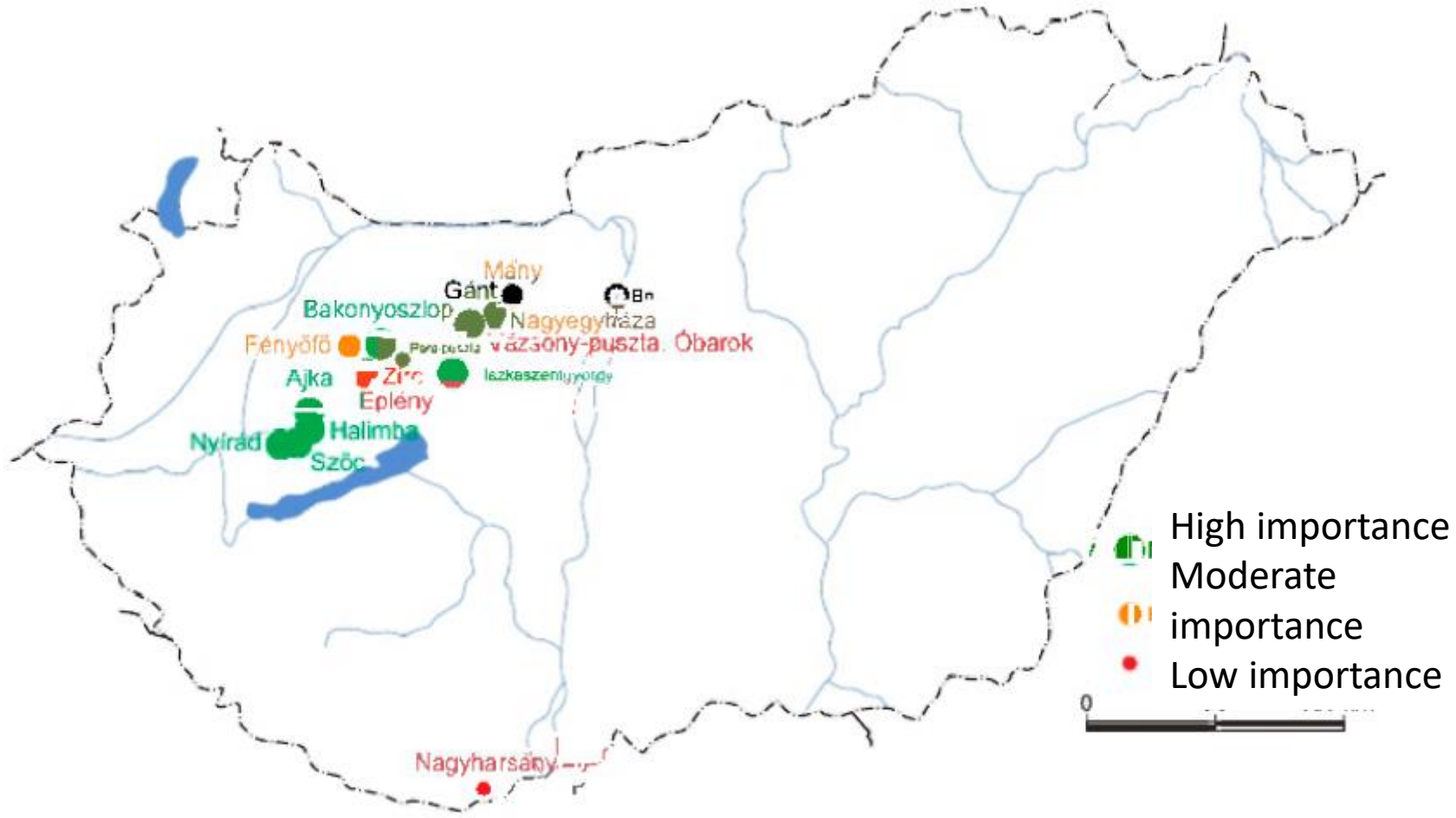
1. ↑ Forrás: *Bányászati és kohászati Lapok. Bányászat 2006/6. szám*

# Introduction

- Hungary has significant bauxite reserves
- REE(+Y) enrichment is mentioned in these bauxites by many authors. (BÁRDOSSY et al. 1975; BÁRDOSSY 1977; PANTÓ 1980).
- From formerly made researches, from different drills, 120 core samples, with 1 m longness were investigated to measure REE+Y content.
- The highest average values of the bulk samples exceeded the 1 m/m % (mass percent)  $\Sigma$ REE+Y-content.
- More than 10 samples (Csabrendek, Iharkút and Németsbánya drill holes) higher than 0,5 m/m % REE+Y-content was detected (STEFÁNIAY 1981).
- That is why we chose the hungarian bauxite samples for further investigations.
- Bauxites of strip mines and deep working mines were sampled with the help of hungarian experts.
- Using the mineralogical measurements technics and the weaponry of geochemistry, origin and REE+Y bearing phases were investigated.



# Bauxites of Transdanubian part of Hungary



Transdanubian Bauxite deposits

More than 10 samples(Csabrendek, Iharkút and Németbánya drill holes) higher than 0,5 m/m % REE+Y-content was detected (STEFÁNIAY 1981).

Csabrendek



# The extreme values

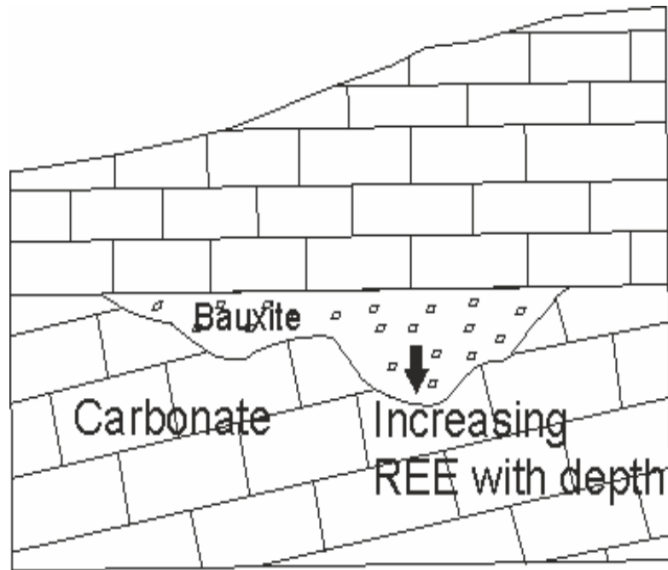
Chemical analyses of  
hungarian bauxite  
samples from  
CN: Csabrendek,  
IK: Iharkút,  
NB: Németbánya

Drill hole	Depth int.	$\Sigma$ REE+Y cont.mg/kg
CN-435	54,7-55,7	11856
CN-559	115,8-116,8	10268
IK-179	6,0-7,0	9384
IK-179	14,0-15,0	8483
IK-42	13,0-14,0	8328
IK-574	82,5-83,5	6654
IK-679	97,8-98,8	6484
CN-833	95,8-96,8	6357
NB-40	127,8-128,4	5388
NB-22	37,4-38,4	5380
IK-324	92,2-93,2	5378
CK-138	52,7-53,7	5341

Measurements of hungarian bauxites  
ALUTERV FKI (STEFÁNIAY 1981).

- We have geochemical theories (REE+Y enrichments)
- We have potential sites
- We have mineral phases containing REE+Y
  - Former measurements, reports

# Karst bauxite deposits



Schematic diagram showing the typical classic Mediterranean type karst bauxite (after BÁRDOSSY 1982 in: ÉIMEAR DEADY et al, 2014)

- Formed by accumulation of residual clays, derived from the weathering of aluminosilicate minerals, in depressions on carbonate palaeotopography.
- The contents of the depressions are bauxitised through deep lateritic weathering and desilicification of ferrilitic soils.
- Silica is incongruently dissolved from minerals such as feldspar and kaolin leaving an aluminium-rich residue.
- Bardossy distinguishes several subtypes:
  - Kazachstonian type,
  - Timan type,
  - Ariège type,
  - Tula type
  - Mediterranean type.

# Karst bauxite deposits

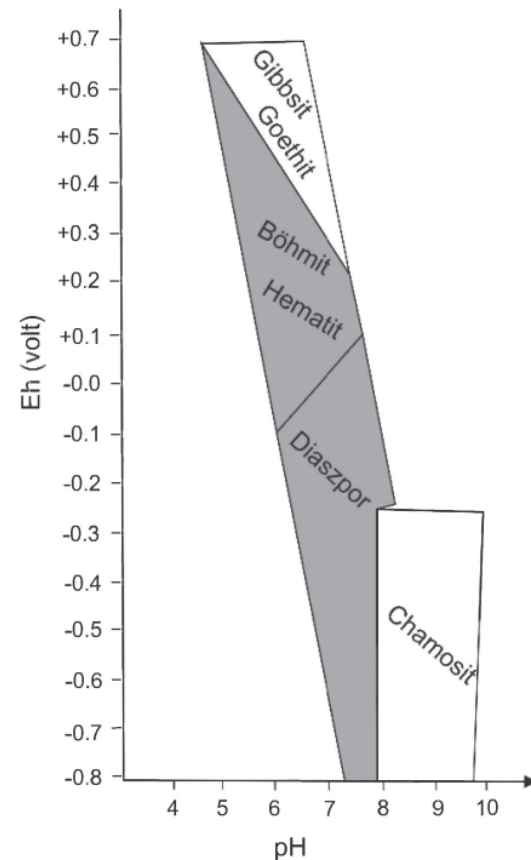
- Mediterranean type karst bauxite deposits formed on both the European and Adriatic Mesozoic carbonate shelves in the Neotethys realm during the Mesozoic to Early Cenozoic.
- Bauxitisation in this area occurred from the surface downwards leading to the ultimate loss of  $\text{SiO}_2$  and  $\text{Fe}_2\text{O}_3$  and accumulation of  $\text{Al}_2\text{O}_3$  with depth.

# Karst bauxite deposits

- Karst bauxites might be significant sources of Ga and REE+Y, as well(LASKOU 1991; CALAGARI & ABEDINI 2007).
- The earlier research results show a very wide range of potential source rocks.
  - Carbonatic rocks ( M A C L E A N et al. 1997)
  - Volcanic ash (MORELLI et al. 2000),
  - Aeolian sediments (BRIMHALL et al. 1988; PYE 1988)
  - Mafic rocks (CALAGARI & ABEDINI 2007; MAMELI et al. 2007)
- After deposition, because of the acidic solution seeping through in the karstic sink-holes, chemical composition of bauxite might be changed. (SZANTNER et al. 1986).
- Hungarian bauxites are solely karst bauxites.

# Main minerals

- Modal composition of bauxites are changing from provenance to provenance.
- Not rarely, this changeability can be detected within a given site of occurrence.
- Main minerals are Al-hydroxides and Al-oxyhydroxides, clay minerals as well as insoluble Fe- (and Ti-) mineral phases (BÁRDOSSY 1977).
- Occurrences of the Al- and Fe-minerals are determined by their creation circumstances.
- As in the given Eh-pH diagram can be seen (KOMLÓSSY 1970), however diaspor and the accessory chamosite are stable on the highest (~9) pH, between reductive environment, gibbsite together with goethite are stable a bit lower (5-7) pH and in oxidative circumstances.
- Bohmite together with hematite can be found in the middle fields.



Stability diagram of the main bauxite minerals as a function of pH and Eh. KOMLÓSSY 1970

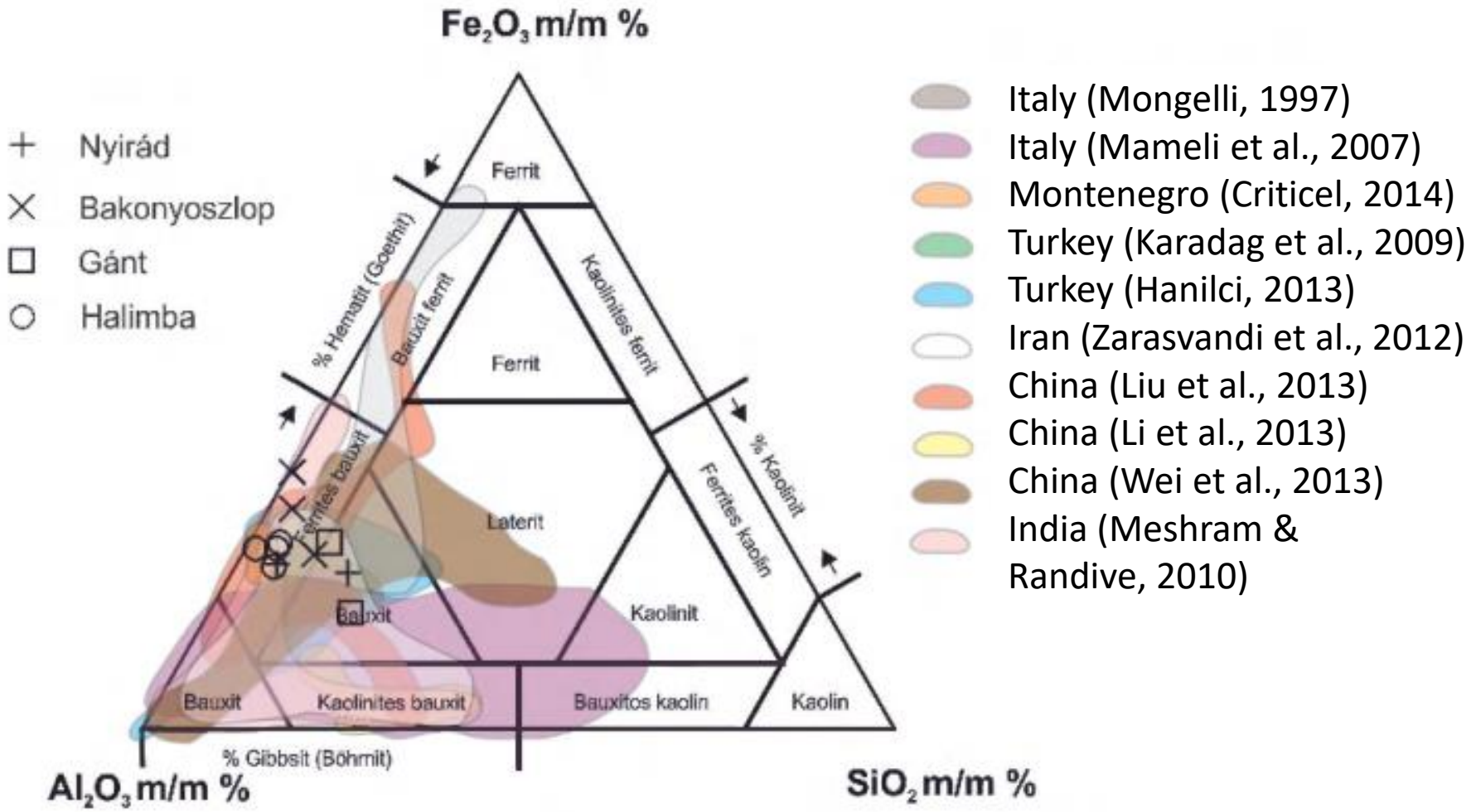


# Main minerals

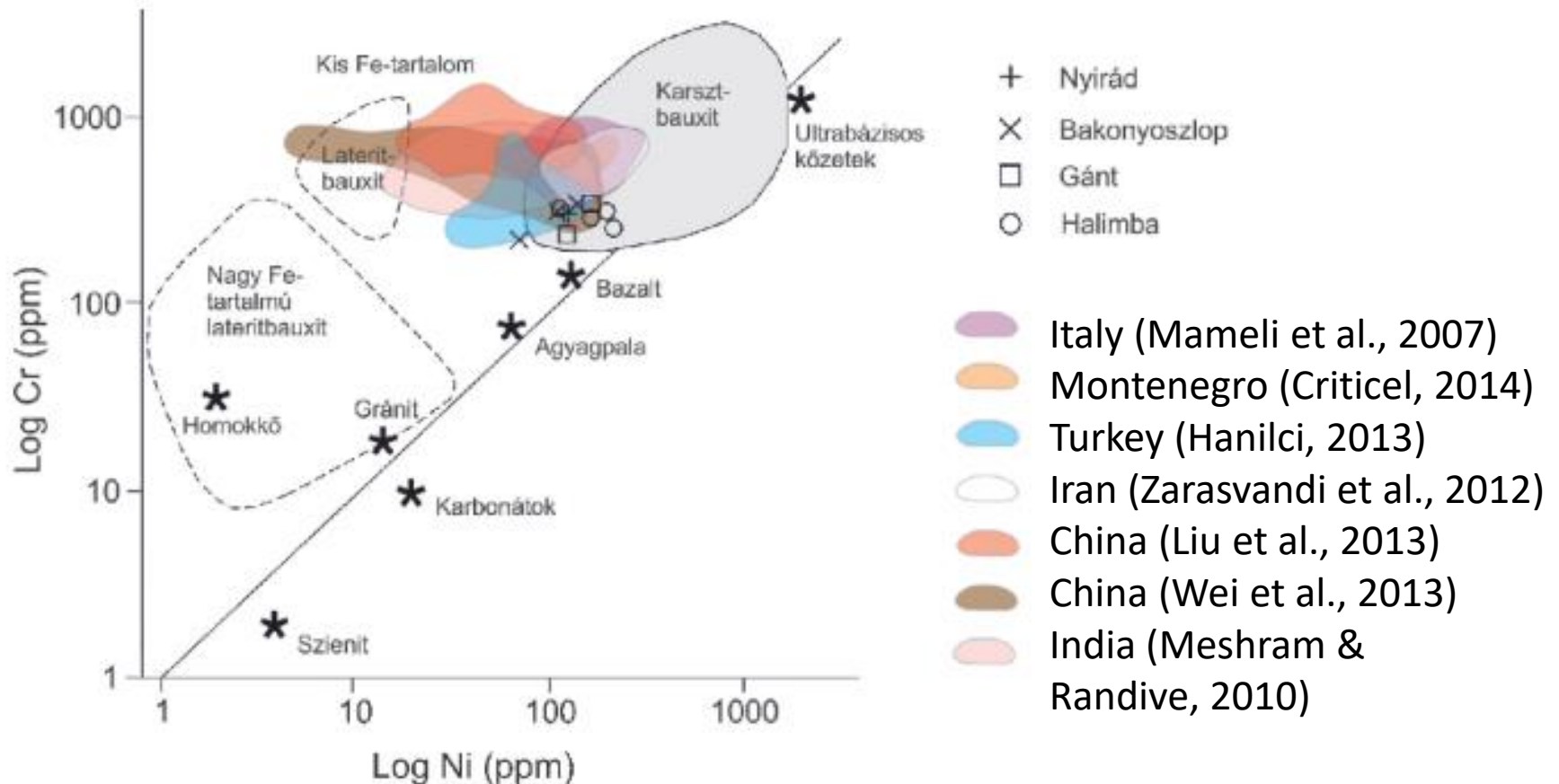
- However, in our karst bauxites gibbsite and bohmite create together the Al-dominant phases of the Cenozoic bauxite deposits, in the older deposits bohmite is the prevalent phase.
- Diaspore occurs only in some deposits as a main mineral phase.
- The most frequent accessory minerals of hungarian bauxite deposits are hematite, goethite, kaolinite, anatase, rutile and quartz (BÁRDOSSY 1977).

# Main elements:

Our bauxites are corresponding to the Mediterranean bauxite province



# Main elements: Potential source rocks



# Rare Earth Elements in Bauxite

- Meteoric water can leach away silica produced from the dissolution of feldspar and kaolinite leaving an Al-rich residue.
- If REE are available to the weathering system, they can be adsorbed onto the surfaces of clay minerals forming the bauxite deposit and are then concentrated with depth because of bauxitisation.
- With intense bauxitisation there is a correlation with depth between increased REE content and decreased silica content.

## 2.4. REE+Y-containing minerals in bauxites

- 1) As a stand alone mineral:  
(for example: light REE bearing monacite, apatite, bastnasite, allanite and heavy REE+Y bearing xenotime),
- 2) as trace element by replacement in some minerals (for example: in rock forming silicates),
- 3) as a free ion produced by bauxitisation.  
Adsorbing or absorbing on suitable solid or gel surfaces.

# Authigenic rare earth element-bearing minerals

- If sufficient REE+Y are available within the bauxite,
- Bauxitisation has occurred *in situ*
- No later transport or erosion of the deposit,
- As waters percolate through the weathering rocks during bauxitisation REE +Y are mobilized from the clays.
- Descending REE +Y -bearing fluids flow through the deposit and reach the carbonate they become physically trapped.
- If REE +Y content is sufficiently high, authigenic REE minerals can form.
- The most common is hydroxylbastnäsite-(Nd) ( $\text{Nd}(\text{CO}_3)(\text{OH})$ ).
- In order for REE minerals to develop, the initial concentration of REE adsorbed onto the clay must be greater than about 1000 ppm. (ÉIMEAR DEADY et al, 2014)

# Authigenic rare earth element-bearing minerals

- If the initial concentration does not reach this threshold, REE minerals are unlikely to form.
- Where the bauxites have been disturbed during formation, REE content can be lost from the system. ( karst-bauxite deposits in the Transdanubian Central Range, Hungary.)
- In Hungary the REE concentrations vary greatly, ranging from ~81–~10 000 ppm.
  - Because: the detrital nature of some REE host minerals such as monazites sourced from the Mecsek mountains in the case of the Nagyharsany deposit, rather than authigenic mineral growth. (ÉIMEAR DEADY et al, 2014)

# REE+Y minerals of karst bauxites

Mineral class	Name	Chemical composition
V. Carbonates	Bastnasit-(Ce)	$(\text{Ce,La})\text{F}(\text{CO}_3)$
	Bastnasit-(La)	$(\text{La,Ce})\text{F}(\text{CO}_3)$
	Szinchizit-(Ce)	$\text{Ca}(\text{Ce,La})\text{F}(\text{CO}_3)_2$
	Szinchizit-(Nd)	$\text{Ca}(\text{Nd,La})\text{F}(\text{CO}_3)_3$
	Parisit-(Ce)	$\text{Ca}(\text{Ce,La})_2\text{F}_2(\text{CO}_3)_3$
	Parisit-(Nd)	$\text{Ca}(\text{Nd,Ce,La})_2\text{F}_2(\text{CO}_3)_4$
	Röntgenit-(Ce)	$\text{Ca}_2\text{Ce}_3\text{F}_3(\text{CO}_3)_5$
	Monacit-(Ce)	$(\text{Ce,La,Nd,Th})\text{PO}_4$
VIII. Phosphates	Xenotim-(Y)	$\text{YPO}_4$
	Cirkon	$\text{ZrSiO}_4$
IX. Silicates		



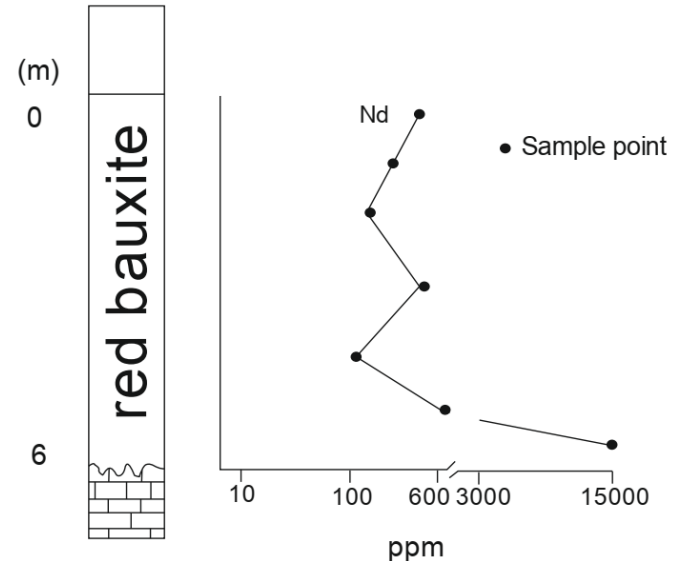
# Classification of REE

														3	IIIB
														21	Sc
														44.956	
														39	Y
														88.906	
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
138.91	140.12	140.91	144.24	(145)	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97	
LREE								HREE							

- The separation of the rare earths was primarily achieved by repeated precipitation or crystallisation.
- The first separation was into two main groups,
  - **the cerium group** earths (scandium, lanthanum, cerium, praseodymium, neodymium, and samarium) and
  - **the yttrium group** earths (yttrium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium).
- Europium, gadolinium, and terbium were either considered as a separate group of rare earth elements (the terbium group),
- Or europium was included in the cerium group, and gadolinium and terbium were included in the yttrium group.
- The reason for this division arose from the difference in solubility of rare earth double sulfates with sodium and potassium. The sodium double sulfates of the cerium group are difficultly soluble, those of the terbium group slightly, and those of the yttrium group are very soluble.

# Key parameters of REE concentration in bauxite

- Water flow: Leaching of the bauxite by meteoric water can remobilise adsorbed REE. The weathered limestone below the bauxite facilitates drainage and thus clay layers do not form within the bauxite, so the downward mobility of REE is not restricted.
- pH: The alkaline nature of the underlying limestone creates a high pH that results in increased stability of REE-carbonate complexes. Stability increases with atomic number, allowing HREE to be preferentially retained in solution as carbonate ions. The distribution of REE along this 'pH barrier' is heterogeneous and the REE can be concentrated in lenses or in micropores, space fillings and microveins.
- Fe content: Fe-rich goethite has a scavenging effect, fixing mobile REE, in particular the LREE, within residual Fe-rich layers. Positive correlations exist between  $\text{Fe}_2\text{O}_3$  and  $\Sigma\text{REE}$ , particularly where Fe oxyhydroxides occur as ferruginous ooids.
- F content: Bauxite is depleted in F; this depletion is a critical factor in controlling the type of minerals that form. F can be substituted by -OH groups to form hydroxylbastnäsites such as hydroxylbastnäsite-(Nd), which has been described from Nikšić in Montenegro. Hydroxylbastnäsites are the most common authigenic REE minerals found in bauxite



Nd distribution through the Štitovo bauxite, Montenegro, The enrichment of Nd at the base allows for the formation of authigenic REE minerals such as Nd-goyazite, bastnäsite and hydroxylbastnäsite-(Nd) (after Maksimovic and Panto 1995 )

# Under acidic pH

- During chemical weathering the light REE mobilised, preferentially from the primary minerals (silicates), linking to almost any solid or gel surfaces in ionic form. (E.g.: clay minerals, amorphous Al and Fe particles).
- At the same time the not so mobile heavy REE+Y elements are caught by authigenic heavy minerals (rutile, anatase, titanite).
- It is a kind of fractionation during weathering (MACLEAN et al. 1997).

## But under neutral or alkaline (basic) pH

- Mobilisation of LREE decreasing and they are concentrating in the autigenic apatite, xenotime and monacite.
- If the pH is extremely alkaline LREE stabilizing in carbonates (e.g. bastnasite).
- Because of this, in the highly weathered products, LREE are abundant.
- In the outer zones of these weathered rock parts, Ce might be oxidized and as cerianite ( $\text{CeO}_2$ ) precipitates, than the other REE+Y-s are dissolving and going away.

# Applied measuring techniques

- SEM-EDX, WDS, JEOL JXA-8600 Superprobe
- XRD, Bruker D8 Advance
- ICP-AES, Jobin Yvon Ultima-2C
- ICP-MS, Perkin Elmer Elan DRC-II
- WDXRF, Rigaku, Supermini200

# REE+Y content of the examined bauxites

Li-metaborate digestion, Sample number		ICP-MS, mg/kg											
Locality		Cs	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho
166/3	Nyírad - Gábor	0,32	40,1	114	265	20,2	55,8	8,34	1,62	8,95	1,48	9,44	2,18
181/3	Nyírad - Gábor készlettér	0,47	34,0	117	250	23,2	75,2	13,7	2,35	10,4	1,40	7,60	1,58
168/3	Bakonyoszlop XI - lencse	<0,25	50,8	120	222	23,9	76,5	13,2	2,46	11,7	1,88	11,1	2,37
169/3	Bakonyoszlop XI - lencse	4,15	51,8	118	198	25,9	83,2	14,9	2,72	12,6	2,01	11,3	2,45
171/3	Gánt - Bagolyhegy	0,87	79,7	106	186	24,7	89,1	19,1	3,59	17,0	2,76	16,0	3,39
172/3	Gánt - Bagolyhegy	1,53	88,8	122	223	29,4	113	23,6	4,37	19,9	2,90	16,2	3,54
174/3	Posusje - Bosznia-Hercegovina	<0,25	56,9	113	158	21,3	70,4	13,1	2,39	11,6	1,90	11,3	2,51
175/3	Niksic - Montenegro	2,00	93,2	180	309	37,6	133	25,2	4,70	21,4	3,45	19,9	4,31
177/3	Halimba - felszín alatti	<0,25	79,4	234	249	45,2	159	26,2	4,86	24,5	3,49	18,3	3,69
178/3	Halimba - felszín alatti	<0,25	67,6	136	275	30,3	103	19,8	3,60	16,8	2,65	15,2	3,12
179/3	Halimba - felszín alatti	0,32	104	158	272	37,3	138	26,3	5,12	23,9	3,63	19,7	4,32
180/3	Halimba - külfejtés	<0,25	40,7	65,1	235	12,1	38,0	7,47	1,39	7,11	1,28	8,36	1,92

Li-metaborate digestion, Sample number		ICP-MS, mg/kg											
Locality		Er	Tm	Yb	Lu	Hf	Ta	W	Tl	Pb	Bi	Th	U
166/3	Nyírad - Gábor	6,36	1,13	7,70	1,29	12,9	3,70	4,99	0,33	191	2,60	42,5	15,6
181/3	Nyírad - Gábor készlettér	4,69	0,82	5,38	0,87	6,58	1,65	3,72	0,38	145	1,37	37,0	11,1
168/3	Bakonyoszlop XI - lencse	6,66	1,14	7,63	1,26	6,17	1,65	3,47	0,22	104	1,13	37,3	18,8
169/3	Bakonyoszlop XI - lencse	6,96	1,14	7,56	1,21	1,14	0,43	2,85	1,21	75,1	1,29	36,8	20,9
171/3	Gánt - Bagolyhegy	9,22	1,51	9,03	1,47	1,93	0,61	3,58	0,17	82,7	1,73	37,9	22,2
172/3	Gánt - Bagolyhegy	9,02	1,48	8,20	1,36	3,21	1,01	3,30	0,37	86,2	1,55	36,5	15,0
174/3	Posusje - Bosznia-Hercegovina	7,11	1,24	7,59	1,26	12,8	2,89	5,51	0,38	120	3,15	49,9	5,70
175/3	Niksic - Montenegro	11,6	2,00	12,2	2,05	9,27	2,01	2,28	0,36	109	2,34	51,5	5,91
177/3	Halimba - felszín alatti	9,40	1,46	8,71	1,51	7,49	2,07	4,95	0,28	105	1,00	45,3	13,6
178/3	Halimba - felszín alatti	8,27	1,30	8,56	1,28	6,51	1,78	3,31	0,26	114	0,90	44,4	17,6
179/3	Halimba - felszín alatti	11,6	1,80	10,4	1,58	5,57	1,77	4,19	0,22	109	0,89	42,2	20,0
180/3	Halimba - külfejtés	5,48	1,00	6,61	1,08	8,23	1,82	4,15	0,39	110	1,63	42,4	11,6

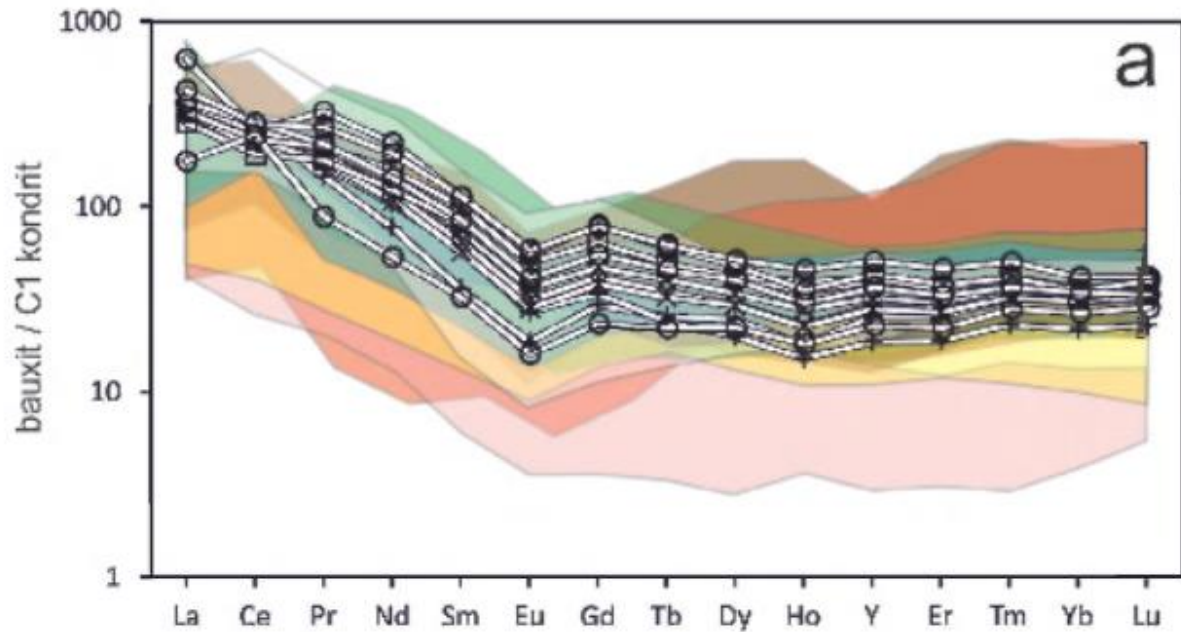
# REE+Y content of the examined bauxites

- Elemental content was measured by ICP-MS.
- $\Sigma$  REE+Y is a good tool to find the origin and follow the diagenetic processes of a given rock.
- From the smallest atomic numbered (and biggest ionic radii) La up to the biggest atomic numbered (and smallest ionic radii) Lu, their geochemical incompatibility and mobility are weakening.
- The  $\Sigma$  REE+Y content of the examined hungarian bauxites Nyirád, Bakonyoszlop, Gánt, Halimba was between 392-788 ppm.
- It is corresponding to the other mediterranean (Italian, Montenegrin, Turkish ) and Iranian bauxites.
- Some author claimed: Hungarian bauxites can contain 2700ppm  $\Sigma$  REE+Y elements.

# REE+Y content of the examined bauxites

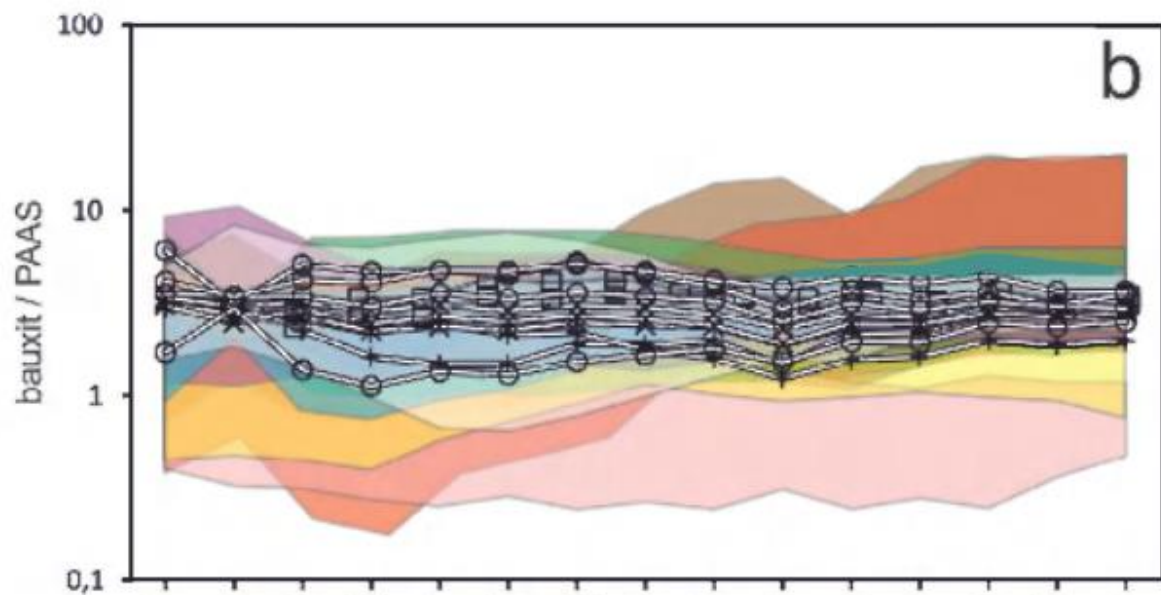
- C1 condrite: are a group of rare stony meteorites belonging to the carbonaceous chondrites. Samples have been discovered in France, Canada, India, and Tanzania. Compared to all the meteorites found so far, their chemical composition most closely resembles the elemental distribution in the sun's photosphere. It is assumed that they originally formed in the outer asteroid belt,
- PAAS: Post Archean Australian Shale :an approach of the very changeable composition of the present (Post-Archean) upper crust





- + Nyirád
- × Bakonyoszlop
- Gánt
- Halimba

- Italy (Mondillo et al., 2011)
- Montenegro (Critcel, 2014)
- Turkey (Karadag et al., 2009)
- Turkey (Hanilci, 2013)
- Iran (Zarasvandi et al., 2012)
- China (Liu et al., 2013)
- China (Li et al., 2013)
- China (Wei et al., 2013)
- India (Meshram & Randive, 2010)



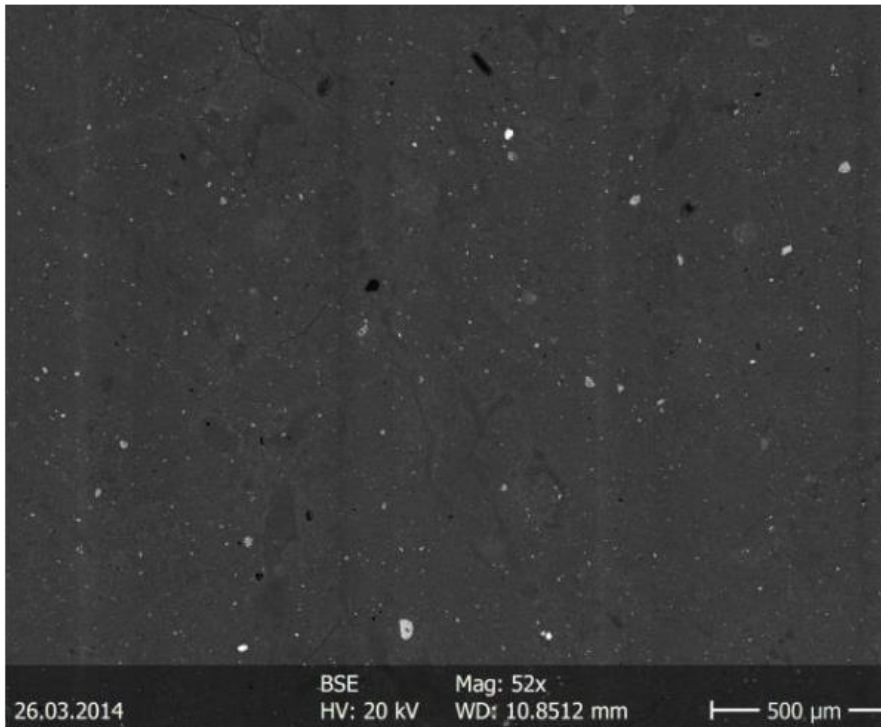
# REE+Y content of the examined bauxites

- The REE+Y profile of the examined hungarian bauxites shows similar pattern to the bauxites from the Mediterranean bauxite province. (Italy, Montenegro, Turkey and the Iranian karst bauxite).
- These facts refer to the strong similarity of the source rocks and/or bauxite producing geological processes in the examined region.
- The samples, normalized to C1 chondrite *show a step by step decreasing in concentration from the LREE to the heavy REE+Y.*
- *Some samples show negative or positive Ce-anomaly and a uniform negative Eu anomaly. (on the Fig. A)*

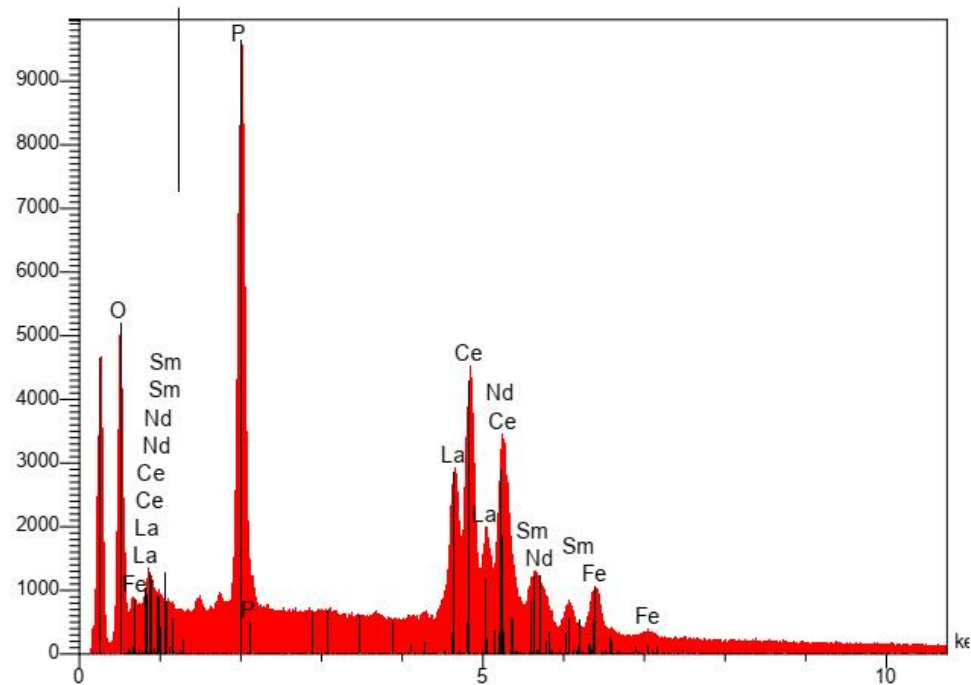
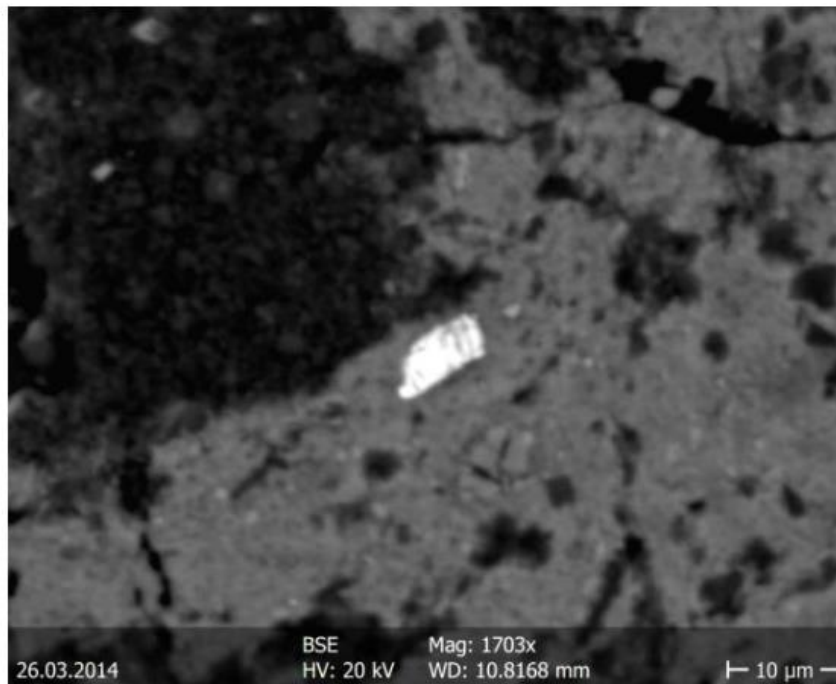
# REE+Y content of the examined bauxites

- Because of the missing Eu negative anomaly on fig. B, normalized to PAAS,
- **the low amount of the Eu content come from the source rocks!**
- **Bauxit producing geological processes not or slightly distorted the Eu distribution.**
- But the Ce positive and negative anomaly can be seen on both element distribution diagrams.
- **It can be explained by the changing of the redox circumstances of the bauxit generation.**
- **Positive Ce anomaly means higher Eh, negative Ce anomaly refers to low Eh values during weathering.**
- Samples from Halimba show the highest enrichment to the PAAS normalized  $\Sigma$ REE+Y content.
  - For the LREE (La-Gd) it is 5-6-fold,
  - Excluding the Ce, which is only 3,5-fold,
  - And for HREE+Y (Tb-Lu) 3,5-5-fold.
  - The smallest enrichment in  $\Sigma$ REE+Y is 1—2-fold , characteristic of only one Halimba and all of the Nyirad samples.
  - The last enrichment pattern equivalent to the main mass of the mediterranean bauxites.

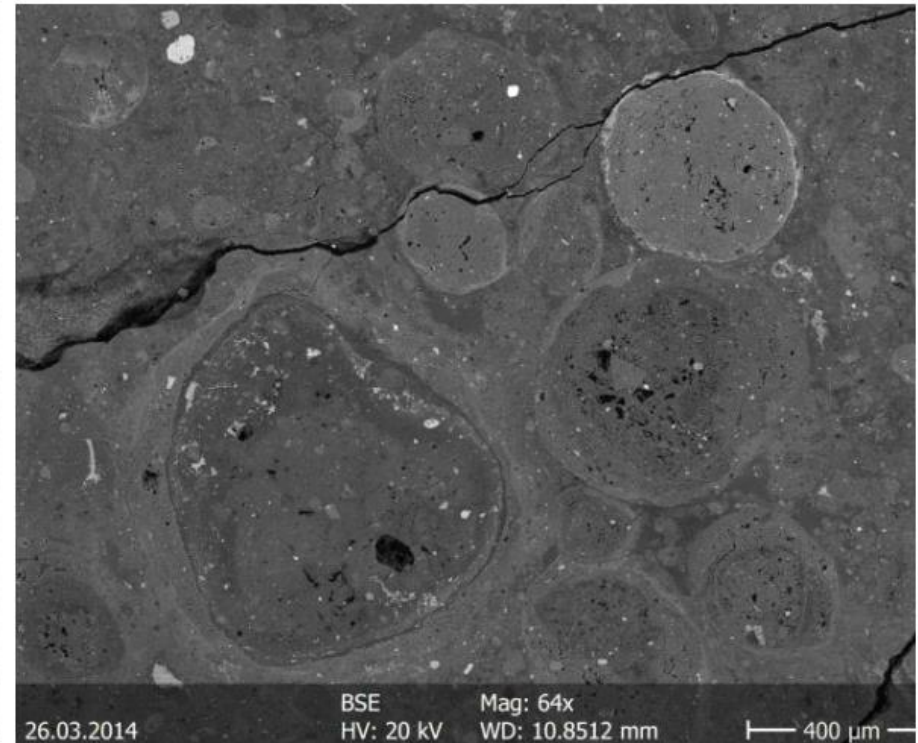
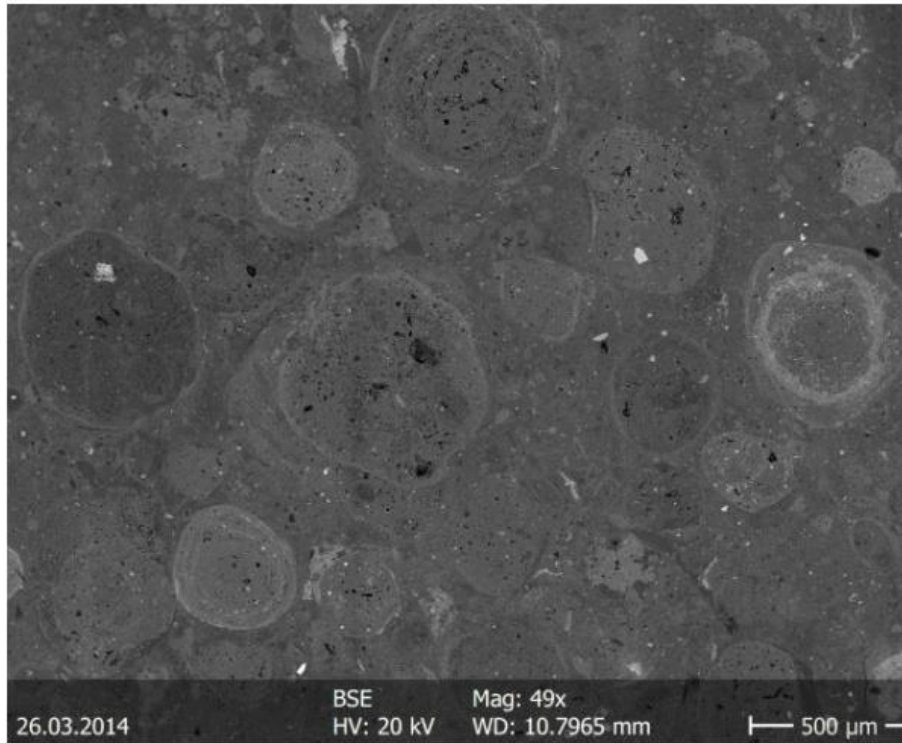
# Bauxite texture (Nyirád) Fe-oxide(spherical aggregate)



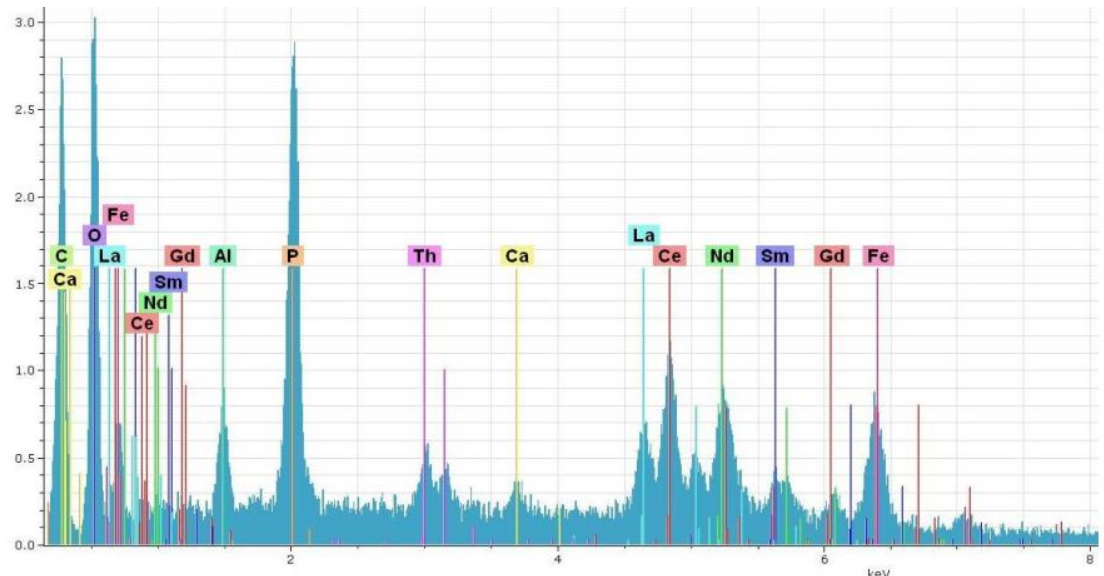
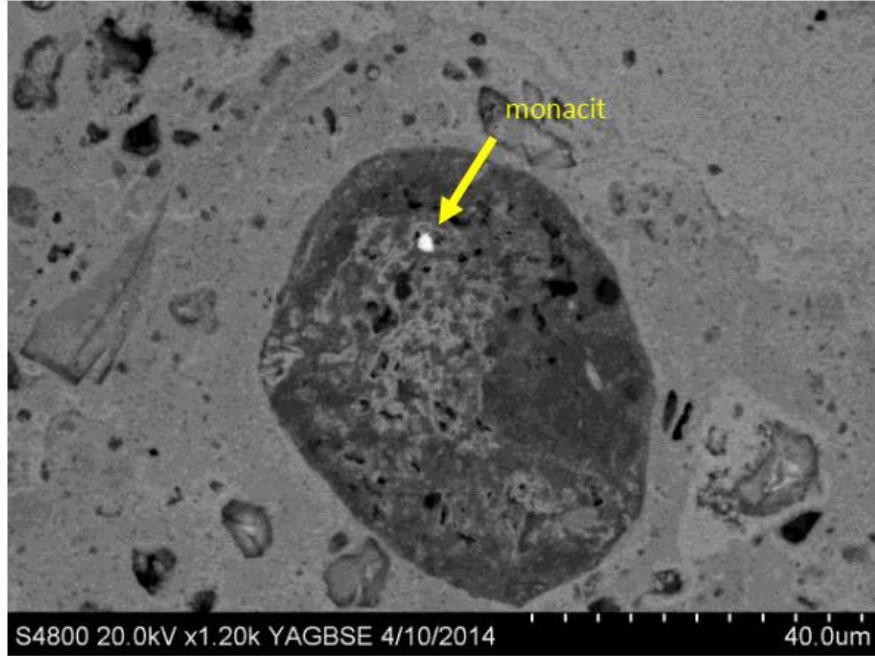
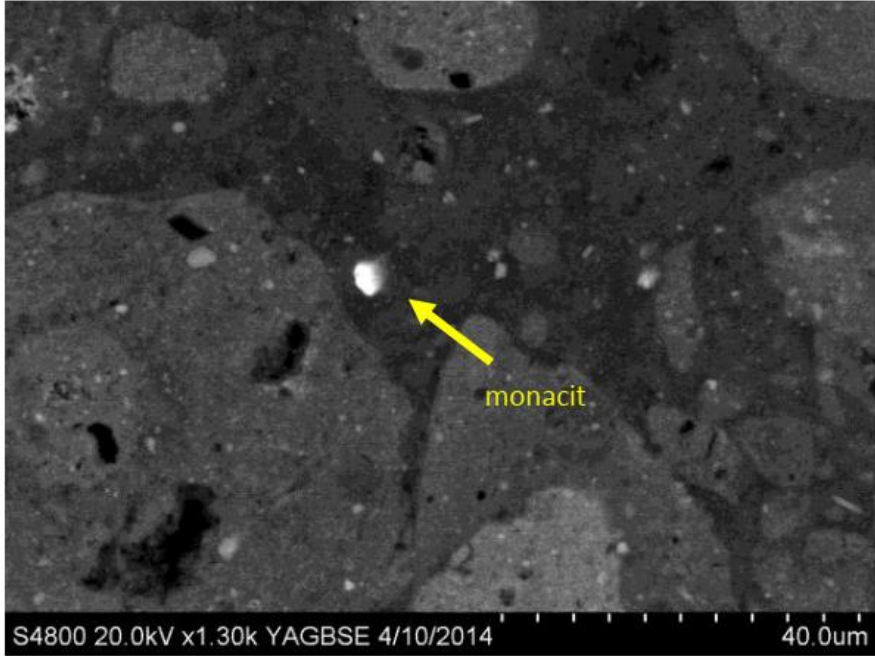
# Monacite (Nyirád)



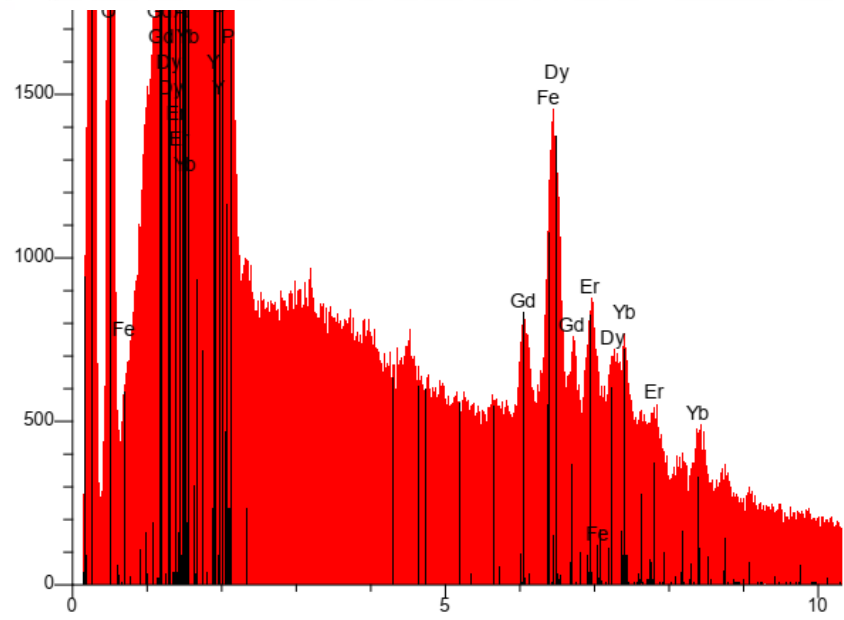
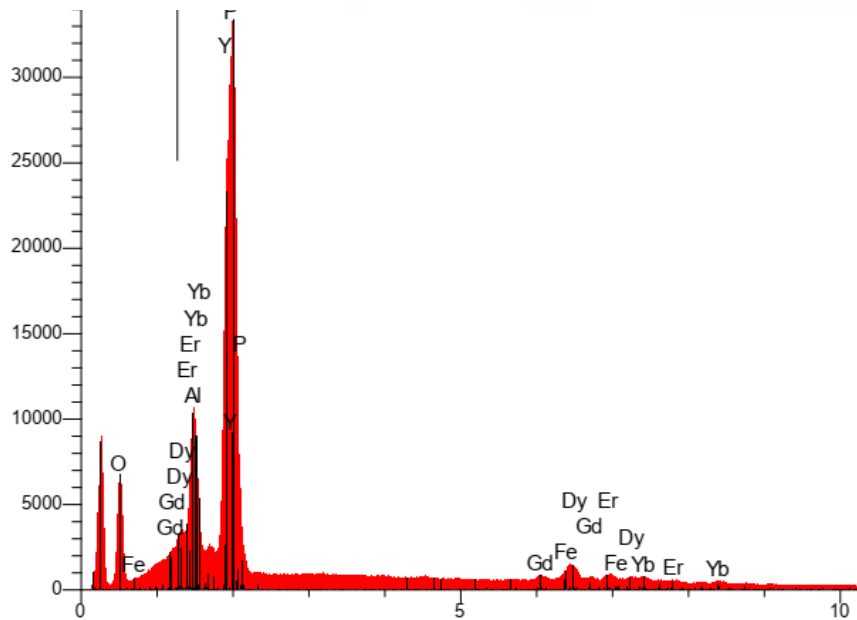
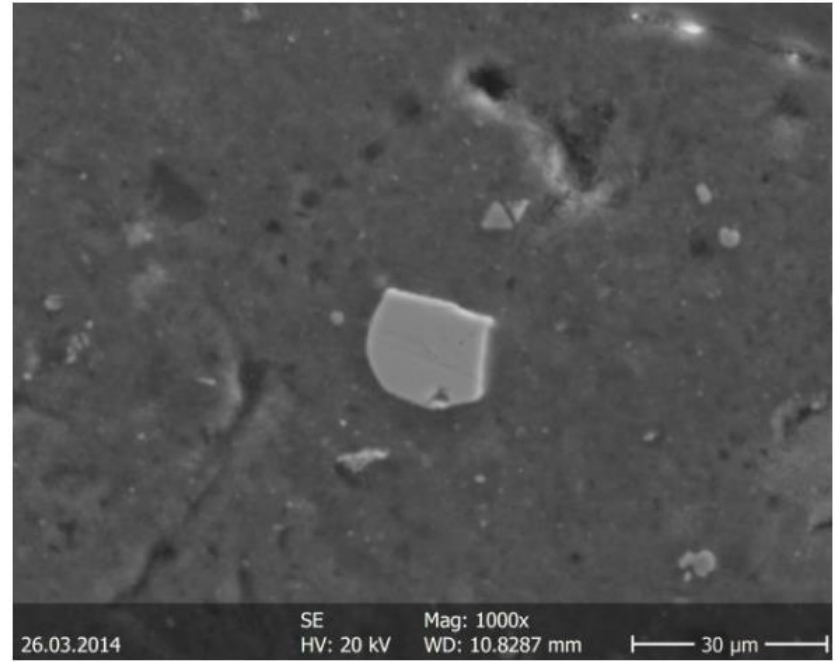
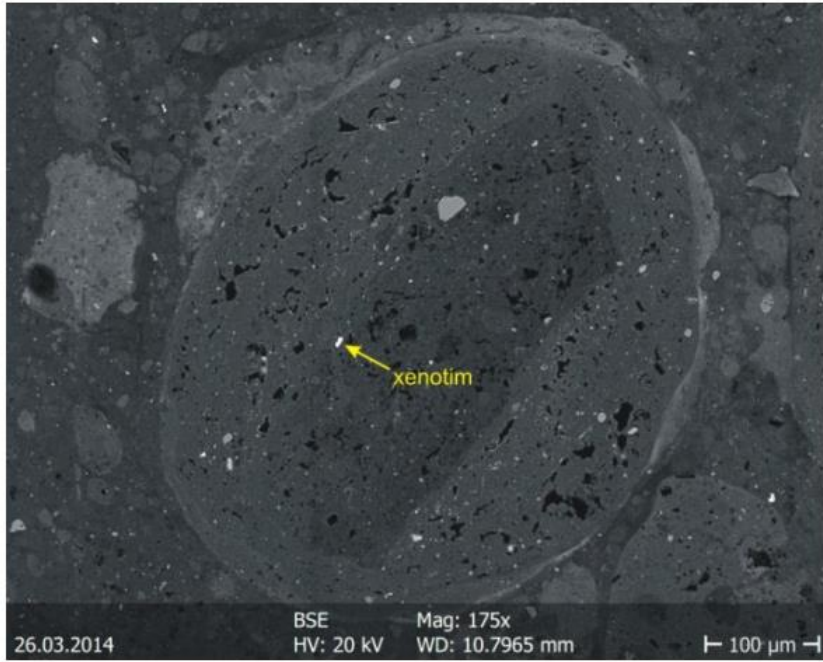
# Typical ooidic-pizoidic texture from Halimba bauxite



# Monacite (Halimba) in matrix and in pizoid



# Xenotime (Halimba) in pizoid





# Summary

- The Hungarian karst bauxites are remarkable mineral deposits. Their genesis secure an excellent accumulation possibilities for the REE+Y elemental group.
- From the 12 samples in the Halimba and Nyirád samples, among the terrigenous zircon, xenotime and monacite grains, in the monacite LREE, in the xenotime HREE were detectable.
- These elements were identified in the matrix and the material of ooids and pizoids with similar chemical composition. But variable morphology and roundness, refer to different transportation and/or autigenic genesis.
- Geochemical investigations show an alkaline-neutral source rock, with igneous or sedimentary origin.
- This type(s) of rock(s) show 3-5-fold enrichment of REE+Y considering the modern upper continental crust.

# Summary

- The REE+Y content of the examined transdanubien hungarian bauxites (Nyirád, Bakonyoszlop, Gánt, Halimba) are between 392-788 ppm. This similar to the other Mediterranean an Iranian bauxites.
- During the genesis of the bauxites pH and Eh directed the geochemical route of the REE+Y enrichment (elemental ratio and form: ionic, surfacial complexation on Fe-oxides or on bauxite minerals or on the other hydroxides, in bauxite minerals as replacing ions in terrigenous and/or autigenic monacite, or xenotime minerals.
- Sometime this led to secondary REE+Y enrichment.
- Because all of these facts, hungarian bauxites are appropriate sources for further detailed research as potential REE+Y bearing rocks.
- And as well, the byproduct of bauxite processing (red mud) is a promising source for REE+Y, containing higher concentration of REE metals.