OCCURRENCE OF SCANDIUM AND RARE EARTH ELEMENTS IN Ni-LATERITES FROM FALCONDO (DOMINICAN REPUBLIC)

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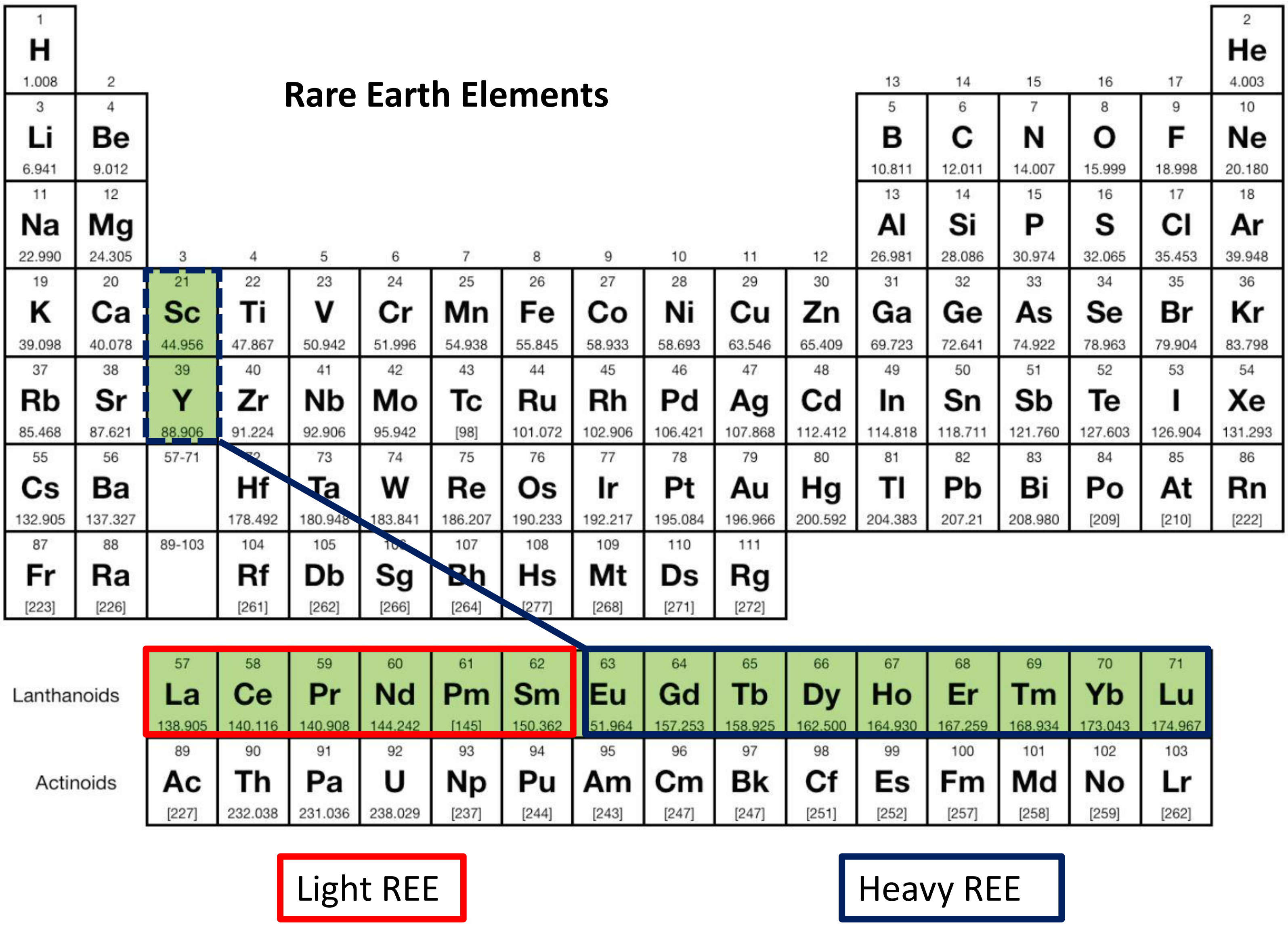
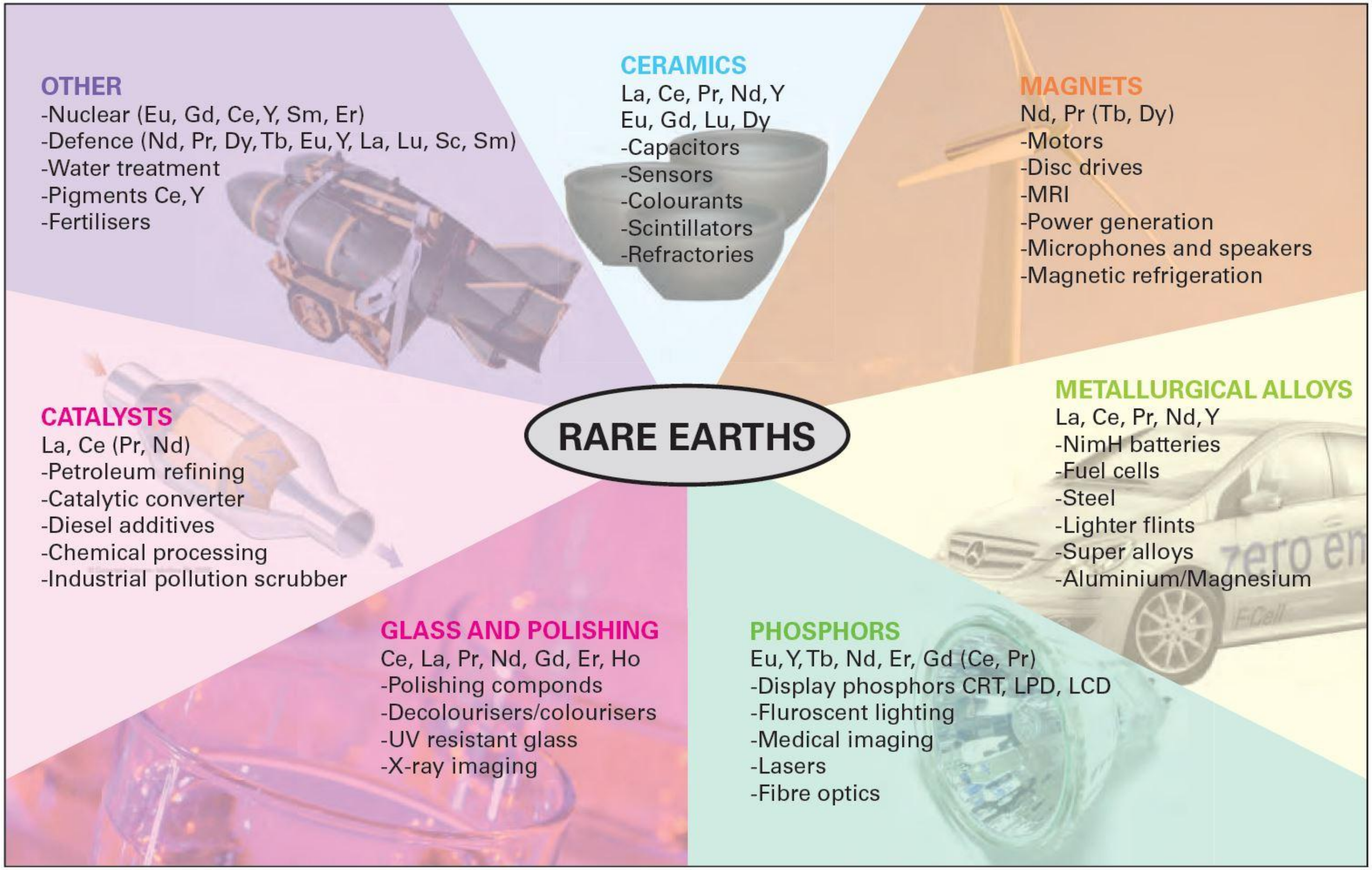
Contents:

"High-tech metals", a relatively new term, are essential for many industries of the modern world. They are needed in various high-end technical applications such as **green technologies** associated with **renewable energy**, **reduction of greenhouse gases** and **energy efficiency**.

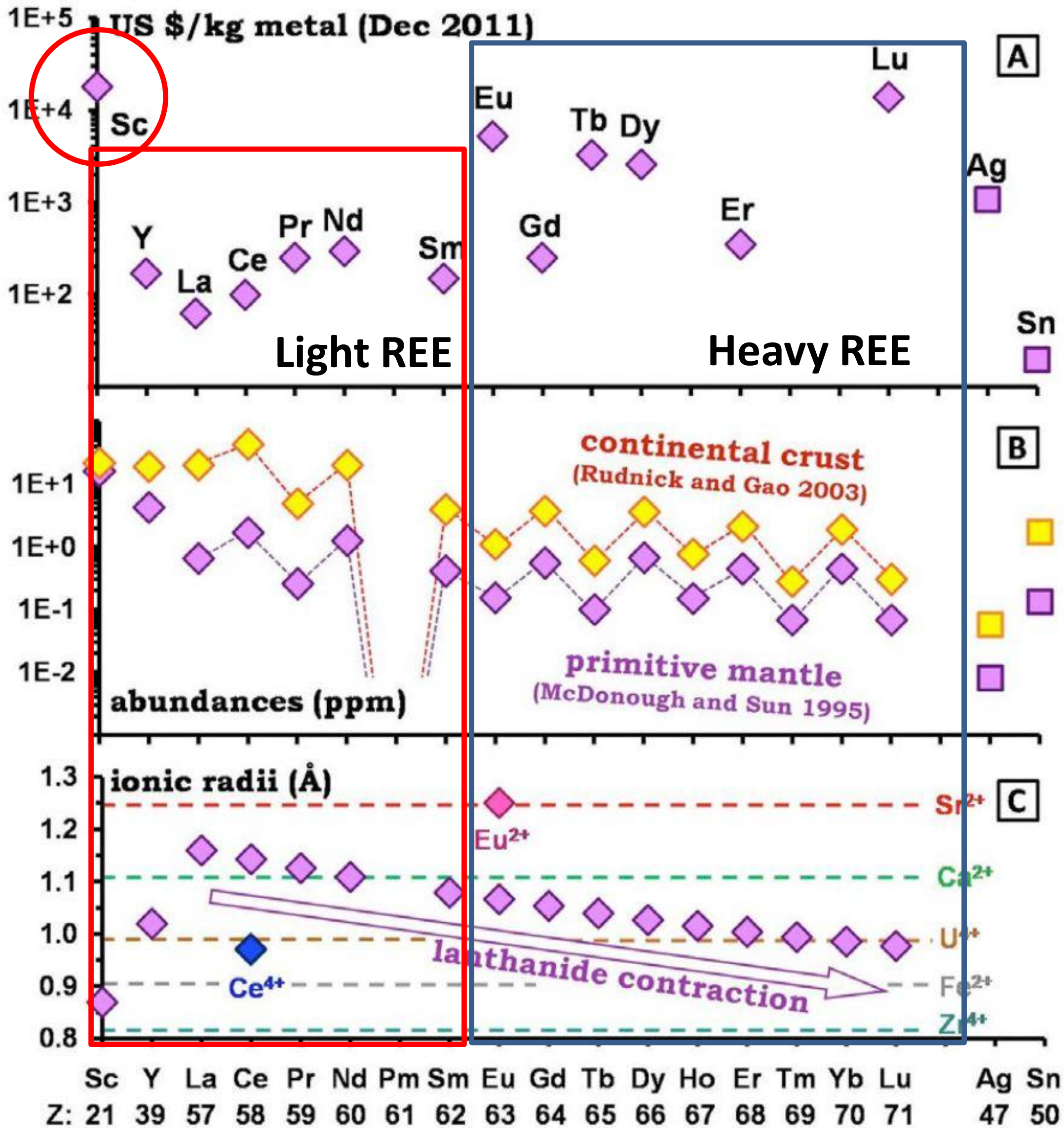
Bailly (2012): Mineral Resources Division, BRGM

Within this group the **Rare Earth Elements** (REE) are ranked as top priority.


Rare Earth Elements
1 H 1.008
2
3 Li 6.941
4 Be 9.012
11 Na 22.990
12 Mg 24.305
3 4 5 6 7 8 9 10 11 12
13 14 15 16 17
2 He 4.003
5 B 10.811
6 C 12.011
7 N 14.007
8 O 15.999
9 F 18.998
10 Ne 20.180
13 Al 26.981
14 Si 28.086
15 P 30.974
16 S 32.065
17 Cl 35.453
18 Ar 39.948
19 K 39.098
20 Ca 40.078
21 Sc 44.956
22 Ti 47.867
23 V 50.942
24 Cr 51.996
25 Mn 54.938
26 Fe 55.845
27 Co 58.933
28 Ni 58.693
29 Cu 63.546
30 Zn 65.409
31 Ga 69.723
32 Ge 72.641
33 As 74.922
34 Se 78.963
35 Br 79.904
36 Kr 83.798
37 Rb 85.468
38 Sr 87.621
39 Y 88.906
40 Zr 91.224
41 Nb 92.906
42 Mo 95.942
43 Tc [98]
44 Ru 101.072
45 Rh 102.906
46 Pd 106.421
47 Ag 107.868
48 Cd 112.412
49 In 114.818
50 Sn 118.711
51 Sb 121.760
52 Te 127.603
53 I 126.904
54 Xe 131.293
55 Cs 132.905
56 Ba 137.327
57-71
72 Hf 178.492
73 Ta 180.948
74 W 183.841
75 Re 186.207
76 Os 190.233
77 Ir 192.217
78 Pt 195.084
79 Au 196.966
80 Hg 200.592
81 Tl 204.383
82 Pb 207.21
83 Bi 208.980
84 Po [209]
85 At [210]
86 Rn [222]
87 Fr [223]
88 Ra [226]
89-103
104 Rf [261]
105 Db [262]
106 Sg [266]
107 Bh [264]
108 Hs [277]
109 Mt [268]
110 Ds [271]
111 Rg [272]
Lanthanoids
57 La 138.905
58 Ce 140.116
59 Pr 140.908
60 Nd 144.242
61 Pm [145]
62 Sm 150.362
63 Eu 151.964
64 Gd 157.253
65 Tb 158.925
66 Dy 162.500
67 Ho 164.930
68 Er 167.259
69 Tm 168.934
70 Yb 173.043
71 Lu 174.967
Actinoids
89 Ac [227]
90 Th 232.038
91 Pa 231.036
92 U 238.029
93 Np [237]
94 Pu [244]
95 Am [243]
96 Cm [247]
97 Bk [247]
98 Cf [251]
99 Es [252]
100 Fm [257]
101 Md [258]
102 No [259]
103 Lr [262]
Light REE
Heavy REE



REE are **essential** for many industries and technological applications

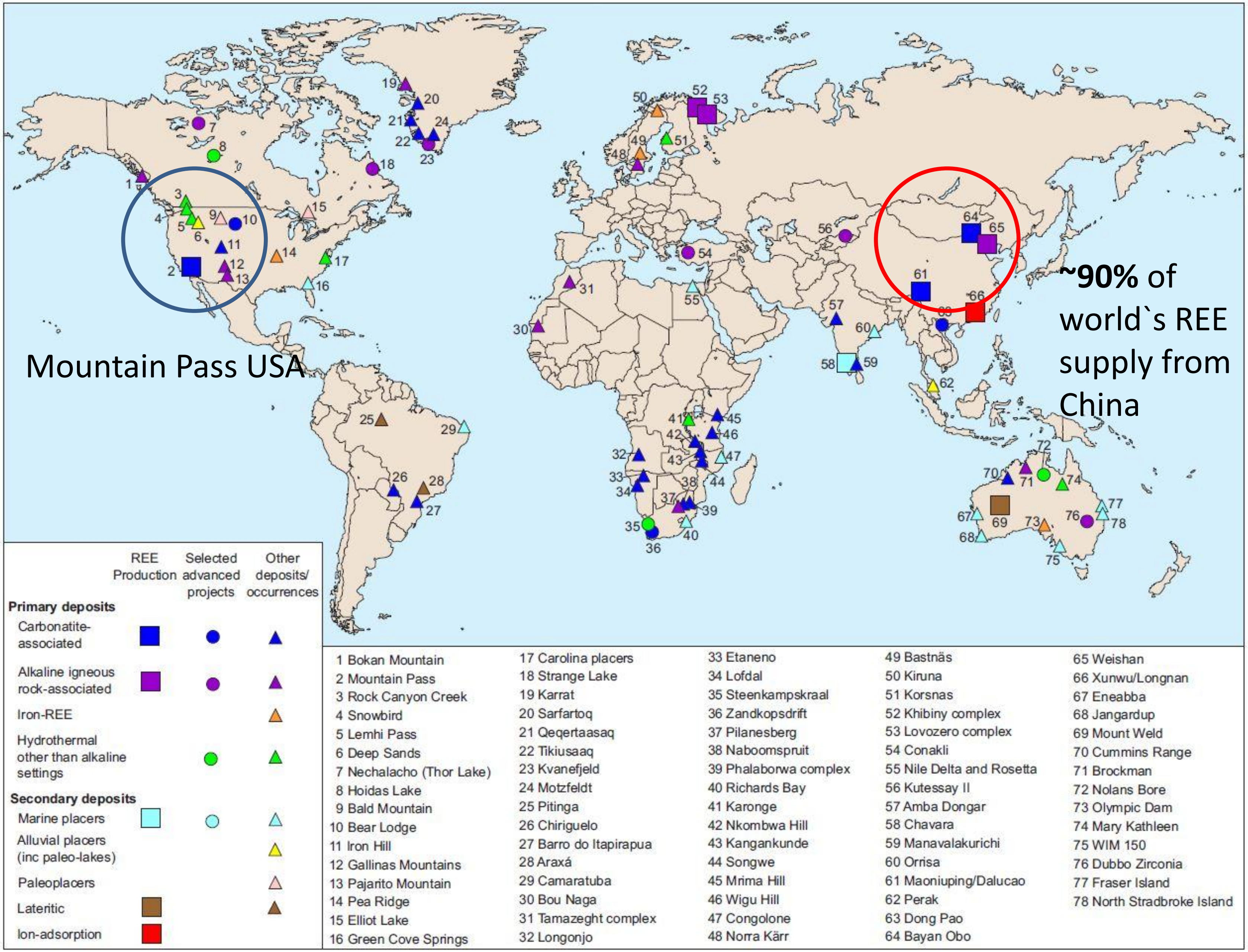


Despite their name, **rare earth elements** (with the exception of the radioactive promethium) are **relatively plentyful in the Earth's crust** (e.g. Cerium = **25th** most abundant element)

Because of their **geochemical properties** REE are typically **dispersed** and not often found concentrated in **economically exploitable** ore deposits.

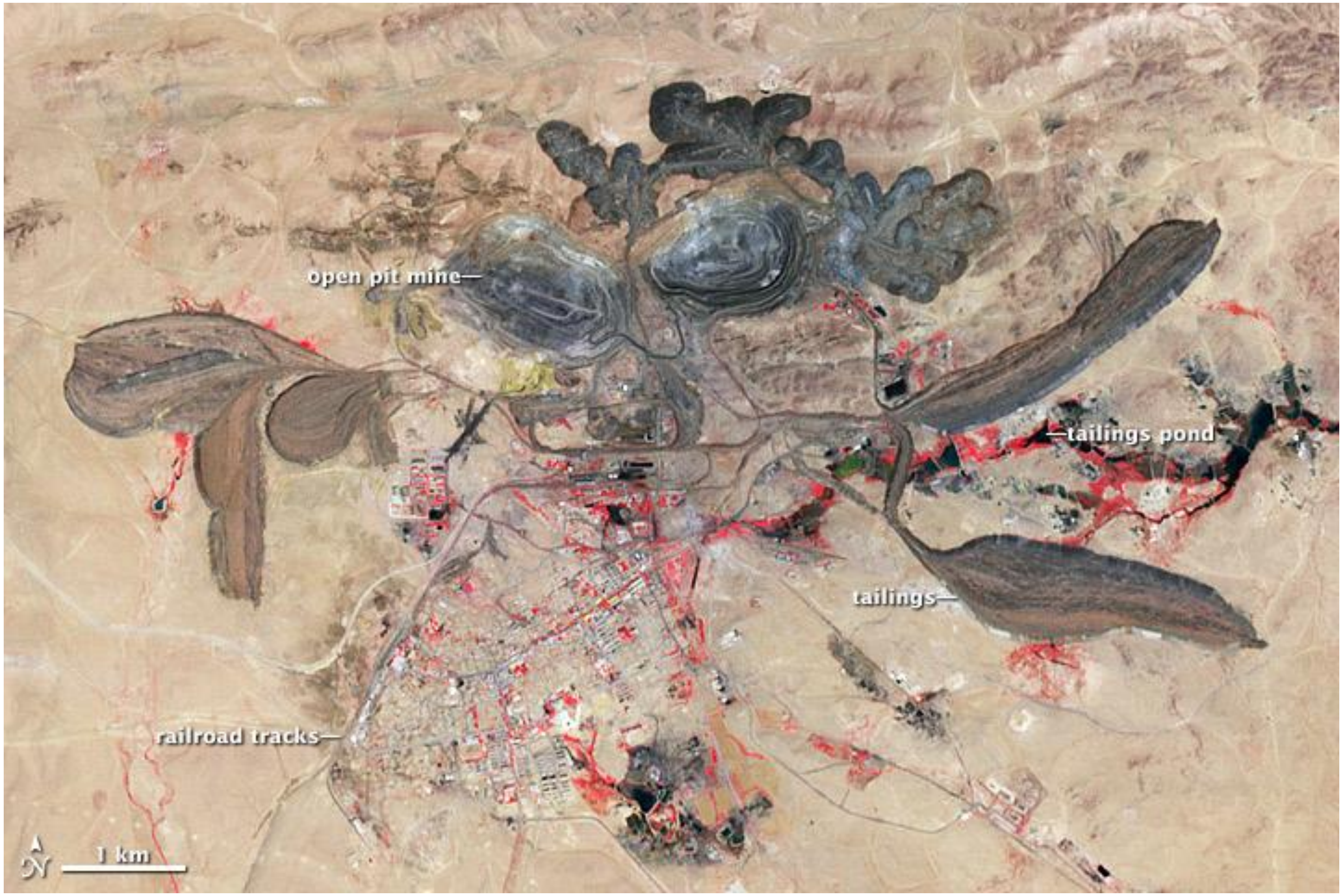
Average Prices:

Early 2010: **US$10-15/kg**
Today: **US$50-100/kg**

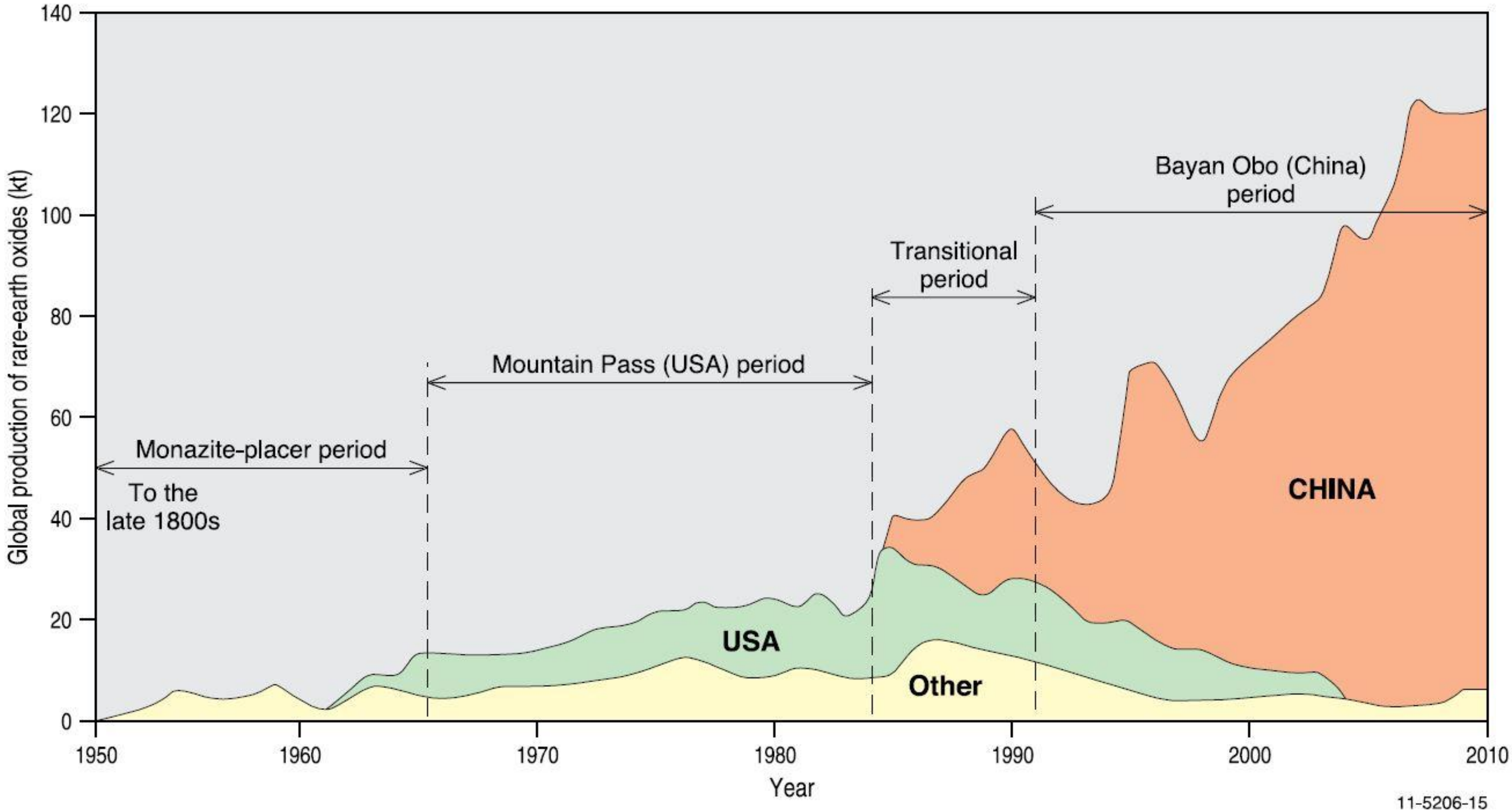

Mountain Pass USA
~90% of world`s REE supply from China
REE Production
Selected advanced projects
Other deposits/ occurrences
Primary deposits
Carbonatite-associated
Alkaline igneous rock-associated
Iron-REE
Hydrothermal other than alkaline settings
Secondary deposits
Marine placers
Alluvial placers (inc paleo-lakes)
Paleoplacers
Lateritic
Ion-adsorption
1 Bokan Mountain
2 Mountain Pass
3 Rock Canyon Creek
4 Snowbird
5 Lemhi Pass
6 Deep Sands
7 Nechalacho (Thor Lake)
8 Hoidas Lake
9 Bald Mountain
10 Bear Lodge
11 Iron Hill
12 Gallinas Mountains
13 Pajarito Mountain
14 Pea Ridge
15 Elliot Lake
16 Green Cove Springs
17 Carolina placers
18 Strange Lake
19 Karrat
20 Sarfartoq
21 Qeqertaasaq
22 Tikiusaaq
23 Kvanefjeld
24 Motzfeldt
25 Pitinga
26 Chiriguelo
27 Barro do Itapirapua
28 Araxá
29 Camaratuba
30 Bou Naga
31 Tamazeght complex
32 Longonjo
33 Etaneno
34 Lofdal
35 Steenkampskraal
36 Zandkopsdrift
37 Pilanesberg
38 Naboomspruit
39 Phalaborwa complex
40 Richards Bay
41 Karonge
42 Nkombwa Hill
43 Kangankunde
44 Songwe
45 Mrima Hill
46 Wigu Hill
47 Congolone
48 Norra Kärr
49 Bastnäs
50 Kiruna
51 Korsnas
52 Khibiny complex
53 Lovozero complex
54 Conakli
55 Nile Delta and Rosetta
56 Kutessay II
57 Amba Dongar
58 Chavara
59 Manavalakurichi
60 Orrisa
61 Maoniuping/Dalucao
62 Perak
63 Dong Pao
64 Bayan Obo
65 Weishan
66 Xunwu/Longnan
67 Eneabba
68 Jangardup
69 Mount Weld
70 Cummins Range
71 Brockman
72 Nolans Bore
73 Olympic Dam
74 Mary Kathleen
75 WIM 150
76 Dubbo Zirconia
77 Fraser Island
78 North Stradbroke Island

Bayan-Obo-Mine in China:

45 % of worldwide REE production; **750 mio. t** at **3-4,1% REO**



Global production of rare-earth oxides from 1950 to 2010



Critical raw materials for the EU

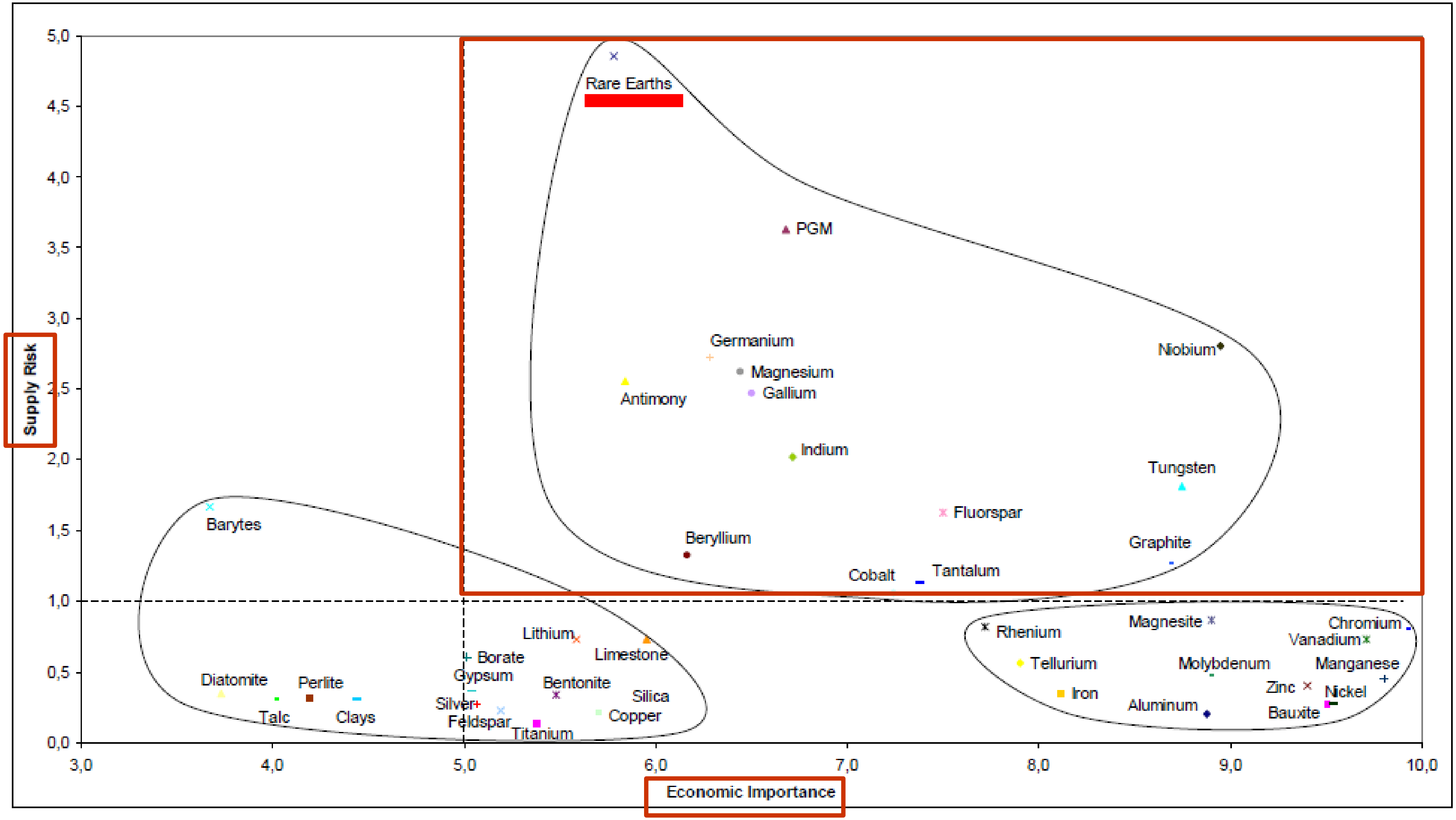
Report of the Ad-hoc Working Group on defining critical raw materials

Version of 30 July 2010

Note: The full report will be available on the Enterprise and Industry Directorate General website http://ec.europa.eu/enterprise/policies/raw-materials/documents/index_en.htm

European Commission
Enterprise and Industry

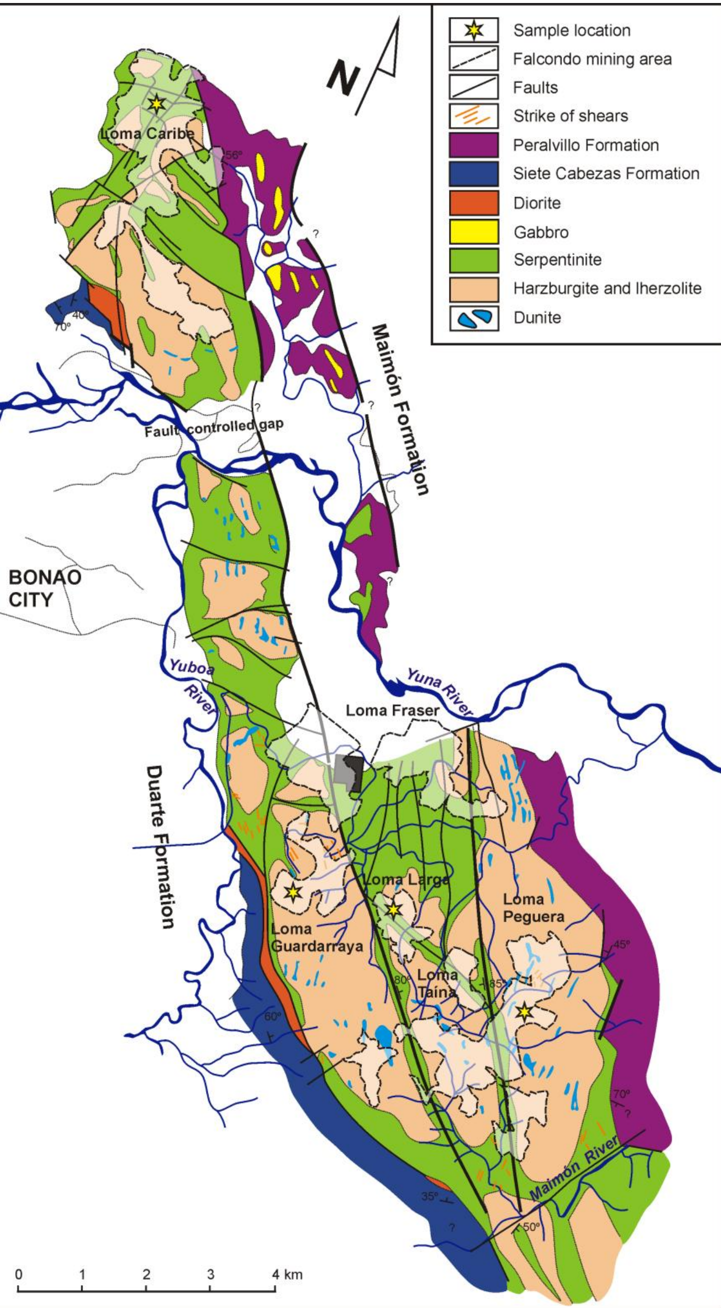
http://ec.europa.eu/enterprise/policies/rawmaterials/documents/index_en.htm



In 2010 the EU Commission defined **14 critical materials** on the basis of **their high relative economic importance** and **their high relative supply risk**.

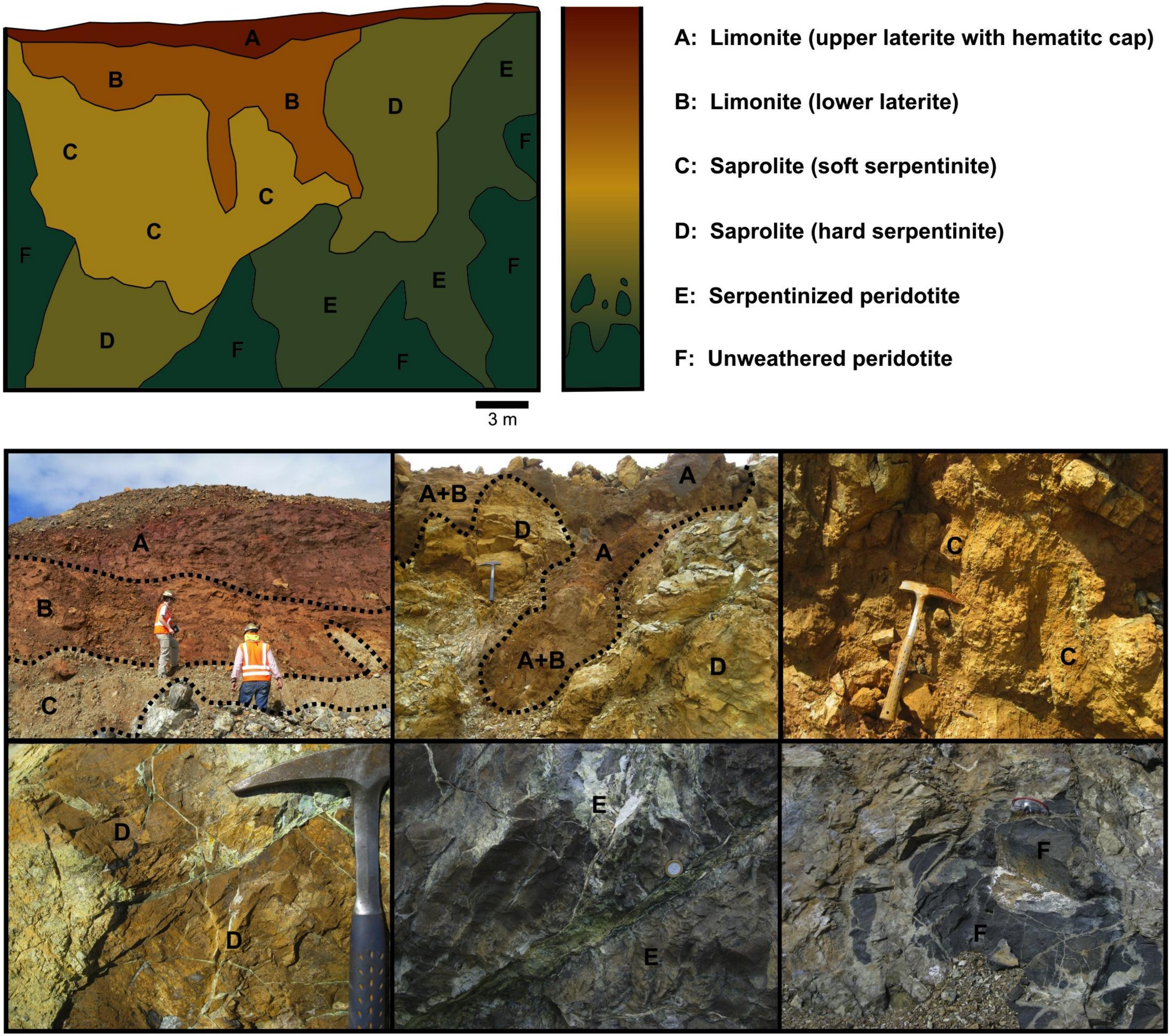
http://ec.europa.eu/enterprise/policies/rawmaterials/documents/index_en.htm

1. INTRODUCTION

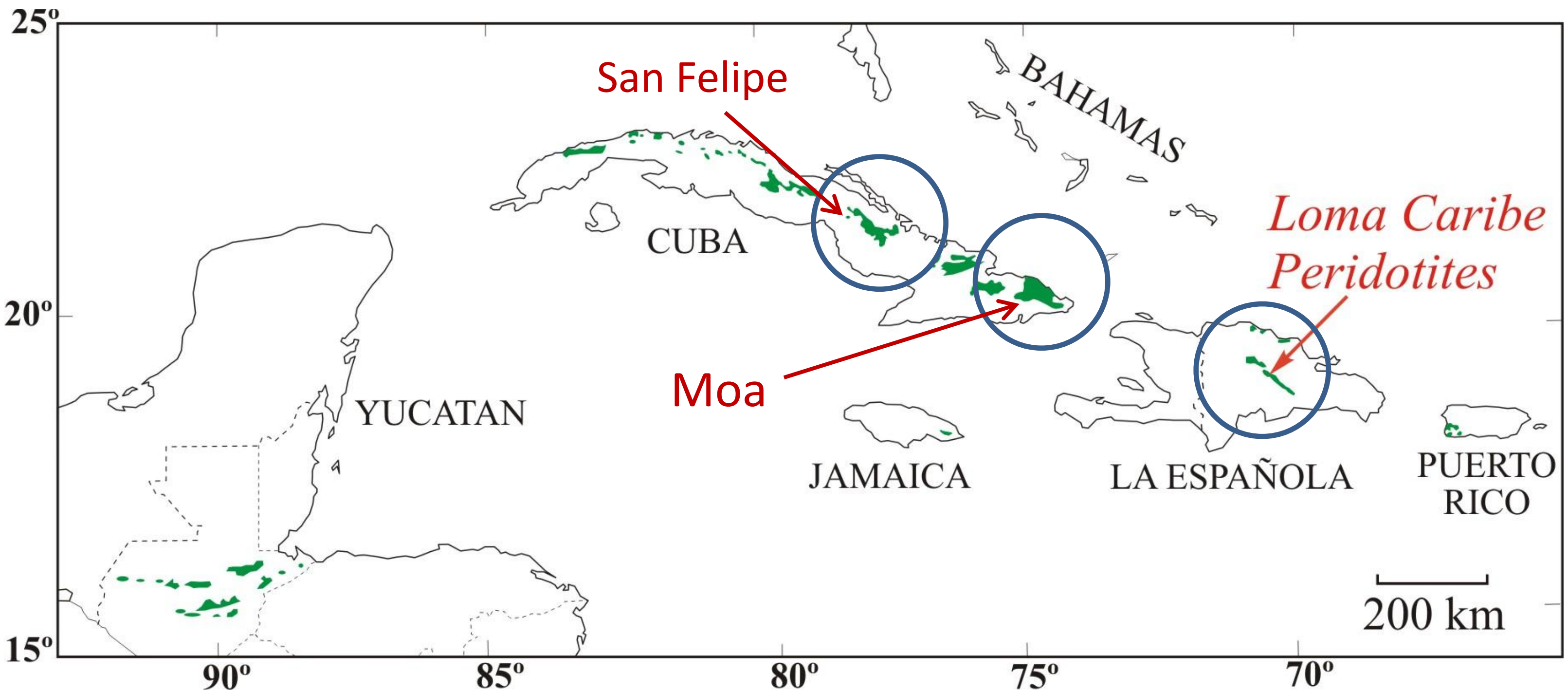


Lewis et al. (2006)

Haldemann et al. (1976)


A: Limonite (upper laterite with hematitc cap)
B: Limonite (lower laterite)
C: Saprolite (soft serpentinite)
D: Saprolite (hard serpentinite)
E: Serpentinized peridotite
F: Unweathered peridotite
3 m

Location of investigated nickel laterites



Characteristics of investigated nickel laterite profiles

(I) Hydrous silicate

The **Falcondo Ni-laterite deposit**:
Parent rock is the Loma Caribe serpentinized peridotite (lherzolite, clinopyroxene-rich harzburgite and harzburgite containing small masses of dunite) Two lateritic profiles, **Loma Peguera** and **Loma Caribe**, have been studied to verify local variations.

(II) Fe oxide

The **Moa Bay district** developed from lateritization of serpentinized peridotites (harzburgite and dunite) from the Mayari-Baracoa ophiolite belt. The investigated profile can be divided into protolith, **saprolite (usually <10 m)**, **limonite (up to 50 m)** and **ferricrust**.

(III) clay silicate

The little studied **laterite profile San Felipe** consists of serpentinized lherzolite, serpentinized harzburgite and dunite (protoliths), which are intruded by gabbros. They are overlain by a **major horizon of smectite rich saprolite (~19 m)** and **minor limonite (~1 m)** with a **thin layer of ferricrust**.

Maximal REE and Scandium contents

(I) Hydrous silicate

Limonites of Loma Peguera and Loma Caribe contain up to **159 ppm** and **375 ppm REE**, respectively. Maximum scandium contents are **122 ppm** (Loma Caribe) and **73 ppm** (Loma Peguera).

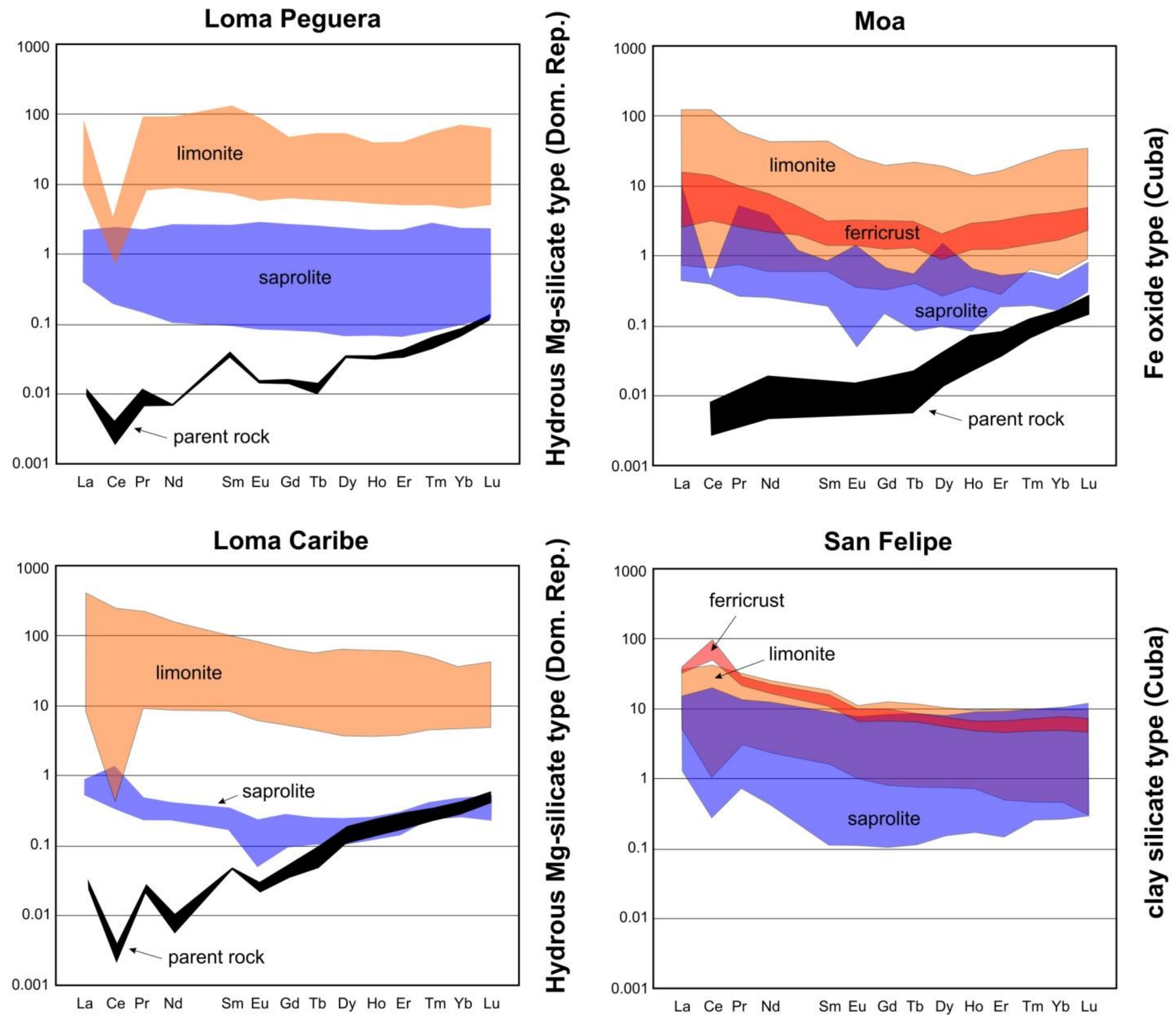
(II) Fe oxide

Moa is characterized by high REE contents within the limonite horizon (**up to 127 ppm**) and max. Sc content of **101 ppm**.

(III) clay silicate

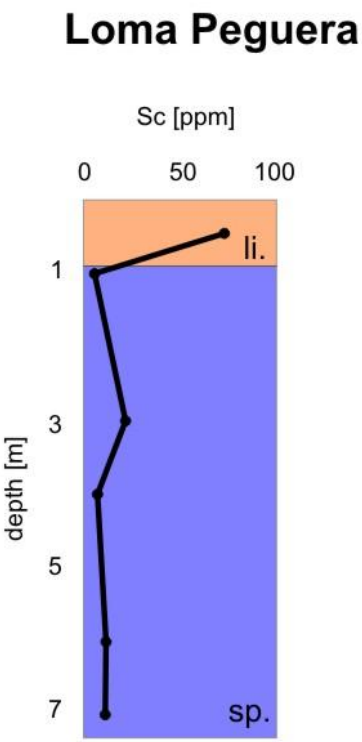
Saprolite and limonite from San Felipe are similarly enriched in REE (**up to 68 ppm** and **50 ppm**, respectively), **duricrust up to 98 ppm**. Max. scandium contents are found within **duricrust** (**up to 61 ppm**).

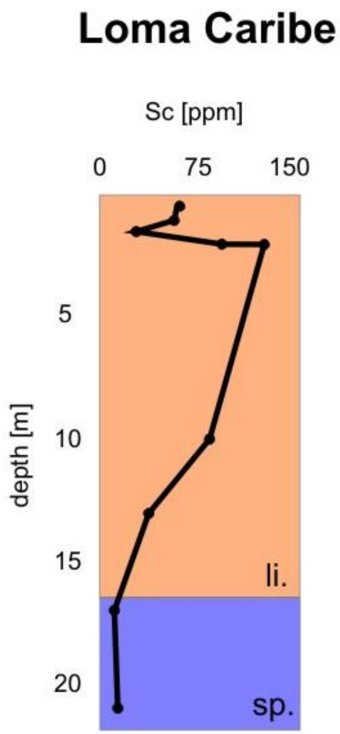
Chondrite normalized pattern REE



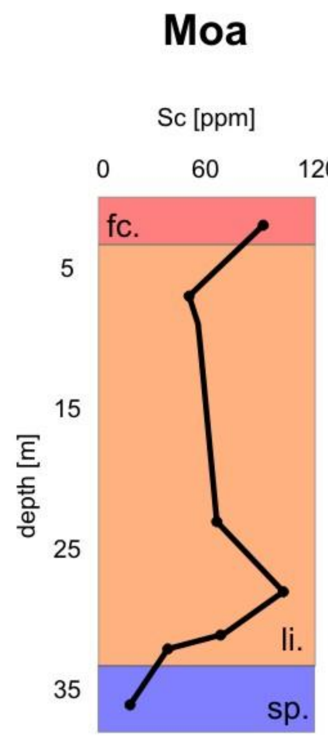
Normalization by values from Anders and Grevesse (1989)

Sc distribution profiles

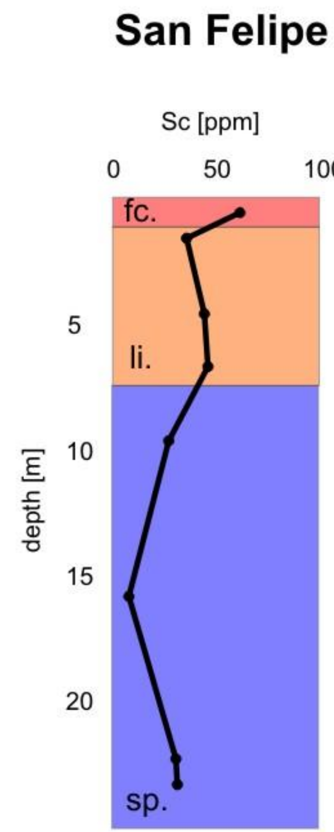




Hydrous silicate type

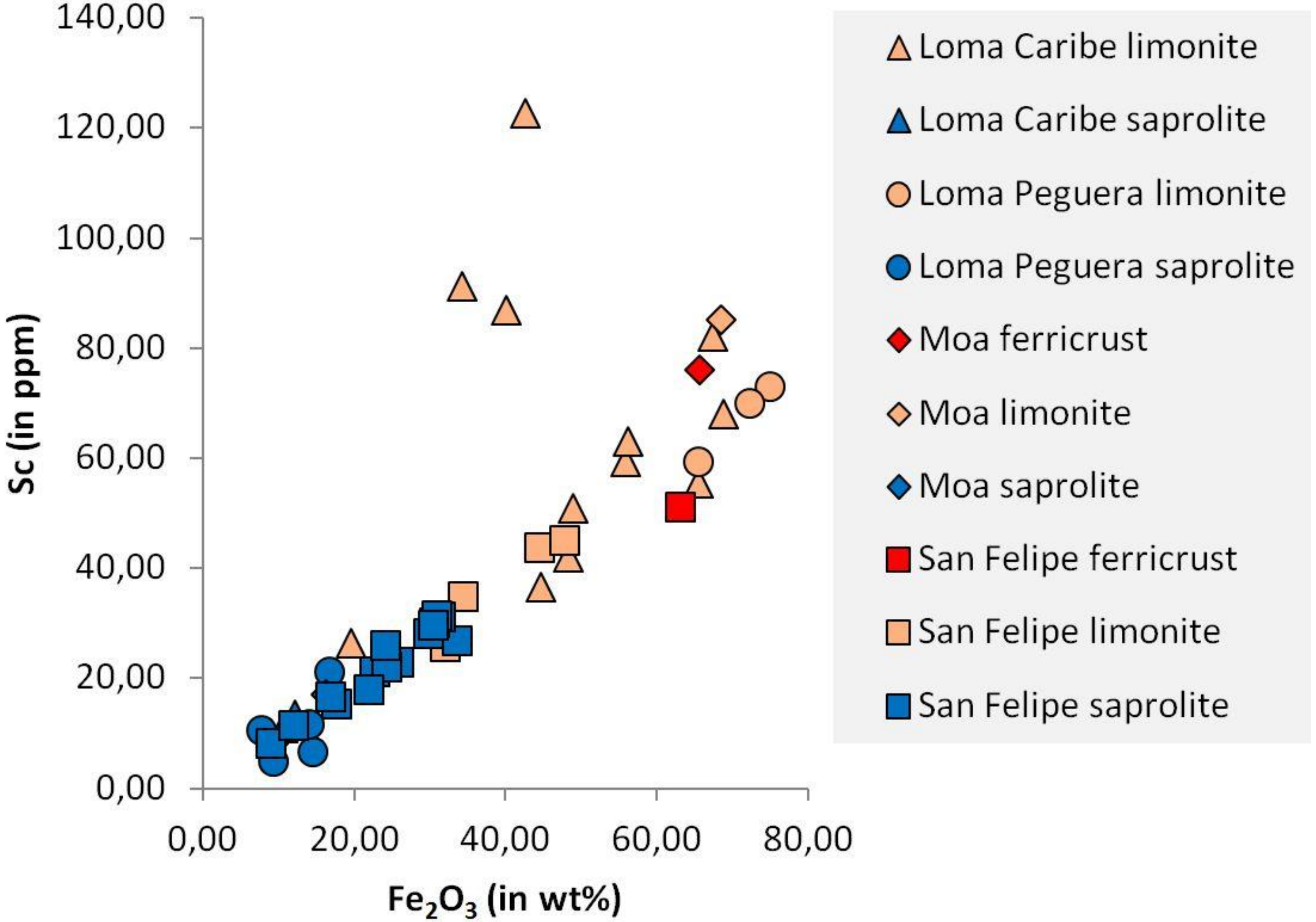


Fe oxide type



clay silicate type

Sc – Fe_2O_3 correlation



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The innovative hydroseparation laboratory (CNT-HS-11, manufactured by CNT Corporation, Canada; www.cnt-mc.com) processes samples of extremely fine -grained (down to<30 µm) water-insoluble grains to produce so called “heavy-mineral concentrates”.

The HS-11 laboratory simulates natural beach placer deposits by combination of laminar water flow at constant pressure with diverse wave impulses (s. video). Dense mineral phases (e.g. gold, PGM, zircons) are collected at the bottom of the GST, whereas the light fraction rises to the top of the GST and leaves the system. By using different GST, flow rates and impulse regimes the total amount of heavy mineral concentrates for each size fraction is reduced to about 0.1 mg (initial sample weights up to 3 kg). Hard rock samples can be disaggregated by EPD technology previously to Hydroseparation.

www.hslab-barcelona.com


Barcelona
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3
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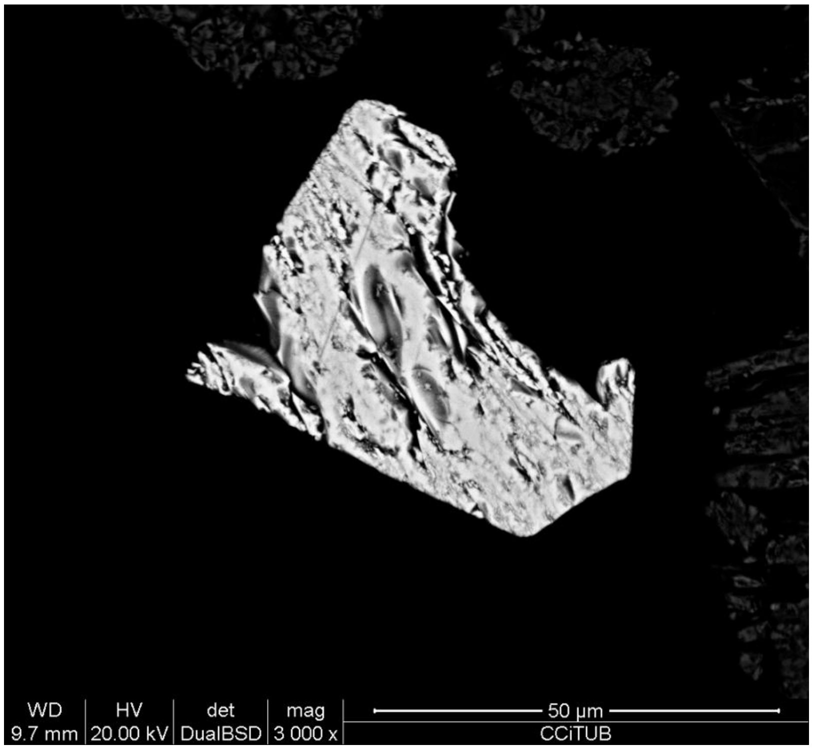
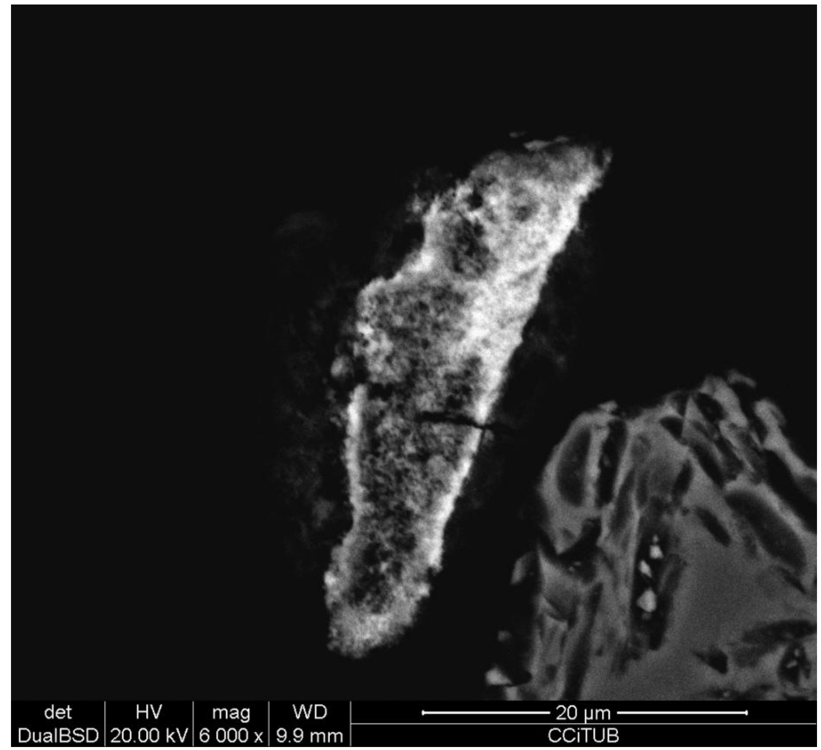
REE – mineralogy at Falcondo (preliminary results)

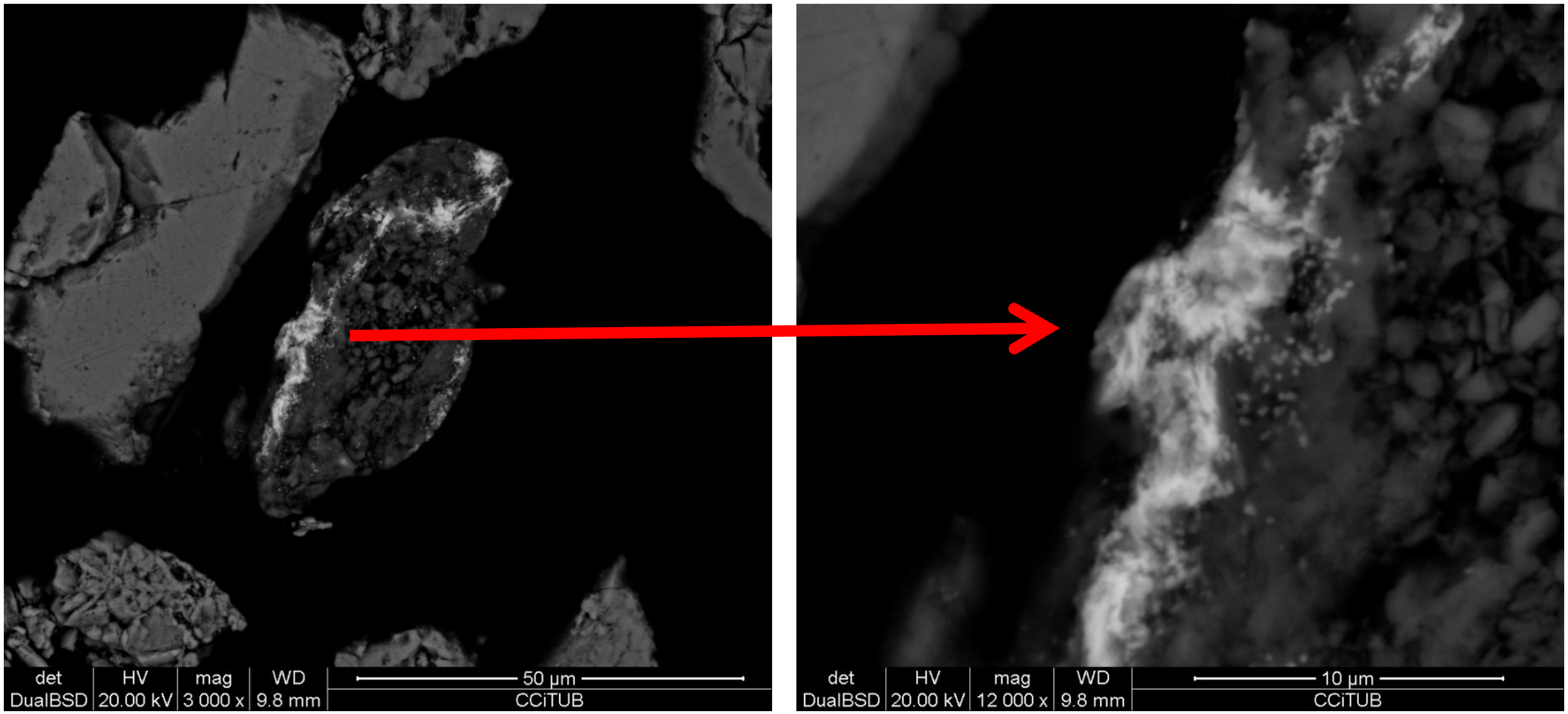


(Ce,La) monazite



(Ce,La) oxide

REE – mineralogy at Falcondo (preliminary results)



Ce-Mn-Al-Fe-Ca-Si-Co-Ni oxide in Fe-Mn-Al-Si oxide

Concluding remarks

- REE and Scandium are generally enriched from protolyte towards limonite for all investigated Ni-laterites.

- The strong correlation between Sc and Fe_2O_3 for most samples indicates a certain degree of mobility of Sc during lateritization with subsequent incorporation of this element in secondary Fe-oxyhydroxides.

- (All types of investigated Ni-laterites have a certain potential for Sc (REE?) exploration.) Too hot??

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Scandium

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Metallurgical processes for scandium recovery from various resources: A review

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ABSTRACT

Metallurgical processes for scandium recovery from various resources are reviewed. Scandium is mainly recovered as by-product from residues, tailings and waste liquors in the production of other metals such as rare earths, uranium, titanium, tungsten, aluminium, nickel, tantalum and niobium. Bauxite and nickel laterite ores are proposed as the most promising scandium resources for its production. Currently, the methods combined with hydro- and pyro-metallurgical processes, including ore pre-treatment, leaching, solvent extraction, precipitation and calcination, are commonly used for scandium recovery. New technologies for scandium recovery such as selective leaching and solvent extraction are possible development direction in the future.

Wang et al. (2011):

“The **nickel ores** in Australia containing **relatively high content of scandium** are considered as **important scandium resources**. For example, the nickel and cobalt deposits at Syerston and Lake Innes, New South Wales **have an average grade of 76 ppm** and in the range of **130–370 ppm**, respectively (Anon, 1998, 1999).”

“The scandium can be **recovered as a byproduct** during nickel and cobalt extraction operations... Scandium was **readily leached** with sulphuric acid from the nickel laterite ores in the **high pressure acid leach (HPAL)** process with over **94% recovery** (Koryakov and Medvedev, 1994).“

MANY THANKS FOR YOUR ATTENTION!