RARE EARTH ELEMENTS

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RARE EARTH ELEMENTS

			31	Y	Yttrium
57	La	Lanthanum	64	Gd	Gadolinium
58	Ce	Cerium	65	Tb	Terbium
59	Pr	Praseodymium	66	Dy	Dysprosium
60	Nd	Neodymium	67	Ho	Holmium
61	Pm	Promethium	68	Er	Erbium
62	Sm	Samarium	69	Tm	Thulium
63	Eu	Europium	70	Yb	Ytterbium
			71	Lu	Lutetium

“Rare earths” (TR, compare Latin terrae rarae - “rare earths”) are rarely found in the earth's crust (1.6-1.7) * 10−2% by mass), form refractory, almost insoluble in water oxides (until the 19th century they were called "lands").

Elements of two subfamilies - **cerium (light - La, Ce, Pr, Nd, Sm, Eu)** and **yttrium (heavy - Y, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu)** - are rare in the earth's crust .

In terms of raw material reserves, which are highly dispersed, REEs are not rare, in their total prevalence they exceed lead by 10 times, molybdenum - 50 times, tungsten - 165 times.

Place 61 was taken by promethium isolated from uranium fission products.

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MINERALS AND CONCENTRATES

- **Of the 250 minerals, only 60-65 contains Me_2O_3 with an excess of 5-8%.** Most important: monazite (Ce, La)PO_4, xenotime YPO4, bastnesite $Ce[CO_3](OH, F)$, parisite $Ca (Ce, La)_2[CO_3]_3F_2$, gadolinite $Y_2FeBe_2Si_2O_{10}$, orthite $(Ca, Ce)_2(Al, Fe)_3Si_3O_{12} (O, OH)$, loparite $(Na, Ca, Ce)(Ti, Nb)O_3$, eschinite $(Ce, Ca, Th)(Ti, Nb)_2O_6$. The most common in the earth's crust is cerium, the least - thulium and lutetium.
- **The main REE concentrates are** bastnesite ($CeCO_3F$) and monazite ($CePO_4$).
- **70% of the extracted REE** is accounted for by these ores. The richest deposits of bastnesite in China and the USA, monazite - in Australia, Brazil, India, Malaysia, South Africa, Sri Lanka, Thailand, USA.

30% of the reserves are concentrated in xenotime deposits, ion-absorption clays, loparites, apatites, phospharites, secondary monazite, eudialyte, etc.

A promising source of REE is the waste production of phosphoric acid from apatites and phosphorites - phosphogypsum.

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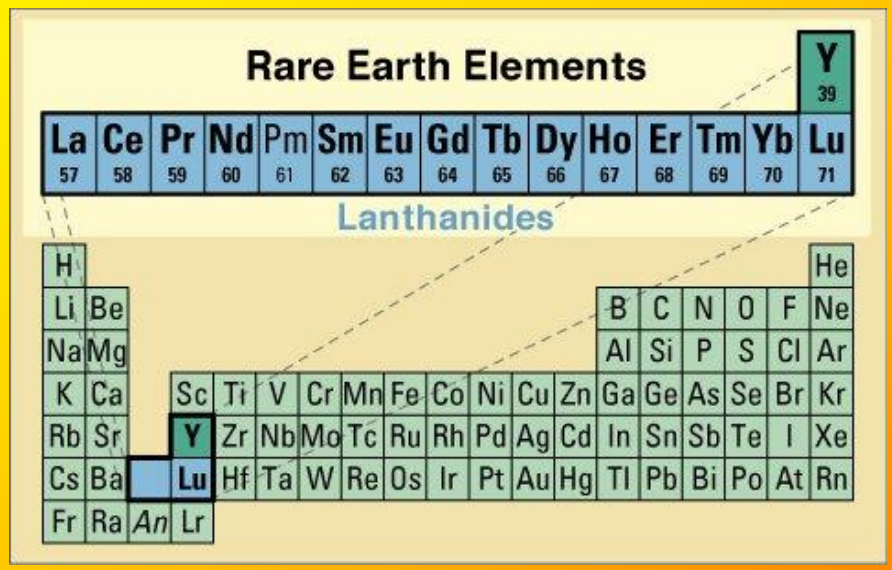
PRODUCTION AND STOCKS

In 2007-2008 124 thousand tons of REE were mined in the world.

The leaders, thousand tons: China - 120.00; India - 2.70; Brazil - 0.65.

Explored world reserves of REE at the end of 2008 amounted to about 130 million tons, including: China - 89, CIS - 21, USA -14, Australia - 5.8, India - 1.3, Brazil - 0, 84 thousand tons).

In July 2011, at the depths of 3500-6000 m in 78 places of the Pacific Ocean west and east of Hawaii, as well as east of Tahiti and French Polynesia, **extensive deposits of rare-earth metals (REM),** which amount to 80-100 billion tons of rare-earth metals, were discovered.



Terbium, lanthanum and neodymium, of which 97% are located in China, are especially valuable from the scattered elements.

The total world demand for REE is 120 thousand tons / year, however, China annually exports less than 30 thousand tons.

According to the British publication Independent, by 2012 **the Chinese government plans to stop exporting rare elements.**

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APPLICATION

Cerium - catalytic filters - exhaust gas neutralizers.
Dysprosium, neodymium, samarium - magnets.
Yttrium, europium, terbium - phosphors.
Lanthanum - capacitors.
Lanthanum, cerium - special optics.
Yttrium - ceramics.
Cerium - high-tech abrasives.
Gadolinium, dysprosium, lanthanum - X-ray films.

REE use: in **electronics, instrumentation, nuclear technology,**

mechanical engineering, chemical industry, metallurgy, etc.; La, Ce, Nd, Pr - in the form of oxides are used to obtain translucency of special-purpose glasses that transmit infrared rays and absorb ultraviolet rays, acid and heat-resistant glasses; in the production of pigments, varnishes and paints, in the oil industry as catalysts; in the production of certain explosives, special steels and alloys, as getters; single-crystal REE compounds (as well as glasses) are used to create laser and other optically active and nonlinear elements in optoelectronics.

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APPLICATION

Rare earth elements (REE) have unique properties.
The level of REE application is an indicator of the scientific and technical development of a particular industry; it contributes to the saving of mineral raw materials, improving the environmental situation, and ensuring national security.

REE cannot be replaced with other raw materials or technologies.

The availability of REEs determines the provision of strategic, valuable types of components, the preservation of their reserve for future generations.

REE have unique properties.

Spheres consumption	Consumption in 2005, thousand tons	Average annual growth in 2001-2005,%
Catalysts	28,5	3-5
Glass industry	24,0	3-5
Metallurgy	16,0	8-10
Magnets	18,0	17-22
Ceramics	3,5	13-15
Phosphors	6,5	7-8
Other	3,5	7-9
Total:	100,0	6-9

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NEED AND COST

Until 2035, the demand for dysprosium and neodymium will increase by 2600 and 7000%, respectively.

For this, the **production of dysprosium should increase 2 times every year. This can be achieved by parallel processing of production waste - phosphogypsum.**

Neodymium and dysprosium are the most sought after. They are used in permanent magnets (Nd2Fe148).

If REE concentrate with a volume of 1-3% can be extracted from phosphogypsum, then its cost can be € 100-600 per 1 ton of phosphogypsum.

Much more cost will be separated from the REE concentrate separately, or products made from them.

1 kg of REE - cerium, lanthanum, neodymium, europium and yttrium on the world market is **$ 11.6-1640.**

1 kg of metallic neodymium costs $ 22-32, and **already 1 kg of neodymium-iron-boron magnets - $ 100-120**, with a neodymium content of about 25%.

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RUSSIAN PHOSPHOGYPSUM AND REE

Khibiny apatite - the best phosphorus raw material in the world, contains: rare earths (up to 1%), strontium (2.3%), fluorine (3.1%). Despite the low content of RE elements in apatite concentrate (0.7-1%).

The volume of apatite of this concentrate in Russia is up to 10 million tons / year.

Raw materials	REE oxides of the Khibiny apatites and loparites														
	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y
Loparitis	25	53	6	14	0,9	0,08	0,6	0,4	0,12	0,08	0,02	0,003	0,008	0,002	0,008
Apatite	27	43	5	14	2,1	0,7	1,7	0,1	1,1	0,1	0,4	-	0,1	-	4,8

For almost 90 years, **1 billion 550 million tons of ore (about half of industrial reserves) have been extracted in Khibiny, 620 million tons of apatite concentrate have been produced.**

Moreover, not a single ton of rare-earth metals was recovered on an industrial scale.

That is, at least 6 million tons of the most valuable metals and about 20 million tons of strontium have been practically written off from the balance sheet, which makes up the triple world balance of this strategic metal.

Thus, tens of billions of dollars were lost to the Russian economy ...

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BELARUSIAN PHOSPHOGYPSUM AND REE

At the republican unitary enterprise **"Gomel Chemical Plant" 450 thousand tons of phosphogypsum are formed annually.** During the operation of the plant, **15.4 million tons were accumulated**, more than 60 hectares of land are occupied under dumps.

Dumps contain about 65 thousand tons of REE. Among them are cerium, lanthanum, neodymium, europium and yttrium. The prices for them in the world market are $ 11.6-1640 per kilogram.

Phosphogypsum contains about 95% calcium sulfate, 3% fluorine, 0.6-0.9% REE and 2.6% strontium and 1.2% P_2O_5. When processing apatite concentrate into phosphoric acid, about 80% of the rare earth elements go into a by-product - phosphogypsum.

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Based on the cost and weight of the REE contained in it, the Gomel mountain can be estimated at $ 6.6 billion.

With the existing technology at the plant, $ 1 is produced from 1 ton of apatite concentrate; as a result of the proposed new technology, **this volume of production can be increased by $ 900.**

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