RAW MATERIALS OF PHOSPHOGIPS. OVERVIEW

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PHOSPHOGYPSUM

$CaSO_4*2H_2O + H_2SO_4 + REE$

- phosphoric acid production waste obtained by treating phosphate feed with sulfuric acid.

Contains more than 60% gypsum and 2-5% phosphoric acid.

Some wastes contain up to 3% rare earth elements (REE).

Often has increased radioactivity.

It is less profitable to produce building materials from phosphogypsum than from natural gypsum.

There are no effective methods for separating REE concentrate.

Use as a fertilizer is limited.

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PRODUCTION VOLUMES

1.35 tons of sulfuric acid are consumed per 1 ton of apatite concentrate, resulting in 1.6 tons of phosphogypsum, which goes to dumps.

The amount of phosphogypsum produced per 1 ton of P2O5 (1.45 tons of H3PO4) is different and is:

- **4.5-5.0** tons, containing 90-95% of two-water gypsum, in terms of dry phosphogypsum;
- 6.0-6.7 t - per filtered cake with a moisture content of 25%;
- 9.3-9.5 t - the same with a moisture content of 56%.

The expected phosphorus consumption (by P2O5) in 2015 amounted to about 45 million tons, therefore, phosphogypsum production - **from 225 million tons per year.**

Until 2008, this figure was from 150 million tons *I* year.

STOCKS, MAINTENANCE COSTS

Reserves of phosphogypsum in Uzbekistan amount to more than 80 million tons and occupy an area of 500 hectares; in Russia - more than 500 million tons of phosphogypsum, in Ukraine - more than 20 million tons, in Belarus - more than 20 million tons.

Given the annual accumulation of waste, its **volume of world reserves should be at least 3 billion tons,** and the occupied **area should be more than 250 square meters. Km**

In most Western countries, phosphogypsum is stored in underground mines.

European companies pay € 15-30, or $ 19.8-39.6 / t per year.

The norm for payment for waste disposal of the 4th hazard class is established:

- in Ukraine at the level of 0.3 hryvnia, **or $ 0.0 4 / t;**

- in Belarus for placing the current output of phosphogypsum **- 271 Belarusian rubles,** or 3.1 Russian rubles, **or $ 0.09 / ton** and 27.1 bel. rub., or 0.31 rubles. rub., **or $ 0.01 / t** for phosphogypsum taking into account the accumulation;

- in Russia - 248.4 rubles., **or $ 7.45 / t.**

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PROCESSING PROFITABILITY

When processing phosphogypsum in a new way, the expected production **profitability should be from € 562 to € 1162 over 20 years.**

Lower returns correspond to:

1. The conversion of waste into raw materials is € 162 / t.
2. Processing of raw materials into marketable products - potassium sulfate K2SO4 and calcium chloride CaCl2 with a yield of € 400 / t

High profitability due to the sale of rare-earth element concentrate (REE) up to € 600 / t.

Taking into account the annual production of phosphogypsum with a volume of 225 million tons or more, the smallest annual **yield can be from € 126.45 billion, over 20 years - € 2529 billion.**

The potential minimum yield from processing 3 billion tons of accumulated man-made deposits will be from **€ 1,686 billion.**

Total return - € 4,215 billion.

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PHOSPHATE RAW MATERIALS

Raw materials are of industrial importance: **apatites** and **phosphorites**.

Countries are world leaders in the extraction of raw materials: Russia, Morocco, USA, Jordan, China, Tunisia.

The USA, China and Morocco account for 67% of the global production of natural phosphates, and the top ten producing countries account for 90% of the market.

In 2011, 190.8 million tons of raw materials were produced - apatite and phosphorite concentrate.

The volume of world consumption of P_2O_5 amounted to 40.7 million tons.

Annual growth in production and consumption is about 3-5%.

World requirements for phosphorus (P_2O_5) in 2015 will amount to about 45 million tons.

About:

- 82% of phosphoric acid is used for the production of fertilizers.
- 18% - for the production of feed phosphates, medicines, food products.

Phosphorus is also used in metal processing, medicine and dentistry.

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PHOSPHATE RAW MATERIALS

The quality of the produced apatite and phosphorite concentrate is estimated by the content of P2O5 in it.

From 1 ton of 39-40% apatite concentrate, up to 0.4 ton of P2O5 can be produced.

For example, PhosAgro produced 26.6 million tons of apatite-nepheline ore in 2011 and produced:

- 7.7 million tons of apatite concentrate (K = 3.45);

- 1 million tons of nepheline concentrate (k = 26.6).

Companies	Content of P_2O_5,% in 1 ton of concentrate produced
Fos Agro, Russia	39-40
Eurochem, Russia	37-38
Agrium	33
OCP, Morocco	32
PCS Canada	29,5
CF Industries	29
GCT, Tunisia	29
Mosaic, USA	28,5

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APATITY

Apatity Ca5[PO4]3(F, Cl, OH).

Depending on the content in the feed, fluorine, chlorine, and hydroxyl apatite are released; fluorine apatite is more common. Sr, Ba, Mg, Mn, TR can be present as impurities (cf. lat. Terrae rarae - “rare earths”), and others. Apatite is noted in all intrusive, many metamorphogenic, sedimentary, and less often effusive rocks. Often associated with nepheline, aegirine, ilmenite, sphene.

Quality is determined by the phosphorus content in terms of P2O5.

The world's largest deposit is the Khibinsky deposit on the Kola Peninsula in Russia, where apatitonefelin ore, consisting of fluorapatite and nepheline, is mined. Large well-formed apatite crystals are known in Transbaikalia from the Slyudyanka deposit (near the city of Slyudyanka, Irkutsk region). Apatite deposits are also known in Brazil, Mexico, the USA, Chile, South Africa, Finland, Spain, Norway and other parts of the world.

PHOSPHORITES

Phosphorites 3Ca3(PO4)2*CaCO3*Ca(OH, F)2

are sedimentary rocks, a significant part of which are phosphates and numerous inclusions of other minerals (quartz, glauconite, calcite, clay minerals, etc.). The content of impurity elements is often observed: U, TR (cf. lat. Terrae rarae - “rare earths”), Sr, less often V, Ti, Zr, etc.

Quality is determined by the phosphorus content in terms of P2O5.

Phosphorites are predominantly marine rocks, but in rare cases they can also form on land, for example, in the weathering crusts of limestone in an arid climate. Only a few countries in the world have large deposits of phosphorites - the USA, the Russian Federation, Morocco, Tunisia, Algeria, Egypt, and some “phosphorite” islands of the Pacific and Indian oceans. Countries that do not have their own phosphate deposits are interested in developing subsea production.

PHOSPHORIC ACID

Phosphoric acid is produced from apatite and phosphorite concentrate, and phosphoric fertilizers, feed phosphates, medicines, and food products are produced from it.

The **extraction method** for producing phosphoric acid with sulfuric acid is the most applicable and economical.

When P_2O_5 is extracted as H_3PO_4, phosphates are treated with H_2SO_4, and the resulting pulp is filtered off from a precipitate of Ca sulfate, thus obtaining pure phosphoric acid and precipitated phosphogypsum $CaSO_4*2H_2O$ with impurities of sand, trace elements (ME), rare-earth elements (REE).

World production of phosphoric acid in 2010 amounted to **38.9 million tons** in terms of P2O5.

The ten largest producers of phosphoric acid account for about 45% of the total global capacity.

PRODUCTION LEADERS

Leaders - integrated companies located near sources of raw materials:

- Moroccan company OCP has the world's largest deposits of phosphorus ores;
- in second place - the North American Mosaic;
- on the third - Canadian PotashCorp, although it should be noted that;
- Chinese Yunnan Yuntianhua International Chemical Co. practically close in volume to the

Canadian leader.

- Russian "Fosagro".

In recent years, companies have been able to significantly increase their capacities for the production of phosphoric acid for fertilizers, (more than, million tons / year):

China - 16.3;

USA - 9.5;

Morocco - 4.4;

Russia - 3.

Until 2015, the total production volume of P_2O_5 will reach **57.6 million tons.**

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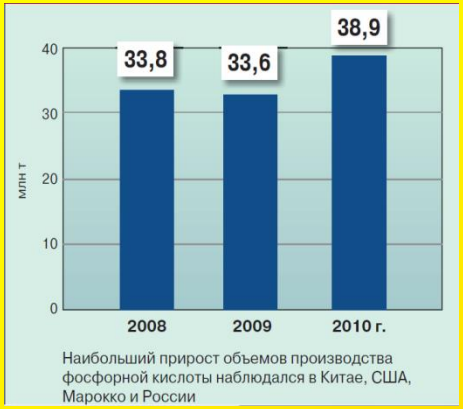
DEVELOPMENT PROSPECTS



World production of phosphoric acid in 2008–2010, mln. P_2O_5.

World production of phosphorus ores in 2010, %

The world's largest producers of phosphate fertilizers.

Morocco: OCP SA, Bunge Fertilizantes.

Tunisia: joint venture Tifert, Skhira, Groupe Chimique Tunisien.

Jordan: Jordanian Phosphate Mines Company, JPMC & Indo-Jordan.

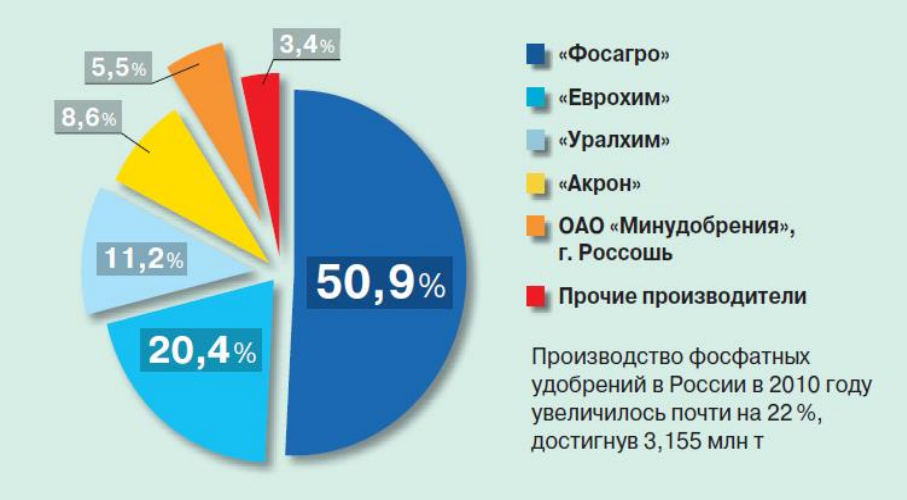
India: Indian Farmers Fertiliser Cooperative Limited (IFFCO).

Saudi Arabia: Saudi Arabian Mining Company (Ma'aden), SABIC, Ras Az Zawr.

Russia: Phosagro, Eurochem, Uralchem, Akron, Mineral Fertilizers, Rossosh.

RUSSIAN MARKET

Key players in the Russian phosphate fertilizer market



Компания	2009 г.	2010 г.	Прирост, %
«Фосагро»	1506	1606	6,6
«Еврохим»	450	643	42,9
«Уралхим»	140	353	151,9
«Акрон»	263	273	3,8
«Минудобрения», г. Россошь	165	173	5,0
Прочие производители	53	107	100,9
Итого	2578	3155	22,4

The structure of production assets of Phosagro includes two production sites - Ammofos OJSC (Cherepovets) and Balakovo Mineral Fertilizers LLC (Balakovo) - BMU.

MCC Eurochem includes a subsidiary - PG Phosphorit.

Uralchem is the owner of Voskresensk Mineral Fertilizers OJSC and in Dagestan - Dagfos OJSC.

CIS MARKET

In Kazakhstan, up to 50 phosphorite deposits have been identified with an estimated ore ore reserves of 5 billion tons.

Kazphosphate LLP will invest in development up to $ 800 million until 2013, increase, thousand tons / year:

- production of phosphorus-containing ore - up to 4300;
- release of ammophos - up to 550;
- complex fertilizers - up to 180;
- thermal phosphoric acid - up to 178.9;
- sodium tripolyphosphate - up to 165.8.

Belarus. The Belarusian producer of phosphate fertilizers - Gomel Chemical Plant OJSC plans to increase production capacities by 1.8 times by 2015, up to 1.26 million tons per year.

By 2017, a new player may appear - Chilisai Chemicals LLP, with an investment project for the production of mono (MAF) and diammonium phosphate (DAF), with a total value of $ 304 million.

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PHOSPHORIC FERTILIZERS

According to the International Industry Industry Association (IFA), in 2010, the consumption of phosphate fertilizers reached a record 40 million tons.

Production of three main types of phosphate fertilizers:

- monoammonium phosphate (MAF), $NH_4H_2PO_4$, $ 900-1100 / t;


- diammonium phosphate (DAP), $(NH_4)_2HPO_4$, $ 575-725 / t;


- triple superphosphate (TSF), $Ca(H_2PO_4)_2$, $ 300-510 / t.


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PHOSPHORUS. APPLICATION

Phosphorus plays a key role in most life processes.

Phosphorus is important for human health:

- participates in the formation of bones and teeth;

- plays a crucial role in energy metabolism at the cellular level and, therefore, in the body as a whole;

- is a necessary element in the structure of DNA;

- is part of many proteins;

Phosphorus is the second most abundant mineral element in the human body (after calcium):

- 85% of the phosphorus in the human body is found in bones;

- 1% - in blood and other fluids;

- 14% - in the soft tissues (mainly in the muscles).

PHOSPHORUS. APPLICATION

Plants accumulate phosphorus and are its source for people and animals:

- found in all parts of green plants - stems, trunks, roots and leaves, but most of all - in fruits and seeds;

- plays a crucial role in photosynthesis and all processes associated with energy recovery;

- promotes the growth of plants and their roots;

- participates in the process of assimilation of nitrogen by plants;

- helps to accelerate the maturation of plants;

- necessary for plant propagation;

- increases the strength of the stems;

- Helps increase plant resistance to cold and drought.

The proportion of phosphoric acid-based fertilizers increased from 75% in 2000 to 82% in 2010 and is expected to increase to 84% by 2015.

PHOSPHORUS. APPLICATION

Phosphorus is necessary for the formation and strengthening of animal bone tissue. It plays an important role in digestion and other metabolic processes:

- necessary for the formation and maintenance of the integrity of teeth and bones - they contain 80% of all phosphorus present in the body;

- participates in the formation of the skeleton;

- plays an important role in energy exchange processes;

- participates in protein synthesis and metabolism;

- is present in nucleic acids that carry genetic information, and also regulates protein biosynthesis and immune processes;

- enhances reproductive function;

- necessary for lactation;

- increases appetite.

PHOSPHORUS. APPLICATION

Phosphorus is also found in the products we use every day, including:

- in food additives (for baking, drinks, cooking meat dishes, cheese, canned food, etc.);

- in medicines and personal care products (toothpaste, cosmetics, etc.);

- in chemical goods and chemicals (detergents and cleaning products, fire extinguishers, water treatment products, batteries for hybrid cars and electric vehicles, ceramics, cement, paints, etc.).

About 82% of the world's phosphoric acid is used for fertilizer production. Another 18% - for the production of feed phosphates, medicines, food.

Phosphorus is also used in metal processing, medicine and dentistry.

PHOSPHOGYPSUM. ECOLOGY PROBLEMS

Phosphogypsum is the main source of environmental pollution (OS) in the areas where mineral fertilizer production is located (in Ukraine it is the cities of Armyansk, Sumy, Rivne). With the sulfuric acid method of opening apatite concentrate per 1 ton of H_3PO_4, depending on the raw materials and the **adopted technology, 4.3-5.8 tons of phosphogypsum is formed.**

With dry storage of phosphogypsum (without preliminary neutralization), **an average of 10 g of fluorine per 1 ton of phosphogypsum is released into the gas phase; approximately 10% of fluorine is washed out by atmospheric precipitation.**

Phosphogypsum should be stored in specially equipped storage facilities, as isolated from water bodies as possible.

Before storage, phosphogypsum must be neutralized with milk of lime.

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