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MINING AND PROCESSING

OF PHOSPHATE RAW MATERIAL IN RUSSIA

by

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Mining and Processing of Phosphate Raw Material in Russia

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The industrial reserves of phosphate raw material in Russia are concentrated in the European part of the country. The biggest among them is the Northern region, where the Khibiny *(Slide 2 – the Khibiny mountains)* deposits of apatite-nepheline ores, the best in the reserves structure and prognosis resources, are located.

The apatite and complex apatite containing ores of other deposits are considerably inferior either by the content of P_2O_5, that is by quality or by the technological indexes of ore-dressing. A number of prospected deposits, particularly in the Far East and Siberia, are not exploited because of the complicated geographical, technical, economical and ecological conditions.

By now within the area of the Khibiny massif, ten deposits have been prospected, six of which are being exploited. The total balance reserves of apatite-nepheline ores are 3.6 billion tonnes.

The exploitation of the deposits is being carried out by the open joint stock company "Apatit". *(Slide 3 – The structure of the JSC "Apatit"),* founded in 1929. Nowadays it is a huge mining and chemical enterprise comprising four mines, two ore-dressing plants, railway and motor-vehicle transport sub-divisions, more than twenty subsidiary work-shops, providing the activity of the "Khibiny giant", as it is often called. *(Slide 4 – The Scheme of the "Apatit" general plan).* The infrastructure of the company is developed on the vast territory, stretching from the west to the east for 70 kilometers and from the north to the south for 30 kilometers.

During the years of the company's existence, more than 1.5 billion tonnes of ore were extracted, more than 540 million tonnes (Mt) of apatite and 50 Mt of nepheline concentrates produced. *(Slide 5 – Volumes of ore extraction, apatite and nepheline concentrates production from 1929 to 2003).*

In the middle of the 1980s the mining level reached 60 Mt per year, the consumers got over 20 Mt of apatite concentrate. In the middle of the 1990s the concentrate production decreased by almost 4 times because of objective reasons. By 1998 they managed to stabilize the work of the enterprise and increase the production and sales of the apatite concentrate.

The main reason for the stabilization was the transition to long-term planning on the basis of the marketing and the optimization of the production organization. *(Slide 6 – The longitudinal section of the Khibiny deposits).*

To evaluate the prospect and the development strategy of the JSC "Apatit" for the next period correctly it is worth to describing the peculiarities of the work of this leading company under the modern conditions.

It is quite normal for any mining enterprise to suffer a gradual increase of negative technical and economical factors. "Apatit" is not an exception. The mining is being carried out under extremely complicated geological and climatic conditions.

The great water flow associated with snow melting during several months of the year, the constant increase of the rock transportation distance, the growth of wastes extraction volume, the lowering of the mining level lead to a considerable extension of both capital and exploitation expenses.

Another negative factor is the decrease of the useful component content in the extracted ore. *(Slide 7 – Mining, Production and the Content of P_2O_5 in 1975 –2003).* The content of P_2O_5 has lowered from 17,4 % to 14,0 % for the last 25 years. If in 1975 it was necessary to extract 2.5 tonnes of ore for the production of one tonne of the apatite concentrate, now this figure is 30 % higher: it equals 3.2 tonnes. The difference in the ratio between the rock (mining mass) extraction and the ready made production is even greater: earlier it was necessary to extract 4.5 t of rock for one tonne of concentrate, now it has become 9,5 t.

At present the mining in the JSC "Apatit" is carried out at 4 mines, 2 of which are open pits and 2 are underground operations. *(Slide 8 – Central mine).*

- The greatest deposit is Plato Rasvumchorr (Central mine) with ore reserves of more than 600 Mt, which is practically exhausted. The ore from the Plato was twice as cheap as the ore from any other mine. From 1980 to 1990 the Central mine gave 28 Mt of ore annually. At present such quantity of ore is worked out by all the four mines of the JSC "Apatit". *(Slide 9 – mining at the Vostochniy mine).* The second open mine – Vostochniy – includes two pits, one of which is Koashva. The dimension of the open pit is 3,5x1,5 km with the depth over 150 m. The large ore and overburden rock transportation distance, extremely high water flow level and the necessity to use the drain systems to pump out more than 40 million cubic meters annually influence the cost of the ore of the Vostochniy mine, which is much higher than that of the Central mine.
- As for the underground mines, Kirovskiy and Rasvumchorrskiy, they demand considerable use of material and labour resources in comparison with the open pits. *(Slide 10 – Kirovskiy mine).* This includes protection from the rock blows with the help of the construction of concrete sidings, additional boring of the discharge bore-holes and other preventive measures for the safety of the workers. It is also necessary to use expensive equipment for the mining of the lower layers of deposits. Besides, the draining of water flow and ventilation of the mine workings lead to high energy expenses.

The technological strategy of supporting the necessary capacities is based on the intensive development of the underground mines – with the purpose of achieving their maximum productivity for the compensation of the declining volumes from the Central mine and the Nyorkpahk pit of the Vostochniy mine.

The realization of the programme of the raw material base is achieved at the expense of**:**

- The increase of the ore extraction volume in the Kirovskiy mine to reach 10,5 Mt in 2006, with the following growth of productivity up to 12-15 Mt/y at the expense of starting the exploitation of the mine level with the capacity of 3 Mt of ore in 2002 and 8,2 Mt of ore in 2013.
- The increase of the ore extraction in the Rasvumchorrskiy mine to 3-4 Mt/y from 2005, with the following support of this volume at the expense of the resumption of the construction and starting the exploitation of the level +310 m with a capacity of 4,0 Mt in 2011.
- The work of the Central mine with the annual volume of 9,0 Mt/y of ore till 2003, with the following decrease of the capacity and the end of mining in 2014-2015.
- The work of the Vostochniy mine with the volume of 6,0-7,0 Mt/y of ore up to 2015. *(Slide 11 – Gradual increase of underground extraction).*

Thus, in such a way, a gradual increase of the ore volume extracted in underground mine will take place: from 38 % in 2001 to 50 % in 2005 and up to 75 % by 2015.

The apatite-nepheline ores are complex, so it is necessary to apply such technological schemes of ore dressing, which allow separating apatite from other components and on the next stages to extract other minerals for the production of nepheline, egirine and other concentrates. *(Slide 12 – Ore-dressing complex – ANOF-2, ANOF-3).*

The ore-dressing complex consists of two concentration plants – ANOF-2, having been in operation since 1963, and ANOF-3, in operation since 1988. At present the volumes of production of both of them are almost equal: each of them produces 4,3–4,5 Mt/y of apatite concentrate. The design capacities of the plants are higher, but nowadays the output volume is determined not by the production capacities but by the payable demand of the consumers, mainly in Russia and the CIS.

The technological cycle of the apatite concentrate production consists of three stages of crushing of ore, transported by rail-way from the mines, grinding in the ball mills, flotation, separation, classification, thickening, filtration and drying. *(Slide 13 – The production of the apatite concentrate).*

Any lowering of the ore quality, a change of its composition, an increase of the share of hard-crushed minerals results in the expense growth and therefore in the increase of cost price of the apatite concentrate.

The clear realization of the growing negative factors and the knowledge of the prospect of the enterprise development gives a possibility to work out a long-term technical policy of the company.

On the basis of the deep analysis of the condition of the mineral and raw material base and ore-dressing production, a new strategic development conception of the JSC “Apatit” was elaborated.

The most optimum version of the development of the raw material base and the support of the processing capacities was determined, which helped to draft “The Program of the optimum development of the JSC “Apatit” till 2020 and for the following prospect up to 2050”. According to this document, the most optimum level of apatite concentrate production is 8,5 Mt of concentrate per year for a long period of time. This volume of output will be provided by the annual extracting and processing of 27-28 Mt of apatite-nepheline ore, which means the necessity of keeping and developing raw material base. To achieve this goal the company increased the capital construction temps. If in 2001 about 10 million dollars were invested for these purposes; in 2002 the sum was raised to 15 million dollars. *(Slide 14 – The opening of the new level of the Kirovskiy mine).*

Last November a new extracting level (+172 m) of the oldest Kirovsk mine was put into exploitation. Thanks to its capacity – 3 Mt/y – it is equated by the mining specialists to a new mine. In the same mine the construction of the second new extracting level with the annual capacity of 8.2 Mt of ore is being fulfilled. At the same time a new extracting horizon (+ 310 m) is being built in the Rasvumchorrskiy mine. All this work is conditioned by the necessity to put them into operation to offset the exhausted deposits and closing quarries.

As it is well known, the mining industry is characterized by the considerable expenses for the support and renewal of the raw material base instead of the worked out capacities. *(Slide 15 – Kovdorskiy GOK*). It is fully related to both JSC “Apatit” and JSC “Kovdorskiy mining-processing complex”, the second company producing apatite concentrate on the Kola Peninsula.

The scientific research institute “Giproruda” together with the specialists of other project institutions and both these enterprises worked out the prospect of keeping their raw material bases till 2020. The main factor in the condition of the raw material base of the JSC “Apatit” will be the exclusion of the Central mine from the number of two exploited open pits by 2016 and of the Nyorkpahk quarry by 2013. Their capacity will be changed by the development of underground mines, which will lead to the further complication of the geological and mining condition of extraction, the change of the ratio of ore extracted by open and underground ways and therefore to the cost growth of ore.

The chief investments will be directed to the development of the underground mines capacity. The total investment in the raw material base for 20 years will be about 465 million US dollars. In connection with these changes there will be innovations in the structure of inner transport and infrastructure on the whole. It is planned to invest 260 million dollars in the reconstruction of the infrastructure in the considered future. As for the work of the concentration complex the expenses will depend upon the choice of the further way of its development – whether one ore-dressing plant or both of them will work – the investment will be from 80 to 150 million dollars. To keep the capacity of apatite-nepheline ore extraction the involvement of reserves from a new deposit Oleniy Ruchey (“Deer’s Stream”) into exploitation is being viewed. Its construction and starting into operation will demand 30-50 million dollars till 2020. In such a way the total capital investment in the mining and processing complex of the JSC “Apatit” till 2020 is evaluated in the sum of 1 billion dollars.

The situation is much the same at the JSC “Kovdorskiy GOK”. At present almost one third of the apatite production volume is provided by the involvement of the technogenic wastes of the iron ore concentrate floatation (accumulated for the period of 1962 to 1980) in the processing. For the substitution of the removing volumes they view the industrial usage of the apatite-nepheline deposit with the ore reserves of about 50 Mt, adjoining the main complex ores deposit. This source will provide the keeping of apatite concentrate production at the current level till 2020. Both of these two Russian manufacturers of phosphate raw material have similar priority tasks – to invest finances in supporting raw material base and to preserve the current manufacturing volumes: 8,5 Mt in “Apatit” and 1,5-1,7 Mt in Kovdor.

Only large holding companies, which have been formed recently in the line of the phosphorous fertilizers, can provide the necessary finance concentration and realize the huge capital construction. They are the Holding company “Phosagro”, comprising JSC “Apatit”, and the Mineral chemical company “Eurochim”, including the JSC “Kovdorskiy GOK”. Both companies have strategic development programmes, in which much attention is paid to the stability of the phosphate base.

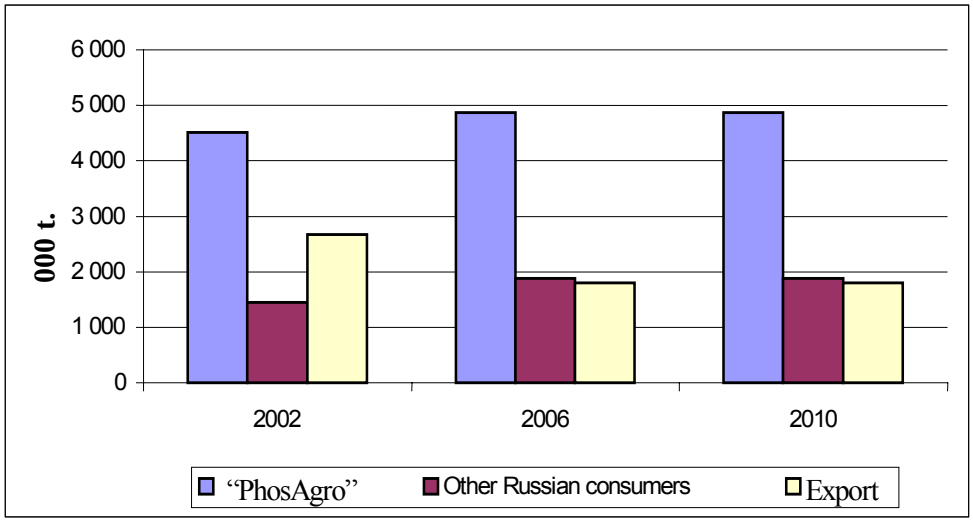
Ore-feedstock base is a determining factor for processing industrial enterprises that is why I have paid the main attention to this point in my report. According to the following information it is possible to make an unambiguous conclusion, that besides the mining-geological condition deterioration and necessity in significant investments, JSC “Apatit” can provide demands of both Russian consumers and traditional foreign ones in high-grade and high-quality. In the middle of the 1990s after the decline in consumption *(Slide 16 – The dynamics of apatite concentrate consumption)* Russian processing enterprises restored apatite concentrate consumption rate - 8,5-9,0 Mt/year.

Apatite concentrates consumption dynamics, JSC "Apatit", ' 000 tonnes

	Consumers	1990	1995	2000	2001	2002	2005 plan
	Total:	**19 305**	**7 461**	**9 101**	**8 402**	**8 629**	**8 550**
1	**Total Russia:**	**9 447**	**4 819**	**5 906**	**6 138**	**6 153**	**6 750**
1.1	JSC "Ammophos", Cherepovets	1 789	1 738	1 886	2 256	2 464	2 580
1.2	JSC "VMU", Voskresensk	1 179	792	999	1 068	1 004	1 100
1.3	LLC "BMU", Balakovo	1 059	698	913	1 035	1 044	1 170
1.4	JSC "Akron", Novgorod	331	397	422	496	493	500
1.5	JSC "Minudobrenia"Rossosh	270	105	324	373	352	415
1.6	JSC"KChHK, Kirovo-Chepetsk	398	156	293	257	256	310
1.7	JSC "Dorogobuzh"	269	238	228	236	239	250
1.8	JSC "GMZ", Lermontov	115	7	66	121	124	130
1.9	Others:	4 038	689	776	295	178	295
2	**Ukraine:**	**3 238**	**878**	**57**	**4**		
3	**Belarus:**	**667**	**168**	**244**	**235**	**221**	**250**
4	**Kazahstan:**	**2 200**	**38**	**0**	**0**	**0**	**0**
5	**Baltic countries:**	**741**	**412**	**750**	**0**	**196**	**0**
6	**Azerbaijan:**	**485**					
7	**Foreign countries export:**	**2 528**	**1 145**	**2 421**	**2 026**	**2 254**	**1 550**

Source: PhosAgro

Within the next three years an insignificant increase of apatite concentrate consumption by Russian enterprises will occur, the most significant growth of apatite concentrate consumption will take place at JSC "Ammophos" as a result of full-scale investment program implementation on radical renewal of production assets. Consequently, it is possible to forecast the next dynamics of apatite concentrate distribution by consumers *(Slide 17 - The prognosis dynamics of the apatite concentrate distribution till 2010).*



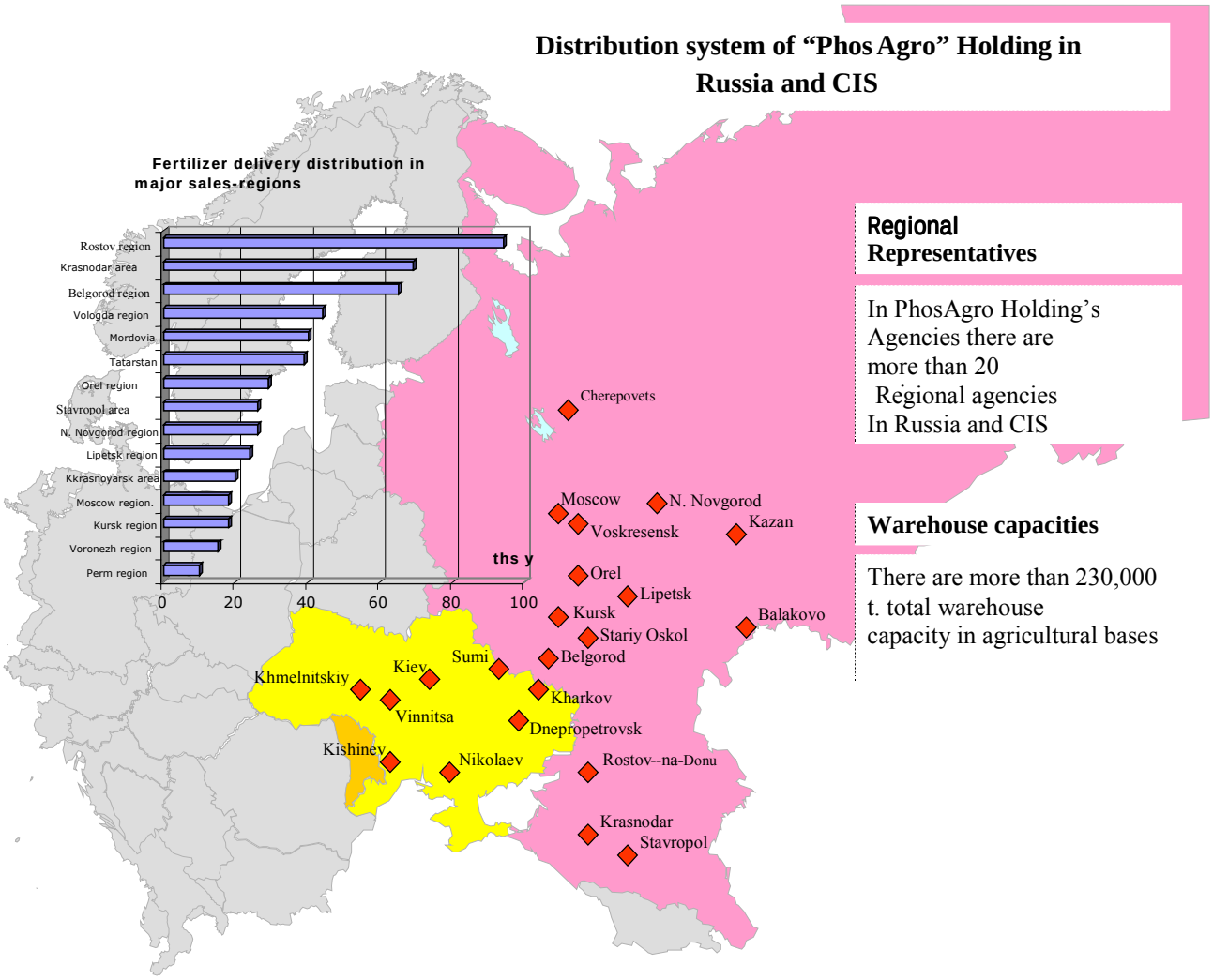
Source: PhosAgro

At the current moment, the major part of industrial processing enterprises achieved the limits of their technological and infrastructure possibilities to produce phosphate fertilizer. Taking into account the forecast of tariff growth for natural monopolies products and services with high physical depreciation of fixed assets, a concentration of efforts will be required to carry out a radical renewal of fixed production assets in order to achieve competitive rate of feedstock and power resources norm for consumption.

Besides fixed production assets the acute and fundamental problem is the infrastructure development of processing enterprises (transport, energy, storage) and transition to the modern automated control systems.

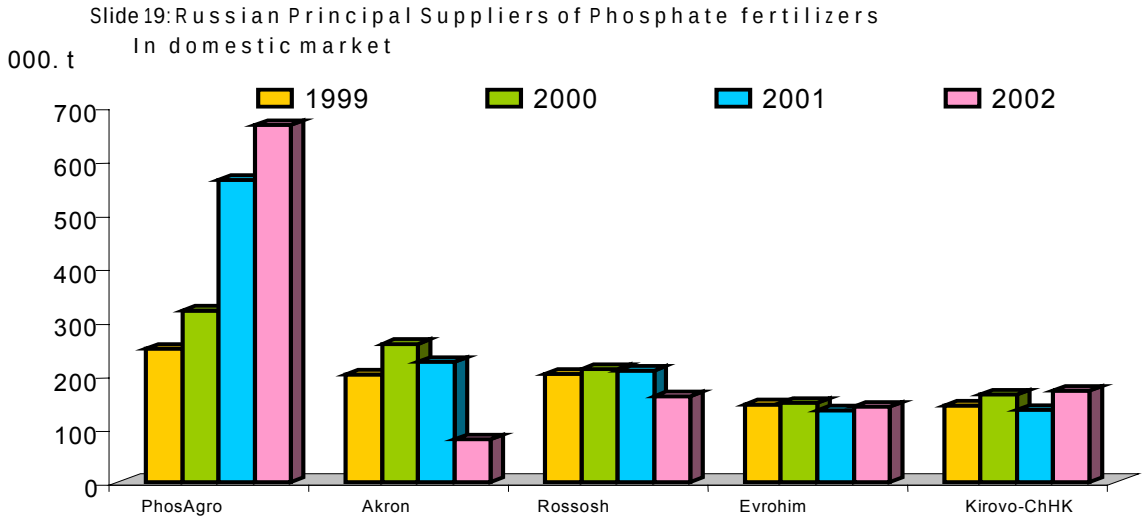
These major problems require concentration of organizational, financial, technical, intellectual efforts, which can be solved only by large companies. The "PhosAgro" strategic aim is domestic market development as the only market that corresponds to the particularities of the territorial distribution of processing facilities and "cost" pricing pattern.

Taking into consideration the destroyed agricultural resource base, beginning from the warehousing to the entering means, working capital insufficiency in many agricultural forms, domestic market development and selling growth means of chemicalization, fertilizers in particular, "PhosAgro" makes substantial investments to reconstruct warehousing in consumption regions for fertilizer promotion into domestic market. To implement distribution policy the priority is given to Russian consumers' satisfaction according to their specific peculiarities: fertilizers stores keeping, delay of payment, flexible discount system use, fertilizer packing, complete satisfaction of demand in chemicalization means. The company founded twelve regional sale structures that cover about 50% of phosphate fertilizer market. The division and regional distribution geographical coverage in Russia and Ukraine is shown in this map.



Source: PhosAgro

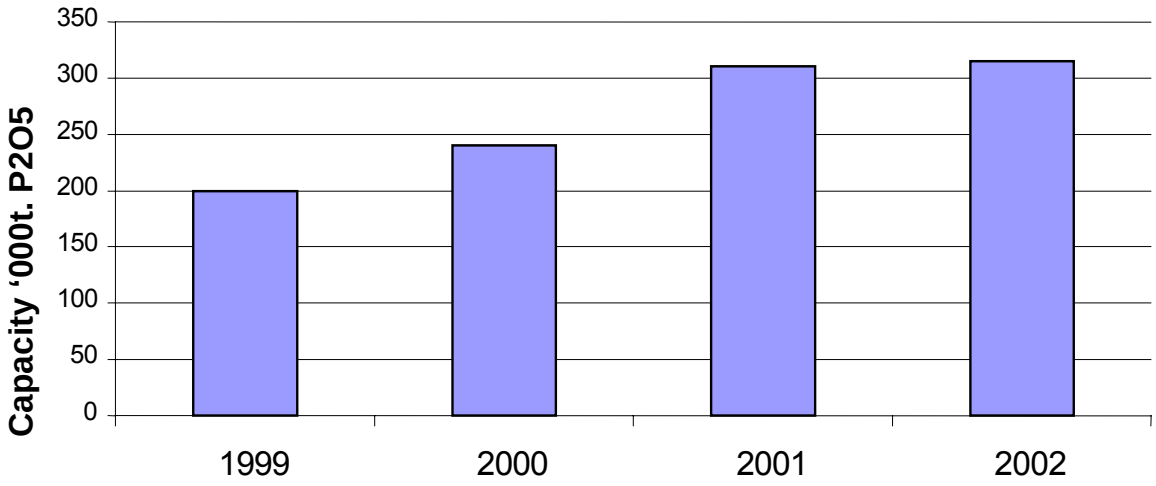
Data on dynamics of phosphate fertilizer deliveries by major Russian producers for the last 4 years are given in Slide 18 *(The system of distribution of "Phosagro" Holding in Russia and CIS).* In Slide 19, the main delivers of phosphorous fertilizers to the domestic market are represented.



Sources: companies' press releases, Ministry of Agriculture, PhosAgro.

According to the given data progressive dynamics the growth of phosphate fertilizer deliveries by "PhosAgro" company is evident, which has a purposeful and balanced policy of positioning in the home market as a leading company, which tries to achieve payable demand saturation in the home market. *(Slide 20 - the dynamics of consumption of the agrochemical phosphorous.)*

Slide 20 - Growth of phosphate fertilizer market capacity in Russia from 1999 to 2002

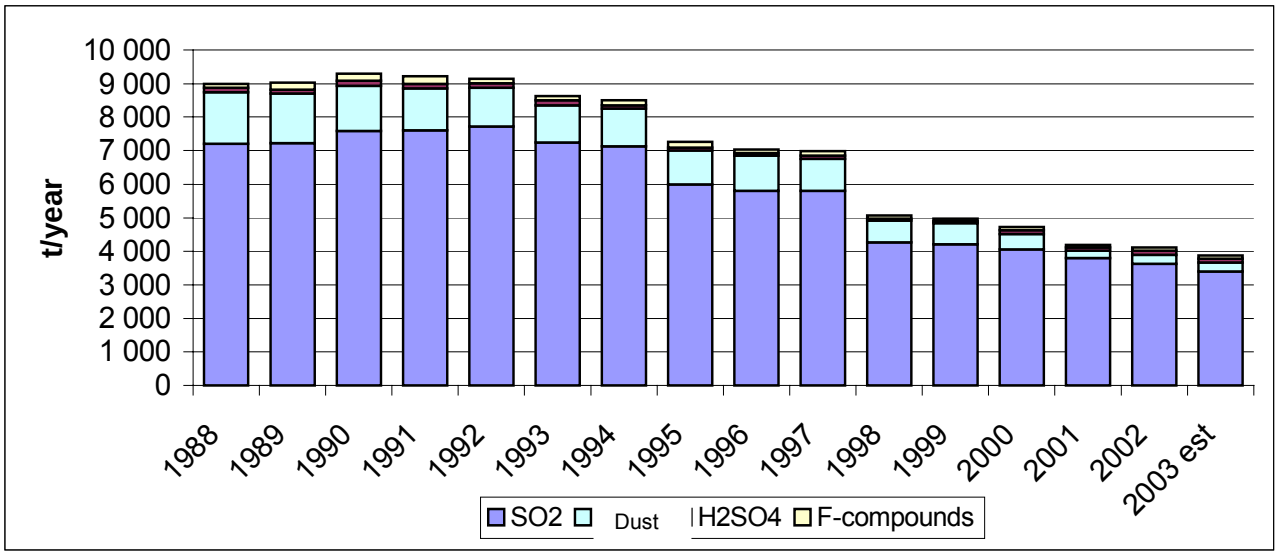


Sources: Ministry of Agriculture in RF.

The policy in the field of quality production control is a priority direction in the activity of "PhosAgro". The control system of products quality through ISO 2001 system was certified in JSC "VMU" in June 2002. Now "PhosAgro" is carrying active operation for the introduction of this quality system model into all controlled enterprises. The responsibility before consumers for keeping up the high quality standards is a major component of our company's management.

The observance and reduction of harmful substances discharge in the environment is the subject of constant control and realization of necessary organizational technical actions. A dynamics of pollutant discharge in the atmosphere of one enterprise of the company is shown in Slide 21.

Dynamics of discharge in the atmosphere, JSC "Ammophos", Cherepovets.



Source: PhosAgro.

According to this diagram the purposeful policy implementation in the field of the environmental protection allows to reduce negative chemical production influence on the environment. The data in the following table (Slide 22) show factual specific discharge of pollutant conformity to the best European recommendations (Best Available Technology), worked out by the European Fertilizer Manufactures Association (EFMA).

№	Enterprise	H2SO4, kg/t		NH3, kg/t		HF, g/t P2O5		Dust, kg/t	
		In fact	EFMA	In fact	EFMA	In fact	EFMA	In fact	EFMA
1	BMU	0.09	0.1	0.02	0.2	81	40	0.14	0.2
2	VMU	0.06	0.1	0.09	0.2	50	40	0.14	0.2
3	Ammophos	0.11	0.2	0.10	0.2	41	40	0.12	0.2

Sources: EFMA, PhosAgro.

The main attention of the company's management and engineering team is focused on the balanced policy of operating capabilities achievement with constant reduction of the negative environmental impact and high-level industrial security. The staff motivation system of the personnel departments of the company is based on this system of criteria, which is aimed at the achievement of the goal.

Consequently, the "PhosAgro" company connects its future with the firm position in the domestic market, modern level of resource-saving technology, controlled level of environmental impact and qualified business management: from ore extraction to sales accompaniment with the account of the consumers' demands.