METHODS OF SOLVING THE PROBLEM OF HIGH-POTASH FELDSPATHIC MATERIALS IN THE UKRAINE

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The main users of high-potash feldspar in the Ukraine are the electrical porcelain and fine-ceramics industries, and a much less quantity is used by the abrasives industry. The total requirements of these regions in 1965 will be 66,000 tons.

According to GOST 7030-54 feldspar and pegmatite for fine ceramics should satisfy the requirements given in Table 1.

TABLE 1

Factors	Feldspar		Pegmatite		
	Grade 1	Grade 2	Grade 1	Grade 2	Grade 3
Fe_2O_3 in %, not more than	0.2	0.3	0.2	0.3	0.5
$K_2O + Na_2O$ in %, not less than	12	11	8	8	8
CaO in %, not more than	1	1	2	2	2
Free quartz in %, not more than	8	8	30	30	30
Gravimetric ratio of $K_2O : Na_2O$		Not less than		2*	

*With agreement of customer may not be normalized.

With the agreement of the customers the amount of free quartz in grade 2-3 pegmatite can be increased to 40%, and the total K_2O and Na_2O reduced to 7%.

Only grade 1 feldspar and pegmatite should be used to make decorative and domestc porcelain.

For the electric porcelain industry the $K_2O : Na_2O$ ratio, equal to not less than 2 : 1, should be strictly observed since otherwise the dielectric properties of the insulators will be seriously impaired. Work done by GIÉKI and other organizations has shown that a higher ratio of oxides improves the dielectric properties, so it is planned to increase this ratio to 3 : 1 and even 4 : 1.

In feldspathic materials used in the abrasives industry the ratio $K_2O : Na_2O$ also should be not less than two, and Fe_2O_3 content not above 0.3%.

Between 1957 and 1963 in the Ukraine three sources of pegmatites were developed—Bel'chakov, "Orly" and Krasnovsk—whose raw materials after manual ore selection satisfy the requirements of GOST 7030-54 including the $K_2O : Na_2O$ ratio. However, the two latter have a number of disadvantages.

The Bel'chakov source is in the Rovensk Region. It was developed in 1957-1959 to supply the Gorodnits porcelain factory. The output of commercial pegmatite with manual sorting equals 52-60%. The Fe_2O_3 content varies from 0.06 to 0.47% (normally not more than 0.2%), $K_2O + Na_2O$, 8.3-11.6%. The ratio of K_2O to Na_2O normally exceeds 2 : 1. The developed reserves in categories A + B + C, are 253,000 tons.

The "Orly" source is in the Zhitomirsk Region and was developed for the Pervomai electrical porcelain factory. Manual working produces 50-55% pegmatite yield meeting GOST 7030-54 requirements. The iron content puts the pegmatite in 1 and 2 classes. The calculated reserves for category B + C, are 544,400 tons, but in view of the thin veins and their steep fall not more than 120,000 tons can be extracted.

The Krasnovsk source is in the Donets Region. It was developed to supply the Slavyansk armature-insulator factory. The pegmatites of this region have a very high content of iron oxides—about 1.44% on average. After manual selecting it drops to 0.43%, but often goes outside the limits of GOST and reaches 0.6% and even higher. The average yield of commercial pegmatite is 64.1%. The estimated reserves in class B + C_1 are 348,800 tons.

Thus, a satisfactory raw material base exists only for the Gorodnits porcelain factory. This is due not to the Ukraine's lack of the appropriate minerals but because many interesting rocks have not been examined or have been given scant attention during exploration projects, and also because the many different conditions characterizing the prospects of the deposits have not been studied.

In 1964 the geological-development services of the Ukraine has the job of providing in the next 1-2 years reserves of high-potash feldspathic materials in amounts of 10 million tons. This job can be done only by studying all aspects of the various feldspar rocks and substitutes, and also by studying new prospective regions such as the central part of the Ukraine crystallite massive and Zakarpat'e.

On the basis of our work and that of other geologists the following ways of solving the problem of producing high-potash feldspar in the Ukraine can be mentioned:

to find sources whose raw materials do not need enrichment;

to prospect for sources whose raw materials should be enriched by hand sorting;

to prospect for sources whose raw materials can be enriched mechanically;

to find sources whose raw materials will be under burdened with feldspathic rocks of other deposits, etc.

Sources of Materials Not Requiring Enrichment

The rocks which may be classed as low-iron high-potash feldspathic materials, not needing enrichment, can include pegmatites, leucocratic and kaolinized granites altered by secondary-processes, granitoides and similar rocks.

The purest materials in regard to Fe_2O_3 are the pegmatites and monomineral feldspar found in separate zones in pegmatite veins.

These rocks in most cases have a $K_2O:Na_2O$ ratio of less than 1.5 : 1, but in some sources or in the pegmatite veins this ratio exceeds 2 : 1 with a Fe_2O_3 content of 0.1-0.5%. For example this is so in the pegmatites of the Kalets and Karl Marx river areas the upper reaches of the river Burtichin (Priazov'e), the Kirovograd pegmatite field and also in the region of the town of Pervomai and the village of Migiya (Nikolaev Region).

The chemical analyses of pegmatites and other rocks examined by the authors are given in Table 2.

Reserves of high-potash pegmatites at most of the above sites are quite small and only those of the Kirovograd pegmatite field are extensive, but a disadvantage is the distance from the railway (20-40 km).

The microclinites and orthophyric rocks are also of great interest. The microlites were formed as a result of the hydro-thermal-metasomatic treatment of granitoids, syenites, tuffs and other rocks. The low iron-oxide microclinites (river Mokraya Volnovakh 0.49% Fe_2O_3, 9.23% K_2O, 3.30% Na_2O) have changed in the main from pegmatites to leucocratic granites. The microclinites are formed mainly from rocks rich in potash, while the mixed potash-soda rocks normally form plagioclase-microclinic feldspatolites, and the plagio-granites form plagioclases. However, quite often we observe microclinization or albite formation. The orthophyric rocks low in iron hydroxides were detected by the authors near the Verbova valley (Priazov). The average content of Fe_2O_3 in the orthophyric dyke up to 7 m thick is 0.11% K_2O—14.02%, Na_2O—0.25%.

Attention should be paid to the kaolinized granites for the discovery of large deposits of high-potash feldspars which require no enrichment. Upon kaolinization of the granitoid rocks there is a sharp drop in Fe_2O_3 content and a rise in the $K_2O:Na_2O$ content, but the total alkalis diminish. An example of this type of deposit is the kaolinized granites of Blagodatnoe (Pervomai Region) which contain 0.25% Fe_2O_3, 4,80% K_2O, 1.93% Na_2O, 6.73% Na_2O+K_2O; but it is true that the reserves here are small. The best source of this type may be found in the developed regions rich in potassium from the leucocratic granites which have high alkali contents (above 8.5-9%).

Sources of Materials Requiring Hand Sorting

To supply the current needs of the electrical porcelain and ceramic plants until the development of large bases for high-potash feldspar it is permissible to use manual selection of pegmatites or other rocks which are suitable for such enrichment. Manual beneficiation may prove suitable in the future if a source of feldspar which is easily hand treated is very close to the users, in particular if these users are situated far away from the main mining concerns.

TABLE 2

Rocks	Source	Content,%							
		SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O
Pegmatites	Village of Peremog, river Kalets	76.04	Traces	13.84	0.18	0.05	0.60	2.17	6.37
"	Village of Andreevok	67.05	"	18.95	0.27	0.10	0.47	3.72	8.91
"	Inzhenerovka, Kirovograd pegmatite field	—	—	14.92	0.28	—	—	2.36	6.02
"	Migiya village	70.48	0.05	17.00	0.21	0.14	0.95	2.94	9.06
"	"Orly" source (analysis by Zhitomirsk KGPÉ)	74.17	—	15.75	0.51	0.11	0.65	3.54	5.36
Granites	Bratolyubovka	—	—	13.05	1.35	—	—	2.20	5.86
"	Mitrofanovka	76.86	0.08	12.33	1.05	0.14	1.50	2.59	5.39
"	Anadol (analysis by Priazov KGPÉ)	72.40	—	14.58	2.83	0.45	0.48	3.12	6.19
Granitic gravels	Karansk pit (analysis by TsNIL of the Armset' Trust)	73.90	0.16	15.09	1.03	0.22	1.34	2.68	5.30
Kaolinized granite	Blagodatnoe village	75.51	Traces	14.90	0.25	—	—	1.93	4.80
Granite strongly kaolinized	Mitrofanovka	—	0.26	20.37	0.22	—	—	0.12	4.42
Microlinite	Bugas	65.92	0.30	19.06	0.49	0.02	0.75	3.30	9.23
The same	Perga (analysis by Zhitomirska KGRÉ)	62.41	0.20	18.03	1.25	0.38	2.08	2.40	13.28
White orthophyr	Verbovaya	65.28	Traces	18.90	0.12	0.04	0.40	0.30	15.30
Cream orthophyr	Verboya	64.08	0.10	17.98	0.87	0.02	0.85	0.18	14.66
Arkose sandstone	Novo-Ignat'evka village	86.78	Traces	7.31	0.23	0.20	0.40	0.29	4.75
Alaskite	Serednikova village	75.04	—	14.87	0.48	—	0.38	7.61	5.10

Pegmatites from Ust'e-Bel'chaksk, Polonno-Baranov, Andreevsk and Volnovakh fields are more or less satisfactory for hand sorting. In our opinion at the Polonno-Baranov pegmatite field the most effective source may prove to be the "Gornyi" or "Ul'akha," and not the "Orly" source developed for the Pervomai factory. At Priazov'e, considering that the pegmatites of Krasnovok after hand sorting frequently have nonstandard iron contents, to satisfy the needs of the Slavyansk plant it may be possible that the Volnovakh pegmatite field or the pegmatites of the Andreevka area, Dolinsk or Kalets may prove more satisfactory.

Sources of Materials Which Can Be Enriched Mechanically

This method is one of the most promising. More attention should be paid to the high-potash granites which are widespread in the central parts of the Ukraine crystallite massive, and also in Priazov'e and around Volyna. They normally have a relatively high content of Fe_2O_3 (1-2.5%), but with electromagnetic enrichment it is quite often reduced to 0.25-0.4%. The high ratio of $K_2O : Na_2O$ is also shown by the granites of Bratolyubov, Mitrofanovak and those in the southern part of Novo-Ukraine (the Kirovograd Region), the Anodol'sk granites (Donets Region) and many others. The content of Fe_2O_3 in the Mitrofanovok granites drops from 1.05 to 0.24% after enrichment, with a yield of concentrate of 92.82%, in the granites of Novo-Ukraine from 1.4 to 0.31% with a yield of 77.89% and in the granites of Anadol'—from 1.59 to 0.39% with a concentrate yield of 72.96%.

Satisfactory results were obtained by enriching the microclinites. For example, in those around the Mokraya Volnovakhu area the Fe_2O_3 content was thus reduced from 0.49 to 0.25% with a concentrate yield of 95.98%. So attention should be paid to the microlinites around Perg (these are being investigated by the Zhitomirsk KGRÉ) which were formed from syenites, though they have a much higher Fe_2O_3 content (1-2%). The method of flotation may also prove quite promising for such rocks.

Granitic gravels and orthophyric rocks are less amenable to electromagnetic enrichment. Thus, in the granite gravel of the Karansk deposit the Fe_2O_3 content was reduced from 1.03 to 0.5% (concentrate yield 95-98%) and in the orthophyric rocks of Verbova, from 0.89 to 0.63% (concentrate yield 88.9%).

It is possible to recommend the fractional separation of strongly kaolinized low-iron granites into feldspar, quartz and kaolin fractions. This would yield feldspar concentrate with $K_2O : Na_2O$ ratio of 4-5 : 1 and above. The processes of kaolinization in the Ukraine crystallite massive have been extensively developed.

Positive results may also be obtained by separative flotation of high-potash arkose sands into feldspar and quartz if the raw material contains not less than 3-4% alkali. From the arkose sandstones of the Kumkol'sk area (Kazakhstan) containing 2.46% K_2O-Na_2O the Institute Uralmekhanobr [1] obtained 24.95% feldspar concentrate containing 7.51 ÷ 9.04% of these oxides. We have found arkose sandstones in the Ukraine which were free of hydroxides; they were situated to the west of Novo-Ignat'evka (Donets Region) and contained up to 5% alkalis and 0.2-0.3% Fe_2O_3.

Special mention should be made of the methods of enrichment whose use permits feldspar to be obtained from nonstandard (in terms of $K_2O : Na_2O$) materials if the new ratio of the treated feldspar is 3 : 1 or above. These are methods connected with the separation of raw materials into microclinic and plagioclase fractions. They apply to electric separation, flotation, selective grinding, separation in heavy media, etc. A lot of work has been done in this connection by the Institute Uralmekhanobr. However, since the object of the work was improperly selected none of the sources investigated has any practical value, mainly owing to the low concentrate output. Thus, the gravitational enrichment of rare-metal ores from the Zhdanov area produced a concentrate yield of 14.2% with a $K_2O : Na_2O$ ratio of 3.5 : 1 and for the granites of the Rezhik (Urals) area 12.53% with a ratio of 2.8 : 1. The data for the enrichment of pegmatites from Eliseev sources in general have not been proved, since the mean ratio of $K_2O : Na_2O$ from this site is 0.8 : 1, while a sample was taken for the study with a ratio of 2.4 : 1.

Higher yields of concentrate in the future will need better studies of the sources of materials in which the $K_2O : Na_2O$ ratio should be in any case not lower than 1.3-1.5 : 1.

Deposits of Materials Which Should Have Underburdens of Feldspathic Rocks From Other Sources

From this aspect no study has been made of the feldspathic rocks of the Ukraine. However, the technique may produce promising results with the discovery of new types of feldspathic rocks in which the $K_2O : Na_2O$ ratio varies from 10-20 : 1 to 50-80 : 1 (orthophyric and arkose sands). Low-iron orthophyric rocks with 0.5-0.9% Fe_2O_3, 14-15% K_2O and 0.2-0.3% Na_2O have been studied by the authors in the Verbova valley, and rich feldspathic arkose sands west of Novo-Ignat'evka (Priazov'e).

Using the low-iron orthophyric rocks containing not more than 1% Fe_2O_3 it is possible to improve the feldspathic materials having a $K_2O : Na_2O$ ratio of 1.3-1.51 and below and a Fe_2O_3 content of no more than 0.3-0.4% (for example, enriched pegmatites from the Polonov-Baranovsk pegmatite field, kaolinized granites). Good results can be obtained by the combined addition to the batch of arkose sandstones and granites, and especially if the latter after enrichment have a Fe_2O_3 content of not more than 0.3% and a $K_2O : Na_2O$ ratio of not less than 1.5 : 1.

This way of solving the problem of high-potash feldspar deserves a lot of attention since with it the $K_2O : Na_2O$ ratio can be brought to 4 : 1 and higher.

Other Methods of Solving the Problem of High-Potash Feldspathic Materials

Some scientific and production bodies have investigated the substitution in the electrical ceramics industry of feldspathic rocks with raw materials having nonstandard $K_2O : Na_2O$ ratios by adding special agents to the batch or changing the batch composition. Thus in the work of Prof. G. V. Kukolev and Cand. Chem. Sci. L. A. Shchukareva (Kharkov Polytechnical Institute) satisfactory results were obtained by adding 2% zircon or 2% zircon + 6% bentonite to the batch. Recently they have developed a method for obtaining high-voltage insulators from a radically altered batch in which the feldspar component was alaskite from the Seredinovsk area. It is true that the tangent of the dielectric loss of the specimens was 0.037 instead of 0.035 according to the new norms.

These experiments should be continued but the objects of the study need to be set by the competent geological organizations. In particular, it is not clear why the researcher concentrated only on the Seredinovsk sources of alaskites. Indeed, in the Ukraine there are several pegmatite fields where the $K_2O : Na_2O$ ratio is much higher; furthermore there is an extensive, well studied source of pegmatites in the Bol'shoi Lager' of Balka where the ratio of the oxides is the same, and the reserves are 5 times bigger than in Seredinovsk.

It should be remembered that with a ratio of $K_2O : Na_2O$ of less than two there is a serious deterioration in the dielectric properties of the high-voltage insulators. In fine ceremics satisfactory results are obtained with a lower ratio.

In conclusion we note that for the successful solution to the Ukraine problem of high-potash feldspar, the fine-ceramics, electrical ceramics and abrasives industry need to study very carefully the existing possibilities, and on the basis of technical and economic data and also the demands of the various industries using the materials, to select optimum sources. Consideration should be made of the possibility of territorial redistribution in the future of regional industries using the feldspar (since the share of this material is 40% or more), i. e., we should consider not only the location of existing factories but the future developments in regions where large, highly effective sources of feldspars and new concerns in the electrical porcelain and ceramics industry may be located.

The answer to the problem of high-potash feldspar in the Ukraine has not merely republican importance, since many adjacent regions of the RSFSR and BSSR have no indigenous supplies of feldspar and must rely on imports from outside

LITERATURE CITED

1. V. N. Revnivtsev, S. N. Kropanev, and V. V. Peskov, "Steklo i Keramika," 1 (1964).