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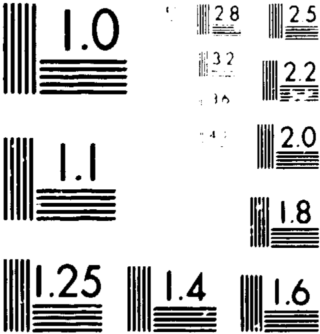

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EXPLOITATION OF NON-METALS - THE YUGOSLAV EXPERIENCE**

by

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1. Introduction

The industrial branch of non-metal mineral raw materials is the youngest one to be exploited of all the useful minerals in Yugoslavia and it is only since the end of the last and the beginning of this century that its development has become more intensive.

This branch includes a much larger number of mineral raw materials which are used in comparison with the branch of metal mineral raw materials. On a world scale, non-metal mineral raw materials are considerably more exploited in terms of economic effect than metal raw materials.

The development of technology and technical progress have brought about exceptionally dynamic increases in the production of non-metal mineral raw materials in relation to metal raw materials:

- There is a clearly marked connection between the geological, technological and economic factors in this branch in contrast to all other branches of natural riches;

- There are still large numbers of non-metal mineral raw materials that have not been sufficiently explored for the purpose of exploitation and application and even with regard to ascertained geological reserves.

2. NONMETAL MINERAL RAW MATERIALS IN YUGOSLAVIA

Nonmetal mineral raw materials were the first to be used among all other natural materials. However, most of them, both in our country and abroad, began to be intensively exploited only during the last sixty years. In the beginning, greatest attention was paid to the following nonmetal mineral raw materials: building stone, sand, gravel, brick clay, roof slate, cement marl and limestone mainly for obtaining lime.

In addition to these mineral raw materials, objects of exploitation were also lithografic stone, water stone, clay and gypsum. Due to poor transport facilities and insufficient knowledge of their quality, the production of these raw materials was oriented only towards meeting local needs.

More intensive production of nonmetal raw materials in the period from 1920–1945 was concentrated on magnesite, ceramic and refractory clay, quartz sand, feldspar and chrysolite-asbestos. At the same time, the first processing facilities were constructed representing our earliest nonmetal industry.

The period of exploitation of nonmetal raw materials up to 1941 was characterized by the fact that the deposits of nonmetal raw materials and processing capacities were in the hands of private domestic and foreign concessionaires. The deposits were not explored, while exploitation was carried out without any plan or system and lacking proper expertise.

3. EXPLORATION OF DEPOSITS OF NONMETAL MINERAL RAW MATERIALS

Since 1945 to date, the exploitation and processing of nonmetal mineral raw materials has assumed more and more significance so that a good deal has been accommplished in the exploration of new deposits of known nonmetal raw materials. More importantly, a large number of mineral raw materials were discovered that had not been known to exist in our country till then.

Thus, today the number of nonmetal mineral raw materials being exploited has reached the figure of thirty and is double the number of exploited raw materials in the period from 1920–1945.

Today the following mineral raw materials are being exploited:

1. asbestos
2. phosphorites
3. stone salt
4. mica
5. barytes
6. feldspar
7. gypsum and anhydrite
8. graphite

9. magnesite
10. pyrophyllite
11. talc and talcstone
12. wollastonite
13. tuff
14. opal breccia
15. cement marl
16. kaolin clay
17. bentonite clay
18. fire and ceramic clay
19. brick clay
20. white bauxites
21. technical stone
22. decorative stone
23. limestone
24. chalk
25. dolomite
26. quartzite and quartz
27. quartz sand
28. silex
29. diatomite
30. sand and gravel
31. perlite

On the other hand, an equal number of nonmetal mineral raw materials needed by our industries are still not being exploited due mainly to insufficient exploration regarding reserves and application.

The biggest expansion since 1945 up to the present has been in the production of magnesite, fire-clay, quartz sand, raw materials for the cement industry and for construction materials.

In the production of construction materials there has been intensive development in the production of brick clay, brick products, technicval and civil engineering decorative stone.

With the purpose or enabling the most economical exploitation of the existing natural resources of nonmetals in Yugoslavia, special attention has been paid to the establishment of legal regulations covering all three phases, namely: exploration, exploitation and processing.

The earliest regulations of thirty years ago covered a comparatively small number of nonmetal mineral raw materials. With the development of the economy and increased needs for new raw materials, it became necessary for all the nonmetal raw materials being exploited to be covered by legal regulations.

During the past period important experience has been gained and this has made it possible to draw up a new presently valid law concerning the exploration, classification and categorization of reserves of hard mineral raw materials which include nonmetal raw materials. These regulations lay down the criteria for determining the reserves of hard mineral raw materials and classifying them as well as the methods of registering reserve deposits.

The deposits of nonmetal mineral raw materials are classed into groups and subgroups depending on their size and complexity of forms, their genetic type, mineralogical composition, the distribution of useful components, structural tectonic features and degree of post-mining tectonic motion.

The group or sub-group of the deposit or ore body determine the optimum type and density of the exploratory work which then determines the degree of exploration and knowledge of the deposit or ore body.

The degree of exploration of the deposits of nonmetal mineral raw materials for the purpose of determining the beginning of exploitation and the applicabilty of the mineral raw materials is determined on the basis of the degree of knowledge of their features, that is, their extent, their genetic type, their mineralogical and chemical composition, the content of useful and harmful components, spatial distribution of various types, physical and chemical characteristics, structural, hydro and engineering-geological factors and the technological possibilities for the preparation and processing of the mineral raw material.

Exploration of deposits is done by geological, geophysical geochemical, hydrogeological and engineering methods, by all kinds of surface and underground mining exploration as well as by surface and underground drilling.

The type of exploratory work for all nonmetal raw materials is precisely determined as well as for all the maximum distances needed to indicate reserves in categories A.B and C_1.

Regulations also stipulate how to establish the quality of nonmetal mineral raw materials in deposits as well as the places where samples for exploration are taken.

Technological examinations of raw materials are undertaken at a laboratory, semi-industrial and industrial level depending on the rawmaterial and the category of the reserves.

Depending on the outlook for profitable exploitation, categories A, B, and C_1 are classed as balance and non-balance reserves.

The reserves of nonmetal mineral raw materials of categories C_2, D_1, and D_2 considered as expected reserves, are also ascertained but are not divided into classes (material balance and non-balance).

Scientific and technical progress, changes in the markets, as well as other technical and economic factors can cause transfers to be made from the non-balance to balance reserves.

The balance reserves of nonmetal raw materials are fixed on the basis of natural and value indices. The natural indices include: quantities of reserves, the mean content of the useful components, the minimum economic and limit content of the mineral raw materials, the degree of exploitation of the mineral raw materials and others.

The value indices are: cost of exploration - total and by the ton, production costs, preparatory work and processing, the total investments needed to construct the mine, processing, installations and other structures.

The balance of mineral raw materials is obtained on the basis of the total indices and estimated profitability.

The prospecting regulations are uniform throughout Yugoslavia.

The exploratory work is carried out by specialized work organisations, as well as by a large number of production organisations engaged in such work for their own needs.

Up-to-date technique and technology in this field are used in exploratory work. The bulk of the equipment used in the prospecting is produced by Yugoslav factories. The Socialist Federal Republic of Yugoslavia as well as the Socialist Republic of Serbia today have highly qualified cadres with a good deal of experience at their disposal in exploratory work for all types of mineral raw materials.

4. Exploitation of deposits

Exploitation work is also regulated by law but at the level of each Socialist Republic.

Mining law determines the procedure necessary to obtain approval for exploitation, the exploitation field, the exploitation (within which the drawing up of relevant blueprints are laid down, as well as stoppage of exploitation, the mining concession land register, mine surveying and mining plans and mining inspection).

Exploitation has, in fact, during the last thirty - five years been constantly followed by an upsurge in the technical and technological production process. In the period between 1945 to 1950 in all the mines of nonmetal and building materials, production was done principally by hand and without hardly any mechanization.

By strengthening production possibilities, mechanization was gradually introduced, first for the transport and then for loading and unloading and at almost the same time for extraction.

Of the mines in which there is a daily production of about 50 t to 100 t, or monthly about 1000 t., we now have mines with hourly prod ction of some one hundred and more tons and an annual production of thousands of tons. Thus today we have a fair number of mines of nonmetal raw materials or of building materials whose annual production figures reach a high of hundreds of thousands of tons. The leading mines in this field are the quartz sand mines (whose production reaches an annual figure of up to a million tons) clay, magnesite, and limestone (mainly for technicalstone).

It can be stated as regards nonmetal raw materials and building materials that in their initial phase with little technologial equipment and mostly manual work, there was practically no planned exploitation often directed towards richer zones or deposits considered more suitable from the viewpoint of morphological, hydrological or hydro-geological conditions. With the introduction of mechanisation, it became necessary to draw up technical documentation and thereby to avoid making the early mistakes.

Today it can be confidently stated that there is practically no deposit with an annual production exceeding 10,000 tons, that does not have its technical documentation or that does not use, at least some of the time, mechanisation in the work of obtaining mineral raw materials.

Of special interest is the qualification of the workers in the mines of nonmetal mineral raw materials. Whereas during the fifties a skilled or highly skilled worker was a rarity, today these mines can boast of up to 90% of the total manpower consisting of skilled labour.

This upsurge in the use of technology and organisation made it possible for production from 1950 to the present to increase by more than twenty times for particular raw materials. A specially high trend has been recorded in the production of clay, quartz sand, magnesite and limestone.

This technological growth was paralleled by our machine construction industry so that it can be stated that today it is possible to fully equip an open-face pit with the capacity of 500,000 tons per year without any difficulty (for instance limestone or some other raw material) from domestic factories. Our machine industry can produce equipment for depth drilling in mines, for the production of bulldozers of various capacity and horsepower, hydraulic excavators with very high capacity, loading caterpillar-tracked or wheeled excavators, trucks of various capacity and a whole range of other auxilliary machines and gear.

5. PREPARATION OF NONMETAL RAW MATERIALS

Nonmetal raw materials are mostly processed before final use, although there are such that can be directly used in production.

Parallel with the development of industry, civil engineering and agriculture, greater requirements began to be made with regard to quantities and quality. Quartz sand, for instance, in the beginning was mainly used directly, without any processing, and for different purposes. Today processing is done mainly with washing, grading and flotation ... the purpose of obtaining a product with a high content of silicium dioxide, together with a favourable granulometric composition.

In magnezite deposits, the reserves with high content of magnezite have been exhausted so that of late various separation methods have been tried out with the purpose of obtaining high quality raw materials ranging all the way to the chemical process of separating the pure magnesite from the previously rejected waste, and the like. Consideration is now being given to the possibilities of obtaining magnesite from sea water and dolomites.

Invaluable experience has been gained in the field of preparatory work and the production of refractory materials so that today our industry supplies nearly the whole domestic market with all kinds of refractory materials.

In addition to this, certain work organisations, producers of refractory materials, successfully complete in foreign markets and sell complete engineering and technology, that is, "know-how".

Yugoslav imports of refractory materials at present are about 10% and this principally to complement the assortment of specific products whose consumption in very small. Otherwise, the production of refractory ma-terials by its quality and quantity covers the needs of our domestic market while a large amount is exported.

6. SURVEY OF THE SYSTEM OF EXPLOITATION OF SOME TYPICAL RAW MATERIALS

6.1. General Considerations

Further in this text we cite only some typical examples of the system of exploitation of nonmetal raw materials which are significant either by their volume, (such as cement marl) or else by their specificity (silex) or by the technique used.

However, it should be borne in mind that the bulk of Yugoslav exploitation of nonmetal deposits is done with the open-face system of work. Construction materials are completely exploited through the surface method. A certain number of nonmetal raw materials are worked by an underground method (some magnesite gypsum, baryte, bentonite clay, stone salt deposits and others).

The choice of system and methods of exploitation as well as the choice of equipment have been adopted according to generally valid regulations with relation to the geological characteristics of the deposits and their economic viability.

It is characteristic of a large number of domestic mines of nonmetals of underground and surface exploitation that there is a tendency to increase the level of mechanisation and to introduce up-to-date equipment because practice has shown that this is the only sure way to ensure the dynamics and capacities of production. Moreover, due to the exhaustion of some deposits worked on the surface, the volume of exploitation of the same raw material by the underground method of work has increased with a clear tendency to maintain production expenses within economic limits as dictated by the cost of the final product in the domestic and foreign markets.

To illustrate the above, we give a basic account of the exploitation of some typical nonmetal mineral raw materials.

6.2. Underground exploitation of magnesite

Magnesites are mostly found and exploited in the SR Serbia and partly also in the SR Bosnia and Hercegovina. Work is done by either a surface or underground system, depending on the deposit.

The over-all annual production of magnesite ore varies from year to year, from 399,000 tons in 1968 to about 485,000 tons in 1975 while the figure for 1978 fell to about 330,000 tons.

Without analysing the causes for this oscillation in the production of magnesite ore, it can only be said that the exhaustion of some deposits of magnesite affected total production, although this was not the decisive reason.

Magnesites are now worked in a number of deposits in various localities, while the biggest user of magnesite for final production in Yugoslavia is "Magnohrom" in Kraljevo.

Magnesites occur in the matrixes, in layers, in various piles, lenticular deposits, as thicknesses and in other forms. The system of exploitation depends on the form of their occurrence as well as the choice of working method and most adequate mechanisation.

A typical example of underground exploitation of magnesite are the "Šumadija" - Čačak mines.

Magnesite deposits have been explored and are still explored with various methods including basic and detailed geological and mining exploration followed in all its phases by laboratory examinations of samples.

After detailed mining exploration has been completed, the deposit is prepared for extraction on the basis of prior projects and the chosen metod of extraction.

Depending on the form of the deposit, its slope, and thickness, methods of extraction and choice of mechanisation are adopted.

The extraction of ores of magresite is usually done in the following ways:

- roof self-filling
- roof with filling and manual loading
- block caving

The cut and fill system is used on ores of 0,5 m to 1 m thickness and a dip of more than 40^{o} in medium hard and hard ore and accompanying serpentinites. Support of benches is done with individual pillars with an upper and lower shoe but very rarely with chocks. The material is secured directly on the bench by blasting the floor and partly the roof serpentinite. The material is obtained by a cut along the matrix and partly it is the serpentinite in the ore itself in view of the fact that the excavation is selective. Haulage of excavated and roughly selected ore is done by Kipp wagonettes on the bench to the shute.

The method of roof excavation with filling is very flexible and suitable under different conditions. It is most frequently used to excavate matrixes of 1,2 m thickness and dips of over 40^{o}, in a weak and medium hard ore with accompanying serpentinites. The cut is always supported and the choice of support unit depends on the prevailing conditions (with of cut, stability of the rock material and the like). Most frequently used are frames with friction pillars and lower shoes.

The material for filling is conveyed via riseheading from a higher horizon. It can also be obtained partially in excavation by separating the waste from the ore (in this case excavation is partially selective), as well as by blasting the floor contact serpentinite.

The material is conveyed along the bench by Kipp wagonettes or by autoloaders to the place of unloading which is at the edge of the stair. The same means of transport are used to convey the ore to the chute.

Application of the magazine method of excavation is limited to matrixes of more than 1 m thickness and a dip of more than 60^{o} but only for medium hard and hard ore and accompanying serpentinite.

The excavation work is not selective. The ore is blasted along its entire thickness together with the inclusions of serpentinite. By cutting the blocks there is a larger volume of excavated ore by about 30% to 35%, so that the ore is dropped from the magazine through a system of chutes. The same method is used to perform the definitive emptying of the magazine of the block ore.

In cases where the working situation is not sufficiently hard and the excavation must be steadily supported, the volume of surplus is loaded and transported by autoloaders to the chutes where the emtyping is done. In this way, the ore mass is not frequently moved so that it is possible to ensure the excavation stair by building supports.

Ensuring the excavation bench is done by applying a friction support with an upper and lower plate.

The capacity of the magazine excavation, as well as the excavation output, primarily depend on the thickness and the dip of the ore, the loading method and haulage of the volume surplus from the chutes and the intensity of the emptying of the stored ore.

Transport of the run-of-mine ore from the chutes to the installations for improving the ore (located on the surface), is done by means of pit wagons and diesel locomotives, on deposits with adits, and in deposits with open shafts, the ore is removed by means of shafts.

BENEFICIATION OF MAGNESITE ORE

Run-of-mine ore is cleansed of waste (serpentinite) in beneficiation areas. As a rule, two basic methods are used to refine the ore:

1. washing and manual separation
2. gravitational concentraction in a dense environment.

Technologically speaking, the procedure of each method depends on the locality in which the ore is exploited because with a change of locality, the pysical and mechanical propertie s are changes as is the content of the useful and harmful components, all of which requires a different treatment in this process.

The system of exploitation also has its effect on the method of refining, because there are great differences in the quality of the run-of-mine ore.

Thus, for instance, in the "Šumadija" mines in order to obtain run-of-mine ore by means of underground working, both given methods are applied, while in the technological series, the ore is first treated to the method of washing and manual selection and then to the method of gravitational concentration in a dense mixture. The ore obtained from surface faces is sent directly to gravitational concentration. A dense mixture is obtained by suspension of ferosilicium and water.

Experience in the Šumadija mines indicates that such simplified patterns of refining run-of-mine ore are not entirely satisfactory because it is impossible to fully evaluate the magnesite component in conditions of heterogeneous physical and mechanical features of the ore from different localities. Sometimes the changes are visible depending or segments of deposits in the same locality. Magnesite grains as well as the grains of sepentinite have a broad range of density so that in practice it is very difficult to find the optimum density of the suspension which would bring about the complete separation of the heavier grain of the magnesite from the lighter grain of the serpentinite. This reason has caused experts in this field to look for more complex ways to refine the ore.

Greater attention has been paid to the exploitation of magnesite due to the significance of this raw material within the framework of final refractory products produced by the "Magnohrom" factory and the overall significance of this activity in our economy, as expressed in value and natural indexes. Solutions to various production and theoretical problems have greatly affected the need for high quality development and technology as well as for professional knowledge and skilled technical personnel.

6.3. Excavation of marl

The excavation of marl for the needs of the cement industry, is linked in Yugoslavia to a number of geological localities. The quality and reserves vary thus conditioning the development and exploitation capacities.

The production of marl has kept abreast of the production of cement so that if one bears in mind that the production of cement in 1969 was 3,96 million tons and in 1978 it was 8,7 million tons, or in other words that production had risen by 2,2 times, this means an increase for the cement industry, and also proportionate increase in the production of marl.

The excavation of marl for the cement industry is now underway at a large number of deposits in Yugoslavia. The surface system is used with discontinued work and blasting (an exception to this is the Beočin Cement Works).

The amount of the overburden, generally is not great with relation to the total mass of useful substance and consists mainly of soft materials so that work on removing the overburdern is usualy done by bulldozers, less frequently by scrapers, with the use of loading units and transport means for various auxilliary work on the surface excavation.

The breaking up of the rock mass during excavation is usually done by drilling and blasting by means of bulldozers an[illegible] 'e-dozers.

Use of bucket wheel excavators for the excavation of marl is done on the surface excavation of marl by the Beočin Cement Works and represents the first successful application in our country of mechanisation for continuous work in exploiting hard non metal raw materials.

For excavation of the marl, a bucket wheel excavator is used, type SH-400, which also loads onto a bench mobile transporter with rubber belt. The loading of the marl onto the feeding belt is done directly by the excavator or by means of a self-drive conveyer belt, type BH-30.

The average pressure hardness of the marl being excavated in this way is from 900 N/cm^2 to 1600 N/cm^2.

The work cycle is as follows: digging the marl, loading it onto the conveyer belt of the excavator, stage loader (if necessary) to a transporter, BH-30, loading on the main belt and transport of the maroto the primary crushing machine in the factory, at a distance of about 2 km.

The projected system of exploitation has been functioning about 5 years with about 11,000 hours of work and about 9 million tons of marl excavated. The average capacity is 818 t/h and the effective work time has been 74%.

These results show that the choice of the conception and mechanisation was the right one and that the organisation of work was good, this being the result of concerted efforts on the part of the engineers and technical personnel of the investor.

The excavator has a propulsive mass of 188,780 kg, the lever is 11 m, the height of the digging is 11 m and the depth is 0,6 m.

6.4. Exploitation of technical building stone

A large number of producers of building stone have been registered in Yugoslavia. The reason for this are the needs, the possibilities for exploitation and the unfavourable relation-ship between transport costs for this material and its selling price.

Prospecting of technical building stone has not to date enjoyed the same treatment as the other mineral raw materials and has been neglected as a whole. The consequences have been insufficient exploration of deposits, a generally weak economic situation of nearly all the producers of these materials and shortages of quality materials in particular regions, for the construction of roadways, materials for hydroprojects, etc. In contrast to the other nonemetal raw materials, in the exploitation of technical stone only a small number of deposits have been sufficiently investigated and which have all the necessary technical documentation and established ore reserves.

Work is being done on deposits eruptive rock and materials are produced mainly for road construction in the form of aggregates for the wear-and-tear layer. However, deposits of carbon rocks are also exploited, primarily limestone, much of whose production is earmarked for other industrial branches such as the sugar industry, the chemical industry and others.

In the exploitation of technical stone and its processing, a vital element is the permanence of good quality of the basic raw material and the technology of exploitation and processing (shovel cutting, excavating, crushing, washing, grading and storaging). The quality of the stone aggregate directly affects the quality of the final product, for instance concrete, so that this field of work is regulated by Yugoslav standards.

Stone aggregater have to meet high standards with regard to pressure resistance and the effects of friction and blows, resistance to freezing and absorption of moisture. That is why refining of this raw material is limited only to mechanical finishing, shaping, de-dusting and granulation, while the quality of the product is conditioned by the quality of the primary material.

These shortcomings as cited are noticeable in the exploitation, the maintenance of quality and in effecting planned production. But the large-scale producers of building stone speedily eliminate shortcomings. A contributing factor to this has been the possession by these producers of the best quality deposits, good technology, broad application of mechanisation and well-organised internal quality control.

One of the principal producrs of technical stone in our country is the Rakovac Nonmetal Mines. The level of technical equipment of the mine is very high. Deposits of trachite are exploited on two surface excavations, the products are finalized and transported to users.

The surface excavation and installations for processing are located on a surface of about 20 km^2 but are inter-linked by modern means of transport.

The technical stone is produced for the needs of road and rail lines of communication.

Intensive exploration is underway for the possibility of enlarging the the applicability of final products in other industrial branches, so that exploration of deposits and their quality are receiving full attention.

Exploitation is done in keeping with the necessary technical documentation.

Preparation for digging is done by means of the traditional methods of drilling and blasting and with the use of mechanization.

Loading and unloading of materials is done by means of BGH-1000 of domestic manufacture and the Avelin Barford and Belaz dump fruchz. Also used are bulldozers TG-70 also of domestic production.

Transport from the surface dig to the processing installations is done by cable-way and trucks with side-cars of domestic production (FAP 18 BK).

The high level of mechanisation and working conditions have called for the need to maintain the mechanisation used. Great attention is being paid to this because it is a prerequisite of the workshop's readiness.

Other big producers of technical stone also carry out their work in accordance with their technical documentation which is subject to relevant regulations. They have the needed mechanisation for work on the cut, the deposit, for the exploitation, loading and transport. To judge by the organisation of production and its physical volume, it may be said that exploitation is organized according to the systems of contemporary surface exavations.

6.5. Exploitation of quartzite (Silex)

Quartzites under the name of Silex have unique physical and mechanical properties. They are very hard and have a small degree of wear.

Our only known deposit of silec so far is in SR Macedonia. It belongs to the group of hydrothermal - metasomatic deposits. Silex deposits are rare on the world scale as well. The Yugoslav silex is, due to its specific structure and physico-chemical characteristics, greatly in demand on the world market. The existing silex reserves can ensure production over a long period of time.

Hardness of the silec from this deposit, according to Brinell) is between 375HB to 538 HB, while according to Moss's scale the hardness is about 7. It has a characteristic fracture with sharp edges. The degree of wear under conditions of grinding of the normal porcelain mass is from 0.09 %/h to 0.1 %/h. Content of SiO_2 is within 97% - 99%, the Fe_2O_3 is from 0.12% to 0.8%, Al_2O_3 from 0,1% to 0,6%. The remaining components are of less significance or else are found in traces.

The stated mechanical and chemical properties have made this raw material very important for industrial uses in the porcelain industry, for the lining of grinders and production of balls for grinding porcelain masses. In the form of fine granules of a specific size, for the production of emery paper, because, the properties of the fracture of the grain make it suitable for this purpose. The high SiO_2 content make it suitable for use in the eletro-metallurgical and eletro-chemical industries, for the production of ferrosiliciums, silicium carbide and others. This broad range of applications makes it possible to attain a high level of the surface system on a number of locations, using drilling and blasting with the tendency to obtain large blocks from which the best commercial products are obtained. Loading and transport to the place of finalization (segments and balls) is done by standard mechanization as used in quarries. Parts of the raw material that do not correspond to the quality required for the segments and balls as well as waste material, are completed in the installations for crushing for various purposes.

This deposit, in many ways a unique one, imposes numerous technical problems within the process of full exploitation of all the possible applications of the basic raw material.

6.6. Exploitation of asbestos

Yugoslavia disposes of large reserves of asbestos ore. There are three active mines of which two are in Serbia and one in Bosnia and Hercegovina. Yugoslav asbestos production covers only one-hald of our needs.

Chrysotile-asbestos is at present exploited in the Korlaće and Stragari deposits in Serbia and in Bosansko Petrovo Selo in Bosnia and Harcegovina. There are more than 10^7 tons of ore in these three deposits.

Due to unsolved technological problems in processing the material, particularly the asbestos ore in Stragari, and partly in Bosansko Petrovo Selo, asbestos production in Yugoslavia has been stagnating for years and showing tendencies to decrease.

The Stragari deposit is a world instance of high asbestos content in the ore. However, the asbestos is of the leather-raggy type and is difficult for processing and this has for years been a production problem. According to latest investigations it is expected that this problem will be solved and thereby also the question of its shortage in Yugoslavia.

The two other mines are also making efforts to solve the problems that have arisen for the sake of increasing production. It is expected that very shortly Yugoslavia will overcome these production difficulties and, from an importer of asbestos, will become in exporter of asbestos of specific classes of this material.

6.7. Exploitation of architectural - decorative stone

The production of architectural-building stone in Yugoslavia in the period up to 1955 was limited both as to quantity and localities (Brač, Jablanica, Venčac, Studenica and others).

A beginning was made only in 1945 with the renewal and development of production in existing quarries which hadhar a certain tradition up to that time. In the fifties, new deposits were opened and organized.

However, the production of crude blocks of decorative stone did not develop until 1958 mainly due to insufficient material means for this industry.

It was only in 1958 that a period of dynamic development began both in the existing and the new quarries. Taking 1955 as the index of 100 (production was 14825 m^3), in 1980 the production of blocks of decorative stone rose to index 527, showing an increase in production by 5,27 times (77616 m^3).

Up to 1955 exploitation was done with negligible mechanisation, mostly with the technique of compressed air, while in some quarries this was done even by hand. One of the rare machine tools used to cut blocks with vertical knives was the so-called "canal machine" imported from the USA back in 1904. For cutting the blocks from the mass, use was made of the compressed-air hammer. Internal transport was by winches and hand operated cranes with large numbers of man power.

Since 1955 much more began to be invested in mech anizing production. Spiral helicoidal ropes using quartz sand were introduced. Thus it became possible to cut large blocks out of the mass and it was also possible to use explosives for uncovering the waste layers or disintegrated parts of the material.

Use of the spiral rope is valuable in quarries where marble or limestone or other not exceptionally hard materials are exploited but which are massive and very thick altough they are sedimental in origin.

In very hard rocks, such as sepentinite, which it is difficult to work on with a chisel, the use of the spiral wire may well be irreplaceable. By using it, it is possible to cut blocks of 100 to 10000 m^3, depending on the method of excavation.

In architectural-building stone mines, cranes are being used. Formerly these were stable cranes called derrick-cranes for raising blocks of 10,20,30 and more tons. Also being introduced are mobile auto-cranes on caterpillars or wheels. The effectiveness of the mines is considerably higher while a large number of workers are relieved of heavier tasks. Winches are also used to draw large masses, with their traction power of 1000 KN and more. The drilling technique is being perfected and new equipment with faster drilling and monoblock chisels are being introduced to increase output.

Of late some mines are introducing the technology of large diamond discs (Venčac mine). This system consists of cutting blocks of marble or limestone on the spot with milling machines with large diamond sics. The cutting is done in two directions, vertically and horizontally, with a constant depth of about 1 m. This system is mainly used with saharoid marbles and massive limestone where the incline is not above 18^0.

Also currently being introduced is the well-known technology of cutting by means of a spiral rope with a diamond segments which is expected to contribute to a further increase in the production of crude blocks.

Parallel with this development other processing capacities have grown. It can even be said that the processing capacities are today even greater than the possibilities of the raw materials base. Processing is now equipped with the most recent equipments such as frame saws with diamond blades, other machines with diamond discs and nearly unlimited possibilites of cutting blocks directly from the blocks, various machines for size cutting, chaping, polishing, etc.

The required loading and transport machinery is produced by Yugoslav factories as well as the equipement for the use of compressed air. All the other equipement for exploitation and processing is imported.

Our machine construction industry is making efforts to manufacture the equipment now being imported. Specific results are to be expected in the next few years.

Is is important to stress that exploitation is focussed on the complete use of the raw material which was not the case twenty years ago. Now all the waste material is used to obtain various other products such as terazzo aggregates, terrazzo products, fillers for asphalt, calcium carbonate fillers for industry, lime and other products, a fact which will contribute even more to the profitability of this exploitation.

In the past period a good deal of experience has been gained and work organisations dispose with numerous skiller personnel in this field. Special experience has been gained in prospecting for raw materials and in opening up new quarries, as more than 50% of the quarries now operating were opened during the past thirty years.

6.8. Exploitation of refractory ceramic and brick clay

The industry of refractory materials, ceramic and brick products started dveloping more radpily after 1950. Large facilities for the production of fire-clay and magnesite refractory material and new facilities for ceramic products went up so that gradually the development of the brick industry started. For each of these a rew materials base was assured. Large reserves of refractory and ceramic clays in the Arandjelovac basin were ascertained in the fifties.

The clay in these deposits is exploited mostly by surface digging. Its capacities are several hundred thousand tons per year. The usual equipment is used: shovel excavator, bulldozers, scrapers, dump trucks, and others.

It should be noted that the exploitation of a high quality crude clay needed by the refractory and ceramic industry is done by underground methods (Vrbica -Šamot mine in Arandjelovac). The capcity of this mine with underground exploitation is not great but even the small quantities (c. 30000 tons annually) are invaluable in the process of improving the quality of other clays as well as for refractory products of high quality.

In the exploitation of fire clay by underground means, very valuable experience has been gained especially in building mining premises for preparation and exploitation, in support units, and others. Exploitation is done in the presence of methane due to which safety measures have to be implemented.

Brick clays are widespread in our country. Up to twenty years ago these raw materials were not explored nor paid particular attention to. By increasing the production of brick products and thereby of clay, investment mistakes were made. Thus it happened that a factory would be built without prior knowledge of the quality of the raw material or whether it was to be found in sufficient quantity in that particular locality.

During the fifties, exploitation was mostly by hand. Today various technologies are applied. Most frequent is the exploitation by means of buckets, while transport is by wagonettes or trucks. In many of the deposits combined technologies are used such as bulldozers, excavators and loaders. Domestic-made equipement is almost exclusively used both for excavation and for transport.

This industry is now highly developed and has at its disposal the most up-to-date equipment. In general, it can be said that in this branch of industry, a good deal of know-how and experience has been gained and is now being implemented in the erection of new factories or reconstruction of existing ones, especially in the insufficiently developed parts of the Republic.

Space does not permit an account of the system of exploitation of the other nonmetal mineral raw materials. This is just a brief survey of the typical exploitation of some characteristic nonmetal raw materials in Yugoslavia.

7. ROLE OF STANDARDIZATION IN THE PRODUCTION AND PROCESSING OF NONMETAL MINERAL RAW MATERIALS

Exploitation of particular nonmetal mineral raw materials takes place in deposits of varying quality, the application of relevant but varied technologies of excavation and possible benefication. All this makes for unequal basic characteristics of primary raw materials and thereby possible changes in the quality of the final product.

The procedure of taking a representative sample, the method of investigating the sample, the method of laboratory examination, etc., can affect the estimate of the economic soundness of a particular deposit in the phase of exploration, but it could also be the subject of countrcversy in the phase of exploration unless there are fixed standards for methods of work and exploration.

The standarization of terms and definitions, shapes and measures, samples, classifications and quality norms, methods of research, marking, packaging, transport and storaging, all provide elements for an objective estimate of all the basic components of the quality of the primary raw material and the final products and reduce the risk of possible misunderstandings and mistaken conclusions. Negotiation between business partners at home and abroad is facilitated because national standards and thereby Yugoslav standards as well (JUS) are the result of international cooperation in the field of standardization.

Bearing in mind the basic purposes of nonmetal mineral raw materials and their final products, we have grouped all the types of standards with relation to the standards for nonmetal mineral raw materials for construction purposes and the standards of the other nonmetal mineral raw materials.

7.1. Standardization of nonmetal mineral raw materials and their products for the building industry

The standards encompass building and architectural stone, aggregates for hydrocarbon mixtures and for concrete, building lime, cement and gypsum, brick clay and products.

More than thirty Yugoslav standards have been fixed for the stone and hydrocarbon mixtures and concrete which specify the forms, measures, quality requirements, methods of testing and the like.

For example, JUS BB3. stipulates the classification, quality requirements and methods of testing stone aggregates for the construction of hydrocarbon and concrete covers.

In addition to the size of the grain, the standards lay down the conditions that must be met for the raw materials to be used: form of the grain, homogeneity, purity, tensile strength, water suction, resistance to freezing, wear and tear, mineralogical composition, adhesiveness, porosity.

Testing methods have also been laid down for chechking these parameters. For cement, gypsum and allied products as well as for building lime, more than 35 Yugoslav standards have been drawn up: for Portland cement; Portland cement with the addition of dross and puzzuolana; metallurgical cement, puzzoulana cement; asbestos-cement products such as piper, wavy plates, plates of gypsum, building lime.

Clay and brick products are standardized as follows: tiles, bricks, sewage pipes, ceramic tiles. More than 40 Yugoslav standards have been fixed for the cited products.

7.2. Standardization of other nonmetal mineral raw materials

Quartz sand

Quartz sand has a very broad application in the industry of glass, in foundries and in the production of fine ceramics. In glass production - glass sand is the basic raw material. For glass sand two Yugoslav standards have been fixed with regard to the classification and technical conditions of quality JUS B.B5 and the testing methods (JUS B.B8.050). JUS B.B5.020 fixes the classes of quality with values for individual raw materials. The production of crystal glass is usbject to the most stringent requirements with relation to the raw material composition, whereas for the production of packaging glass these norms are much more lenient. Such classification makes it possible for the manufacturer of quartz sand to adapt his products to the requirements for individual types of glass.

For foundries, three Yugoslav standards have been worked out: for classification, quality requirements and testing methods. Phere are also standards for moulding sand and the classes of sand (JUS B.B5.012 and JUS B.B8.020).

In the production of fine ceramics two standards have been set for quartz sant. One stablishes the norms for classification and the technical quality conditions (JUS B.B5.030) and the standard relating to sample taking and testing (JUS B.B8.060).

Limestone and dolomites

In addition to their use in civil engineering, their use is also wide spread in other industrial branches.

In metallurgy, standards stipulate the classification and technical conditions of limestone. (JUS B.B6.011) and the standard relating to the technical conditions of lime (JUS B.C1.023).

For the needs of the glass industry 2 standards have been set for limestone and dolomites: one relating to their quality (JUS B.B6.020) and the other to testing methods (JUS B.B8.070).

Yugoslav standards have also been set for calcium carbonate fillers used in the manufacture of dyes, paper, the rubber industry and others.

Refractory Materials

Standardization in the production of refractory materials has made an important contribution to the growth of this industry in Yugoslavia. Standards cover the refractory raw materials and products.

Classification and technical standards for the following refractory raw materials have been set: fire clay and kaolin (JUS B.F1.010); fired clay and kaolin (JUS B.F1.030); quartzite (JUS B.F1.050); bauxite (JUS B.G5.010); magnesite (JUS B.G5.020); dolomites (JUS B.B6.010); chromite (JUS B.G1.050).

The following refractory products have norms relating to terminology, classification, technical conditions, testing methods, forms and measurements, identification, transport and storaging: shaped and non-shaped products; silica brick; fire clay acid products; fire clay neutral products and basic products; magnesite and chrome-magnesite products; dolomite brick and blocks; various kinds of brick and other products.

A total of 90 yugoslav standards for refractory materials have been established.

We wish here to stress our cooperation with the Technical Committee for refractory materials ISO/TC 33, of the International Organization on Standardization (ISO) as all the Comittee's standards have been included in the corresponding Yugoslav standards for refractory materials.

Asbestos

Six standards have been set for this important non-metal mineral raw material with its wide applications in various industries. Of these six standards, 4 apply to asbestos and two to asbestos tar - board.

Standards for the following non-metal mineral raw materials have also been set: for foundry bentonite (2 standards); barytes (2 standards); feldspar (2 standards); fluorite (2 standards).

In addition to the above standards of great importance for exploration and exploitation in the standardization of equipment and tools, and other facilities needed for their exploitation, have also been fixed.

Standards are set for the tools and equipement for the exploratory drilling of hard mineral raw materials and for mine drilling as well as for mining explosives, blasting caps, and electric detonators.

The exploitation of non-metal mineral raw materials is also fixed through technical regulations providing for safety measures and health and environmental protection.

Standardization of non-metal mineral raw materials achieves the following results:

- a basis is laid for the classification and categorization of deposits of mineral raw materials according to their use;

- quality parameters determine whether the available raw materials can be used in their raw state or whether they have first to be prepared. This is particularly important when there is substitution of imported raw materials by domestic ones after prior preparation;

- permanent product quality in accordance with standards enables products to be competitive in the domestic and foreign markets;

- by harmonizing the characteristics of products with standards geared to international norms, the technical barriers in trade between countries are eliminated;

- the coordination of products in accordance with various standards for classes of quality, makes it possible to coordinate the exploitation of deposits with the development of the processing industry;

- standards set the criteria for the better use of secondary raw materials in combination with primary raw materials (an example of this is the standard for cement with the addition of dross from furnaces).

- by the setting of testing methods and technical requirements for equipment and reagents, it becomes possible to better organize laboratories for checking the quality of raw materials and other needed tests as well as for the control of the process of production and the acquisition of the finished product.

8. FINAL CONSIDERATIONS AND PROPOSALS

1. Exploration of non-metal mineral raw materials must be undertaken in keeping with programmes established beforehand. Programmes determine the raw materials to be explored, the volume of work required, the locations, and the scope of laboratory, semi-industrial and industrial exploration, the time limits and total costs.

For the exploration of nonmetal raw materials, regulations must be drawn up to regulate the vital problems in this field.

2. The purpose of exploring the possibility of expanding the application of particular mineral raw materials beyond the field of their basic purpose as determined by the technical documentation, is of significance for the technical personnel throughout the exploitation of the deposit. The prospect of expanding the area of use for some nonmetal raw materials from a particular deposit (for instance quartzite, limestone, dacite, etc.) can improve the direct economic effects of exploitation of the one hand, and on the other it can affect the degree of exploitation of the deposit by reducing the waste material.

3. The beginning of work on preparing the deposit for exploitation and the construction of installations for refining and processing, is done after the necessary technical documentation has been adopted whereby the technical conditions and economic effects of exploitation of any given nonmetal raw material are determined.

4. Great significance in the exploration and exploitation phase should be attributed to standards, not only as to legal prescriptions, but also in the sense that they lay down more precise quality norms for the primary raw materials or the final products and determine testing methods.

5. It is proposed that there should be more frequent exchanges of experience between the producess of nonmetal raw materials as well as between the producers and the processing industry (beneficiaries) with the purpose of perfecting technologies of excavation, as well as contacts with the producers of equipment for the purpose of receiving suggestions and proposals aimed at improving the construction and technical characteristics of equipment, introducing changes or supplementing the construction of equipment in keeping with the specific features of desposits.

9. PROPOSALS FOR COOPERATION

In view of the development and experiences gained so for in the exploitation of mineral raw materials, we are in a position to cooperate with the developing countries in the exploiration, exploitation and preparation of nonmetal mineral raw materials, namely clay, magnesite, quartz sand and quartzite, limestone and dolomites, building and decorative stone.

In addition to this, we can offer consulting and engineering services for all the phases of work with the above-cited mineral raw materials, ranging from design to processing.

Also of interest is cooperation in the exchange of information on the needs in specific nonmetal mineral raw materials for the development of particular nonmetal raw materials and for their successful application, a fact that is of great importance for mutual trade and joint operations in the world markets.

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