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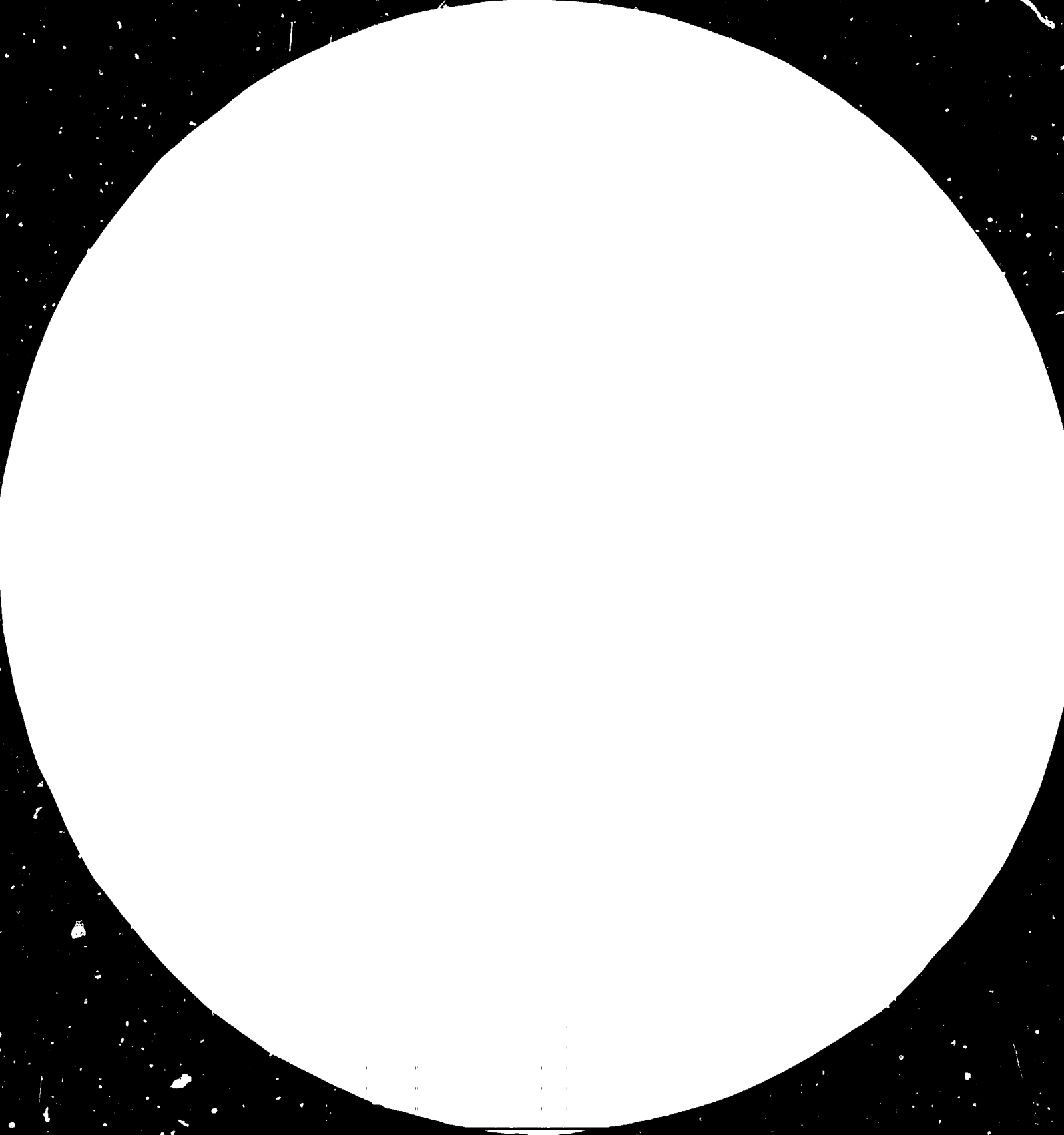
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INDUSTRIAL UTILIZATION OF NON-METALLIC MINERALS AND
PRODUCTION AND UTILIZATION OF QUARTZ, FELDSPAR, KAOLIN AND CLAYS,
IN SFR YUGOSLAVIA

DP/YUG/73/003

DP/YUG/78/009

DP/YUG/82/004

YUGOSLAVIA

Technical Report*

Prepared for the Government of Yugoslavia
by the United Nations Industrial Development Organization
acting as the executing agency for the United Nations Development Programme

Based on the work of K. Engelthaler,
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Vienna

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S U M M A R Y

The author of this paper was attached as expert of the United Nations Industrial Development Organization to three UNDP Projects.

Two of them DP/YUG/73/003 (Phase I) and DP/YUG/78/009 (Phase II) the name of which was "Industrial Utilization of Non-Metallic Minerals" were programmed to solve the non-metallic minerals problems of SR Serbia as well as of SFR Yugoslavia as the whole theoretically and in laboratory scale while the third project DP/YUG/82/004 "Production and Utilization of Quartz, Feldspar, Kaolin, and Clays in SFR Yugoslavia" was approved in order to certify the laboratory results obtained in semi-industrial, pilot plant or industrial scale and give in such a way enough parameters and solid base for industrial investment on particular selected deposits.

Phase I. what means the Project in its beginning was a typically "Institution building" one and helped to increase the capability of the Institute to work seriously on various non-metallic programmes announced by the Government of SR Serbia. Therefore also the greatest deal of the laboratory equipment necessary for investigation of non-metallic minerals was requested at that time as well as technical magazines and study tours to world known producers of these materials.

It is difficult to measure the level of Institution Building but it can be said that the Project (Phase I.) was the base for future very good performance of the Institute in the field of non-metallic minerals. On the end

of Phase I. the PMS section (section for dressing and beneficiation of mineral raw materials) of the Institute previously oriented hundred per cent on metallic minerals dressing worked practically 70% on non-metallic problems. Level of knowledge of local specialists in this field of activity increased.

Good results achieved during the implementation of the Project were reported in the Terminal Report which was submitted to the Government of SFR Yugoslavia in September 1978 and where was also recommended to continue with this Project as Phase II.

From a great deal of non-metallic minerals which were treated during Phase I. only the most important for Yugoslav economy non-metallic minerals were treated during the implementation of Phase II. They are: quartz sand, kaolin, feldspar, and ceramic as well as refractory clays. The activity on Institution Building decreased and was only marginal while the activity direct support in dressing of selected non-metallic resources and their utilization as well as research and development activity were dominant.

All that time known and available deposits of above mentioned minerals were technologically tested under the assistance of the author of this paper. Potential deposits are the following:

Bare (Garaši)	SR Serbia
Bela Reka	SR Serbia
Bratunac	SR B i H
Bujanovac	SR Serbia
Djevdjelijska	SR Macedonia
Karačevo	AP Kosovo
Mesiči	AP Vojvodina
Motajica	SR B i H
Rgotina	SR Serbia
Valjevo	SR Serbia

Laboratory tests of crude materials from all these deposits were finished and technologically best deposits selected. However, two more deposits were found and laboratory tested in 1983. They are: deposit Konic (pyrophyllite, SR BiH) and deposit Karlovac (quartz sand and kaolin, SR Croatia).

On the basis of laboratory tests and results it was clearly stated that for a high quality quartz sand production deposits Bare, Bela Reka, Mesići, Rgotina, Valjevo and Karlovac can be used.

For the production of kaolin deposits Djevdjelija, Karačevo, and Motajica were selected as the best ones. Kaolin from the deposit Bela Reka is actually a by-product and its production is limited in accordance with the production of high quality quartz sand to approximately 8 - 10.000 tons per year. Similar situation is with kaolin from the locality Karlovac where the production might be about 25 - 30.000 tons per year.

Kaolin from the deposit Bare (Garaši) is suitable for refractory industry only because it has a higher content of Fe compounds which cannot be decreased to a for fine ceramic or paper industry acceptable limit. Pyrophyllite from the deposit Konic is suitable as filler in paper industry because of its high whiteness and low abrasion.

Feldspar can be produced from crude raw materials of Bare, Bujanovac, Karačevo, Mesići and Motajica deposits. Because the crude raw materials of particular deposits geologically differ potassium feldspar on one hand as well as nearly pure sodium feldspar on the other hand can be produced. For example deposits Bare (Garaši) and Mesići give high quality potassium feldspars while deposit Buja-

novac and Karačevo are typical deposits for Na-feldspar. From this point of view the Yugoslav customers and export will have a good choice in produced feldspars qualities.

The situation in refractory and ceramic white burning clays is still not satisfactory. It is the truth that SFR Yugoslavia has a lot of clay deposits which unfortunately are based mostly on the mineral montmorillonite and their content of iron oxides is rather high so that after firing they give a brown colour to the products. Only few clays e.g. Jovanoviča Brdo dark clay are of excellent quality and can be used as ceramic clays especially for casting processes.

Lack of good quality refractory clays forces the factory "Šamot" at Arandjelovac to use the kaolin Baro (Garaši) instead of up to now used and presently exhausted Rudovci clay. Many other clays might be suitable for ceramic and refractory industries but they need dressing either using washing or magnetic separation. In my opinion both dressing processes are too expensive for ordinary clays and it can be said that their price after dressing will increase nearly to that of dressed kaolin.

On selected deposits laboratory results were certified by semi-industrial, industrial or pilot plant tests. The industrial tests' results obtained were used for elaboration of final technological processes and for elaboration of obligatory investment studies. The dressed minerals were used for laboratory, large laboratory, semi-industrial or industrial tests in utilization of these raw materials by local industries, particularly in the production of porcelain utility ware, sanitary ware, glass, poroconcrete, casting moulds preparation, production of submerged tubes for continuous steel casting, production of sag-gars and ribbed slabs for wall tiles and floor

tiles industries, production of electromelted quartz, production of refractories (firebricks and high alumina bricks), as filler in paper industry, etc.

All these tests were done under the supervision of the author and were in final stage successful. On the base of these tests particular technological processes were elaborated using mainly local raw materials. Exception is in the production of ribbed slabs in "malcorit" quality for which a good quality talc should be imported.

That means that SFR Yugoslavia will after erection of recommended factories be self-sustaining in the production of quartz sand and kaolin of all required qualities. Production of feldspar which is bind with the production of local kaolins or quartz sands on all deposits of kaolinized granites will overgrow local consumption and should be exported. This will not make any difficulties because feldspar is a very valuable mineral which is in deficiency in the whole world and is necessary not only for the production of ceramics but also for the production of various types of glasses and it can be also be used for the production of potassium fertilizers.

It is evident that the UNDP Projects clearly and systematically show the way to bring SFR Yugoslavia to self-sufficiency in these three basic non-metallic minerals. This statement is based on complete laboratory results from all deposits mentioned above as well as on the semi-industrial, industrial, and pilot plant tests performed on selected deposits. Based on this knowledge the following recommendations were formulated:

1. Utilize for industrial production of quartz sand the monomineral deposit Oblaci and recon-

struct the factory "Kvarc" Rgotina in such a way to conform to the new technological process prepared for this deposit.

This recommendation is already fulfilled reconstructed factory has the capacity 760.000 tons per year and is in the full operation.

- ii. Erect a new factory producing high quality quartz sand from the monomineral deposit Bela Raka. Except quartz sand to produce also kaolin as by-product which is present as washable impurity in quantity of approximately 2%.

Also this recommendation is practically fulfilled because a new factory with capacity of 450.000 tons per year is under construction and is expected to give the first products during 1983 year. This capacity will also give about 8 - 10.000 tons of kaolin which may be used in fine ceramics production.

- iii. Utilize for industrial production of quartz sand and high quality potassium feldspar the deposit of kaolinized granite "Mesiči" near Vršac. The waste - low quality kaolin with a high content of colouring iron compounds - can be used in the ceramic factory at Bela Crkva for the production of acid resisting products (acidproof bricks and tiles), or for the production of facade tiles.

A Tender for supply of equipment for a factory with the capacity of 200.000 tons per year was opened and announced in Government Gazzete in July 1982. Negotiations with equipment suppliers was not yet finished. However, official announcement of the Tender is actually acceptance of the recommendation.

- iv. Establish the production of 100.000 tons

of kaolin and 120.000 tons of high quality feldspar per year from kaolinized granite from the deposit Bare (Garaši). Utilize this kaolin for the production of firebricks and high alumina bricks at the factory "Šamot" Arandjelovac.

This recommendation will be definitely realized because "Šamot" Arandjelovac has no other available raw material for the production because the deposit of Rudovci clay used up to now is exhausted. By-products are quartz sand and mica which is of a low quality and can be used only for the production of welding electrodes.

- v. Erect a kaolin dressing plant for the capacity of 30.000 tons/year at Kosovo using as crude ore kaolinized granite from the deposit Karačevo. As by-product produce sodium-potassium feldspar of a good quality as well as quartz sand which can be used for the production of poroconcrete (Siporex type).

RIK Karačevo the owner of the deposit is now preparing financial construction and evaluating offers received from four possible equipment suppliers. The erection of the factory is expected to start in 1983 year.

- vi. Establish production of 3.700 tons/year of porcelain utility ware at Kosovo within the framework of RIK Karačevo enterprise utilizing for the body composition about 50% of its own dressed kaolin (see point 5).

This recommendation was also accepted and a detailed investment study based on our technological study is under preparation.

- vii. Establish production of 100.000 m³ poroconcrete (Siporex type) and utilize for

this production the waste sand (see point 5) remaining after kaolin washing and feldspar and mica froth flotation.

The recommendation was accepted and negotiations are being done between RIK Karačevo and other possible potential producers of building materials at Kosovo.

- viii. Erect a kaolin dressing plant for the capacity of 30.000 tons/year at Bosansky Kobaš (SR BiH) using as crude ore kaolinized granite from the deposit Motajica. As by-product produce high quality potassium - sodium feldspar, quartz sand and mica.

This recommendation is still discussed in spite of the fact that the kaolin washing plant is expected to build the base for establishment of fine ceramic industries (porcelain utility ware and sanitary ware) in the socialistic republic Bosna and Herzegovina.

- ix. Utilize for industrial production of quartz sand the monomineral deposit Karlovac. Except quartz sand to produce as by-product kaolin which is present as washable impurity in quantity of approximately 6-7%.

This recommendation was accepted and it is expected to start with the capacity of 500.000 tons per year what gives except high quality fine quartz sand also about 30.000 t of kaolin suitable for ceramic industry.

- x. Establish production of 50.000 tons per year of dressed pyrophyllite which will be used as filler in paper industry. The dressed product has an excellent whiteness (above 82%ELR) and a low abrasion test.

Intensive discussions about technological process and necessary equipment are in the course.

- xi. Establish production of 30.000 tons per year of dressed kaolin at Djevdjelija (SR Macedonia) using as crude ore kaolinized dacite from the deposit Novo Konjsko. This quality of kaolin is suitable for paper industry as filler or for rubber and cable industries.

This recommendation is not yet accepted but intensive geological survey on the deposit is before its finishing.

For the Institute for Technology of Nuclear and Other Mineral Raw Materials which was the Government Implementing Agency were formulated the following recommendations:

- xii. To continue in follow-up of technical and technological solution of every non-metallic problem using semi-industrial or pilot plant results as the base because it is essential that the dressing methods applied are related to the end-use of the dressed raw materials in such a way that reasonable balance between the quality and their cost should be reached.
- xiii. To continue in increasing of knowledge and education of the Institute's scientific workers, specialists, and technicians in the field of dressing of non-metallic minerals and their utilization among others also through the bilateral collaboration with ČKZ Prague and VUHK Bratislava which was established under the activity of the Projects.
- xiv. To prepare also in future technical lectures and scientific papers for various seminars, symposiums and congresses either local or with international participation about dressing and possible utilization of local dressed raw materials. This activity can also make a good publicity to the Institute and help to stabilize the leading position of the Institute in the field of non-metallic

minerals not only in SR Serbia but also in Yugoslavia as a whole.

- xv. To be in a very close contact not only with actual but also with potential end-users. Fulfilling of this recommendation will lead to the extension of utilization of local dressed raw materials by local industries and will help to stop import of these raw materials to the country.
- xvi. To find any possible way to equip the PMS Section of the Institute with the pilot plant equipment for dressing (washing) of kaolins with a capacity of about 1,0 - 1,5 tons of dressed product per hour. Pilot plant equipment of similar capacity for froth flotation is already in possession of the Institute and being combined with kaolin washing pilot plant equipment will give the possibility to solve all technical as well as economical problems in the production of local kaolins.

I. I N T R O D U C T I O N

1.) The author of this report was attached to the Project DP/YUG/73/003 "Industrial Utilization of Non-Metallic Minerals" on 30. October 1977 that means practically nine months before its finishing. During this period he worked intensively except on his daily routine work also on future programme and together with the representatives of local industry and the Institute it was decided to devote the activities of the follow-up project to four main raw materials, their dressing and industrial utilization.

2.) With this clear idea for future work Phase II. of the project was on the end after mutual discussions accepted not only by the Government of SR Serbia but also from the representatives of UNDP and UNIDO. The appointment of the expert was several times extended so that he was present not only during the whole time of the implementation of Phase II. but also one more year under the Project DP/YUG/82/004 "Production and Utilization of quartz, feldspar, kaolin, and clays in SFR Yugoslavia".

3.) The international expert as well as local project and Institute's personnel were in a very close collaboration with local industries. It was very soon ascertained that the production in existing as well as newly built factories is based mainly on imported raw materials thus increasing import to the country and spending of convertible currency in spite of the fact that SFR Yugoslavia has many local deposits of these raw materials not being used up to now. Therefore during Phase I. of the Project all available non-metallic raw

materials were accepted for testing and dressing so that on the end of Phase I. the situation seemed to be little chaotic. Actually the Institute's staff being in the very beginning more metallic than non-metallic specialists were trained in dressing and utilization of all available non-metallic raw materials in accordance with the main activity of Phase I. - Institution Building.

4.) During the operation of Phase II. it was necessary as recommended by the expert to concentrate the capacity of the Project and also the capacity of the Institute as its implementing agency to only few selected non-metallic minerals which are in the biggest demand and are also most important for the country and local industries.

5.) So it was decided to concentrate the effort on beneficiation and utilization of quartz sand, kaolins, feldspars, and refractory and ceramic (white burning) clays. This decision was also supported not only with the critical situation in supplies of kaolin on the European market but also with the programme of stabilization announced by the federal Government of SFR Yugoslavia.

6.) That moment was actually the milestone in the fulfilling of immediate as well as development objectives. Local industries' representatives saw that the project is coming with progressive but realistic ideas how to increase utilization of local dressed raw materials and that these ideas are realized first in laboratory, later in large laboratory, semi-industrial and finally in pilot plant or industrial scale with a good success. Local industries joint the Institute and supported its R+D activities financially what was actually the basic condition to bring the whole matter to a successful end.

7.) The UNDP contributions were mainly utilized for procurement of some special equipment items and later for spare parts for them. As far as special equipment items are concerned the most important one was the wet high gradient high intensity magnetic separator which was supplied by UNIDO in the middle of Phase II. Because it was known that many local raw materials such as feldspars, kaolins, clays, and others contain a higher content of iron compounds than allowed by JU Standards or than required by local industries their dressing by magnetic separation was a necessity. Actually it can be said that many deposits of kaolins and clays were known for a long time and could not be exploited and utilized because final products were not competitive as far as their quality and namely content of colouring iron oxides is concerned with similar imported materials. From this point of view supply of the wet high gradient high intensity magnetic separator was another milestone in successful implementation of the project what means in successful dressing and particularly in successful utilization of local crude raw materials.

8.) The SR Serbia Government contribution was mainly used for payment of locally recruited personnel including the Project Director and Project Co-Director, maintenance of existing premises and equipment and supply of few new machines necessary for a smooth continuation of the project activities.

9.) Institute's premises and equipment together with the equipment supplied under the Projects made a good base for successful implementation of all programmed activities. Namely Institute's semi-industrial and pilot plant equipment for froth flotation with a capacity of 1,5 tons per hour helped to realize all necessary semi-industrial and pilot plant tests. Unfortunately similar equipment for kaolin

and clays dressing (washing) was not available and all tests had to be done either on large laboratory equipment of the Institute what was very difficult and time consuming matter or abroad.

10.) Institute's workers being trained in the field of non-metallic minerals were able to give lectures on particular non-metallic problems on various Yugoslav and international Symposiums, Seminars, Workshops, etc. making in this way a good publicity for the Institute and also for the Projects.

11.) It is evident that the Institute's activities in the field of non-metallic raw materials will continue (and most probably also grow) after the departure of the expert. However, the experts opinion is that a part of the Institute's staff is now able to solve the ordinary problems themselves. For special problems which also might appear the expert is ready to help also in future.

the content of which in crude ore is about 18%. The quality is excellent and corresponds to the first stage according to JU Standard. Its production will amount to 150.000 - 120.000 tons per year in case if production of kaolin will be 100.000 tons.

Also quartz sand (29-30% of input material) can be produced and utilized as moulding sand or sand for ordinary glass (sheet and containers) production. The most difficult answer is what to do with mica (biotite type) and the experts recommendation is to count it as waste because its quality is very low.

Generally it can be said that deposit Bare (Garaši) has lower degree of kaolinization and therefore the content of feldspar is rather high. However, a complex utilization of the crude material can give also satisfactory economical results and what is of the main importance a good raw material base for the production of firebricks at "Šamot Arandjelovac which is now practically without local raw materials.

14.) Monomineral deposit of quartz sand Bela Reka (SR Serbia) contains few percent of clay (kaolin) impurities which must be washed out in order to reach the requested quality of the main product. Washed kaolin what is actually a mixture of 43% of kaolinite, 42% of fine quartz sand and 15% of potassium K-Feldspar can be used by local industries in various fine ceramic body compositions. Laboratory tests which have been done show that this kaolin has good casting properties, a low content of colouring (Fe, Ti) oxides and also other technological results are very promising.

Quartz sand - actually the main product -

was tested in laboratory and semi-industrial scale not only in SFR Yugoslavia but also by the British Glass Industry Research Association and is of excellent quality. Analytical results speak for themselves. They show that white sand conforming to B.S. 2975, Grade B, can be produced from Bela Raka crude raw material.

In experts opinion deposit Bela Raka is one of the best deposits of quartz sand in Yugoslavia. The end-user accepted all recommendations and started with erection of a dressing plant the capacity of which is expected to be 450.000 tons yearly. Simultaneously about 8 - 10.000 tons of above quality kaolin can be produced. The production is planned to start either end of 1983 or in the very beginning of 1984 year.

15.) Deposit of kaolinized dacite Bratunac (SR Bosnia and Herzegovina) is rather small and the crude kaolin is presently mined in small quantities and used without any treatment for the production of wall and floor tiles. By magnetic separation of kaolin fraction the content of iron oxide can be decreased up to 1,02 to 1,10% when fine steel wool matrix is used. However, the dressed kaolin is still intensively yellow because iron is present in limonitic form which makes a thin film around the kaolinite crystal aggregates and penetrates also between the crystal layers.

When chemical treatment with hydrosulphid at chloric acid pH 3 is used this thin limonitic film dissolves and kaolin can reach whiteness of ELR 46= 87,6% with 0,38% Fe₂O₃ content. However, from economical point of view it is known that price for chemical treatment can be accepted only for production of coating clays (white pigment). But this is also not economic to produce from this raw material.

The author of this report means that the deposit is too small to start with an economical industrial production of dressed kaolin. And the reality is that this kaolin can be used after dressing because of its colour and Fe⁺⁺⁺ content for the production of firebricks only. Therefore the most economical utilization is for wall tiles production as it is done up to now.

16.) Kaolinized granite from the deposit Bujanovac (SR Serbia) passed up to now through a very poor kaolinization process. Therefore content of kaolinite is very low while on the other hand content of mixed sodium-potassium feldspar is high - 54% - and its quality is excellent. Mixed feldspar from deposit Bujanovac after separation from crude ore contains 55% of sodium feldspar, 25% potassium feldspar while the remaining 20% is mainly free SiO₂ with a little amount of kaolinite and impurities. Also dressed quartz sand is expected to be used in the glass factory at Paraćin. The end-user started with erection of a dressing plant with a capacity of 20000 tons of feldspar per year.

Generally it can be said that this kind of feldspar (sodium-potassium) is used in many ceramic factories in Yugoslavia in order to decrease the sintering temperature of the products. Therefore it was highly recommended to start with the production of this quality of feldspar as soon as possible.

17.) Deposit of kaolinized gabbro near Djevdjelija (SR Macedonia) is a part of a large Vardar gabbro massif. Washed kaolin after magnetic separation is of excellent quality for paper industry as filler. It can be also used in small quantities in ceramic body compositions. Its plasticity and CCS are unfortunately very low.

It was recommended to build a kaolin washing plant with a capacity of 30.000 t per year. However, before any investment is done it would be necessary to complete the detailed geological survey and approve industrial reserves. All above mentioned results and recommendations have been done on uncomplete and simple geological judgments.

18.) Deposit of kaolinized granite at Karačevo near the town Kosovaka Kamenica (AP Kosovo) is known for a long time and kaolinized granite used in crude stage for the production of floor and wall tiles and in smaller quantities as an addition to various ceramic body compositions. From the crude ore 24% of kaolin fraction, 24% of sodium-potassium feldspar, 1,5% of mica and 51% of quartz sand waste can be separated.

Kaolin itself because it is actually a mixture of kaolinite and hydrous micas (illite) has excellent CCS and a very high plasticity and is suitable therefore for shaping process of ceramic bodies. On the other hand rheological properties are not so excellent and organic defloculants should be used to reach a low viscosity of casting slips. Kaolin is also suitable for cable and rubber industries and can be used as filler in paper industry. However, its main utilization is in fine ceramic industries. (see also paras 26 and 27).

Feldspar what is actually a mixture of sodium and potassium feldspar can be successfully used in many floor and wall tiles productions decreasing the sintering temperature of final products. Quartz sand waste was tested with success in the production of light poroconcrete (Siporex type). (See also para 28).

The end-user RIK Karačevo accepted the recommendation to build a kaolin washing plant with capacity of 30.000 tons of washed kaolin per year and a flotation plant with a capacity of 32.000 tons of froth flotated feldspar while 65.000 tons of quartz sand waste will be used for the production of approximately 100.000 m³ of light poroconcrete (Siporex type).

19.) Deposit of kaolinized granite Mesiči (AP Vojvodina) is actually a secondary deposit of kaolinized granite heavy soiled with clay impurities and containing a high content of Fe⁺⁺⁺ compounds. Therefore the clay fraction was not recommended for further dressing. However, being a mixture of kaolinite and illite it can be used successfully in the production of acidproof slabs, tiles, and bricks in the new factory at Bela Crkva. The acidproof test gave the value of 98,7%.

Dressed feldspar by froth flotation is of a very high quality and corresponds to I. quality of JU Standard for potassium feldspar. The content of Fe₂O₃ is after magnetic separation only 0,09% what means that it can be used in the production of glazes and glasses. Its chemical composition shows that the product is practically pure feldspar without any admixtures.

Also quartz sand after magnetic separation corresponds to a good quality of glass sand. However, the dressed sand without magnetic separation can be used also as moulding sand in the steel and alloys industries. In this way it was successfully tested in cast iron and steel casting factories in Vojvodina at Kikinda, Vršac and Bela Crkva.

Based on the above good results it was recommended and also accepted to build a new

factory for the production of feldspar and moulding sand with a capacity of 200.000 t per year. Tender for this factory was announced in the Government Gazzete.

20.) Deposit of kaolinized granite Motajica (SR Bosna and Herzegovina) is geologically rather young and dressed kaolin is therefore slightly coarser than e.g. kaolin Karačevo or kaolin Djevdjelija. On the other hand this kaolin is as far as content of mineral kaolinite is concerned one of the best kaolins in SFR Yugoslavia. It can be therefore used in combination with any other more plastic kaolin for the production of fine ceramics, electroceramics, and sanitary ware. It is not suitable for paper, rubber, and cable industries.

Also dressed feldspar after magnetic separation is of a very good quality and it is a mixture of both sodium and potassium feldspars having about 10% of K_2O and 4% of Na_2O . Such a feldspar can be used not only in the ceramic body productions but also in the production of glasses and glazes.

Quartz sand - feldspar mixture remaining as a waste after kaolin and feldspar separation is as far as Fe_2O_3 content concerned pure enough and can be used for any ceramic production or for production of ordinary glass products such as e.g. glass containers or sheet glass. Content of iron impurities can be dropped still more down but the question is if it is economical. This quartz sand - feldspar mixture can also be used for production of light weight building materials (poroconcrete) or simply as sand in building industry.

The end-user wishes to build in accordance with our recommendations a dressing plant producing 30.000 tons/year of dressed kaolin and 50.000 tons/year of dressed feld-

spar. This production is expected to be the raw material base for further future investments in the field of ceramics such as production of porcelain utility ware and vitreous sanitary ware. However, the question is when enough money will be available for it.

21.) Monomineral deposit of quartz sand Karlovac (SR Croatia) is a deposit of fine quartz sand contaminated with about 5 - 6% of clay (kaolinite) impurities which should be washed out to reach the requested quality of the main product. The quality of washed kaolin is as far as content of mineral kaolinite is concerned better than kaolin Bela Reka. The kaolin fraction contains nearly 70% of mineral kaolinite and content of coloured impurities is after magnetic separation slightly over 1% only.

Quartz sand fraction is very fine and after separation of Ti impurities by froth flotation and magnetic separation also very pure. It can be used after dressing in the production of glass as well as in casting moulds preparation. The fine fraction of quartz sand (-60 +10 micrometers) what is actually the waste can be used as filler or in the production of light building materials or in the production of various cleaning detergents, etc.

Because the deposit is relatively a new one only laboratory and large laboratory tests have been done. Based on the promising results obtained the end-user plans to build a dressing plant with a capacity of 500.000 tons per year what will give about 25-30.000 tons of washable kaolin fraction as a by-product yearly.

22.) Quartz sand deposit Rgotina (Oblaci) is another monomineral deposit of quartz sand which appeared during the time of implementa-

tion of the projects. After separation and dressing 84,5% of high quality quartz sand, 14,9% of potassium feldspar and 0,6% of waste (washable clay fraction) can be obtained. The washable clay fraction based on mineral kaolinite is unfortunately heavily contaminated with colouring oxides and cannot be successfully dressed by magnetic separation. However, there is the possibility to use it similarly as the waste from deposit Mesiči what means in the ceramic factory at Bela Crkva.

Quartz sand as the main product has a very low content of Fe_2O_3 without magnetic separation and is of a very good quality and is ordinary used for the glass production as well as for steel and alloys casting mould preparation. However, the content of colouring iron oxides can be still decreased by magnetic separation so that the quartz sand may be used than for production of special kinds of glass such as optical glass, pharmaceutical glass, TV screens, etc.

There is only the difference of 0,22% of $K_2O + Na_2O$ to be called the I. quality potassium feldspar in accordance with JU Standard. Content of Fe_2O_3 and CaO also permits to place this product under I. quality potassium feldspar. It is produced by froth flotation after washing out the clay fraction.

The end-user accepted all recommendations and started immediately with the reconstruction of the factory to satisfy the obligatory technological process worked out in the Institute. The production is now in a full operation and gives together with the old part of the factory the capacity of 1,400.000 tons per year. This is a good example of collaboration between the project, Institute and investor (end-user). The regular production goes smoothly.

23.) Deposit of pyrophyllite at Konic (SR Bosna and Herzegovina) is known for a long time. However, only a small part of the deposit was pure enough to start with its exploitation while the base of the deposit was contaminated with colouring impurities. New methods of dressing especially dressing by magnetic separation allow utilization of the whole deposit.

Separated and by magnetic separation dressed pyrophyllite is according to the tests of the Institute for Pulp and Paper in Ljubljana excellent filler in paper industry. Its whiteness is extremely high and reaches 83,5% by Elrepho. Abrasion is low and the dressed raw material can be used also in high speed paper production machines.

Many recommendations of the author of this report were accepted during the preparation of final obligatory technological process. The end-user expects to start with a production of 85.000 tons of dressed and magnetically treated pyrophyllite per year what is in experts opinion to much for SFR Yugoslavia for only local use. The paper industry consumes about 50.000 tons of filling clay yearly. However, it is believed that a very high whiteness of the product will help to place the surplus of the production on the European market.

24.) Deposit of Black Clay Jovanoviča Brdo (SR Serbia) is very interesting because the clay is actually a white burning clay which is in the raw stage contaminated with huminats and algaeas. Therefore also its rheological properties are excellent. There are only few clays with similar good ceramic properties in Yugoslavia and therefore it was recommended to observe this clay for the production of vitreous sanitary ware and for the production of electroceramics.

The clay itself is based on the mineral kaolinite and is very fine. Therefore its plasticity is also good and its strength is high. Based on this very good properties it was used as one of the main local components in laboratory and semi-industrial trials on sanitary ware production (see also paragraph 27) and ribbed slabs production (see paragraph 29).

The owner of the deposit - Zorka Šabac enterprise - immediately accepted the recommendation and the Black Clay is mined separately and deposited on a special deposit while the white clay which is used in the production of floor tiles is further mined without interruption.

25.) Laboratory testing of clay deposits "Crni vrh", "Slatina I and II", "Rudovci", "Vlasotince", "UMA", and other have been finished. However, it should be said that no one of them (except Rudovci - podina which is unfortunately now hidden behind the newly deposited waste upper layers) is a good quality refractory clay and it seems that only production of kaolin at Baro (Garaši) can satisfy the requirements of "Šamot" Arandjelovac factory on refractoriness which should be equivalent to PCE 32 - 34. Above mentioned clays are mainly based on mineral illite and montmorillonite and are contaminated with coloured impurities and their refractoriness is far below the requirements for quality firebricks.

It is evident that the situation in refractory clays is not satisfactory and only further geological survey can help to solve this problem. It is said that good quality clays are near the town Dimitrovgrad near the Bulgarian border but samples of these clays never reached the Institute in Belgrade.

26.) On the field of utilization of local dres-

sed raw materials the first activity was devoted to the production of porcelain utility ware. Many combinations were tested using various mixtures of local kaolins and other raw materials.

The best results were found with mixtures of kaolin Karačevo with kaolin Bela Reka (or kaolin Motajica). Addition of dressed pyrophyllite helped to increase the brightness of the body after firing. Laboratory tests were repeated several times in order to be sure that the composition is good. On the end an industrial test on production of porcelain utility ware was done in CSSR at the factory "Karlovarsky porcelan". The industrial test certified the laboratory results. On request of RIK Karačevo technological part of Investment Study for a capacity of 3.700 tons of porcelain utility ware was elaborated under the guidance of the expert.

RIK Karačevo plans to build first the kaolin washing plant as mentioned in para 18 and immediately continue with erection of porcelain utility ware plant which will use about 50-60% of locally dressed kaolin. Remaining 40-50% should be supplied from other local deposits so that the body composition will be composed completely from local dressed raw materials.

27.) Also sanitary ware production can be released from import of kaolins and clays from abroad. After testing of many body compositions in laboratory scale the following as the best one was selected: 18,0% karačevo kaolin, 17,0% Bela Reka kaolin, 22,5% Jovanoviča Brdo Black Clay, 26,0% Jovanoviča Brdo White Clay calcined, 12,0% feldspar Prokuplje and 4,5% quartz sand Bela Reka.

The products correspond as far as their

quality is concerned with ordinary production of Keramika Mladenovac where all products were glazed with industrial glaze and fired in the industrial tunnel kiln. Even it can be said that the products of our composition had lower water absorption which did not overcome 0.5%.

The body composition recommended for sanitary ware production was accepted by Keramika Mladenovac and with slight changes (because of different firing temperature) also by Jugokeramika Zagreb. Both are now waiting for the industrial production of necessary kaolins.

28.) Waste after kaolin washing and feldspar froth flotation from Karačevo deposit was requested to be utilized and in such a way to utilize practically 100% of crude ore (except 2% of magnetic waste and 1,5% of mica) input. After basic tests it was recommended to utilize this quartz sand waste for the production of light poro-concrete (Siporex type).

The industrial test has been done at Kaznejov (CSSR) near the town Pilsen and about 25 m³ of poroconcrete produced during one Saturday and Sunday. The ready poroconcrete was partly transported by a lorry back to Karačevo.

The properties of industrially produced poroconcrete were excellent. Specific gravity was 0,65 g/cm³ and the cold crushing strength (CCS) was 37 kp/cm² while the Standard requires 30 kp/cm². In this way was industrially certified that all components received by dressing of kaolinized granite Karačevo can be utilized for some productions.

29.) Preparation of final obligatory techno-

logical process for industrial production of ribbed slabs for wall and floor tiles glost firing in SITI kilns was requested from Zorka Šabac enterprise. In the production of floor and wall tiles Zorka Šabac has two SITI kilns and they must replace in average 8 - 12 pieces of these ribbed slabs daily because they are rejected. These slabs are imported from Italy and are very costly because they are produced in mullite-cordierite quality.

A small production of these slabs for the own consumption only is expected to be established in the ceramic factory at Šabac. The products will be produced by casting slip method in plaster-of Paris moulds. Few body compositions corresponding to mullite-cordierite quality based as much as possible on local raw materials were tested and the best one selected for industrial production. Except imported talc all other components of the selected body composition are local. The slabs prepared in large laboratory trial were fired to the temperature of 1380°C and are tested now in the industrial SITI kilns for their life.

30.) Body composition for saggars for wall tiles glost firing was also prepared using local talc and various semi-refractory clays. The production was expected to be realized at Šamot Arandjelovac factory. In spite of the fact that the results were good the realization of this problem did not take place because the Šamot factory lost interest in this production. A new factory producing only car furniture is believed to be built in a near future. In that case also this problem will come to its realization.

31.) The author of this Report prepared many body compositions of facade tiles and facade bricks which were requested by many lo-

cal tile and brick factories. However, in spite of the fact that the results were promising the ideas on production of facade tiles was not realized up to now. Body compositions calculated by the expert are deposited in the Institute for any possible use in future.

32.) The UNDP Projects and through them also the author helped the Institute to reach gradually the leading role in technical matters connected with the beneficiation and dressing of kaolins, clays, feldspars, and quartz sand not only in the soc. republic of Serbia but in SFR Yugoslavia as a whole. Especially in kaolin dressing problems and in wet high gradient magnetic separation problems the Institute is the supreme one among other institutions in SR Serbia.

33.) Through a very close collaboration between the expert and the staff of the Institute on all project activities the knowledge of local specialists increased so that they are able now to continue themselves in problems of dressing and beneficiation as well as in the field of utilization of non-metallic raw materials especially those selected during the implementation of Phase II. The expert prepared also together with local staff many papers and lectures which were presented on various local and international seminars and symposiums.

34.) The expert had also a big influence in establishing of bilateral collaboration between the Czechoslovak Ceramic Works in Prague and the Institute as well as between the Institute for Basic Refractories (VUHK) in Bratislava and the Institute (ITRMS). Among other activities training of Institute's specialists in VUK Karlovy Vary can be mentioned as a good example of this bilateral collaboration.

35.) Establishment of a good collaboration between the expert and all end-users helped in a smooth continuation of work on each particular problem. End-users accepted to pay all necessary large laboratory, semi-industrial, industrial or pilot plant tests to ensure themselves about the quality of expected and possible future products.

III. R E C O M M E N D A T I O N S.

Based on the results obtained and mentioned in chapter II. Findings as well as in previous technical and terminal reports and the own experience accumulated during the implementation of the projects the following recommendations can be formulated:

36.) Utilize for industrial production of quartz sand the monomineral deposit Oblaci. Reconstruct the factory "Kvarz" Bgotina in such a way to conform to the new technological process worked out for this deposit in the Institute. Introduce froth flotation of impurities and feldspar and increase so the quality of the main product - quartz sand.

This recommendation was completely accepted and is already fulfilled. The reconstructed factory has the capacity 760.000 t per year and is in a full operation for two years and together with the old part (department) produces about 1,4 million tons yearly.

37.) Erect a new factory producing high quality quartz sand from the monomineral deposit Bela Reka according to the obligatory technological process prepared and tested under the activities of the projects. Except quartz sand to produce also kaolin as a by-product which is present as washable impurity in a quantity of approximately 2% in the crude raw material.

Also this recommendation is practically fulfilled because a new factory with a capacity of 450.000 tons per year is under construction and is expected to give the first quartz sand products during 1983. A full pro-

duction is expected in 1984. This capacity will also give about 8-10,000 tons of kaolin fraction which was tested as a suitable one in the production of fine ceramics. However, washing plant for kaolin production is not up to now fully financially covered. Agreements with some ceramic producers to cover partly the factory erection expenses is under negotiations.

38.) Utilize for industrial production of quartz sand and high quality potassium feldspar the deposit of kaolinized granite "Me-siči" near Vršac, for which the detailed technological production process was worked out in accordance to pilot plant results obtained. The waste - low quality kaolin with a high content of Fe_2O_3 - utilize for the production of acid resisting products (acid-proof bricks and tiles) or for the production of glazed facade tiles in the existing factory at Bela Crkva or as replacement for montmorillonitic and therefore unsuitable clay Kusič which is used now in the ceramic production.

This recommendation was accepted by the Committee for Energy and Raw Materials of the Government of AP Vojvodina and a tender for supply of equipment for a dressing plant with froth flotation for a capacity of 200,000 t yearly was opened and announced in Government Gazzete in July 1982. However, financial negotiations with selected suppliers are not finished yet.

39.) Establish the production of 100,000 tons of kaolin and 120,000 tons of high quality potassium feldspar yearly from kaolinized granite from the deposit Bare (Garaši). About 50% of kaolin production separate bellow 40 milimicrons and so produce low grade kaolin with refractoriness PCE 30/31 and 50% of kao-

lin production separated bellow 11 micrometers and produce high quality kaolin with refractoriness PCZ 33/34. Utilize this kaolin for the production of firebricks and high alumina bricks at the factory "Šamot" Arandjelovac. In case if the waterabsorption of kaolin grog will be after firing too high mix the washed kaolin with dressed Rudovci-podina clay and stabilize in such a way production of high quality grog.

This recommendation was accepted and will be definitely realized because "Šamot" Arandjelovac has no other available and suitable raw material of higher quality for the production of grog and firebricks because the deposit of Rudovci clay used up to now for ordinary production is exhausted. However, very detailed tests on mixing of kaolin and dressed Rudovci clay should be done in order to "squeeze" the optimal properties of both raw materials.

It is to be mentioned that by-products are quartz sand recommended for utilization as moulding sand or sand for glass containers production or suitable for building industries and mica which is of a low quality and can be used only for the production of welding electrodes. However, consumption of mica for this production is not too high.

40.) Erect a kaolin washing and dressing plant for a capacity of 30.000 tons per year at Kosovo using as crude ore kaolinized granite from the deposit Karačevo. Kaolin should be separated bellow 10 micrometers and magnetically treated in order to decrease the content of iron compounds.

For complex utilization of kaolinized granite to produce by froth flotation sodium potassium feldspar of a good quality. Quartz

sand waste after flotation utilize for the production of light poroconcrete (Siporex type). Kaolin produced from this deposit is a typical ceramic kaolin (for fine ceramic production) because it has a very good plasticity and high CCS (strenght) after drying.

The end-user and also the owner of the deposit accepted this recommendation. Investment study with a final obligatory technological process was prepared in accordance with the results obtained during the semi-industrial tests. Preparation of financial construction for investment and evaluation of offers received from four possible suppliers is in the course. It is expected that erection of the factory will start in the beginning of 1984.

41.) Establish production of 3.700 tons of porcelain utility ware at Kosovo within the framework of RIK Karačevo utilizing its own dressed kaolin (see recommendation under paragraph 40) as well as other local raw materials. The best combination seems to be a mixture of kaolin Karačevo with kaolin Bela Reka or kaolin Karačevo with dressed and calcined pyrophyllite and quartz sand. It is also recommended to use slightly opacified glaze with addition of cirkonia or cirkonsilicate. Laboratory, semi-industrial and industrial tests approved utilization of kaolin Karačevo for this production.

This recommendation was also accepted by the management of RIK Karačevo enterprise. Detailed investment study based on our technological study is now under preparation. This investment will be realized immediately when kaolin washing plant will start with the production of dressed kaolin.

42.) In order to utilize also the quartz sand

waste after the froth flotation of feldspar for complex utilization of Karačevo kaolinized granite it is recommended to establish a production of 100.000 - 120.000 m³ per year of light poroconcrete (Siporex type). The quartz sand is actually a mixture with feldspar which is not possible to be flotated because the crystals of both minerals are grown together and fine milling of this material to release the feldspar crystals and so more or less purify the quartz fraction will help but quartz sand of such a finesse cannot be used either in glass nor in sand mould for steel casting. Production of poroconcrete is therefore the best way for its utilization. Otherwise it can be consumed as an ordinary quartz sand in building industry.

Our recommendation was accepted and negotiations are being done between RIK Karačevo and other possible potential producers of building materials at Kosovo. Results of the industrial test made in CSSR with this waste sand fully certified a high quality of produced light poroconcrete.

43.) Erect a kaolin dressing plant for a capacity of 30.000 tons per year in SR Bosna and Herzegovina at Bosansky Kobaš using as crude ore kaolinized granite from the deposit Motajica. As by-products produce high quality potassium-sodium feldspar, quartz sand and mica. Laboratory tests with dressed kaolin and feldspar made in the Institute as well as semi-industrial tests made by Jugokeramika Zagreb certified the quality of both dressed components. Quartz sand is suitable for the production of ordinary sheet glass and glass containers.

This recommendation is still discussed on the level of Government of BiH in spite of the fact that the kaolin washing plant is expected to build the base for establishment of

fine ceramic industries (porcelain utility ware and sanitary ware) in the soc. republic Bosna and Herzegovina.

44.) Utilize for industrial production of quartz sand the crude ore from monomineral deposit Karlovac. The quartz sand is finer and can be used for preparation of precise sand moulds as well as in glass industry. Except quartz sand to produce kaolin which is present as washable impurity in the crude ore in quantity of approximately 6-7%. This kaolin can be used in ceramic industry as partly replacement of imported kaolins. It seems to have sufficient plasticity as well as good CCS (cold crushing strenght).

This recommendation was accepted and the end-user expects to start with the capacity of 500.000 tons per year what gives except high quality fine quartz sand also about 30.000 tons of kaolin suitable for ceramic industry. The enterprise Jugokeramika Zagreb is interested in these both components for the production of porcelain hotel ware and sanitary ware because this deposit is relatively close to the ceramic factories.

45.) Establish production of 50.000 tons of dressed pyrophyllite which will be used as filler in paper industry. The dressed product after magnetic separation has a high whiteness above 82% ELR and a low abrasion test. The expert believes that this raw material can be after separation below 2 milimicrons used as coating clay (white pigment) if rheological properties are good. It is recommended to test also this possibility because whiteness of this raw material is very promising.

Intensive discussions about the capacity, obligatory technological process, and necessary equipment are in the course. The ex-

pert's opinion is that the by the end-user recommended capacity of 86.000 tons per year is too high for Yugoslav local consumption in paper industry.

46.) Establish production of 30.000 tons per year of dressed kaolin at Djevdjelijska using as crude ore kaolinized dacite from the deposit Novo Konjako. This quality of kaolin is suitable for paper industry as filler or for rubber and cable industries. However, it is not suitable for ceramic industry because its plasticity and cold crushing strength are very low. Consumption of paper filling clay in Yugoslavia is about 50.000 tons/year what might be covered with the production of dressed pyrophyllite and before starting with any investment on this deposit agreement between both paper filling material producers is highly recommended.

Recommendation for this production not yet accepted but intensive geological survey on the deposit is continuing and it is before its finishing.

47.) Because the Institute for Technology of Nuclear and Other Mineral Raw Materials which is the Government Implementing Agency reached as far as public relations are concerned the name of one of the best Institutes in the field of dressing and utilization of non-metallic minerals in Yugoslavia it would be necessary to continue in this activity. From this point of view the following recommendations were formulated for the Institute:

48.) To continue in follow-up of technical and technological solution of every non-metallic problem using semi-industrial or Pilot Plant results as the base because it is essential that the dressing methods applied are related to the end-use of the dressed

raw materials in such a way that reasonable balance between the quality and cost should be reached.

49.) To continue in increasing of knowledge and education of its scientific workers, specialists, and technicians in the field of dressing of non-metallic minerals and their utilization among others also through the bilateral collaboration with ČKZ Praha and VUHK Bratislava which was established under the activity of the Projects.

50.) To prepare also in future technical lectures and scientific papers for various seminars, symposiums, and congresses either local or with international participation about dressing and possible utilization of local dressed raw materials. This activity is very important because it can also make a good publicity for the Institute and help to stabilize the leading position of the Institute in the field of non-metallic minerals through the whole Yugoslavia.

51.) To be in a very close contact not only with actual but also with potential end-users. In spite of the fact that thanks to the existing actual end-users the realization of the Project results can be called as more than satisfactory fulfilling of this recommendation will lead to the extension of utilization of locally dressed raw materials by local industry and will, therefore, help to stop import of these minerals to SFR Yugoslavia.

52.) To utilize from UNIDO and UNDP side the Institute for training of specialists from other developing countries similarly as was the case with Mr. Macking of Tanzania. Accept also the suggestion of the Institute in utilization of magnetic separator and other equipment for tests of non-metallic raw materials from other developing countries.

IV. CONCLUSIONS.

To satisfy the requirements of local industries for quartz sand factories at Rgotina Valjevo, Bela Reka, and Vršac (Mesiči) should work with full recommended capacities. Factories at Rgotina and Valjevo are in a full operation for more than two years while factory at Bela Reka is under erection and factory at Vršac under bidding of machinery. It is evident that in a near future Yugoslavia will be fully self-sustaining in this material. However, deposits at Karlovac, Bare, and Motajica expect also to produce quartz sand what means that the quartz consuming industries can expand in future without having problems with basic raw materials.

Consumption of kaolin in SFR Yugoslavia reaches up to 86.000 tons per year. From this amount about 50 - 55.000 tons is consumed by paper industry, 10 - 15.000 tons by rubber and cable industry, 10 - 15.000 tons by ceramic industry and the remaining 5 - 6.000 tons by other industries.

Production of quartz sand at Bela Reka will give necessarily about 8.000 tons of kaolin as by-product. Similarly production of quartz sand at Karlovac will give about 30000 tons of kaolin as a by-product. A new factory at Karačevo which is expected to produce kaolin for ceramic, cable, rubber, and other industries is programmed for a capacity of 30.000 tons per year in order the production to be economical. Than erection of a factory producing maximum 50.000 tons of dressed pyrophyllite for paper industry (and a small amount for ceramic industry) will cover all the Yugoslavia's requirements for kaolin not only in the present times but also in futu-

re having in mind expansion of consuming industries. In such a case erection of factories at Djevdjelija and Motajica will be excessive.

The factory at Bare (Garaši) cannot be counted among the kaolin producers because the 100.000 tons of this dressed kaolin will be used exclusively for the production of refractories at Šemot Arandjelovac factory. From that what was said above it is evident that Yugoslavia can be self-sustaining also in kaolin production in a very near future. Karačevo factory is under bidding, Bela Reka factory is under construction and for pyrophyllite factory the investment study is before finishing.

As far as feldspar production is concerned the situation in SFR Yugoslavia is as follows: In present times there are two main producers of feldspar - Prokuplje producing potassium feldspar of a very good quality and Strumica producing good quality sodium feldspar.

Except these two existing producers of feldspar "Partizan" Prilep wishes to produce 50.000 tons per year of high quality potassium feldspar from local syenites available in SR Macedonia. Technological process for this production was elaborated also under the guidance of the UN Projects. Complex utilization of local granites gives the possibility to produce also feldspar by froth flotation. In that case production of

30.000 tons per year on deposit Karačevo
40.000 tons per year on deposit Mesiči
120.000 tons per year on deposit Bare and
30.000 tons per year on deposit Motajica
can be realized or better to say should be realized in order to ensure economical production of kaolins and quartz sands on deposits Mesiči, Bare, and Motajica. Also "Feld-

spar" Bujanovac factory expects to produce 20.000 tons of sodium feldspar.

It is evident that realization of all above mentioned productions of feldspars will necessarily lead to the surplus of feldspar on local market. This problem should be solved either through export of feldspar to other countries or through utilization of potassium feldspar for the production of potassium fertilizers which problem is now occupying many countries in the whole world.

From that what was said above it is evident that the development objectives as well as immediate objectives of the Projects were fulfilled. The Institute for Technology of Nuclear and Other Mineral Raw Materials was equipped with many useful machines and apparatus for testing of non-metallic minerals and the staff of the Institute collected a great deal of knowledge in this field of activity.

However, it is to be mentioned that the Institute should establish in future also corresponding equipment for performance of Pilot Plant tests. Such equipment for froth flotation is available in the Institute but pilot plant equipment for clay washing and dressing is not available and to perform pilot plant tests on existing laboratory equipment is impossible and cannot give solid results not only from technological but also from economical point of view. Therefore also all important pilot plant tests were done abroad on industrial equipment.

Technical Reports
prepared by the expert during his appointments.

- 1.) Study on the possibility of the production of pyrometric cones November 1977
- 2.) Some aspects on the dressing problems of quartz sand and feldspar from the deposit Vlaško Pole "Štala". December 1977
- 3.) Study on dressing of quartz sand from Valjevo (Čučuge) January 1978
- 4.) Study on dressing of refractory clay from Rudovci March 1978
- 5.) Pre-feasibility study on the kaolin and feldspar dressing in the deposit of granite in the Arandjelovac basin. February 1978
- 6.) Granite and its use May 1978
- 7.) Floating effect in keramsit June 1978
- 8.) Production of saggars for wall tiles glost firing from local raw materials at factory "Šamot" Arandjelovac. August 1978
- 9.) Pre-feasibility study on the production of kaolin at Bela Reka December 1978
- 10.) Study on dressing of Rudovci clay - Part II. January 1979
- 11.) Pre-feasibility study on the combined production of 3.000 tons of sanitary ware and 5.000 tons of utility ware based on dressed kaolin Bela Reka. March 1979
- 12.) Utilization of local non-metallic minerals in Yugoslavia (Seminar) August 1979
- 13.) Pre-feasibility study on the production of 250 tons/year of decorative ceramic at Vojvodina. January 1980

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| 14.) Report on preliminary tests with white-grayish clay of Zorka Šabac | February | 1980 |
| 15.) Report on preliminary tests with white clay of Zorka Šabac | July | 1980 |
| 16.) Report on semi-large laboratory scale trial with kaolinized gabbro from locality "Novo Konjako" Djevdjelija. | September | 1980 |
| 17.) Report on semi-large laboratory scale trial with clay from locality UMA Djevdjelija. | December | 1980 |
| 18.) Report on testing of kaolinized granite from deposit Motajica | March | 1981 |
| 19.) Local sources of kaolin production in Yugoslavia | July | 1981 |
| 20.) Deposits of quartz sands with a higher content of feldspar and kaolin and their full employment. | November | 1981 |
| 21.) Technological study for production of 3.700 tons of porcelain utility ware per year at RIK Karačevo. | March | 1982 |
| 22.) Tender conditions for a plant producing 3.700 t/per year of porcelain utility ware. | August | 1982 |
| 23.) Production of kaolin from local sources | March | 1983 |
| 24.) Utilization of "Jovanoviča Brdo" clay by local industries | March | 1983 |

