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Technical Assistance to Institute of Geology and Mineral Exploration (IGME) for the Development of Non-metallic Industrial Minerals in Greece

DP/GRE/86/008/11 - 03

D r a f t

Terminal Report

Prepared for the Institute of Geology and Mineral Exploration (IGME) by the United Nations Industrial Development Organization, the executing agency for the United Nations Development Programme.

Based on the work of Z. A. Engelthaler
UNIDO Technical Assistance
Expert

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Vienna

This report has not been cleared with the United Nations Industrial Development Organization which does not, therefore, necessarily share the views expressed.

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Mr. G. Kanaris, Senior Geologist, Head of the Department of Industrial Minerals

Dr. G. Kosharis, Geologist

Mrs. Martha Grossou - Valta, Director, Mineral Technology Department

Mr. A. Makris - Chief of Department of International Scientific Co-operation

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During the field trip to deposits of Milos, the Silver and Baryte Ores Mining Company was helpful to the UNIDO expert, namely

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Mr. Ulrich Lutat, Geologist of the Company

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Mr. Nassos Iliopoulos, Director General of Perlomin and Memeber of the Board

Mr. G. A. Saniotakis, Chief Chemist

Mr. Koliarakis, Chemist

CERECO, i. e. Ceramic and Refractory Company, Athens, namely

Dr. C. J. Stournaros, General Manager

ABSTRACT

Greece is a rich country as far as the availability of different non-metallics is concerned, having deposits of kaolins, clays, bentonites, perlites, feldspars, quartz, siliceous sands, bauxites, zeolites, pumice, gypsum, pozzolana, magnesites, dolomites, marbles, asbestos cyanites and others. The biggest concentration of non-metallics is on Milos Island. The Institute of Geology and Mineral Exploration represents a Governmental organization, which deals with non-metallics as well as with metallic raw materials, geological research, evaluation, up-grading and refining. A new research organization was established recently in Greece for the technological development of ceramic and refractory industries, called Ceramic and Refractory Company (CERECo). Greek strong enterpreneurial companies are also interested in the development and expansion of the industrial exploitation of locally available non-metallic raw materials. Therefore different visits to selected non-metallic deposits as well as to their processing plants were realized during the mission and necessary recommendations were negotiated with IGME as well as with the industry with the attention to the industrial exploitation of bentonites, perlites, kaolin, feldspars and silica.

TABLE OF CONTENTS

I. INTRODUCTION

Within the framework of the UNDP Project DP GRE/86/008 "Technical Assistance to Institute of Geology and Mineral Exploration (IGME) for the Development of Non-metallic Industrial Minerals in Greece", the UNIDO expert was appointed as the consultant with the duration of the mission 15 days. The expert was attached to IGME to assist in efforts of industrial exploitation of locally available non-metallics, of substituting imported non-metallics with locally existing ones as well as of suggesting non-traditional ways for the commercial exploitation of selected non-metallics. Logically, the UNIDO mission was the follow-up mission of other three UNIDO experts' missions, assigned to IGME within the same project under the numbers

DP/GRE/86/008/11 - 01
DP/GRE/86/008/11 - 02
DP/GRE/86/008/11 - 04

The duties, specified for the UNIDO expert in the Job Description, were related to the following activities:

1. Review of existing data on raw materials and the industrial minerals industry in Greece
2. Study of the laboratory results and the pilot tests
3. Recommendations on the industrial evaluation of the studied raw materials in connection with industry.
4. Visits to main industries dealing with non-metallics for discussion of technological problems.
5. Organizational principals and prerequisities for the establishment of an advisory centre closely connected with the needs of industrial minerals industry
6. Submission of a report containing observations, conclusions and recommendations.

Aside the foregoing duties during his briefing, the UNIDO expert was requested to negotiate, in full details, the Draft Terminal Report of previously assigned three UNIDO experts to IGME with the Governmental Authorities in order to get their approval as the necessary condition for the report's eddition. Since the financial site of the project must be closed beginning of December 1987, all technological and evaluating tests must be finished end of November 1987.

Institute of Geology and Mineral Exploration, Athens, represents a highly experienced body with professional presonnel for the geology, extraction and evaluation of non-metallics as well as metallic raw materials in Greece. The industrial exploitation of non-metallics in Greece was started already in the past, however, different possibilities exist in this field to substitute imported raw materials wich locally available ones, to extend the up-grading and retininf technologies of non-metallics in order to meet requirements of end-users in Greece as well as in the international market.

IGME has paid attention to the actual situation and to the requests from the market. It expanded its Mineral Technology Department and transferred this department to the new buildings. IGME decided to co-operate with the applied research organization in Athens Ceramic and Refractory Company (CERECo). Meanwhile IGME will produce a "Non-metallic raw materials inventory", the CERECo will conduct a survey on existing ceramic and refractory industries in order to identify actual and future needs on non-metallics in Greece as the orientation for further geological and technological activities of IGME.

Powerful Greek companies, such as Silver and Baryte Ores Mining Company and KYRIAKOPOULOS-ILIOPOULOS Concern are interested in the non-metallic materials industrial development as well as with further co-operation with IGME Athens and with UNIDO-Czechoslovakia Joint Programme in Pilsen.

Following the request of IGME, the UNIDO expert visited different mines and production plants of non-metallics in Athens and in the Island Milos, where very interesting negotiations and discussions were realized as a basis for further industrialization of the country, based on the exploitation of selected non-metallics. Special attention was paid to bentonites, perlites, kaolins, feldspars and silica materials. Aside different technological developments of existing refining plants, negotiations and recommendations were released for the non-traditional and integrated application of bentonites in agriculture as well as in the environmental engineering, hydrophobization of expanded perlite, production of shaped perlite products based on expanded perlite raw material, possibility of washing Greek kaolins in order to separate undesirable minerals from kaolinite, production of feldspar-siliceous mixtures for the glass industry and other.

The mission of the UNIDO expert was evaluated very positively by IGME. Greek authorities also appreciated the supporting mission from the UNIDO-Czechoslovakia Joint Programme in Pilsen, which, in the same time, paid attention to high level visits to the Joint Programme, to the training programmes of thesecond group of Greek experts amounting 4 people and to different economic and organizational aspects of ventures, negotiated by IGME and other Greek companies for the forthcomming period.

II. FINDINGS AND RECOMMENDATIONS

1. Greece is a very rich country as far as the availability of non-metallics is concerned.

2. Non-metallics, existing locally in Greece, are represented by different types such as kaolins, clays, bentonites, feldspars, quartz, siliceous sands, perlite, pumice, zeolites, gypsum, pozzolana, bauxites, magnesites, dolomites, marbles, cyanites, chromites and asbestos.

3. The industrial exploitation of selected non-metallics was started in Greece already in the past, such as of bentonites, perlites, gypsum, kaolins, clays, asbestos, marble and some others. Taking into the consideration the fact, that some of important non-metallic raw materials are still imported to cover partly or completely local demands and that mining and shipping conditions are very good in Greece, non-metallics can be produced and exported in the future on a wider scale, as they will contribute to the industrial and economic development of the country.

4. Not enough attention was yet paid in Greece for the up-grading and refining of non-metallics both from the view traditional as well as advanced ceramics. Since raw materials, produced chemically were 10 x to 100 x more expensive that the natural property up-graded raw materials, new area was opened even for more expensive industrial refining methods. The geological research was recommended to be opened for non-traditional non-metallic raw materials, such as for high alumina, zirconia, zirconia, trace elements and others.

5. The Institute of Geology and Mineral Exploration (IGME) represents a highly experienced bpdy with professional personnel for carrying out geological, geophysical and geochemical exploration on both metallics and non-metallics, as well as for testing of different industrial minerals.
IGME has more than 1500 employees. Its Headquarters are in Athens, six other branches are located in different centres

accross Greece. IGME's proffessional structure is built up by different departments and sectors, specialized on economic geology, hydrogeology, fuel and geothermal energy, mapping mineralogy and petrology, geo-chemistry, geo-physics and by different technical bodies such as department of mineral technology, sectors for technical control of deposits, drilling, chemistry and feasibility studies.

6. Mineral Technology Department of IGME finished new buildings early 1987 in PEANIA the eastern suburb of Athens. This department serves for both metallic as weel as non-metallic industrial minerals. Aside the laboratory research the pilot plant is being equipped. The Mineral Technology Department of IGME is a good basis for the establishment of an advisory centre closely connected with the needs of industrial minerals industries. Additional equipping and stabilization of engineers and laborants was recommended.

7. Develop the close co-operation with CERECO, i. e. with the Ceramic and Refractory Company, Athens, which was established recently by the Ministry of Research and Technology in order to develop applied research and to support local ceramic and refractory industry in the field of technological development.

a. provide CERECO with the inventory of available local non-metallic raw materials to support them in the replacement of imported ones and in lowering manufacturing costs in different ceramic and refractory plants

b. ask CERECO to conduct a survey on ceramic and refractory factories in order to clasify actual and future needs of non-metallic raw materials.

8. CERECO is intending to develop a co-operation with the Research Institute for Ceramics, Refractories and Raw Materials in Pilsen, a member of Czechoslovak Ceramic Works, and with UNIDO-Czechoslovakia Joint Programme in Pilsen. Therefore, CERECO requests to obtain information papers on activities of both proffessional bodies.

9. Messers Kiriakopoulos - Iliopoulos Concern intend to arrange in 1988 a Pan-Hellenic experts meeting in the co-operation with IGME Athens and UNIDO-Czechoslovakia Joint Programme, Pilsen. The experts meeting should be composed from the theoretical lectures and practical demonstrations on the integrated exploitation of selected non-metallics.

10. High-level visits to the UNIDO-Czechoslovakia Joint Programme in Pilsen are expected in October 1987. Training programme for the second group of Greek experts amounting to 4 people, was elaborated on the spot and agreed up. Greek authorities, therefore, appreciated the supporting mission of the UNIDO-Czechoslovakia Joint Programme´s Pilsen, which contributed to results achieved and to the positive evaluation of the UNIDO mission.

11. IGME appreciated four programmes, which UNIDO-Czechoslovakia Joint Programme Pilsen elaborated on a video-casett. Those programmes were related to

    a. 24 hours with bentonites
    b. Energy Management in Silicate Industry
    c. Application of Activated Bentonites for Waste Water Treatment
    d. Applied Research of Non-metallics

    The four programmes were prepared for training purposes. IGME recopied all of them for its further training opportunities.

12. The joint Draft Terminal Report of 3 UNIDO experts from June 1987 was negotiated with IGME, evaluated and approved by the top management of IGME with minor corrections on page No. 1, 2, and 3. The formal approval for its editting was cabled to UNIDO on 11 September 1987.

13. As far as further steps on the industrial exploitation of non-metallic raw materials are concerned, the following recommendations were negotiated and agreed:

a. Bentonites

The non-traditional application of bentonites into sandy soils for the reclamation offields as well as special activation of bentonites for waste waters purification will help not only to expand the actual bentonite market, but also will help to the agricultural sector and will contribute to the environmental engineering. The best bentonites of Greece are extracted on Milos Island. Meanwhile Angeria and Migikolo bentonites contain more than 90% of montmorillonite, Komia bentonites, occuring in biggest geological reserves, show their average bentonite content of 60 to 65% from total. Komia bentonites, as being calcium bentonites, are recommended for the application in agriculture and for special activation for the environmental engineering.

b. Perlite

To promote the Greek growing perlite industry, development and the production of shaped perlite products was recommended as well as the manufacture of hydrophobic expanded perlites.

c. Kaolin

The production of Greek kaolin is growing. However, the up-grading technologies are based only on dry methods. Separation of udesirable minerals from kaolinite on the wet way can lead to new kaolin qualities, applicable also as coating grades for the paper industry. The whitness of local kaolins is excellent, reaching, without any bleaching, up to 85-87 degrees with the blue filter.

d. Feldspar

High purity of several feldspar deposits in Greece, but medium content of alcali-oxides indicates the possibility to produce feldspar-siliceous mixtures for the glass industry by replacing partly the importation and by lowering manufacturing costs.

e. Silica

Silica sands from Haniotis arkoses show very high content of iron oxide, fluctuating between 1.52 to 2.43%. Their alumina oxide is also hogher than 8% from total, meanwhile the alcali oxides amount to about 5% from total. To make silica sands from Haniotis better in quality, washing test is recommended to be conducted. Quartzites from Analipsi show much better content of colouring oxides, with iron oxide below 0.5% in average and titanium oxide below 0.11%. These quartzite can be applied in the ceramic manufacture without any refining, meanwhile theri application in the white glass manufactures requires the decrease of colcuring oxides. Siliceous sands from Krios and Dikea can be applied after regulating their grain composition, in the foundries, however, their application in the glass industry requires up-grading and refining to the limits of impurities and grain composition of the glass industry.

11. All objectives of the UNIDO mission to Greece were fulfilled and, in selected case, different other actual questions were analyzed and negotiated according to the request of IGME.

III. SUBSTANTIVE SECTION - CASE STUDIES

a. Bentonite

The largest deposits of bentonites in Greece are situated in Milos Island, the extreme Southwestern island of the Cyclades. The Milos surface amounts to 161 square kilometres. Its geology is quite varied, with a wide variety of both volcanic formations. From the point of view of non-metallics, the Milos Island can be considered as a geological miracle. Deposits of different industrial minerals are closed each to other and they include bentonite, perlite, kaolin, alunite, baryte, silica in different modifications, millstones, pozzolana obsidian, sulphur as well as manganese, lead sulfite and others.

There are several companies, extracting non-metallics on Milos. The largest company is Silver and Baryte Ores Mining Company, which was established in 1934 and has, since than, been engaged in mining activity almost without any interruption. The expectation that silver will be fond on Milos was wrong and, therefore, at present the Company is concentrated on the following industrial mineral yearly outputs

400,000 tons of bentonites
200,000 tons of perlite, granulated, expanded only for local market
100,000 tons of ground kaolins without washing
12,000 tons of beneficiated baryte.

The Company is mainly an export industry, 85% of its sales being directed to West Europe, America and Japan. Thanks to the activities of this Company, Greece holds the third place in world perlite production, ranking after USA and Soviet Union and is firts among exporting countries.

The Company operates several bentonites deposits. The most important deposits from localities ANGERIA and MIGIOKOLA show their content of montmorillonite exceeding 90% from the total. These bentonites are excavated during the dry season between May and October homogenized perfectly and predried

naturally by placing their layers of bentonites on a large field. by sun-drying the natural content of water is lowered from 26-28% to about 16-17%. The additional drying is realized in vertical fluid-bed driers or the requested moisture content. Part of bentonite is activated by the natrification.

The Company does not operate bentonites´mine in the locality KOMIA because of lower content of montmorillonite, which amounts, in average, to about 65% from the total. Therefore, preliminary tests were conducted in that way that KOMIA bentonites were specially activated by aluminium sulfate and tested for the water purification of waters, contaminated by styren--butylacrylate copolymer dispersion.

The following are results achieved in the comparison of KOMIA bentonites with bentonites from ANGERIA and MIGIKOLO.

Special modifications of bentonites from Milos island for wastewater treatment purposes

PRELIMINARY LABORATORY RESULTS

1. Origin of samples — Bentonites from Milos island (Greece), quarried by Silver and Baryte Ores Mining Co.

2. Localities — 1. ANGERIA, 90% of montmorillonite
   2. MIGIKOLO, - " -
   3. KOMIA, 60-65% of montmorillonite

3. Reference sample — Czechoslovak Al^{3+} - bentonite (North-bohemian Ceramic Works Most)

4. Dispersion tested — SOKRAT 497 (product of Chemical industries plant, Sokolov, Czechoslovakia)

   Contains: styren-butylacrylate copolymer

   Wastewater prepared in the form of 1% wt. aqueous dispersion.

5. Activation agent for bentonites: $Al_2(SO_4)_3$

6. Analytical test for cleaning efficiency: in terms of chemical oxygen demand (COD) decrease

RESULTS - optimal doses of Al^{3+} - modified bentonite suspension (per 100 ml of modelled wastewater)

Wastewater original			Wastewater after treatment								
			1. step of modification			2. step of modification			Reference		
	pH	COD	Dose (ml)	pH	COD	Dose (ml)	pH	COD	pH	Dose (ml)	COD
ANGERIA	7.33	18,550	21	4.08	520	13	3.86	560	3.95	13	310
MIGIKOLO	7.33	18,550	19	3.89	460	11	3.75	560	3.95	13	310
KOMIA	7.33	18,550	19	3,70	500	7	3.73	590	3.95	13	310

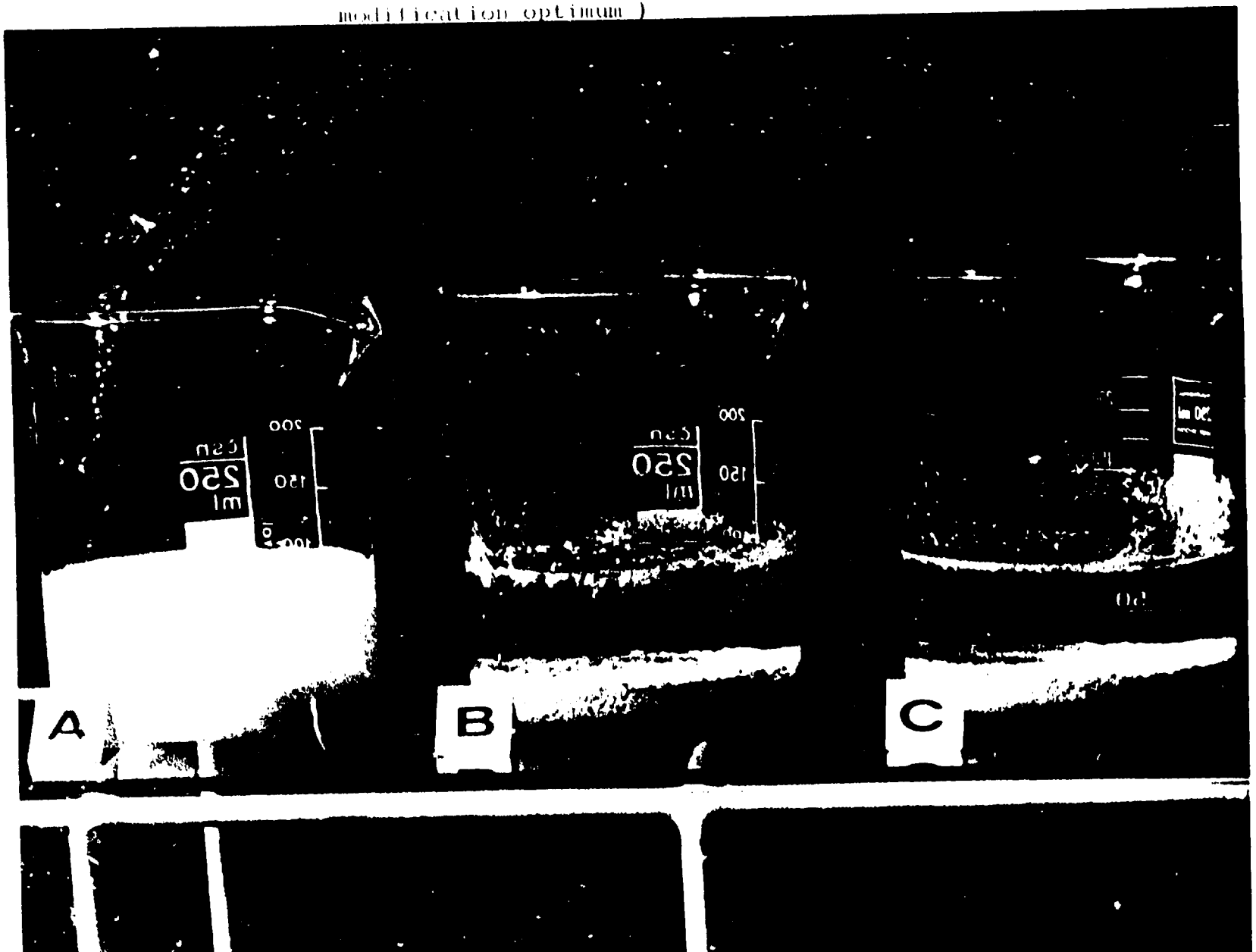
Sludge volume (after 2-hr sedimentation): ANGERIA 24% of total
MIGIOKOLO 19% of total
KOMIA 16% of total

(for optimal doses)

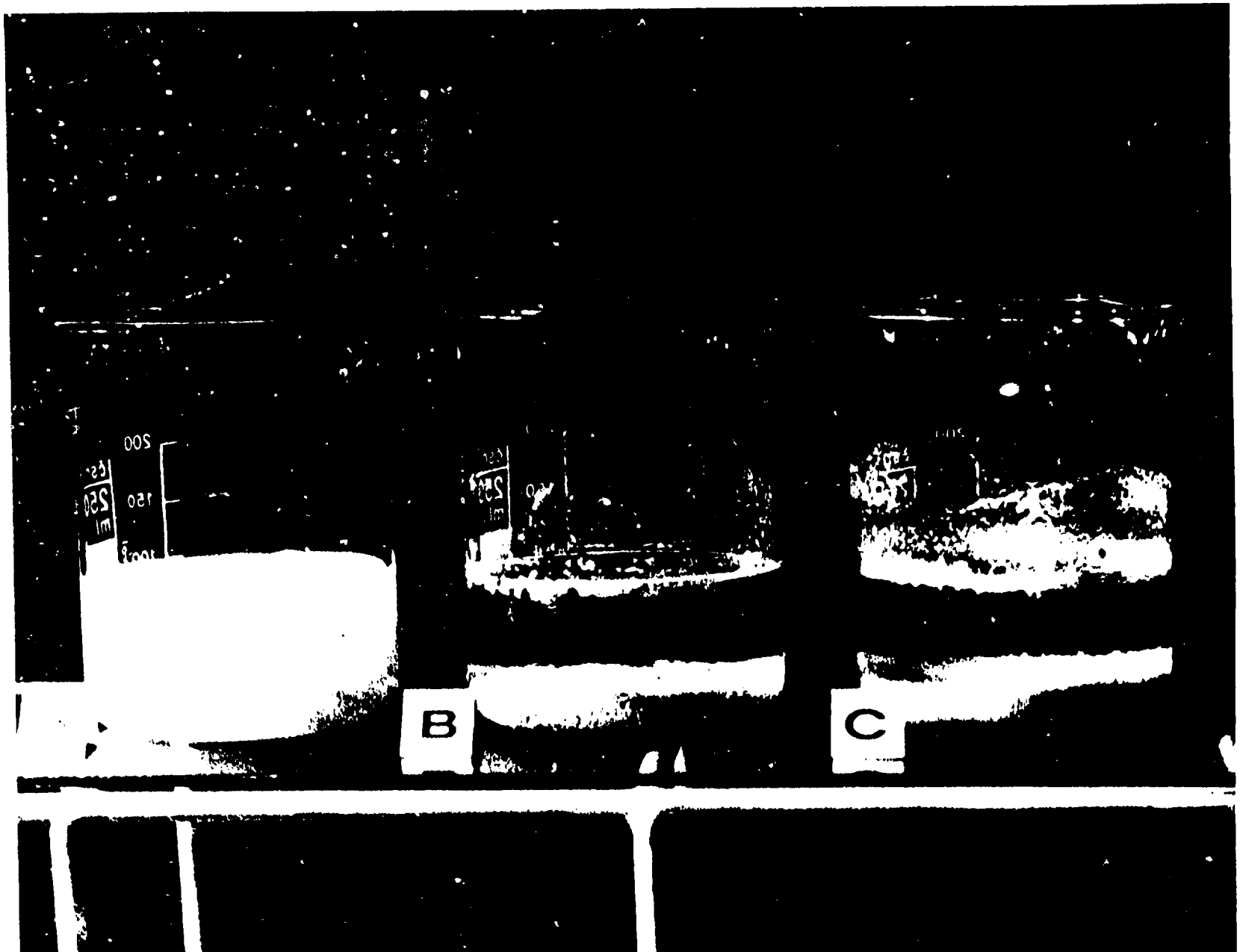
Results: KOMIA bentonite is the most suitable one, by the optimal dose of 7 ml/100 ml of wastewater the overall contamination-in terms of COD- is reduced by 97%. The dose represents 14 kg of modified bentonite/1 m^3 of wastewater. Due to the lowest dose the sludge volume is minimalized as well. Flocks are big, stable, can be removed by filtration on screens.

Recommendation: a) testing of suitability for oil-polluted waters
b) try iron-modificated forms

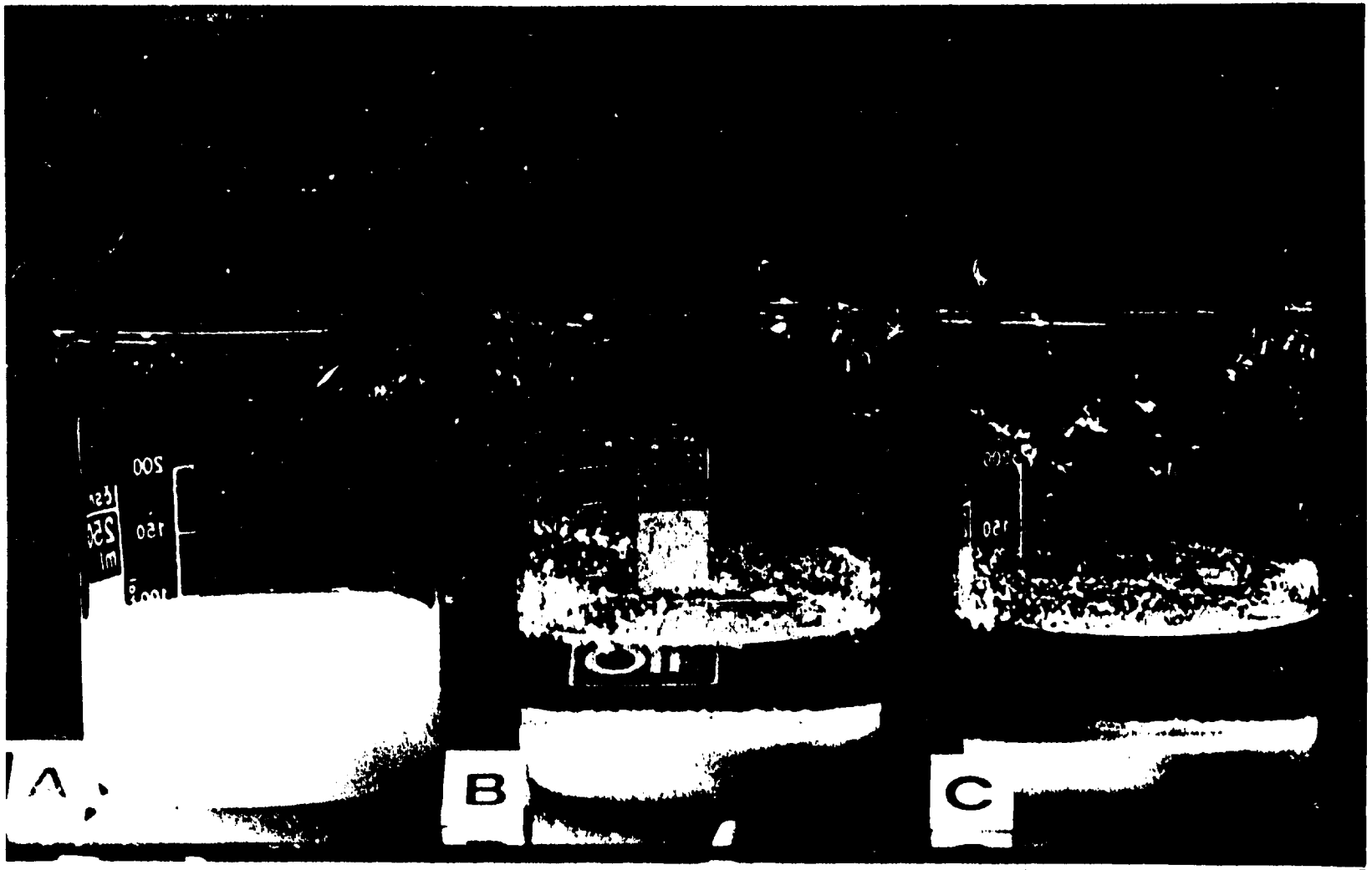
FIG.A BENTONITE (A-original watlevator,B- 2.step of modif.optimum, C-1.step of modification optimum)



ANGLERIA BENTONITE (A-original water dep., B-2.step of modif.optimum, C-1.step)



MIKROFOLO BENTONITE (A-original seawater, B-2.step of modif.,optimum, C-1.step)



Since there is a depression in the world bentonite market, as many companies are stopping the application of bentonites for the palletization of iron ore by replacing bentonites with organic binders in order to reduce the manufacturing costs per ton of iron produced by 1.5 US Dollar, non-traditional applications of bentonites are recommended to be tested in order maintain the actual output of the company. Such applications are for example

1. Application of bentonites into sandy soils as a reclaiming agent. Taking into account 25 years experience of Czechoslovakia, favourable results achieved in Egypt, Ethiopia, Algeria and China, pilot tests are recommended to be conducted and evaluated according to the experience of UNIDO-Czechoslovakia Joint Programme in Pilsen and Czechoslovak Ceramic Works in Prague. Increase of harvests by 50% to 100% can be expected by lowering the irrigation water up to a half of the original consumption.

2. Special activation of bentonites modifies their activity to an ideal water purification natural matter. Preliminary results show that Greek bentonites are good for special activation and water purification for waste waters from the chemical and food industry, from the agricultural sector as well as for waters contaminated emulgated oil. This method is very cheap and efficient and it enables each produced to clean his waste waters below any world limit.

   On the other hand, bentonites having adsorbed organic matters on the surface, are very good for composting and for the soil´s fertility increase. Bentonites with oil emulsion can be applied into the heavy ceramics´blends (bricks and tiles), as they lower jointly the fuel consumption during the firing process.

3. Other possible non-traditional applications of bentonites are in the hydroponic methods, cash plants nurseries, purification of wines, binding elements and fillers in the pharamaceutical industries.

4. Since high grade bentonites reserves with the content of montmorillonite above 90% from total in Milos can be estimated to about 5 million tons and medium grade bentonites are represented in dozens of million tons, it is recommended to pay attention to up-grading and refining methods of medium grade bentonites in order to extract and sell both types of bentonites jointly and to extend the life of high grade bentonites.

b. Perlite.

Greece is the third world producer of perlite and is first among exporting countries. The best reserves of perlite are located in Milos Island, Kos, Lesvos and Antiparos. They occur in two different faces, as hard solid rocks, which are mined by explosives or broken rocks into pieces of the size in centimeters, which can be mined by excavators directly.

There are several mining companies, dealing with the extraction of perlite. The most powerful and developed company is the Silver and Baryte Ores Mining Company, which operates several mines in Milos. This company has also the well equipped grinding and sizing plant so it sells dried and grained perlite in the following grain size compositions

2.5 up to 0.8 mm
1.2 up to 0.6 mm
0.6 up to 0.3 mm
0.3 up to 0.075 mm

The dust of perlite, resulting from grinding and screening in the amount of 5 - 7 Tons per hour, is being wasted to the sea. However, attemps are made to commercialize also the dust perlite as the flux for ceramic industry or as the extender for the cement production as the Greek perlite shows hydraulic activities similar to those of pozzolana.

High quality of Greek perlite results into the high coefficient of expansion, which amounts to 20 and high purity with

a low content of colouring oxides.

Smaller amount of granulated and sized perlite is expanded in a plant in Athens, the majority is exported without expansion.

In order to promote the perlite industry in Greece, the following technologies are recommended to be considered for the further development of non-metallic industries.

1. Production of hydrophobic expanded perlite, which is a suitable material for water purification and filtration for the protection of different cables against underground corrosive waters.
2. Continue with hydropnic trials, based on perlite utilization. However, test the possibility to enrich expanded perlite with bentonites, peat or other humus matters.
3. Following the market requirements, develop the manufacture of products, based on the application of expanded perlite as the entering raw material into the blends. Such products are blocks of perlite bound with different fibres, insulating low temperature, medium and refractory bricks, different insulating non-shaped masses etc.

c. Kaolins.

Kaolins of Greece mostly are represented by residual rocks, which were transformed to the mineral kaolinite either by weathering or by hydrothermal activity.

Kaolins occur in Greece in several localities, of which the most important are Skala Messotopou, Petri, Argenos and Ralaki.

Greece is not a large producer in world terms and nor does it produce the top quality materials used in the paper or other types of industries. However, Greece produces a number of grades of kaolins which find important application in the ceramic and refractory industry, in white cement and in the industrial fillers production. Because of very high brightness of selected kaolins, reaching up to 80 - 85 grades with the blue filter, the paper industry started to use local kaolins as the filling grade.

High abrasivity of refined kaolins is claimed by paper factories.

To lower the abrasivity of local kaolins, the separation of undesirable minerals from kaolinite by washing was negotiated. Tests were negotiated to determine the grain size of quartz and residual feldspar in the raw kaolin and to verify the possibility to wash out the pure kaolinite from the raw ore from the kaolin deposits of MILOS and LESVOS. Chemical analyses from both types of kaolins indicate very high content of kaolinite in the raw kaolin, exceeding in major cases 70% from total, and low content of colouring oxides. Because of very low content of alcali oxides those kaolins will show high refractoriness.

However, the most economic exploitation of Greek kaolins would as the coating grade for the paper industry, providing their abrasivity will be lowered, requested grain size will be achieved and good whiteness will be maintained.

d. Feldspar.

Until recently Greece imported nearly all its feldspar requirements. In 1986, two new feldspar mining and processing plants entered the production. Both plants are located in the northern Greece and interestingly one plant produces high soda feldspar meanwhile the other one high potassium feldspar.

However, they are other interesting feldspar deposits in Greece. The deposit in Kato Potamia near Thessaloniki was used for the production of aggregates for roads construction and as a building material. Chemical analyses of this feldspar show very low content of colouring oxides. Meanwhile titanium dioxides is below 0.06%, iron oxides reach their minimum by 0.36%. Recalculated mineralogical composition of the Kato Potamia feldspar shows that aside 50% to 60% of pure feldspar, 35 to 45% of quartz are represented in the raw ore.

Such a feldspar always can be use as a valuable raw material - as a feldspar-siliceous mixture for the glass making industry, after being ground to the requested grain size.

Semi-industrial tests with Kao Potamia feldspars were recommended to be conducted with the glass sector of Greece.

e. Silica.

Greece productio of silica covers only a part of different types of quartz and silica snads, required by local industry. TAking into consideration different purities of locally available siliceous materials it is seen that low purity siliceous sand and aggregates as raw materials for the building industry are locally produced and their production covers the market. There are also existing siliceous raw materials in Greece, which are applied in local ceramic manufactures. However, siliceous sands and quartz raw materials with a high purity, required by the production glass, cristal glass or other so called electronic grades or sands for foundries are not produced locally and all of them are to be imported.

This is the reason why IGME is deeply interested in the development of local silica mines and industries. Analyses from two localities were studied, i. e.

quartzites form Analipsi, and
sands from Krios and Dikea

Quartzites form Analipsi show lower content of iron oxide between 0.36% and 0.52%, meanwhile titanium dioxide content is below 0.11% from total. According to the silica content (above 92% in average), the pure quartz content in the raw ore is higher than 80% from total. Such a raw material can be always used in tne ceramic manufacture and it is worthy to consider the up-grading and refining of quartzities from Analipsi in order to reach the purity required by the glass and cristal glass manufacture.

Sands from Krios and Dikea show higher content of iron oxides, exceeding 1% from total. Since they contain 5% to 10% of clay minerals, it is recommended to conduct semi-industrial tests on their up-grading for the utilization in the foundry industries.

f. Mineral Technology Department of IGME

Mineral Technology Department of IGME is an important department for testing, up-grading and refining research of different metallic as well as non-metallic raw materials. It is managed by Dr. Martha Grossou - Valta, Director.

Early 1987, IGME finished new buildings for its Mineral Technology Department in the Eastern part of Athens. The upper part of the department has been furnished for applied and basic researching, the down part is being prepared as the Pilot plant for the verification of research results. The department has 32 people, composed from scientists, laboratory technicians and necessary small amount of workers.

The department has been, until now, more oriented for metallic industrial minerals researching, such as lead,zinc and others. Interesting results are obtained by the biological transformation of copper ores in the underground extraction. The application of biological methods for the purification of non-metallics has not yet been searched. Different methods are applied during the research on purification and up-grading, such as dry electrostatic and electromagnetic separation, high intensity dry and wet electromagnetic separation, flotation, determination of whiteness, plasticity and thermal expansion, making microscope research, chemical analyses, cyclosizing particles between 60 to 5 microns, screening, separation of fractions of particles with hydrocyclons, expansion of non-metallics during the heat treatment, drying and calcining of different raw materials etc. The preparation of samples is done separately by crushing, milling and sieving. At present, the pilot plant is oriented for up-grading and enriching of different sulfites ores.

The structure of apparatusses and machinery of the Mineral TEchnology Department is very flexible, enabling the researchers to utilize them mostly on both ways, i. e. for metallic as well as for non-metallic raw materials. However, for the integrated exploitation of non-metallics,

the following recommendations are to be taken into considerations

1. Additional equipment to be installed step by step, such as cold and hot presses, both hydraulic and isostatic ones, high temperature kilns with standard as well as regulated atmospheres, installation for the classification of particles below 5 microns, for chemical treatment and purification of raw as well as calcined non-metallics, apparatusses for high temperature thermal expansion determination, for the coefficient of thermal conductivity, casting properties determination, abrasivity of non-metallics etc.

   The priority of additional equipment to be established according to the situation in the market, i. e. according to the actual duties to be conducted by the MIneral Technology Department.

2. Stabilization of local technical staff which will lead to higher skill

   Mineral Technology Department of IGME is a well equipped body as having apparatusses, new buildings, consultant and scientific laboratory officers and engineering. Therefore, this department is a good basis for the establishment of an advisory centre closely connected with the needs of industrial minerals industries.

g. Ceramic and Refractory Company Athens (CERECO)

The Ceramic and Refractory Company, Athens was founded in April 1987 by the Ministry of Research and TEchnology of Greece. The Government of Greece is the main share holder, meanwhile the minor part of shares is purchased by other 16 Greek companies, which are present and future customers of CERECO.

The reason for the establishing of CERECO is the reality that the universities and research institutions closed to universities deal with the basic research meanwhile the factories research is relatively on a low level. Therefore, the need of an applied research in the ceramic and refractory industries was settled by CERECO, which jointly will support the industrial development in Greece, will extend different services first to the Greek ceramic and refractory industry, than to other non-metallic industries, will transfer the technology, conduct quality control, contribute to testing of raw materials as well as finished products, co-operate on the elaboration of technical standards etc.

Good co-operation between CERECO and IGME was established during the UNIDO expert's mission to Greece. IGME will elaborate the non-metallic raw materials inventory for CERECO, will enable CERECO to conduct different tests and to utilize different apparatusses of Mineral TEchnology Department of IGME. CERECO will conduct a survey on existing ceramic and refractory factories in Greece, will identify actual and future needs of traditional as well as non-traditional non-metallic raw materials as the valuable information for the further management of geological research in Greece.

Dr. C. J. Stournaras was appointed as the General Manager of CERECO. He is very well aware of the hard developing period of CERECO. Therefore, he is studying the possibility to develop also external co-operation with different foreign institutes, specialized on the fields, needed by CERECO.

h. KYRIAKOPOULOS - ILIOPOULOS Concern, Athens

Kyriakopoulos - Iliopoulos Concern in Athens is a very powerful concern, which groups several companies, such as Silver and Byryte Ores Mining Company, Bauxite Parnas Company, Vehicles Import Company and others. Before the concern was born, the Kyriakopoulos Company was dealing mostly with bauxites, meanwhile Iliopoulos Company with perlites, bentonites and kaolins.

This concern has a perlite expanding plant in Athens, which produces different types of expanded perlites for both agriculture application - called Perloflor and as insulating agent - called Perlomin. This plant covers completely the need of the middle and southern part of Greece.

The granulated and screened perlite is supplied from the company's plant in Milos. Two expanding units are installed in the factory. The prlite expanding temperature fluctuates around 900°C. The expanede perlite is verry good, reaching its volume weight according to different grain sizes between 45 kg up to 120 kg per meter cubic.

The concern has very well equipped central laboratory in Athens, which conducts all necessary tests for testing and researching, such as X-Ray, different types of chemical, physical and mineralogical analyses and the expansion test.

IV. FINAL NOTE

The UNIDO experts mission DP/GRE/86/008/11-03 to Greece was successful. It realized the technical assistance to the Insititute of Geology and Mineral Exploration for the development of non-metallic industrial minerals in Greece.

The success of the mission was due to very well prepared briefing in UNIDO Headquarters and due to extraordinary support from IGME during the field missions and for a very well prepared work programme.

Further co-operation between IGME, UNIDO and UNIDO-Czechoslovakia Joint Programme in Pilsen can be expected in testing of non-metallic raw materials, new technology development, feasibility studies, evaluation by computers and geothermal energy with low enthalpy exploitation in different activities.