OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

16546

RESTRICTED JUNE 1987

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 - 01/J 13419
DP/GRE/86/008/11 - 02/J 13419
DP/GRE/86/008/11 - 04/J 13419

D r a f t

T e r m i n a l R e p o r t

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

Miloš Kužvart
Zdeněk Štěpánek
Petr Duchek

Unido Technical Assistance Experts

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Vienna

ACKNOWLEDGEMENT

The UNIDO experts would like to express that the success of theri mission was possible due to very well conducted preparatory activities and supports of UNIDO Headquarters in Vienna and the UNEP office in Athens.

The representative of Institute of Geology and Mineral Exploration in Athens extended to the experts all help in arranging high level meetings, collection of necessary data, field trips, counterpart assistance and secretarial facilities needed for successful implementation of missions.

Thanks for help and assistance belong to Mr. Dr. C.T. Papavassiliou, Geolcgist, BSc., PhD., F:G:S. - Lecturer, University of Athens, Director General of IGME, and to representatives of IGME Divisions, Branches and Departments as follows:

Mr. P. Antoniadis, Chief of the Section for Economic Geology

Mr. G. Kanaris, Geologist - Head of Department of Industrial Minerals

Mr. D. G. Kosharis, Geologist, whom special thanks belong for his enormous effort in organizing and co-ordinating the whole geological and technological expedition,

Department of Technical and Feasibility Studies of IGME in Athens,

Mrs. E. Constantinidou-Hagiou, Mining Engineer

Miss V. Pefani, Mining Engineer

Department of Mineralogy and Petrography of Laboratory Division of IGME in Athens

Miss S. Karantassi, Petrologist

Division of Laboratories of IGME in Athens

Mrs. M. Grossou-Valta, Mining Engineer-Metallurgist DIC, MSc., Director of Division

Department of Mineral Processing of Laboratory Division of IGME in Athens

Mr. N. Kaklamanins, Mining Engineer

Mrs. F. Chalkiopoulou, Mining Engineer

Ms. V. Agelatou, Chemical Engineer

Mr. V. Pontolos, Mining Engineer

Branch of IGME in Salonica

Mr. P. Tsamantouridis, Ph.D. Economic Geologist, Head of IGME Branch

Mr. Ch. Krawas, Geologist - Department of Industrial Minerals

Mr. P. Minopoulos, Technologist - Department of Industrial Minerals

Branch of IGME in Xanthi

Mr. Dr. P. Papadopoulos, Head of IGME Branch

Mr. J. Marantos, Geologist - Department of Industrial Minerals

Mr. S. Zachos, Geologist

Other Institutions

Prof. J. C. Drakopoulos, Head of Seismological Department, University of Athens

Mr. Ch. G. Gyras, Director of Silver and Baryte Ores Mining Co´s, Exploitation Department on Milos

Mr. S. D. Porphyris, Chief Chemist, R and D Manager, Silver and Baryte Ores Mining Co.

ABSTRACT

Selected industrial deposit in Greece - kaolin, feldspar, quartz, clays, zeolites, bentonites, perlite, silica and illite were studied in the field. Deposits of kaolin, metarhyolite and gravel sand were sampled by 100 kg each from the point of view of promising reserves and quality for semi-industrial tests. Small samples for laboratory testing were taken from all deposits. Concerning further industrial exploitation of Greek non-metallic raw materials especially of kaolin, quartz and feldspar in ceramic and glass industries, the unambiguous need for the kaolin processing plant establishment has been recommended. Production of feldspar and quartz is ensured by several companies in Greece and therefore there is no urgent need for erecting other up-grading plants. In case of zeolites and mainly bentonites, possibilities of non-traditional applications have been evaluated and proposed. Exploitation of lower-grade bentonites from Milos island would be especially prosperous for these purposes.

TABLE OF CONTENTS

I. INTRODUCTION

Within the framework of the UNIDO Project DP/GRE/86/008 Technical Assistance to Institute of Geological and Mineral Exploration (IGME) for the Development of Non-metallic Industrial Minerals in Greece, three UNIDO experts, Messrs. M. Kužvart, Z. Štěpánek and P. Duchek were appointed as Consultants with the duration of the mission of one month (Messrs Z. Štěpánek and P. Duchek) and two months (Mr. M. Kužvart). The experts were attached to IGME to assist in the effort of substituting imported non-metallics with locally existing ones and their application in known as well as non-traditional sectors of industry and agriculture.

The activity of consultants was outlined in their Job Descriptions DP/GRE/86/008/11-01, 11-02, 11-04/D 134119 which are attached as Annex 1. The main duties were specified as follows:

1) To review existing geological, technological and economic data related to various areas in Greece favoured with the existence of selected industrial minerals

2) To visit selected areas of interest, to select and prepare samples.

3) To propose applications of traditional and new processing methods for different uses of products.

4) To possess economy on the possibility of industrial exploitation and production of new products from known industrial minerals.

5) To train the IGME personnel

6) To submit a report containing major observations, findings and recommendations.

Although Greece is favoured by the existence of a wide variety of non-metallics (marble, bentonite, magnesite, perlite, pumice etc.) some of important raw materials are imported either partially or fully to cover local demands of various industrial sectors.

From the point of view of non-metallic raw materials monitored within this project, only kaolin exhibits a higher share of consumption over production the difference being ensured by imports. The Greek production itself covers about 30% of the total kaolin demand and 60 - 100,000 tpa should be imported. Quartz and feldspar economic data are not mapped to such an extend as for kaolin, it can be supposed that relatively big processing plants of MEVIOR S.A. and PORCEL are able to saturate market demands of Greece to a certain extent. The quality of quartz and feldspar as being advertised is high enough to meet requirements of different industrial sectors. Owing to the fact that new producers MEVIOR S.A. and PORCEL are focusing on extraction, crushing, grinding and drying of quartz, feldspar, wollastonite, mica, dolomite and limestone, the topic of local kaolin production seems to be very important from the point of view of anti-imports regulations.

During the field activity of UNIDO experts, several localities of the most important non-metallics were visited, evaluated and sampled. Twenty point samples as well as 300 kg of large scale samples will be thoroughly analyzed in frame of this Project aiming at further orientation of geological survey and proposal of industrial up-grading and applicability of products.

Localities which were large-scale sampled represent further reserves of kaolin (Skala Messotopou-Lesvos island), feldspar (Kato Potamia) and sand (Haniotis). Concerning bentonites found on the Milos island, they represent the raw material of top quality being controlled by several mining companies of which, Silver and Baryte Ores Mining Co. is the biggest one. However, some bentonites of lower content of montmorillonite being also found on Milos exhibit depresion in extraction due to marketing difficulties. For this type of material, special activations by common inorganic salts aiming at new products utilizable mostly as flocculating agents suitable for wastewater purification will be advantageous. It will result not only in a better exploitation of bentonite reserves and enhancing of extraction in quarries opened earlier but also in contributing significantly to environmental protection in Greece. Natural zeolites are another example of non-metallic industrial mineral with plenty uses. Its outstanding sorption and ion-exchange properties are inter alia widely utilized in environmental engineering for removal of ammonia from wastewaters. The reserves of natural zeolites in the north-eastern Greece are big enough to be exploited in classic and non-traditional spheres.

As the fielding of UNIDO experts was performed in June-July, 1987 with many duties carried out jointly, it was decided by UNIDO Headquarters, Vienna, to prepare one joint terminal report covering all activities executed. In the report, the authors contributed as follows:

Mr. P. Duchek	- Chapters I, II, III, - 1,2,4,5 IV, V, VI making the frame of report (without formal editing)
Mr. M. Kuzvart	- Chapters I, II, III, - 1., IV, V, VI
Mr. Z. Stepanek	- Chapters I, II, III - 1., 2., 3., 5., IV, V, VI.

The scheme of UNIDO experts´field activity is attached in Annex 19.

II. FINDINGS AND RECOMMENDATIONS

1. The Institute of Geological and Mineral Exploration (IGME) represents a highly experienced centre with profesionally skilled personnel for conducting geological, geophysical and geochemical exploration, metallics and non-metallics research and testing of raw materials under interest.

2. The laboratories of IGME are very well equipped for conducting testing and researching of different problems of metallic and non-metallic raw materials.

3. The main areas of mineral occurence have been identified by IGME:

Macedonia -	silica sand, feldspar, quartz, olivinite (dunite)and dolomite
Thrace -	silica sand, feldspar, zeolite,
Western Greece and Ionian Islands -	gypsum
Crete -	gypsum
Milos Island -	perlite, kaolin, bentonite, silica, pozzolana
Central Greece and Euboea -	bauxite, magnezite, dolomite,
Northern Greece -	asbestos, chromite, magnezite
Lesvos Island -	kaolin
Nisyros and Yali Islands -	pumice

4. In some instances the exploration (and later possible exploitation) of non-metallic mineral resources is blocked due to negative attitude of the landowner. On the other hand, law is more favourable to the metallic ores, which might be explored and mined under certain conditions also on private land for the benefit of the landowner and the Republic. Legal reform which will put non-metals and metals on the same level, will boost the utilization of non-metallics substantially. Building raw materials (sand, gravel,

brick loam, stone for aggregate) should not be included to this reform.

5. The results of systematic documentation of occassional cuttings of roads, channels a. o. might be important for future geological research, when the cuttings will no more be accessible. This task can be done by the regional geologist, and documentation (in the scale 1:20 or 1:50) with legend and explanatory text should be collected in an archive.

The same should be valid for all borings done for other then purely exploratory purposes (e.g. hydrogeological borings).

6. The quality of research reports (geological, petrographical, mineralogical, technological, hydrogeological a. o.) will gain, if they will be subject to reviewing by a specialist from IGME or any other institution. Reviewer´s report and author´s attitude and replies to the rebukes should be taken into consideration by a committee of IGME nominated by the Director General. This committee should be responsible for the designation of reviewers.

7. During the mission of UNIDO experts, following deposits of non-metallic raw materials were visited together with selected IGME´s staff:

Macedonia -	feldspar, quartz (Assiros, Kilkis, Argiroupoli, Kolhiko, Analipsi)
Halkidiki -	red clay, granite, sand (Simandra, Sithonia, Haniotis)
Thrace -	feldspar, quartz, silica sand, zeolite (Krikos, Dikea, Tolos, Feres)
Lesvos Island -	kaolin
Milos Island -	bentonite, perlite, kaolin, illite, silica

8. Following the Job Descriptions, briefing at the UNIDO Headquarters as well as discussions with IGME counterpart in Greece several studies were conducted with following recommendations:

a) Of all kaolin, feldspar and quartz deposits studied in the field, three were chosen for further investigation: Skala

Messotopou (Lesvos Island - kaolin), Kato Potamia (feldspar) and Haniotis (quartz raw material)

These deposits have sufficient reserves, their dressability is promising, mining conditions favourable, transport conditions plausible, and no prohibitive environmental problems are anticipated. All other deposits are either small, or have low quality, their dressing would be too expensive, they are remote from motorable roads or deep-sea ports, or are already mined by a mining company.

b) To arrange for raw material model testing:

1) Kaolin

100 kg of raw kaolin, Skala Messotopou Tavari (together 5 samples of 20 kg each from different spots of locality)

2) Feldspar

100 kg of raw feldspar, Kato Potamia (together 5 samples of 20 kg each, KP1 - KP5, from different spots of locality)

3) Sand

60 kg of arkose sand, Haniotis (together 4 samples of 15 kg each, 1-4, from different spots of locality)

In case of positive proved results of model tests, further pilot-plant tests demanding 1-5 t of raw material should be performed. Further on, high exploratory workings (trenches and shallow borings) proposed in the report, aimed at the assessment of reserves sufficient for 20-30 years of exploitation, should start immediately afterwards. The positive result of the whole geological and technological study will be the reduction of imports of kaolin, feldspar and quartz, as postulated by the Background Information in the Job Description.

c) To arrange for raw material laboratory testing:

1) 2 kg of kaolin, Skala Messotopou Spiglia, 2 samples of 1 kg each

2) 2 kg of kaolin, Skala Messotopou, 2 samples of 1 kg each

3) 28 kg of zeolite, Metaxades (7 kg of fine-grained, 9 kg of

middle-grained, 12 kg of coarse-grained)

4) 12.5 kg of metaarkose, Analipsi (5 samples of 2.5 kg each)

5) 2 kg of zeolite, Ferres

6) 1 kg of white material Skoutaros (2 samples of 0.5 kg each)

7) 0.5 kg of kaolin, Petra

8) 5 kg of illite, Kumaria (Milos Island)

9) 1.5 kg of bentonite, Milos Island (3 samples of 0.5 kg each)

The laboratory testing will evaluate the quality, possible sectors of utilization and will focuse the attention to a detailed geological prospection.

9. Some deposits of feldspar and quartz are industrially exploited, e. g. by MEVIOR S. A. Company in Assiros region and by PORCEL company in Tholos region. There is also a private etracting without detailed data on amount and quality. Exploitation of feldspar and quartz has been monitored since 1978. The production covers Greek demands, however the principal producers aim is exporting of quartz and feldspar.

10. Statistical data obtained from IGME are reflecting a long tradition in extraction, processing and export of kaolin in Greece. Despite of this fact, about 60 - 100,000 tpa of kaolin should be imported from abroad.

11. To diminish imports of kaolin, an extension of processing plant for kaolin on Lesvos Island should be considered as perspective. For preparation of feasibility study of this investment proposal, following should be done:

- to test on a model scale 100 kg of the raw material and prove the efficiency of up-grading and quality of the product;
- to carry out pilot-plant testing with 1-5 ton sample resulting in data for feasibility study
- to prove quantity of utilizable reserves on the basis of pilot testing results (by geological prospecting)

12. Lower-quality grades of bentonite from Milos Island (deposit Komia - property of Silver and Baryte Ores Mining Co.) can be utilized after special activation for purification of wastewaters and sludge treatment. The company is deeply interested in this matter having all necessary presuppositions for introducing the manufacture.

13. Lower-quality grades of bentonite from Milos Island will be also suitable for agricultural purposes (soil reclamation, animal breeding). This application does not need any special processing of bentonite, only crushing or coarse grinding.

14. Perlite production is highly developed in Greece amounting about 21% of the world total production. The applications are comprising both traditional and modern sectors from which horticultural use is of the greatest extent. Silver Baryte Ores Mining Co. is performing an extensive own research on this field.

15. Zeolite which is abundant in the northern Greece but not sophistically exploited, should be tested concerning inter alia its ion-exchanging and sorption properties. Its application despite of lower content of clinoptilolite could involve fields of catalysis, wastewater treatment, sorption of harmful gases and agriculture.

16. IGME research and scientific staff expressed its interest in non-traditional processing and applications of nonmetallics and bentonite in particular. Concerning special activations of bentonite and its application in environmental sphere, technology of testing was suggested.

17. All objectives of the mission were fulfilled thanks to well-prepared preliminary phase and briefing by the UNIDO Headquarters Vienna, support from UNEP Athens and the active participation and co-operation of IGME.

III. SUBSTANTIVE SECTION

1. Deposits of non-metallic raw materials

According to the Project of the Technical Assistance to IGME for the Development of Non-metallic Industrial Minerals in Greece No GRE/86/008/A/01/37 (dated in December 1986), page 2, clay (kaolin) feldspar and quartz sand were chosen as main objects of the investigation.

The aim of the field and archive study was to assess deposits with sufficient reserves (for 20-30 years of exploitation) and adequate quality. The deposits should be also free for subsequent exploitation, i. e. unclaimed by any private company. Positive results of qualitative study and - in some cases - exploration results will tend to diminish or eliminate imports of the given raw materials, or to open new ways of utilization of materials in question.

Bentonite and zeolite were also evaluated and sampled concerning possible non-traditional applications of these industrial minerals mainly in environmental engineering. Special inexpensive modifications of lower-quality bentonites would be advantageous to enhance its use value.

Fourteen deposits were studied and sampled in the field, and from those most promising from the point of view of quality and reserves samples of 100 kg weight were taken.

1.1 Metaarcose (Annex 1)

The deposit is located about 25 km to ENE of Salonica, near Kolnikon - Analipsi - Drakondium sites.

This rock occurs in the Examili formation of the Serbo-Macedonian zone. The rock in question is of Permian age and is developed in a stripe several hundred meters wide and several kilometers long.

According to chemical analyses some parts of this material should be quite pure silica (average of four samples: 96.5 - 98.8 SiO_2, 0.1 - 0.9% Fe_2O_3 (1), but the study in the field revealed that the mass of the deposit contains substantial amount of feldspar and/or chlorite and sericite. Segregation quartz is present in veinlets and lenses (thickness in cm to dm).

Five samples, each about 2 kg in weight were taken from this rock in the valley close to the east of the village Analipsi: three of them near the valley bottom, 20 m apart, another about 100 m above the valley bottom, and the last sample 200 m above the valley bottom close to a quartz vein about 6 m thick. As quartz material this rock is not usable, being most probably (as will the analyses of the five samples show) high in alkalies.

Conclusion: As a source of feldspar it is of lower quality (especially due to higher content of iron bound to chlorite) if compared with other sampled materials (e.g. metarhyolite Kato Potamia).

1.2 Red clay (Annex 1)

The locality is found in the Northern Greece on Halkidiki Peninsula some 10 km to the west of Poligiros, near the site of Simandra. The deposit Agios Panteleimon is composed of continental red sandy clays, sands with plastic clay and siltstone intercalations (Upper Miocene - Pliocene) covered on the surface with travertine hardpan. The raw material is quarried and used for production of bricks and roofing tiles.

IGME elaborated the geological-technological study (2) in which qualitative parameters based on a detailed study of this region is given (Tables I, II). The clay contains chlorite, montmorillonite, quartz, feldspar, dolomite and mica. The fraction below 0.063 mm contains 4-5% of $Na_2O + K_2O$ and 16.15 to 19.60% Al_2O_3. The extent of this formation is about 200 km^2.

Geological reserves proved reach about 1 million m^3 of the clay (2 million tons) but they are supposed to be higher and very perspective. For production purposes about 12,000 tpa is won and processed in the near brick factory.

Conclusion: Besides the on-going exploitation, the raw material has been tested for pottery and ornamental glazed products with hopeful results (2). It is very probable that this clay can also be used for ceiling blocks, drainage pipes as well as for floor tiles with coloured body and thus the production amount could be elevated.

Table I. Characterization of red clay from Agios Panteleimon deposit [x]

Component	Chemical analysis in wt. %		
SiO_2	58.20 - 80.80	63.60	54.00
Al_2O_3	6.81 - 15.84	14.72	19.60
TiO_2	0.19 - 1.60	1.48	0.67
Fe_2O_3	2.01 - 7.36	5.75	6.15
CaO	0.87 - 7.04	1.61	1.12
MgO	0.62 - 7.35	1.85	2.32
K_2O	1.00 - 3.46	2.91	3.40
Na_2O	1.16 - 2.82	2.36	1.48
SO_3	0.07 - 0.18	-	-
L.O.I.	1.52 - 10.98	5.46	10.50
	samples 1-32	average sample	fraction below 63 μm

[x] Source: Ref. 2

X-Ray found minerals: Kaolinite
Montmorillonite
Chlorite
Mica
Dolomite
Quartz
Feldspar

Table II. Selected technological properties of the red clay (Agios Panteleimon locality)

pH	8.10 - 9.47
water absorption (firing at 1150°C)	12 - 14%
mixing water	23 - 30 ml/1 cm^3
colour of fired body (1150°C)	red

1.3 Granite (Annex 1)

Granodiorite eluvium is located in the northern Greece (Halkidiki) on the Sitonia peninsula, about 8 km to the north-east of Neos Marmaras.

Schistose biotite and two-mica granodiorite with occasional inclusions of diorite, and with aplite, pegmatite, and quartz veins on the Sitonia peninsula weathered mechanically to a depth up to approx. 8 m. The weathering was made easier by parallel structure of the rocks giving them an apearance of gneisses. The fracture zones were the cause of greater thickness of the weathering crust. Products of weathering which are easily to eroded by running water were preserved in the relatively even parts of the backbone of the peninsula. The age of weathering was probably Upper Miocene - Pleistocene.

Three areas close to the axis of the penninsula were explored by shafts down to 13 m depth. Area No. 2 (Dragudeli) which was explored by shafts in a grid of 200 m, is situated in the central part of the peninsula between Neos Marmaras and Sarti being connected with the former town by a rough forest motorable road about 10 km long overcoming an elevation of 600 m. The raw material has the grain between 3.0 - 3.5 mm and contains 60 to 70% of both feldspars, 20% of quartz, the rest are micas and accessories. Chemical composition of raw materials from areas No. II and III are given in Table III:

Table III Chemical analyses of granite from Sithonia peninsula

Component	Content (% wt.)	
	Area No. II[a]	Area No. III[b]
SiO_2	72.57	67.11
Al_2O_3	15.09	16.17
Fe_2O_3	0.98	2.07
TiO_2	0.15	0.06
MgO	0.15	1.25
CaO	1.26	3.19
Na_2O	3.64	4.28
K_2O	3.14	2.11
L.O.I.	1.72	2.00

[a] Ref. 3, [b] Ref. 4 (Samples of the grain size 1 mm).

The raw material war submitted for dressing by combination of flotation and magnetic separation methods (3.5) with following effect:

40.7% - yield of Fe-bearing minerals concentrate (content of Fe_2O_3 4.68%)

40.0% - yield of feldspathic concentrate

19.3% - yield of silica sand

The chemical composition of both utilizable concentrates is evident from Table IV:

Table IV. Chemical analyses of products of granite up-grading

Component	content (% wt.) in concentrate	
	feldspathic	quartz
SiO_2	56.60	90.50
Al_2O_3	20.20	5.00
Fe_2O_3	0.25	0.09
CaO	3.46	0.83
K_2O	2.90	1.22
Na_2O	6.59	2.01
$K_2O + Na_2O$	9.49	3.23

Conclusion: To reach quality of both products listed which are suitable for production of first-grade glass and ceramics, a considerably very costly up-grading technology should be applied. This would be transport-demanding and probably harmful for environment in the tourist very important site of Sithonia. On the other hand, transportation of raw material to the processing plant apart from this site would be impacting negatively on the economy of new establishment.

That is why this raw material is recommended to be considered as a reserve for potential future up-grading by grain classifying and dry magnetic separation yielding semi-processed materials with different share of feldspar and quartz according to proposed example:

1. raw material fraction +5 mm: to crush for fraction 0.01-0.6 mm (for magnetic separation), fraction less than 0.1 mm to mix with fraction 3.

2. raw material fraction 5-0.1 mm: to crush for fraction 0.1-0.6 mm (for magnetic separation), fraction less than 0.1 mm to mix with fraction 3.

3. raw material fraction -0.1 mm: semi-processed material for construction ceramics

1.4 Feldspar

This chapter comprises three types of raw materials: compact rocks, as rhyolite of Lower-Triassic age, metamorphosed during the alpine orogenesis, metamorphosed arcose (Palaeozoic), then loose uncemented rocks as gravel-sands (Upper Miocene - Pliocene - Haniotis, orPliocene to Pleistocene - Spileo, Dikea) and granodiorite eluvia (derived by weathering during the Neogene and Quaternary).

a) The Metarhyolite (Kato Potania deposit)-Annex 1

The first deposit is situated 10 km to the east of Kilkis (Macedonia) being formed of metarhyolite in a zone 70 km x 9 to 20 km as a part of the Serbo-Macedonian zone. It was upgraded by hydrothermal leaching in a zone trending NEN-SWS 1000 x 800 m (the deposit proper), where the content of Fe_2O_3 present in chlorite and limonite, rarely in pyrite, was lowered to 0.2 - 0.3% in the grain size more than 0.1 mm in diameter. The fraction 0.1 - 0.6 mm contains highest amount of alkalies - K_2O up to 9% (Na_2O is present in low amounts). It is the proper useful substance of the deposit.

The up-graded (leached) metarhyolite is a white schistose medium-grained rock composed mostly of quartz and feldspar with veins of younger (undeformed) pegmatite several ten of centimeters thick with feldspar crystals around 2 x 4 cm and with platelets of mica. The hydrothermal activity made itself perceptible also by the origin of thin (tens of cm) baryte veins at the margins of the altered zone.

The deposit is the property of the village and is quarried for the road-building purposes. The quarry face is about 50 m long and 8 m high. It was sampled by five

Table V Chemical analyses of Kato Potamia metarhyolite

Component	Content (% wt.)							
SiO_2	75.50	76.00	74.00	76.00	75.50	77.50	75.00	77.50
Al_2O_3	11.80	11.80	13.10	11.80	12.00	11.00	12.35	11.40
Fe_2O_3	1.86	1.39	0.85	0.57	1.43	0.57	0.57	0.71
CaO	0.63	0.52	0.42	0.53	0.74	0.45	0.43	0.52
MgO	0.16	0.33	0.33	0.16	0.33	0.33	0.16	0.50
Na_2O	0.54	1.48	0.13	0.67	0.54	0.67	0.94	3.77
K_2O	8.43	7.70	9.51	9.00	8.20	8.20	9.51	3.97
L.O.I.	0.83	0.79	1.40	0.77	1.05	0.65	0.40	1.12
	KP 1	KP 2	KP 3	KP 4	KP 5	KP 6a	KP 6b	KP 7

samples (20 kg each) taken in horizontal channels which run perpendicular to the (vertical) foliation of metarhyolite, in following way: (Annex 5) sample No. 1 was taken near the NW edge of the quarry face, sample No. 5 was taken near the SE edge of the quarry face. The distances between the samples (and their colours) were: No. 1 (white) - 15 m, No. 2 (white) - 10 m, No. 3 (yellow) - 10 m, No. 4 (white) - 15 m, No. 5 -(grey). The rock between the samples No. 2 and 3 contains chlorite and sericite. The yellowish rock from the sample channel No. 3 was sampled once more by a sample of 2 kg weight. Pegmatite, which is outcropping in sample channel No. 1 was also sampled by a small sample for petrographic study. IGME explored this deposit by 5 trenches up to 130 m long. The analytical data of the raw material found by IGME are given in Table V.

All data on the deposit show that its greatest part is hidden in depth. Reserves of the deposit are sufficient (assumed amount about 10 million tons). Their verification will be possible by means of shallow drill-holes in a grid 50 x 50 m in the foreground of the quarry face (drilled to the elevation point of the base of the quarry), probably with combination of a small power shovel for digging shallow trenches.

The exploitation of the deposit can easily occur from the present quarry. The overburden can be stripped away by a buldozer. The transport conditions are not adverse. The area is far from tourist routes. No environmental problems are envisaged.

b) Pegmatite - potassium feldspar (Annex 1)

Pegmatites of this type are found about 5 km to the north of Paranestio (deposits Temenos, Tholos) located some 55 km to the north-west from Xanthi.

Feldspar (K > Na) in pegmatite veins (0.1 - 8 m thick and about 150 m long) and in pegmatite lenses (tens of meters thick and long) is a part of the Rhodope cristallin massif. This massif comprises a unique concentration of pegmatites in Europe. The wall rock of pegmatite is gneiss, granite or amfibolite, which is in some places outside the area in question accompanied by marbles and graphitic rocks. Parent rock of pegmatite - granite - is supposed to be at depth.

The veins contain up to 14.5% of alkalies, in most cases as K_2O only. On the other hand, the pegmatite lenses contain K - feldspar and Na-feldspar in a ratio 7:3, the content of alkalies being 11 - 13%, and of quartz 8%. This material contains biotite, almandine and spessartine, all iron-bearing minerals. After magnetic separation the content of Fe_2O_3 is 0.12 - 0.14% only.

Seven deposits in the area of Temenos, Tholos and Silli are prepared for exploitation, mostly the pegmatite lenses (reserves about 1 mil. tons). They are quarried in several benches opening the lenses (dipping under 30 - 35^{o} to E) along their strike. The irregular network of pegmatite veins and veinlets in gneiss, granite or aplite (which is not utilized) is blasted at large and feldspar lumps are then selected and hauled to up-grading. The overburden of pegmatites is negligible (tens of cm).

c) Pegmatite - sodium feldspar (Annex 2)

Sodium feldspar deposits are located about 10 km to the north from Soufli round the sites of Protoklisi and Korimonos. Protoklisi pegmatite veins with Na-feldspar and accessory tourmaline occur in amfibole schists. Their thickness is up to 20 m, as is the case of a vein exploited on an area about 30 x 40 m 2 km to the S of Protoklisi. The pegmatite contains 6.45% K_2O and 1.0% of Fe_2O_3. The quarried area is controlled.

Pegmatite veins with 50 m thick and 150 m long with Na-feldspar, muscovite (up to 4 cm thick books) and accessory tourmaline occur in amphibole schists between Korimvos and Metaxades. It contains 5.7% Na_2O, 1.3% K_2O and 1.2% Fe_2O_3. Feldspar grain size of pegmatites near Protoklisi and Korimvos is 1 - 10 cm. They are lacking the zonal structure usual in thick pegmatite bodies, and typical by its central zone with microcline crystals one meter or more in diameter. The Korimos deposit is exploited by the ELVIOR company.

Sodium and potassium feldspathic raw materials from deposits described above are brought into a processing plant which is based about 5 km from Paranestio site, very close to places of potassium feldspar occurence. The plant is owned by the PORCEL company and was put into operation just in time of UNIDO experts´ mission in June, 1987.

In the near future, other up-grading plants for processing pegmatites are considered seriously to be erected and located near far deposits of sodium feldspar occurence.

Conclusion: There are also other plants for processing feldspars in Greece of which the establishment near Salonica was visited. The plant is described in chapter 2 and produces also suitable feldspar grades for glass industry and ceramics.

As found from visiting deposits of feldspars and from information given, Greece can be self-sufficient in production of this indispensable mineral providing that there will be a reasonable ratio between export-import amounts.

1.5 Sands

According to ascertained data (6) Greek demand for silica sand is currently satisfied by imports predominantly from Belgium, Luxembourg, smaller imports being from Bulgaria, Spain and Yugoslavia reaching approximately 120,000 tons per year As the production of glass amounts to about 150,000 tpa (of which approximately 50% represents container glass, 35-40% flat glasses and 10-15% other forms of glass including glass wool) it is therefore in Greece´s interest to find a cost effective alteration source of silica sand.

a) Spilea - Dikea deposits near Greek-Bulgarian-Turkish joint border point (Annex 2)

Spilea fluvial gravel-sands of Pliocene - Pleistocene age are quarried for building purposes (subbase, road base) in a cutting 80 m long and 10 m high. The uppermost part of the deposit is very coarse grained pebble, which must be either dumped or crushed. Granitoids (granites, pegmatites), volcanic rocks and serpentinites are the most common rocks, composing the pebbles. Cross bedding is often. The deposit covers tens of square kilometers. It was sampled in the quarry face (sample Krios 1-10 kg). Sample Krios 2 from a probably antitank trench 100 m long and 4 m deep about 1.5 km W of Krios 1 was taken earlier and studied in Czechoslovakia. It has higher content of sandy fraction and thin intercalations of green clay.

The face of a sand pit 20 m long and 8 m high at the road Spileo-Dikea just above the valley bottom with cross-bedded fluvial gravel-sands was sampled (Dikea 1, 20 kg, vertical chanel sample 1.5 m long, between two beds with large pebbles, but without them). In one place of the face the bedding of sand is disturbed as if by cryoturbation (which might be the case provided that the Rhodope Mts. were glaciated 18 000 years ago or earlier). Disturbed beds are impregnated by limonite cementing the sands to such a degree that thin beds of sandstone originate. The overburden of gravel-sand is negligible - 0.1 to 0.2 m.

Conclusion: Results of model up-grading tests which have been carried out on this material show that it cannot be supposed as a source of glass and foundry sands. Some possibilities of application may be in ceramics but the detailed testing including evaluation of presence of minerals in separated fractions of the raw material is to be performed.

b) Haniotis on Kassandra Peninsula (Annex 1)

Almost the whole surface of Kassandra is covered by Pliocene-Pleistocene gravel-sands. The area for sampling (and future exploitation) was chosen near the central ridge of the peninsula about 250 m high 5 km to the SW of Haniotis. That is a guarantee that the tourist areas on both coasts of the peninsula will not be disturbed by the exploitation (but they will be troubled, unfortunately, by the transport of the raw material between Haniotis and Nea Fokea).

The deposit belongs to the cover of the Vardar tectonic and seismic zone. The Serbo-Macedonian massif was thrusted westward on Vardar zone, which was submerged to depth with the exception of small "islands" of rocks of mostly Jurassic age between the Cape Paliouri and Thessaloniki. The sedimentation basin formed as described was filled by debris of weathered near by rocks. In the area of Kassandra, fortunately, it was the Sitonia granite of the Serbo-Macedonian zone, and not carbonate rocks like elsewhere. Very young (Upper Pleistocene) tectonic movements in the Vardar zone heaved the gravel-sands by several hundreds of meters and formed the Kassandra peninsula and the deposit under study.

The deposit is built by subhorizontal beds of alternating quartz and feldspar gravels and sands with intercalations of pebbles 5-10 cm in diameter or beds of very hard sandstones about 10 cm thick. In some places cross bedding occurs. Gravel-sands were deposited in streams which often changed their course and velocity.

The content of feldspar is about 30% (the content of alkalies is 4-5%), quartz 70%. The ratio Na-feldspar/K feldspar changes from 1.2:1. The Fe_2O_3 content is about 1.5% (fraction above 2 mm 1.1%, fraction 0.25 - 2 mm about 2%, fraction less than 0.25 mm 4%). Fraction 0.08 - 0.5 mm after magnetic separation (20 000 Gauss) contains only 0.3-0.7% Fe_2O_3, but the crushing lasts 3 times longer than crushing of the disintegrated granite from Sithonia (see further), supposedly the parent rock of the gravel-sands on Kassandra.

Three vertical channel samples 1.5 - 2 m long, 25 kg each were taken along the road on the crest of the peninsula - No 1 being the southernmost and 200 m distant from No 2 and 300 m from No 3. Sample No 4 was taken 700 m to the NE and on an elevation about 70 m lower than samples No 1, 2, 3. This was done to verify the thickness and homogeneity of the deposit as well as the areal extent of the deposit. In the cross section of the sample No 3 there is an intercalation of hard sandstone 10 cm thick, in the channel sample No 4 is a clay lense about 70 cm thick and 140 cm long.

From the above description of the deposit follows that the raw material beneficiated by screening and magnetic separation may be the source of quartz-feldspar batch usable in the ceramic body. After crushing and flotation, quartz for glass industry and feldspar for the ceramic industry might be obtained. For all applications it should be kept in mind that Na- and K- feldspars present side by side in the raw material might complicate the usability. Their behaviour in the technological process should be thoroughly examined.

Conclusion: The locality is state-owned without any present significant extraction. Reserves of the deposit are large, even if only the area covered by samples 1, 2 and 3 is taken in consideration. This can be verified by one (hand-drill) borehole near the crest of the peninsula in the area of samples No 1, 2, 3 (to asses the thickness) and by a grid of exploratory cut-offs in the slopes of hills, probably by means of a small power shovel.

The mining conditions are good; the deposit can be exploited in an open pit (face quarry) with a power shovel. Transport and environmental problems were shortly discussed above.

1.6 Arkose (Annex 2)

This locality is situated about 40 km to the north from Xanthi, round Theotokato-Satres district, about 10 km from a motorable road in Satres. The path from Satres crosses two ridges about 250 m high each and is passable only on foot or on muleback taking about two hours.

Tilted or folded beds of fine-grained arkose with greenish tint (chlorite) are alternating with beds of coarse grained arkose passing to conglomerate. The whole sequence hundreds of meters thisk is Eocene (Priabonian) age and fills a small intermontane depression in the cristalline formations of theRhodope massif. In places it is covered by basaltoid andesite (Upper Eocene).

Arkoses found here were twice tested in the UNIDO-Czechoslovakia Joint Programme in Pilsen (3, 4). It was concluded that only applying of flotation and magnetic separation up-grading can lead to the applicable product (Table VI).

Table VI. Basic results of testing of arkoses from Theotokato-Satres locality [a]

Sample No	starting material		yield of fraction [b] (%)	product (%)			
	Fe_2O_3 (%)	TiO_2 (%)		Feldspath		Quartz	
				Fe_2O_3	TiO_2	Fe_2O_3	TiO_2
1.	2.59	0.49	26.1	0.26	0.16	0.92	0.10
2.	1.25	0.26	32.0	0.19	0.11	0.31	0.14
3.	3.98	0.78	29.6	1.04	0.39	1.83	0.47

[a] Source: Ref. 4, [b] Fraction 0.1 - 0.3 mm.

Conclusions: Taking into consideration the variable quality of arkoses from this locality, especially the high content of Fe_2O_3, necessity of relatively costly up-grading technologies as well as accessibility, transport difficulties and infrastructural conditions of this region, exploitation of this deposit does not seem to be perspective in the near future. That is why no samples were taken for testing and it is recommended to pay attention to quartz-feldspathic materials from other regions which are more suitable for processing from the techno-economic point of view.

1.7 Zeolites (Annex 2)

Zeolite are industrial minerals of growing importance in many regions in human´s activity. Regardless of synthetic zeolites which are of indispensable use as catalysts mainly in petrochemistry, naturally occuring material is an important research topic studied in all developing countries. The largest market for natural zeolites is in Europe with about 90% of its utilization in contruction industry in the form of building stone, in cement production and as a low density insulating material. But there exist a lot of other exploitations which are dealt in Chapter 4 in detail.

In the northern Greece two important localities of natural zeolites were visited the first being about 3 km to the west of Ferres near Alexandroupoli (Annex 2).

Rhyolite is an early stage of zeolitization (clinoptilolite originates) is quarried in shallow pits on an area 100 x 100 m and utilized for repairing unpaved roads. It is very hard, not usable as a zeolite raw material. About 3 km to the SW there occurs a laminated mordenite tuff outcropping on a small hill about 50 m in diameter. The sample taken here will be used in experiments with cleaning sewage waters, especially with removal of ammonia. In case of positive results, one boring 30 m deep at the foot of the small hill, and exploration trench from to foot to the crest of the hill will verify sufficient reserves.

The second deposit is situated near Metaxades, about 19 km to the west-north-west from Didimothio near Greek-Bulgarian border (Annex 2).

Three zeolite lenses - 1.5 km, 1 km and 0.5 km long strike NE-SW. The longest of them is cut by the river Erithropotamos and opened by two quarries with faces 150 and 100 m long and 30 m high (the thickness of zeolite is higher) on both sides of the valley. The quarry on the NW river bank is still operating. Zeolite is of Eocene (Priabonian) age and is covered by a lumachella bed 0.5 - 1 m thick (Upper Eocene) and with progressively thicker (up to 15 m) bed of limestone. This growing thickness of overburden will soon limit the operation in the quarry. (Here it is necessary to mention that the quarry on the opposit side across the valley was not abandoned because the deposit was exhausted, but the quarry face met the boundary of another private property. The overburden on this part of the deposit is not so thick as in the other quarry).

The zeolite body is not homogeneous. Very fine grained zeolite (sample 1) up to 1 m thick alternates with middle grained (sample 2) and coarse grained zeolite (sample 3) with relics of tuffaceous material. Zeolite raw material is composed of clinoptilolite (50-55%), quartz, feldspar and accessory montmorillonite. The content of clinoptilolite is not very high, and and the material is not homogeneous.

It is supposed that the Eocene volcano that produced ash (tuff) - the parent rock of zeolite - was on the territory of what is now Bulgaria.

Another zeolite deposit with 70% clinoptilolite near Lefkimi (thickness 300 m, length 3 km) encloses blocks of unaltered volcanic material. It is not open for exploration or exploitation being in a natural reserve of rare species of serpents and birds.

Conclusion: Before any speculation about possible selective exploitation of fine-grained zeolite only (the other types being left for building purposes, as it is the case with all types of the material up to now), a thorough investigation of this material for utilization in agriculture and environmental protection (ammonia removal from wastewaters) should be done.

1.8 Bentonite (Annex 3)

Greece belongs to the world´s most important producers of bentonite which is found in bulk in the island of Milos and a smaller quantity of white bentonite is extracted on nearby Kimolos. Three main producers of this mineral on Milos island are Silver and Baryte Ores Mining Co., Mykobar Mining Co. and Mediterranean Bentonite Co. Ltd. of which the first one is the largest. The overall production of raw bentonite in 1985 reached 887.000 tones. Some 2.850 tons of bentonite was produced in a crushed form and 240.000 tons was activated into sodium form. The export data (1985) for Greek bentonite show amounts of 58.670 t of the crude form, 584 t of the crushed and 224.000 t of activated raw material. Greek bentonite, in addition to principal applications in drilling industry also has the outlets in iron ore pelletization, civil engineering and foundries. Iron ore pelletizing industries of the Netherlands and Canada are supplied nearly exclusively by the Milos bentonite which meet all demanded parameters. From the economic point of view, low freight costs across the Atlantic ocean allow Greek bentonite to compete successfully in Canada with US raw material which is very costly to be transported overland.

During the mission, several bentonite quarries managed by the Silver and Baryte Ores Mining Co. on the Milos island were visited. In all cases the calcium montmorillonite is the principal mineral of bentonite composition. Two mineralogically different types of bentonite were seen and evaluated:

1. pure bentonite containing up to 90% of montmorillonite with minority of admixtures (deposits Migiokolo, Mitakas, Angeria)
2. bentonite containing also α- quartz, cristoballite and alunite (deposits Komia, Tria Pigadia).

a) Deposit Migikolo

3 km to the SW of Voudia on Milos island (property of Silver and Baryte Ores Mining Co.)

The outrop of the bentonite body is 2 km long and 200 m wide, the depth of exploitation pit is 70 m. The green colour of the bentonite changes through oxidation to yellow with no change of the technol ogical properties. Markasite is present as accessory. It does not influence the quality.

b) Deposit Angeria

Immediately to the W of Migikolo (property of Silver and Baryte Mining Co.) Very pure bentonite with 95% of montmorillonite is exploited in a pit with the wall 30 m high, but it reaches to depth below the sea level. It is activated with soda and used in drilling technique.

c) Deposit Komia

3 km to the south of Voudia. The raw material is composed of about 60-65% of montmorillonite. 22% of cristoballite, about of 3% of α-quartz and alunite. Due to the lower content of the active montmorillonite and subsequent quality problems the production declined markedly in last years contributing only by 5% for the total amount of raw bentonite quarried although geological reserves are speaking of

2 millon tons. Another bentonitic body of this type which reserves have been estimated to be at least 4 million tons is also exploited sporadically. The former annual production of 70,000-90,000 tons declined to only 2-3,000 tons in 1986.

The only present important utilization of bentonite with cristoballite is for iron-ore pelletization. Contamination of bentonite with α-quartz prevents it from foundry applications and drilling uses. Bentonites of lower quality should be utilized for hydropony (together with expanded perlite) and for treating wastewaters.

Conclusions: Silver and Baryte Ores Mining Co. produces *inter alia* first-grade bentonite suitable for all its principal uses exporting a great deal of the production. On the other hand, the material with a lower montmorillonite content is marketable with difficulties and it would be worth starting research in the field of non-traditional activations as will be described in Chapter 4. The obtained data indicate suitability of the clay for special modifications by means of ion-exchanging and sorption. Two small samples of the first quality bentonite and one sample of the bentonite with cristoballite admixture (montmorillonite content given about 60%), each of 0.5 kg weight, were taken for special testing for its non-traditional applications.

1.9 Perlite (Annex 3)

Perlite is abundant in the Greek islands of Milos, Kos, Lesvos and Antiparos. Greece is the third largest producer of perlite after the U.S.A. and U.S.S.R. (see Table VII) although having nearly the same production as U.S.S.R.

Table VII. World production of crude perlite in 1984 (tonnes)

Producent	Production	% of total world production
U.S.A.	592.000	35
U.S.S.R.	360.000	21
Greece	358.000	21

Source: Industrial Minerals, November 1986

Production of raw perlite fell under 300.000 tons in 1985 (7):

Production (1985)		Export (1985)	
raw perlite	240.000 t	raw perlite	30.000 t
screened product	161.161 t	screened product	160.134 t

Two different perlite deposits were visited on Milos island:

a) Trahilas; to the north of the Milos capital Plaka (property of Silver and Baryte Ores Mining Co.)

A huge deposit of perlite (reserves 300 mil. t, thickness 300 m) with 3% of combined water covered by marine terrace sediments several meters thick yields about 180.000 t yearly (potential is also 200.000 t per year). It is crushed, classified and exported presently to the eastern coast of U.S.A. (60 000 t per year), India, Rep. of South Africa. Before the appearance ofn the market of perlite from Armenia it was exported also to Europe. After expanding perlite is used as filler aid and for insulation purposes.

b) Provatas, 3 km to the South-west from the Airport of Milos (property of Silver and Baryte Ores Mining Co.)

Perlite deposit of lower quality as compared with the raw material from the Tranhilas deposit, with reserves about 500 mil. t, is used for building purposes only.

1.10 Kaolin, illite

Note on nomenclature. The Project mentions clay as one of three targets of the investigation. As clay are designated raw materials with substantial content of clay substance (less than 0.02 mm), e. g. bentonite, ball clay, refractory clay, kaolin a. o. Bentonite exploited in Greece for decades is outside of the scope of investigation. Ball clays and refractory clays (kaolinite clays) are washed-over and sedimented products of weathering. They are rare in Greece, e. g. ceramic clays in Arkadia and Lakonia, and clays at Lefkogia near Drama, which are cited by some authors). Kaolin is a residual rock (on the place where it originated either by weathering or hydrothermal - solfataric activity). Because of its clay mineral (kaolinite) content it is also sometimes designated as clay. Among all above mentioned raw materials kaolin was the target of our investigation.

All four kaolin deposits under study belong to the hydrothermal-solfataric type (8). Compared with kaolin deposits of the weathering crust, whose erosion remnants cover tens of square kilometers of feldspathic parent rocks, the deposits of the hydrothermal-solfataric type are smaller - usually tens of thousands square meters. They are elongated parallel to the fracture or fault which was the channel of circulation of hot waters, which gave rise not only to kaolinite, but also to alunite and pyrite (near the surface), and illite, montmorillonite and cristoballite (in depth, and in zone as the margin of the deposit). These deposits usually being small, do not provide enough of material for kaolinite clays in the vicinity of the primary deposit, to form by erosion and redeposition of the residual rock, as is the case with extensive kaolin deposits of the weathering derivation.

IGME proposed the kaolin deposits on the island Lesbos (Mytilene) for field investigation.

Lesbos is with its 1630 km^2 the largest island in the northern part of the Aegean Sea. The north-eastern part of the island, where the kaolin deposits are situated, is built by volcanic rocks (lavas and tuffs) - dacite, rhyodacite, latite and andesite. Their age is Upper Miocene-Lower Pliocene.

1. <u>Skala Messotopou</u> (10 km to the SE Eressos on Lesbos (Annex 4)

   The parent rock of kaolin is andesite tuff of Neogene age with lapilli and volcanic bombs (8). The fumaroles which gave rise to kaolin were bound to a zone 1.5 km long striking NEN-SWS, which conforms with main tectonic zones on Lesbos island as well as in the western part of Anatolia. Kaolinization along the zone is not continuous being divided in four individual segments originated along separate hydrothermal channels.

The southernmost segment designated as No. 4 (locality Tavari) is the largest (400 x 150 m) and most homogeneous as far as mineralogical composition is concerned. Chemical and mineralogical analyses of this material are given in Table VIII.

Other parts of the altered zone are smaller in extent, heterogeneous, mostly with alunite (10-70%), cristoballite (traces up to 35%), and traces of jarosite, markasite and feldspar.

Southern segment of the altered zone was chosen for detailed sampling (Annex 6). Five samples 20 kg each of hard white kaolin with violet or pink tint in some places were taken in a cutting 400 m to NE from St. Nicolas in following way: samples 4a, 4b and 4c were taken in the front face, 4b 2 m below it, 4c near the bottom in a vertical channel 1 m long). Sample 4d was taken from the wall of the cutting 5 m from the face, sample 4e from the opposite wall 4 m from sample 4d.

For verification of reserves sufficient for 20-30 years of anticipated yearly production at least one boring about 50 m deep should be done in the deposit on the elevation about 75 m above sea level. The assumed boundary of the deposit as pictured in the paper of Mattias and Kanaris (8) and in the unpublished geological map 1:5000 should be verified by exploratory trenches perpendicular to the boundary of the deposit.

By the same method should be verified the extent of alunite mineralization in the northern part of the deposit Tavari, especially if sample No. 3 (see further) should be rich in this mineral which is damaging to all equipment for thermal processing of kaolin.

The exploitation of the deposit Tavari can occur by a quarry with several levels 5-10 m high. The overburden and the wall rock should be kept carefully from kaolin, and dumped 20-25 m above the sea level. At this elevation should the deposit be opened for exploitation by the lowermost level.

Two smaller heterogeneous kaolin outcrops to NEN of the deposit just described were also sampled (2 kg each sample):

Table VIII Chemical and mineralogical data on raw kaolin from Skala Messotopou-Lesvos island

SiO_2	55.30	59.20	53.70	44.50	56.30	53.60	56.93
TiO_2	0.76	0.62	0.35	0.45	0.65	0.95	0.81
Al_2O_3	26.90	21.00	21.90	29.80	27.00	25.20	28.13
Fe_2O_3	0.55	0.93	0.91	2.99	0.32	0.73	0.98
CaO	0.29	0.26	0.19	0.26	0.29	0.29	0.17
MgO	0.18	0.15	0.09	0.20	0.23	0.34	0.07
MnO	0.03	0.01	0.01	0.01	0.01	0.01	
Na_2O	0.07	0.08	0.05	0.10	0.18	0.50	0.11
K_2O	0.75	0.44	1.88	1.17	0.01	0.14	0.08
P_2O_4	1.88	1.72	1.72	1.99	1.03	1.81	
L.O.I.	12.10	14.20	17.22	16.90	12.70	14.70	11.09
	27	28	31	33	34	36	
	by P. Mattias and G. Kanaris						+/
K	65-70	90	40-45	95	95	95	
A	15	10	20-25	-	-	-	
J	tr	-	-	tr	-	tr	
Cr	15	-	30-35	-	-	-	
Q	-	-	-	-	tr	tr	
F	-	-	-	-	-	-	
M	tr	-	-	-	-	tr	
I	-	-	-	-	tr	-	

+/ by Z. A. Engelthaler, M. Hladeček, V. Hanus, P. Duchek

K kaolinite
A alunite
Cr cristoballite
Q quartz
F feldspar
I illite

sample No 1 (locality Spilia 300 x 150 m) 400 m to the N from the elevation point 179.4 - white kaolin with violet spots (from a shallow pit), sample No 2 - 400 m to NW from elevation point 179.4 - very hard kaolin (area 200 x 100 m), sample No 3 400 m to SW from the elevation point 179.4. The last sample is situated about 150 m to the N from the margin of the main deposit (Tavari). The aim of study of this sample is to trace the content of alunite, which was found to be present in substantial amount in an old IGME sample 60 m to the NE of sample No 3 (area of kaolinization 200 x 100 m).

2. Petri (Aspres Petres) 1.5 km to SE from Petra on Lesbos (Annex 4)

This deposit of white kaolin is situated to the NE from the deposit Skala Mesotopou just described, and belongs most probably - together with the deposit Argenos (see further) - to the same NE-SW trending hydrothermal zone. It is the only deposit on Lesbos that is worked (leaseholder E. Horafas), with yearly output 10 000 tons (capacity 40 000 t). Kaolin is used as alumosilicate correction for production of white cement in a plant of AGET near Athens. The parent rock - rhyolite with occassional xenoliths of andesite up to 5 m in diameter - was hydrothermally kaolinized on area 200 x 60 m. Kaolin contains disordered to triclinic kaolinite, quartz, clay mineral with illite - montmorillonite mixed layered structure, and three minerals containing sulphur-alunite, jarosite and markasite which may cause troubles in the thermal technological process, if applied. Andesite inclusions in the rhyolite parent rock give rise to clay material rich in monmorillonite. Content of iron oxide is 0.28 - 0.73%.

Kaolin is very hard. Before shipment it must be crushed in a hammer crusher.

3. Argenos (Annex 4)

The parent rock of kaolin - andesite was kaolinized in a zone 600 m long and 100 m wide, probably before or contemporaneously with the effusion of younger dacites and rhyodacites. The deposit is a part of a hydrothermal zone trending NEN-SWS with deposits described above, and itself has the same strike. Kaolin contains kaolinite, quartz, feldspar, alunite, montmorillonite (up to 15%), jarosite, I-M mixed layered clay mineral.

Exploration of this deposit, planned as long ago as in 1971, is being delayed because of the private ownership of the land.

4. Ralaki 8 km to SW of Adamas on the Milos island (property of Silver and Baryte Ores Mining Co. - Annex 3)

The kaolinization occured along faults trending NW-SE. (In the eastern part of the island where the deposits of bentonite and perlite are situated the trend is SW-NE).

Eastern segment of the deposit with reserves 1.7 mil. tons has raw material with 0.4 -0.6% Fe_2O_3, 0.8% TiO_2 , 67% SiO_2, 24% Al_2O_3, and 3.5% SO_3. It is utilized mostly for production of white cement, to a lesser extent in ceramics. The parent rock is rhyolite tuff and ignimbrite (age 480 000 years). Kaolinite is close to the triclinic type. This part of the deposit is nearly worked out.

The eastern segment of the deposit contains more quartz (and 15-20% of alunite only, 0.1% Fe_2O_3), which is reduced to 5% by crushing and sieving. This material is used as filler in paper and paints.

Raw kaolin from both segments of the deposit is used in production of white cement. For this purpose it is homogenized by heaping in alternating beds and then loading in trucks by a power shovel.

Illite is also found on the Milos Island, to the north of Ralaki (deposit Kumaria - Annex 3) which is owned by Silver and Baryte Ores Mining Co.

The material from a boring situated to the north of Ralaki in the western part of the island contains about 77% of SiO_2, 13.60% of Al_2O_3, 0.8-1% of Fe_2O_3, 2.5-4% of alkalis and has L.O.I. value ranging 2.68-2.99%.

Testing specimens from illite were fired under 3 different temperatures with following results:

1000°C - pink after firing
1100°C - beige
1200°C - brightly grey

Tha parent rocks are andesite and dacite. The deposit is not yet utilized.

Illites are widely used in ceramics as a part of batch for certain structural products, because they contain their own flux (alkalies) and glass former. If the raw material is white and burns white (due to low content of iron), it can be used for production of white stoneware (floor tiles, pottery), which is not common, and if in agreement with transient fashion might be a financial success.

Conclusion: Kaolin - according to results of previous testing (3), the raw material may be up-graded by means of washing and magnetic separation. The product after beneficiation exhibits a favourable brightness in a green as well as fired form and is recommended for ceramic and paper industry applications. To prove this suitability, samples for semi-industrial tests were taken. Basic structure of the washing kaolin plant together with economy data for the capacity 85,000 tpa of washed kaolin is attached as Annex 7 and 8.

1.11 Quartz, silica

a) Vein quartz (ELVIOR property)

Stefania 8 km to the SE of Kilkis (Annex 1)
Quartz veins (thickness in meters) penetrating across the foliation of the cristalline schists are very pure. The thickest vein yields 10 000 t per year for exports to Scandinavia. Quartz is most probably suitable for production of quartz glass and metallic silicium. It is an exceptionally pure material.

Terpilos 10 km to the NE of Kilkis (Annex 1)
Quartz veins (thickness in meters) are inserted into the cristalline schists concordantly with their almost horizontal

foliation. The reserves are smaller than in Stefania, and the quality is lower. Quartz contains 3 g of gold per ton. Gold is not utilized.

b) Silica (Silver and Baryte Ores Mining Co. property).

The locality is situated near Kastriani in the western part of Milos island (Annex 3).

This fine-grained material is composed of α-quartz. (In depth cristoballite is present). It is very similar to tripoli. Tripoli has the grain-size between 1 and 10 μm and SiO_2 content up to 98-99%. It was originally used for water filters, now it is used as abrasive, buffing or polishing material (99.5% of the particles should be less than 10 μm), inert mineral filler (extender and filler in paint, plastics, rubber and epoxy sealants for electrical applications), and recently also as organically surface treated silica used as both thermoplastic and thermosetting resins for molded engineering plastics, casting compounds, adhesives and coatings, as fillers and carriers in insecticides a. o.

2. Producers of up-graded non-metallic raw materials

2.1 Mevior S.A.

MEVIOR S.A. company located in Assiros about 20 km to the north of Salonica (Annex 1) is processing pegmatites and quartz from near deposits producing quartz and feldspar. The raw materials processed have following applications (6): quartz - occuring in vertical veins of 4-6 m width and 150 m average length, min. 99.5% SiO_2, max. 0.05 Fe_2O_3, max. 0.04% Al_2O_3, max. 0.01% CaO, feldspar -sodium type occuring in pegmatite veins of 15-17 thickness and 11 km length.

The technology consists of two following processes of which the first one is common for feldspar and quartz. This outdoor stage comprises wet classification and crushing (jaw crusher, cone crusher). In the second (indoor) phase the crushed material dried in a rotary drier, then submitted for twofold dry magnetic separation with screening and grinding (ball mill). The final stage is screening and subsequent air classification resulting in the product of the grain size less than 0.075 mm possibility of sinking down to 0.030 mm.

Alpine crushing and classification system and Rapid magnetic separators operating at 1.8 T are utilized.

The capacity of the plant is 4 tons of fine fraction per hour (about 20 000 tpa) and about 3 tons of the crushed material (about 15 000 tpa). The milled product is sold in bags, the crushed one is produced in bulk.

Conclusion: The quartz and feldspar is sold mostly for ceramics, the minus 100 microns fraction of feldspar removed by screening may be used in the manufacture of floor tiles. Other materials like pumice may be grinded in the plant. MEVIOR S.A. processing plant is operating safely. Although having no detailed specifications of products they seem to meet requirements of exploiting industries.

2.2 Porcel

Porcel company is processing feldspars, quartz, dolomite, limestone and mica. The plant is situated near Tholos, about 5 km from Paranestio site (to the north-west of Xanthi), very close to deposits of potassium feldspar (Annex 1)

The quality of products has been proved by pilot-plant tests carried out abroad by suppliers of machinery. The plant has been put into operation just during UNIDO experts' visit of pegmatite localities in June, 1987.

Potassium feldspar (from veins and lenses) as well as sodium feldspar from eastern Greece which will be supplied later are the basic raw materials being up-graded. The raw material is very pure and rich, content of K_2O reaching up to 14.5%, that of Fe_2O_3 being in range 0.12 - 0.14% and the free quartz amounts up to 8%.

Quarrying of pegmatites involves about 50% of the product and 50% of overburden. The industrial reserves proved are reaching up to 1 million tons of exploitable material. Fe_2O_3 is present in rock cracks, never in the silicate lattice. Its content is going down with higher depth of occurence.

Following economic data were obtained (6):

total investment costs	Drachmae	860, 000, 000
of which:		
equipment costs	"	630, 000, 000
employees	80	
capacity planned	120, 000 tpa feldspars	
marketing policy	to supply domestic market and mainly exporting (West Germany, France)	

Conclusion: The processing plant is going to produce, inter alia, eight grades of feldspar as well as quartz (see Table IX). The products will be supplied for ceramic and glass industries, as fillers and extenders etc.

2.3 Silver and Baryte Ores Mining Co.

This company belongs to the most important producers of raw and processed industrial minerals in Greece. Its scope of activity involves extraction and up-grading of bentonite, perlite, kaolin and baryte. The processing plant for bentonites and perlite was erected in Voudia Bay on the Milos island where these materials are also quarried. Plant specifications:

Total investment costs	....	42, 000, 000 Drachmae
Output: Bentonite	....	300, 000 tpa
Perlite	....	200, 000 tpa
Baryte	....	10, 000 tpa
Kaolin	....	30, 000 tpa

Table IX. Chemical analyses of non-metallic products from the new PORCEL processing plant

up-graded product	grade	SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	K_2O	Na_2O	L.O.I.	
feldspar	450	64.70	18.70	0.35	0.03	0.09	12.80	2.50	0.8	
feldspar	482	66.17	18.10	0.50	0.04	0.11	11.85	2.60	0.53	
feldspar	670	69.00	17.10	0.45	0.02	0.15	10.70	2.75	0.30	
feldspar	982	68.06	17.20	0.63	0.06	0.19	9.50	3.30	1.1	
feldspar	1010	69.00	16.80	0.67	0.09	0.22	7.80	5.25	0.30	
feldspar	1023	68.20	18.30	1.65	0.22	0.08	2.60	8.05	0.90	
feldspar	1150	66.10	19.80	2.70	0.07	0.08	1.05	9.40	0.80	
feldspar	1200	65.90	20.64	1.95	0.08	0.16	0.25	10.20	0.75	
quartz	1340	99.55	0.18	–	–	0.02	–	–	0.06	
dolomite	1410	–	–	30.90	21.60	0.12	–	–	46.62	
muscovite	1500	47.85	32.40	0.093	0.31	0.99	11.14	2.19	4.75	
limestone powder	1550	$CaCO_3$ min. 99	SiO_2 –	Al_2O_3 –	MgO 0.32	Fe_2O_3 –	MnO_2 –	SO_4^{2-} –	PO_4^{3-} –	L.O.I. 43.28

Source: PORCEL´s information booklet

Bentonite processing

The raw material extracted contains about 28-30% wt. of moisture and is transported frcm 10 open-pit mines to the plant. Firstly, bentonite is crushed and then activated by soda which is imported in bulk from Italy being crushed in hammer mills. In the activation process, fraction ranging 0.1-0.6 mm is utilized. This technology of natrification is fully automatized and screen controlled. The amount of soda added takes 5-6% according to laboratory results and specifications. Open-air drying of natrified form follows the beneficiation process resulting in product of about 14-15% of moisture. This product is ready for bulk vessel expedition for which there are excellent contitions in Voudia Bay. Some amount of activated bentonite is dried in fluidizers, dried and screened to the final grain size (-100 mesh).

Perlite processing

Raw perlite of two qualities is up-graded in three following stages: primary crushing station, secondary crushing station and then it is dried and screened.

Primary crushing station operating in 1 shift, 7 days/week with capacity of 150 t/hour is equipped with jaw crusher crushing the perlite rocks into lumps of 15-17 cm diameter. The pre-crushed material is stock-piled in 125-t silos.

Secondary crushing station with continuous operation is processing the pre-crushed material (96% of less then 16 cm) into fraction less then 3 mm (90% from total). This achieved in hammer mill for bigger lumps and two roller mills.

Drying station with capacity of about 5-7 t/hour is using fluidizers applied with heavy oil. The dried product is multiple-screened on horizontal and vertical screens producing perlite of following grain sizes:

$>$ 2.5 mm
2.5 - 0.6 mm
0.6 - 0.3 mm
0.3 - 0.15 mm
0.15 - 0.075 mm

Fractions finer than 0.075 mm are classified in cyclone for coarser and finer ones the latter being filtered. Through all processing technology, dedusting is paid attention. Dust is sucked-off in exposed processes and separated into bag filters.

Silver and Baryte Ores Mining Co. posses a well-equipped plant laboratory for all the necessary determination of chemical, physical and technological properties of bentonite and perlite.

Perlite expandation is performed in Athens in the PERLOMIN division of Silver and Baryte. Perlite is expanded for domestic use producing about 50,000 cu.m. per annum of expanded material. This is sold for building and agricultural use whilst material which has been crushed, expanded and milled is supplied for filtering and cryogenic applications. Typical chemical analysis of expanded perlite is given in Table X:

Table X Chemical analysis of expanded perlite PERLOMIN (Silver and Baryte Ores Mining Co.)

Component	% wt.
SiO_2	76.10
Al_2O_3	13.78
TiO_2	0.13
Fe_2O_3	1.25
CaO	1.20
MgO	0.56
Na_2O	3.76
K_2O	3.12
CO_2	0.00
S	0.018
L.O.I. ($1000^{o}C$)	0.00
TOTAL	99.918

3. Tests of sampled raw materials

3.1 List of samples

a) Point samples for orientation tests (aiming at possible further orientation of geological survey)

1.	Kaoline, Skala Messotopou Spiglia (256) white colour	1 kg
2.	Kaoline, Skala Messotopou Spiglia (256) violet colour	1 kg
3.	Kaolin, Skala Messotopou (41 100)	1 kg
4.	Kaolin, Skala Messotopou (41 065)	1 kg
5.	Zeolite, Metaxades, fine-grained	7 kg
6.	Zeolite, Metaxades, middle-grained	9 kg
7.	Zeolite Metaxades, coarse-grained	12 kg
8.	Metaarkose Analipsi 1	2.50 kg
9.	Metaarkose Analipsi 2	2.50 kg
10.	Metaarkose Analipsi 3	2.50 kg
11.	Metaarkose Analipsi 4	2.50 kg
12.	Metaarkose Analipsi 5	2.50 kg
13.	Zeolite Ferres	2 kg
14.	White material Skoutaros - light	0.50 kg
15.	White material Skoutaros - dark	0.50 kg
16.	Kaolin Petra	0.50 kg
17.	Illite, Milos - Kumaria	5 kg
18.	Bentonite Milos - Angeria	0.50 kg
19.	Bentonite Milos - Migikolo	0.50 kg
20.	Bentonite Milos - Komia	0.50 kg
	TOTAL about	55 kg

b) Large-scale samples for model tests of up-grading and applicability of raw materials

1.	Kaolin, Skala Messotoupou Tavari, a	20 kg
2.	Kaolin, Skala Messotoupou Tavari, b	20 kg
3.	Kaolin, Skala Messotoupou Tavari, c	20 kg
4.	Kaolin, Skala Messotoupou Tavari, d	20 kg
5.	Kaolin, Skala Messotoupou Tavari, e	20 kg
6.	Feldspar, Kato Potamia, KP 1	20 kg
7.	Feldspar, Kato Potamia, KP 2	20 kg
8.	Feldspar, Kato Potamia, KP 3	20 kg
9.	Feldspar, Kato Potamia, KP 4	20 kg
10.	Feldspar, Kato Potamia, KP 5	20 kg
11.	Sand Haniotis - arkose 1	15 kg
12.	Sand Haniotis - arkose 2	15 kg
13.	Sand Haniotis - arkose 3	15 kg
14.	Sand Haniotis - arkose 4	15 kg
15.	Sand Krios - 1	15 kg
16.	Sand Dikea - 1	15 kg
	TOTAL	about 290 kg

3.2 Proposal on laboratory and semi-industrial tests

DRAFT TERMS OF REFERENCE

UNIDO Project No. DP/GRE/86/008

Mineral processing of Industrial Minerals

Research Institute for Ceramics, Refractories and Non-metallic Rawm Materials, Pilsen, CSSR

1. Background Information

During the field activities in the period May-July, 1987 in the framework of the UNIDO Project No DP/GRE/86/008, our experts in co-operation with technicians of IGME, Athens visited selected non-metallic minerals localities in different regions of Greece.

Point sampling of selected non-metallics occurence has been executed in order to evaluate basically their quality focussing the attention to a precise geological prospection. In the localities where reserves had been before partially searched by geological prospection, large-scale sampling was carried out to recognize their up-grading ability as well as industrial applicability of refined products.

2. List of Samples

Point Sampling:

Lesvos Isle	- Petra-petrion kaolin	1 sample
	- Skoutaros kaolin	2 samples
	- Skala Messotopos kaolin	4 samples
Milos Isle	- Kumaria illite	1 sample
	- Angeria bentonite	1 sample
	- Migikolo bentonite	1 sample
	- Komia bentonite	1 sample
Macedonia Region	- Analipsi quartzite	5 samples
Thrace Region	- Krios sand	1 sample
	- Dikea sand	1 sample
	- Ferres zeolite	1 sample
	- Metaxades zeolite	3 samples
	TOTAL	22 samples

Large-scale sampling:

Lesvos Isle - Skala Messotopos, Tavari kaolin	5 samples
Macedonia Region - Kato Potamia feldspar	5 samples
Halkidiki Region - arkose sand Haniotis	4 samples
TOTAL	14 samples

Total mass of samples 410 kg

3. Testing Methods

Sample testing is to be carried out in two phases:

Phase I. - will be oriented to obtain basic data suitable to evaluate quickly eventual applicability of respective non-metallic raw materials

- chemical compositions of point and large-scale samples
- mineralogical composition of point amd large-scale samples
- testing of bentonites for wastewater treatment

Phase II. - will be oriented to verify the effectivity of up-grading methods and to evaluate the properties of up-graded products

Skala Messotopos, Tavari kaolin cca 100 kg

- homogenization of the sample
- crushing
- washing, sieving
- classifying on hydro-cyclones dia 50 mm
- magnetic separation
- dewatering
- drying
- grinding
- properties evaluation of the products in the range of over 63 μm, 20 - 63 μm and below 20 μm according to the significance of their application in the ceramic or paper industry

Kato Potamia feldspar cca 100 kg

- homogenization of the sample
- crushing of the sample under 1 mm
- classifying to fractions over 0.6 mm, 0.6-0.1 mm and under 0.1 mm

- possibility of up-grading the fraction 0.1-0.6 mm by flotation and magnetic separation
- properties evaluation of classified and up-graded products according to their significance of application in the ceramic and glass industries

Haniotis arkose sand cca 100 kg

- homogenization of the sample
- crushing of the sample under 1 mm
- classifying to fractions under 0.6 mm, 0.6-0.1 mm and under 0.1 mm
- possibility of up-grading the fraction 0.1-0,6 mm by flotation and magnetic separation
- properties evaluation of classified and up-graded products according to the significance of their application in the ceramic and glass industries

4. Evaluation of Tests and Recommendation

Evaluation of the point samples will be focussed to the decision of taking up geological prospection and to appreciation of industrial applicability of the respective non-metallic raw materials.

As regards large-scale samples technology of their industrial up-grading and the evaluation of up-graded products for their further industrial application will be proposed.

5. Reports

The report on the test results will be elaborated in English and presented to UNIDO, Vienna in 10 copies.

6. Price Estimates

It is supposed that the price of works executed in the framework of this Project will not exceed 20,600 US $.

Pilsen, August 4, 1987

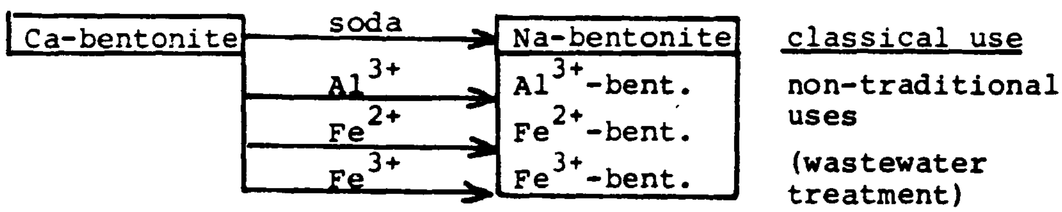
Z. A. Engelthaler, Director
Research Institute for Ceramics, Refractories and Raw Materials

4. Non-traditional applications of bentonite, perlite, zeolite

a) Bentonite

Although bentonites of the highest quality are abundant on the Milos Island (montmoriloonite content more than 95%), some deposits contain raw material of lower quality. It is just the case of Komia locality (property of Silver and Baryte Ores Mining Co.) where bentonite with α-quartz, cristoballite and alunite containing about 60-65% of montmorillonite occurs. The mineralogical composition prevents it from foundry uses.

This type of bentonite is suitable for special activations, other than the well-known natrification by soda. These new processes involve mechanical-chemical treatment with inorganic soluble salts of aluminium and iron resulting in new grades of modified bentonites suitable for treatment of wastewaters, above all (9-13) :



1) Technology of activation

All processes suitable for alkaline activation, such as dry process, paste process and slurry process, are applicable for this type of activation with other ions. The slurry process is more suitable than in case of alkaline activation, because water suspensions of bentonites in non-alkaline cycles are not so thixotropic and geleous and it is possible to prepare these suspensions with good rheological properties containing about 300 grams of bentonite in one litre.

The direct activation is quite cheap and simple process but on the other hand, its product is always an equilibrium mixture of different ionic forms of montmorillonite, activating salts and by-products of activation. The position of equilibrium depends on concentration of activating ion, type of anion, pH value and, if bentonite is in water suspension, also on concentration of suspension. If these conditions are changed during the application of bentonite, also equilibrium position is deviated and bentonite can change its properties. This phenomenon is advantageously utilized in the case of waste water treatment with specially activated bentonites.

The quantity of applied activating salt varies in dependence on ion-exchange capacity of bentonite and required degree of activation, usually it is from 0.2 to 0.6 mols of activating ion per one kilogramme of bentonite.

2) Application

Before the application proper, bentonite should be dispersed in water amounting about 200 g/l. The slurry can be transported by slurry pumps into the treating process. For blunging bentonite, propeller stirrers are commonly used. Polluted water is treated with modified bentonite with possible pH adjustment and organic flocculant adding either in batch or continuous arrangement. The Scheme of the continuous process is given in Annex 9.

3) Suitability of the method

The process of purification is based on following properties:

- high value of the specific surface area
- ion-exchange capacity
- flocculation activity
- role of "weighting medium" in sedimenatation processes (bulk density about 2,200 kg^{-3}).

Specially modified bentonites are utilized as a combined sorption-deemulgation chemicals for purification of following types of wastewaters:

- water polluted with oily substances (dissolved and/or emulsified)
- water polluted with dispersions of organic polymers (adhesives, dyes, paints etc. based e. g. on polyacrylates)

- wastewaters from food industry (slaughterhouse, dairy)
- washing wastewaters from cattle breeding
- other types of polluted waters being characterized by emulsified or finely dispersed insoluble matter.

4) Testing of bentonites for treating wastewaters

Orientation tests of applicability of modified bentonites for these purposes may be performed very quickly with basic laboratory equipment (Annex 10) Carrying out the experiments, following is to be monitored:

a) data on raw wastewater

(pH, total solids, insoluble substances, chemical oxygen demand - COD or biological oxygen demand - BOD_5, content of non-polar substances if present).

b) optimalization of bentonitedoses with respect to flocks formation, degree of clarification, sludge volume, temperature influence etc.

c) determination of sedimentation rates

d) analysis of water after treatment (parameters ad a).

5) Efficiency of the process - given in Tables XII and XIII.

6) Sludge treatment

Activated bentonite may be successfully used in sludge treatment resulting in its better dewatering and reducing of organic polyelectrolytes demand. Aluminium-modified of otherwise up-graded bentonite is suitable for these purposes (9).

In Europe, West Germany in particular, there is also interest in using up-graded bentonite as an additional aid to sewage sludge treatment to reduce the heavy metal content. This is important in cases where the treated sludge is disposed on farm land (14).

Table XII Supposed doses of Al^{3+}- bentonite for different types of wastewaters

No.	Type of wastewater	Dose of bentonite (kg/m^3)	Dose of flocculant (g/m^3)	Neutralization
1.	Low oily pollution	1 - 3	1 - 3	Lime after bentonite dosing up to pH 5-8
2.	heavy oily polluted	5 - 10	0 - 5	usually not necessary or ad 1)
3.	dispersions of organic polymers	7 - 25	0	not necessary
4.	cattle breeding washing waters	5 - 10	0	usually not necessary or ad 1)
5.	food industry wastewaters	3 - 10	usually not necessary	H_2SO_4 or lime

Table XIII Orientation results achieved by application of Al^{3+} - bentonite on different wastewaters

Type of wastewater	Parameter	wastewater in (mg/l)	out (mg/l)	Efficiency (%)
Heavy oily pollution	oily substances (hydrocarbons)	50-500	<5	99
low oily pollution	- " -	5-50	<0.2	>98
dispersions of organic polymers	COD	up 50 000	$<1\ 000$	>95
food industry	COD	up 15 000	$<2\ 000$	>60
cattle breeding	COD	up 20 000	$<3\ 000$	>80

7) Agricultural uses

Bentonite from Komia deposit containing about 60-65% of montmorillonite will be also suitable for agricultural purposes either in animal breeding or for soil reclamation. For the former use the raw calcium form of bentonite is applicable having ammonia ion-exchange capacity of 12-15 mg NH_4^+/ 1 kg of dry matter. Only drying and milling is supposed as processing for this purpose. Soil reclamation demands calcium bentonite in as-mined state, only crushed and submitted for weathering (for disintegration of lumps spontaneously). The optimal dose to be applied into sandy soild amount 20 tonnes per ha with about 7 years of the service life.

b) Perlite

As stated in Chapter 1.9 in detail, Greece is producing and exporting a high-quality perlite for different applications including also those in horticulture where perlite lightweight and sterile nature after processing is advantageous to in terms of handling and freedom from plant disease. The low density of the individual particles imports excellent insulation properties to the soil/peat growing medium and therefore protects the plants from excessive temperature variations.

Silver and Baryte Ores Mining Co. in its PERLOMIN branch performs an extensive research on horticultural applications of perlite (and bentonite) with very good results.

c) Zeolite

Greek zeolites, namely of Metaxades deposit should be extensively tested concerning their mineralogical and chemical properties mainly with respect to their sorption capacity, ion-exchange properties and active mineral content (clinoptiolite or mordenite). Following application spheres will be of the greatest interest:

- environmental protection (wastewater treatment, efluent clean-up)
- agricultural uses
- catalysis

1) Environmental protection

This sphere comprises both gas pollutant removal (SO_2 from stack gases, Co_2 from sour natural gas) and effluent treatment (removalof NH_3 and heavy metals from wastewaters). For this use, crushed and carefully screened zeolites (utilizable fraction - 20 + 30 mesh) of clinoptiolite type are of use. The laboratory testing of zeolites thus should comprise:

- specific surface area determination
- absorption-desorption behaviour for gases under consideration, e. g. SO_2, NO_x, CO_2, NH_3 (isotherms)
- sorption-desorption of heavy metals and ammonia from contaminated waters

2) Agricultural uses

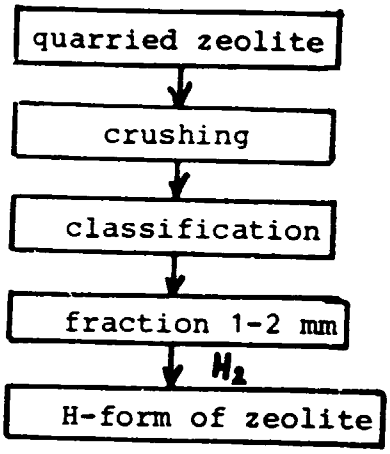
This area utilizes zeolite as a soil conditioner (similarly to perlite) and fertilizer. Zeolites perform well as soil aerators and neutralizate acidic soils. Further, they control the release of ammonium, nitrogen and potassium from fertilizers.

The zeolite may be applied in either the "as mined" condition followed by addition of fertilizer or the zeolite can be pre-charged or exchanged with the nutrient ions (NH_4^+ , K^+) and then added to the soil. Low quality zeolite with admixed clays) are applicable. The doses of zeolite which must be applied varies according to the type and origin of the soil and should be proved experimentally.

3) Catalysis

It was proved that zeolites with 65-70% of clinoptiolite and mordenite content are suitable for catalysis application. Moreover, presence of iron oxide, quartz and other amorphous admixtures has no significant disadvantage for the process but has to be proved experimentally for each case in detail.

The processing usually involves following steps:



5. Economic assessment of products

a) kaolin, feldspar, quartz

From the statistical data, which have been obtained at IGME Department of Technical and Feasibility Studies, about annual production, export and import of non-metallic raw materials, there is evident long-termed tradition of kaolin processing. The industrial processing of quartz is evidenced since year 1978 and of feldspar since year 1979 (7).

In amount the kaolin annual production fluctuates (Annex 11,12)between 40 to 80 kt, and during period of 1981 to 1985 years there is registered continual increase of production up to 90 kt.

The increase of quartz annual production is evidenced since year 1982 and of feldspar since year 1985 (Annexes 13-16).

Kaolin and quartz are also exported and it is possible to suppose also export of feldspar from the production of MEVIOR S.A. and PORCEL firms. The exported products, quartz since year 1978 and kaolin long-termaly, are characterized by price only. The qualitative parameters of products as well as some information about customers have not been obtained. Only from the price relation between exported and imported commodities it is possible to get some idea about a quality. The price of exported kaolin is in a relation with imported products and since year 1981 it has following effective increase:

price in DR/t

year	export	import	
		raw kaolin	treated kaolin
1979	2 177	2 483	6 936
1980	2 914	3 417	6 290
1981	5 635		
1982	6 098		
1983	7 171		
1984	9 840		
1985	12 138		

1 US $ ≐ 133 DR

The quartz production shows an increase of the price too, but the value of imported commodity is higher (Annexes 11,13,15). The data about feldspar export are not released and so to compare the values of export and import is impossible.

The information about the import of a relative wide assortment of non-metallics are accessible for the period of 1979 - 1980 only, and so the real view about the individual sorts consumption is not obtained, it means the sum of domestic production and import of period 1981 - 1986 years.

From the following sorts of non-metallics, only kaolin shows higher consumption than domestic production at Greece is, and therefore it has to be covered by import.

The quality, it means the trade marks of foreign producers, nor the area of their utilization (paper, ceramic , rubber and other industries) are not accessible. Therefore the question where to orientate the research and production will be dependant on the quality of the non-metallic industrial reserves - in the first step of the kaolin.

The Greek production of kaolin covers approximately 30% of total consumption (Annex 10) and approximative 60-100 kt of kaolin product should be annualy imported.

b) Bentonite

Greece is the second greatest producer of bentonite in the world where the total production has been estimated to range between 6-7,000 000 tpa (Table XIV). Concerning the world export data on bentonite, Greece is placed on the same level (Annex 17).

Table XIV World most important producers of bentonite (tonnes)

Country	1977	1978	1979	1980
U. S. A.	3,399,716	4,054,446	4,012,772	3,797,295
Greece	441,252	385,067	478,335	509,095
Japan	400,000[e]	400,000[e]	400,000[e]	400,000[e]
Italy	292?428	224,208	282,446	322,888
Bulgaria	274,700	179,700	205,700[e]	na
India	150,568	153,026	146,922	158,675
Yugoslavia	116,000	154,000	na	na
Brazil	108,395	167,614	212,503	247,954

e - estimated, na - not available
Source: Industrial Minerals, October 1982, p. 23

The annual exports costs of Greek bentonites are well-documented according to produced grade (Annex 18). Without any other economic comments it is evident that Greece can sufficiently supply both domestic and foreign markets.

The proposed specially-modified bentonites by aluminium ore iron salts which can be utilized as effective agents for wastewater treatment are supposed to hold the world price level for civil engineering grades up to $ 70/t. For iron-modified bentonites the price will be even lower due to the abundance of $FeSO_4$ (activating agent).

Evaluating production costs of this bentonite grade they should not exceed those for natrification by soda being lower for iron than aluminium treatment.

c) Zeolite

World sales of natural zeolites demonstrate the substantial growth in the market of this unique raw material (15):

year	quantity (tons)
1965	12,000
1970	80,000
1975	180,000
1979	280,000

The sophisticated utilization of natural zeolites is growing rapidly, mainly in wastewater treatment systems and gas adsorption. The prices of natural zeolites are differing according to grade:

powder, medium grade	- about 40 ƀ/tonne
powder, high grade	- about 55 ƀ/tonne
granule, pellet	- about 100 ƀ/tonne
paper filling grade	- about 65 ƀ/tonne

(Data from 1980; Japanese products ex-mill).

For purposes of wastewater treatment applications, it is to be noted that costs of regenerating the ammonium-exchanged zeolite account for about 50-60% of the total operating costs.

IV. FINAL NOTE

The presented report shows high interest of Greek Authorities in the continuous development of non-metallic raw materials in the country. Greece has an outstanding raw material base for promoting different industrial sectors. Some of non-metallics exhibit the first-grade quality, big geological reserves and thus contribute significantly to the world´s mineral market. In the near future, also new applications of bentonites and zeolites should not be ommited. Results of laboratory and model tests which will be performed on sampled material will guide both geological and technological research staff in the further effort to utilize non-metallics sophistically. Institute of Geological and Mineral Exploration (IGME) is achieving splendid results within its activity with a favourable outlook for future years.

V. REFERENCES

1. Kaklamanis N.D., Chalkiopoulou F.D.: Preliminary tests on granite and quartzite samples from the area north to Thessaloniki. IGME Athens, 1986.

2. Minopoulos P.A.: Preliminary report on study of clay samples form the area Agios Panteleimon, peninsula Halkidiki. IGME Athens, division Thessaloniki, 1987.

3. Hladeček M., Hanus V., Duchek P., Engelthaler Z.A.: Laboratory tests and up-grading of selected raw materials from Greece. UNIDO-Czechoslovakia Joint Programme, Pilsen, 1987 (JP/332/87).

4. Bareš M., Müller J.: Beneficiation and up-grading of arkoses from Greece UNIDO-Czechoslovakia Joint Programme Pilsen, 1984 (JP/214/84).

5. Chalkiopoulou F., Kaklamanis N.D., Kanaris G., Kravas Ch.: Separation of feldspar and quartz from granite. IGME Athens, 1984.

6. Griffiths, J.: Hellenic Industrial Minerals. Industrial Minerals, January 1985, p. 19.

7. Constantinidou E., Pefani V.: Statistical information about annual production of industrial minerals in Greece. IGME Athens, 1987.

8. Mattias P.P., Kanaris G.: Le alterazioni a caolino dell´ Isola di Lesbo (Grecia). Boll. Soc. Geol. It. 97 (1978), 647.

9. Duchek P., Kačín J.: Bentonites for Wastewater Treatment. UNIDO-Czechoslovakia Joint Programme Pilsen, 1985 (JP/232/85)

10. Duchek P.: Utilization of bentonite for wastewater treatment. UNIDO-Czechoslovakia Joint Programme Pilsen, 1986 (JP/285/86)

11. Engelthaler Z.A.: Non-metallic and environmental protection. UNIDO-Czechoslovakia Joint Programme, Pilsen 1986 (JP/288/86)

12. Duchek P.: Aluminium Bentonite - an effective agent for treatment of wastewaters polluted with acrylate dispersions. UNIDO-Czechoslovakia Joint Programme Pilsen, 1986 (JP/289/86)

13. Engelthaler Z.A., Kačín J.: Possibilities of utilization of special activated bentonites for wastewater treatment. UNIDO-Czechoslovakia Joint Programme Pilsen, 1986 (JP/308/86)

14. Power T.: Water treatment - clarifying the market for minerals. Minerals, Aug. 1985, p. 35

15. Clarke G.: Zeolites-take off for the tuff guys? Industrial Minerals, Febr. 1980, p. 21

a) Concise handbook of applied geology:

Geological Reserves and Resources of Non-metallic Mineral Raw Materials - Criteria of Assessment (74 pages).

Among others includes chapters: (a) Sampling, (b) Calculation of reserves, (c) Specific criteria for prospecting and explorations of most types of industrial minerals and rocks, (d) Unconventional and potential non-metallics in the 21st century.

This text was photocopied by IGME Athens and sent during July 1987 to all six branches of IGME, to the Ministry of Industry, to Technical University in Athens, to Laboratory of Silver and Baryte Ores Mining Co. Athens, a.o. With additional chapters of technology and economics of non-metallics will be handed to the Director General of IGME in September 1987.

b) General introducing textbooks on non-metallics (in use by geologists of IGME since June 1987 or earlier; additional copies may be secured during summer 1987).

Kužvart M. (1984): Industrial Minerals and Rocks. - 454 p., Elsevier-Amsterdam, Academia-Praha (second revised eddition is presently being prepared).

Kužvart M., Böhmer M. (1986): Prospecting and Exploration of Mineral Deposits - 508 p., Elsevier-Amsterdam, Academia-Praha (second revised eddition).

VI. ANNEXES

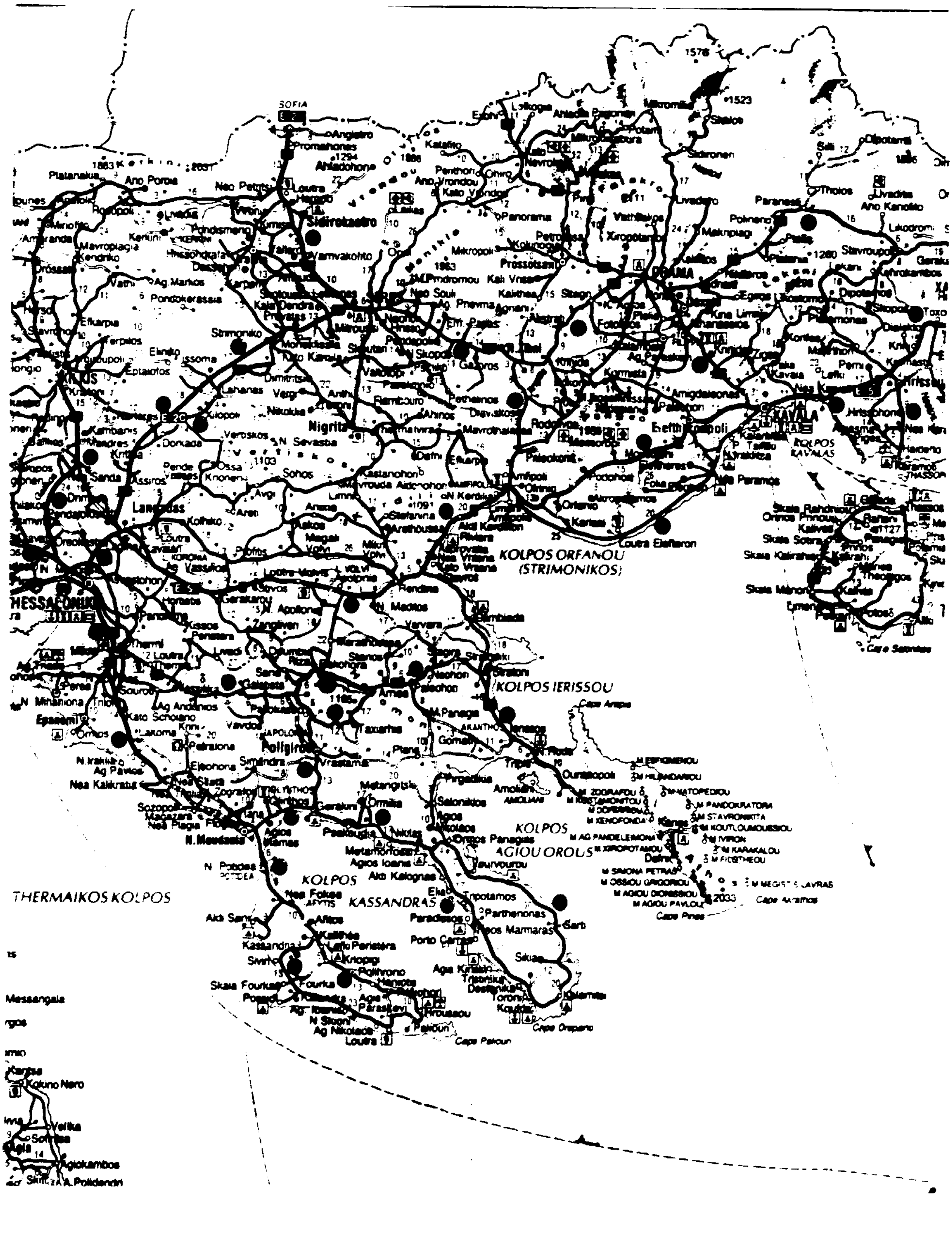
1. Localities of non-metallic raw material occurence - Macedonia
2. Localities of non-metallic raw material occurence - Thrace
3. Bentonite, perlite, kaolin a illite deposits on Milos island
4. Kaolin deposits on Lesvos island
5. The situation of feldspar occurence at Kato Potamia area
6. The outcrops of kaolin at Skala Messotopou
7. a) Technological scheme of wet dressing of kaoline
   b) Wet dressing of kaoline - description of equipments
8. Kaolin washing plant - technoeconomic data
9. Technological scheme of the continuous treatment of wastewaters by means of specially modified bentonites
10. List of laboratory equipment - application of specially modified bentonites for wastewater treatment
11. Survey of production, export and import of kaoline (graph)
12. Survey of production, export and import of kaoline (table)
13. Survey of production, export and import of feldspar (graph)
14. Survey of production, export and import of feldspar (table)
15. Survey of production, export and import of quartz (graph)
16. Survey of production, export and import of quartz (table)
17. Selected exporters and importers of montmorillonite clays
18. FOB value of selected exports of bentonite and Fuller´s Earth
19. Field activity of UNIDO Technical Assistance Experts

20 a-c. Job descriptions for posts 11-01, 11-02, 11-04

Annex 1

Localities of non-metallic raw materials occurence - Macedonia

1. Tholos - Porcel Co.
2. Assiros - Mevior S.A.
3. Argiroupoli - Kato Potamia Feldspar
4. Kolhiko - Metaarkose
5. Simandra - Red Clay
6. Dragudelli - Sithonia Granite
7. Paranestio - Feldspar
8. Haniotis - Kassandra Sand
9. Kilkis, Terpilos - Quartz



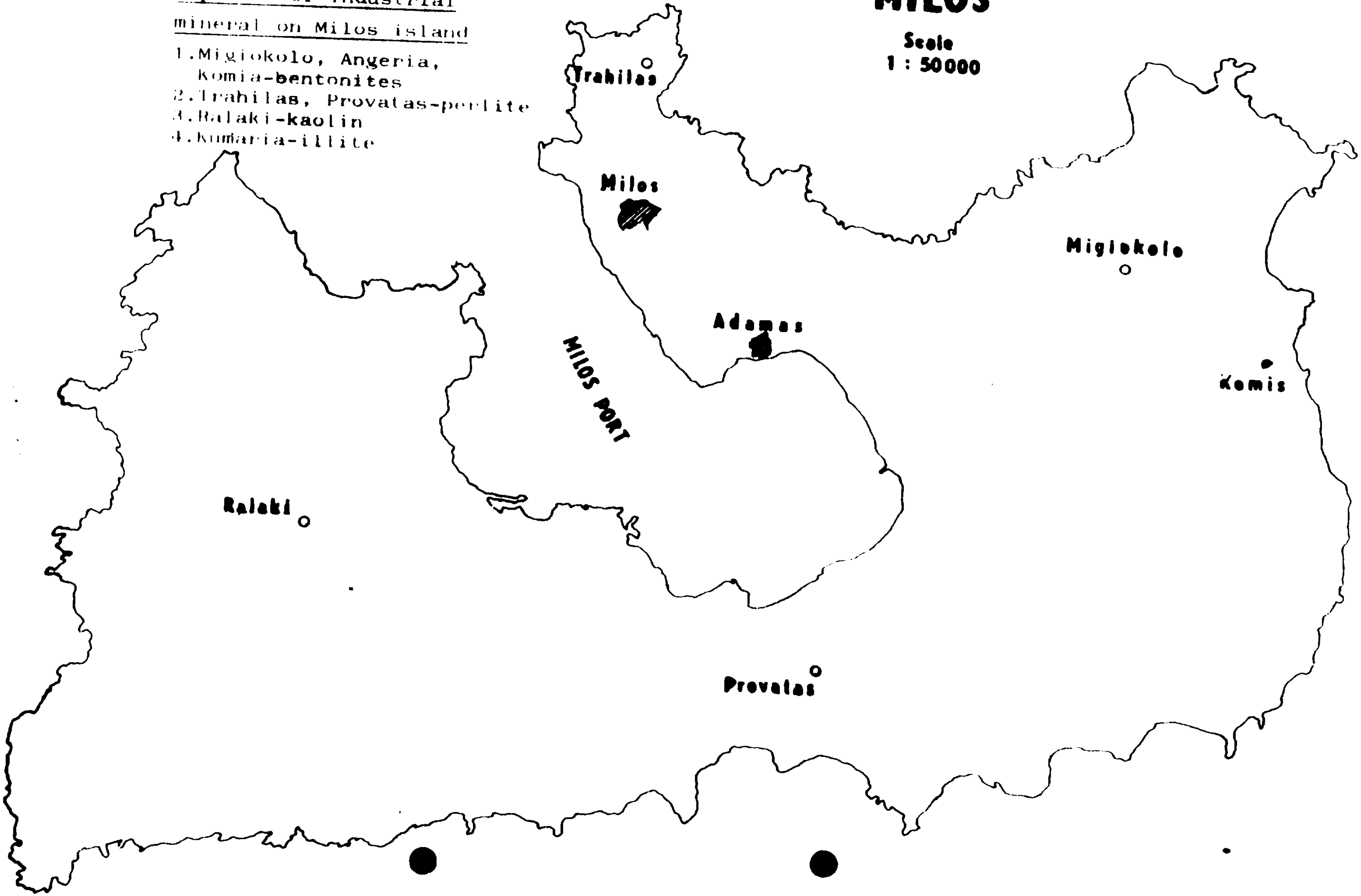
Annex 2

Localities of non-metallic raw material occurence - Thrace

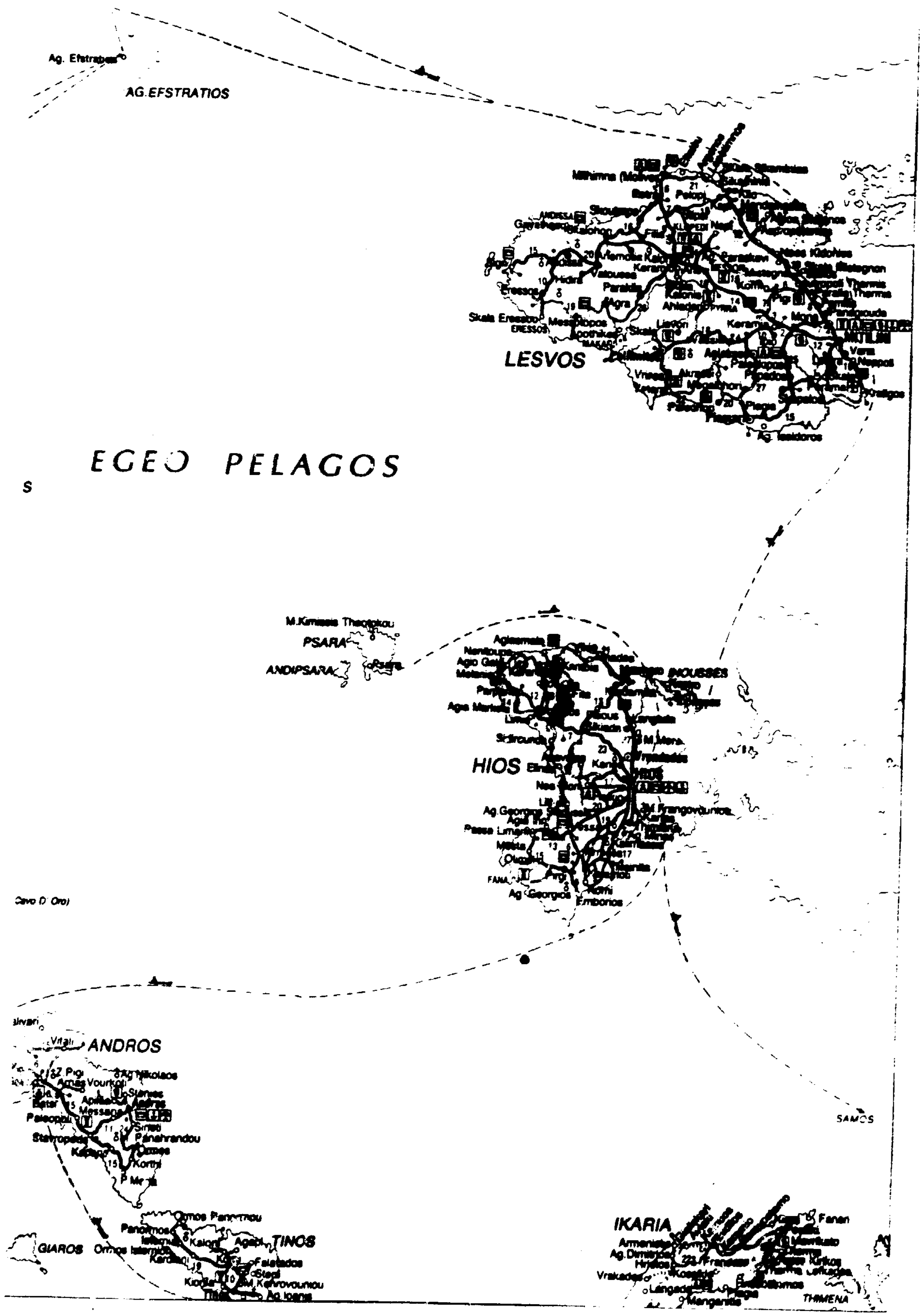
1. Dikea - Spileo - Sands
2. Feres - Zeolites
3. Sapes - Mesti, Clays
4. Korimvos - Feldspars
5. Satres - Arkose
6. Metaxades - Zeolites

Annex 3 Deposits of industrial mineral on Milos island

1. Migiokolo, Angeria, Komia-bentonites
2. Trahilas, Provatas-perlite
3. Ralaki-kaolin
4. Kumaria-illite



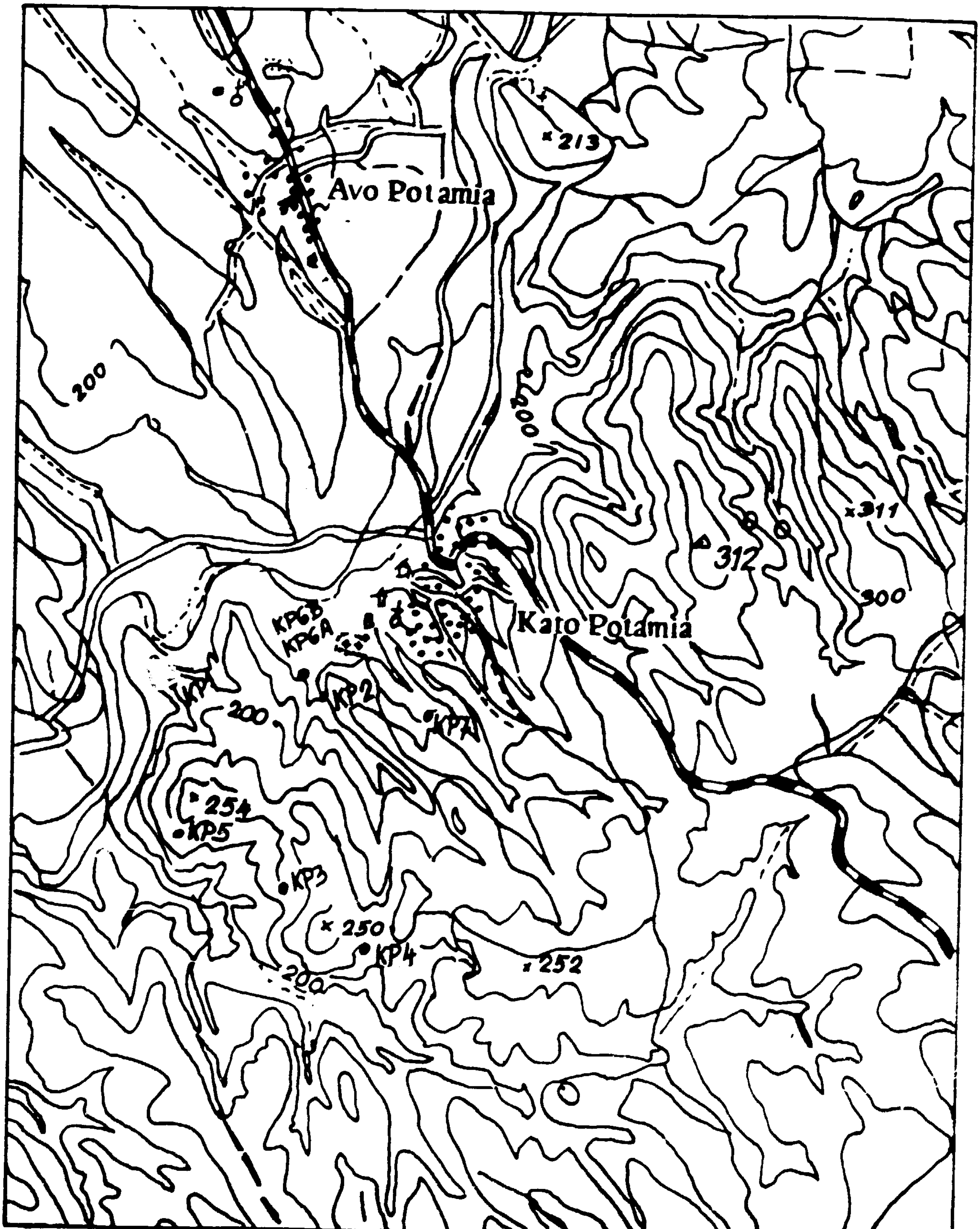
Annex 4 Kaolin deposits on Lesvos island



Annex 5

The situation of feldspar occurrence at Kato Potamia area

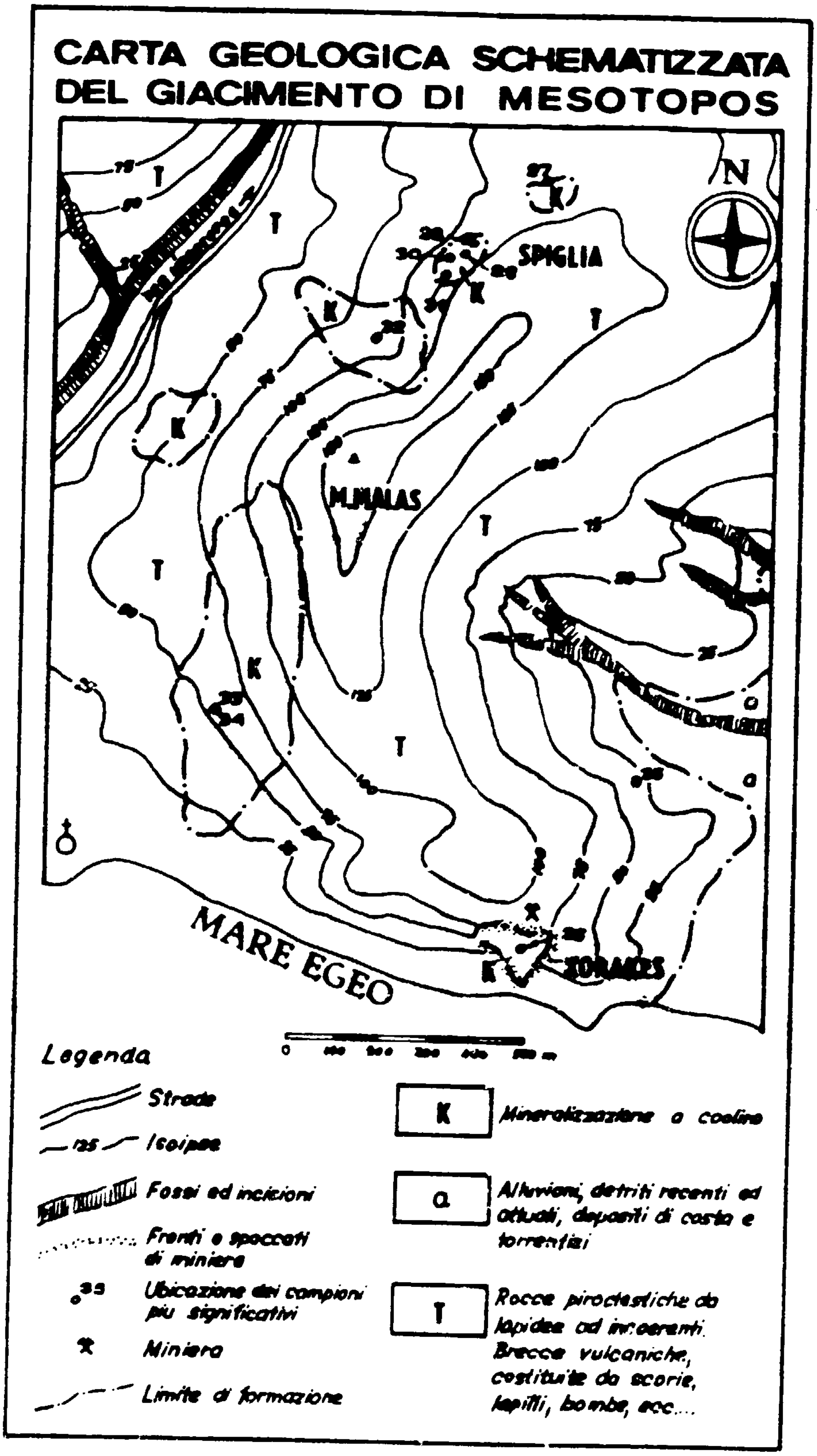
The locality of samples KP 1 - KP 7



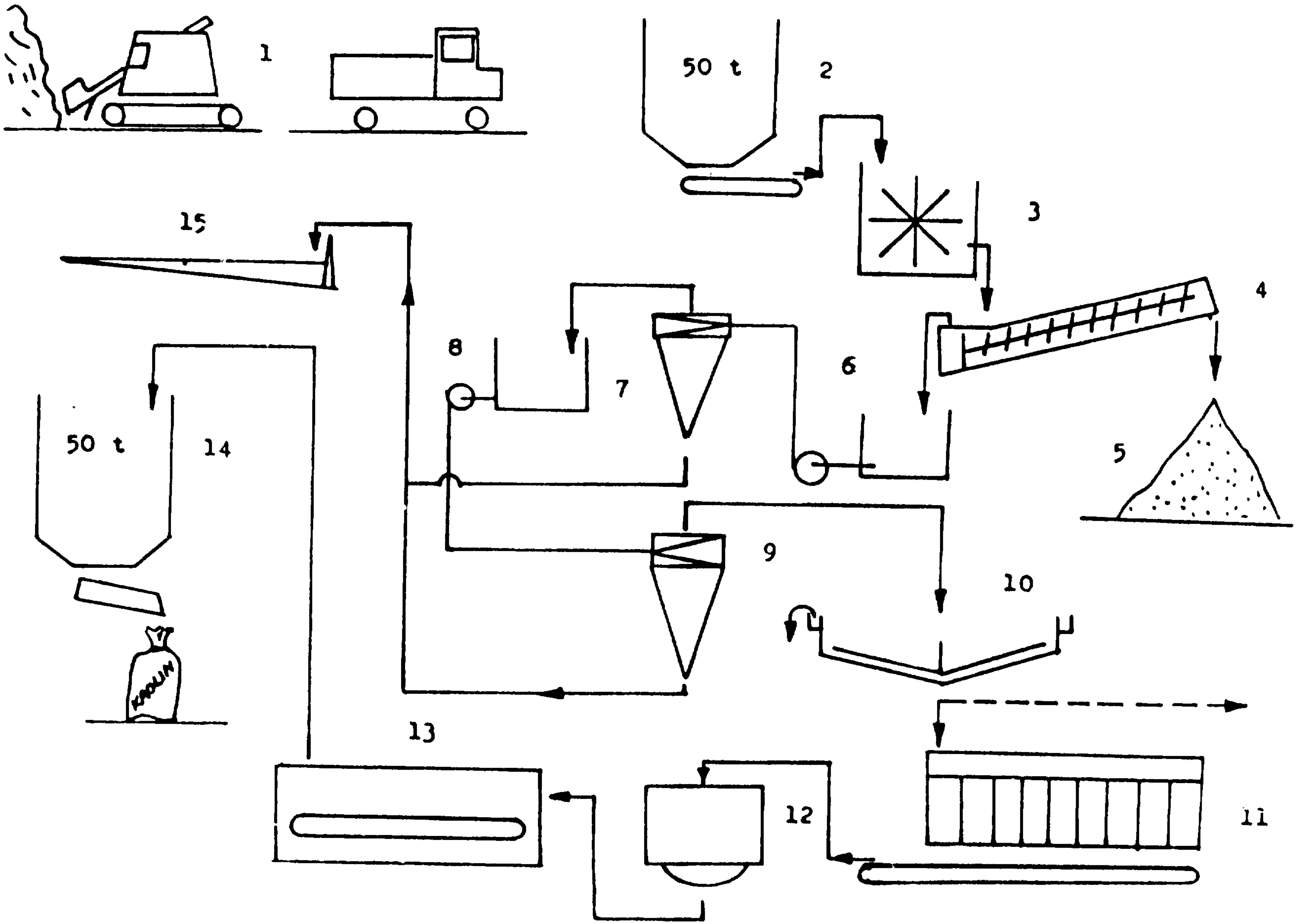
Annex 6

The outcrops of kaolin at Skala Messotopou

1. sampled area for semi-industrial test



Annex 7a Technological scheme of Wet Dressing of Kaoline



Annex 7b <u>Wet dressing of kaoline - description of equipments</u>

1. Mining and transport of raw kaolin
2. The bin with belt feeder type PSS 600, 1.5 kW
3. The knife blunger Excelsior type
4. Spiral classifier
5. Pile of sand fraction
6. Pumping tank, pump MAPE 100
7. Hydrocyclone, 250 Ø mm
8. Pumping tank, pump MAPE 50
9. Battery of hydrocyclone 50 Ø mm
10. Thickener, type DOOR or PASSAVANT
11. Filter press, type LFA 1250
12. Noodle machine
13. The belt drier
14. Bin of kaolin product with sacking machine
15. The sludge bed

Annex 8. Kaolin washing plant - technoeconomic data

Capacity of the plant 85 000 t/year

1) The quaranted plant capacities when using 250 days per year will make an average daily production, resp. capacities of the plant:
   85 000 t/year : 250 days - 340 t/day
   resp.
   340 t/day : 24 h/day = 14.2 t/h
   Recovery of raw run-of-mine ore is 25%

2) Working capacity of the plant is:
   250 days per year
   3 shifts daily
   8 hours per shift

3) Grain size distribution of raw kaolin (5)

Fraction in μm	Share in wt. %
above 63	66.2 building sand
20 - 63	9.0 semi product
below 20	24.8 washed kaolin

4) For ten years of production the industrial reserves recovered by geological survey have to be approximately 3.4 mil. tons of raw kaolin. In case of lower reserves, a lower plant capacity should be taken into account.

5) 3 400 000 tons of raw kaolin in industrial reserves per 10 years
   340 000 tons of raw kaolin for annual mining
   85 000 tons of washed kaolin yield per year it means 25% of raw kaolin

6) The quality of the product (washed kaolin) will be approximately:

	content (wt. %) Fe_2O_3	TiO_2	Fe_2O_3 + TiO_2	brightness in %	abrasivity in mg
washed kaolin	1.35	0.57	1.92	74.1	-
after mag.sep.	0.39	0.42	0.81	84.1	9.3

Annex 8 cont.

7) Capacity of water supply and water preparation for technological requirements is 38.7 cub. m./h resp. 930 cub.m./day.

8) Steam pressure: 13 bar
   Steam temperature: 194°C
   Capacity: 12.5 t of steam/h

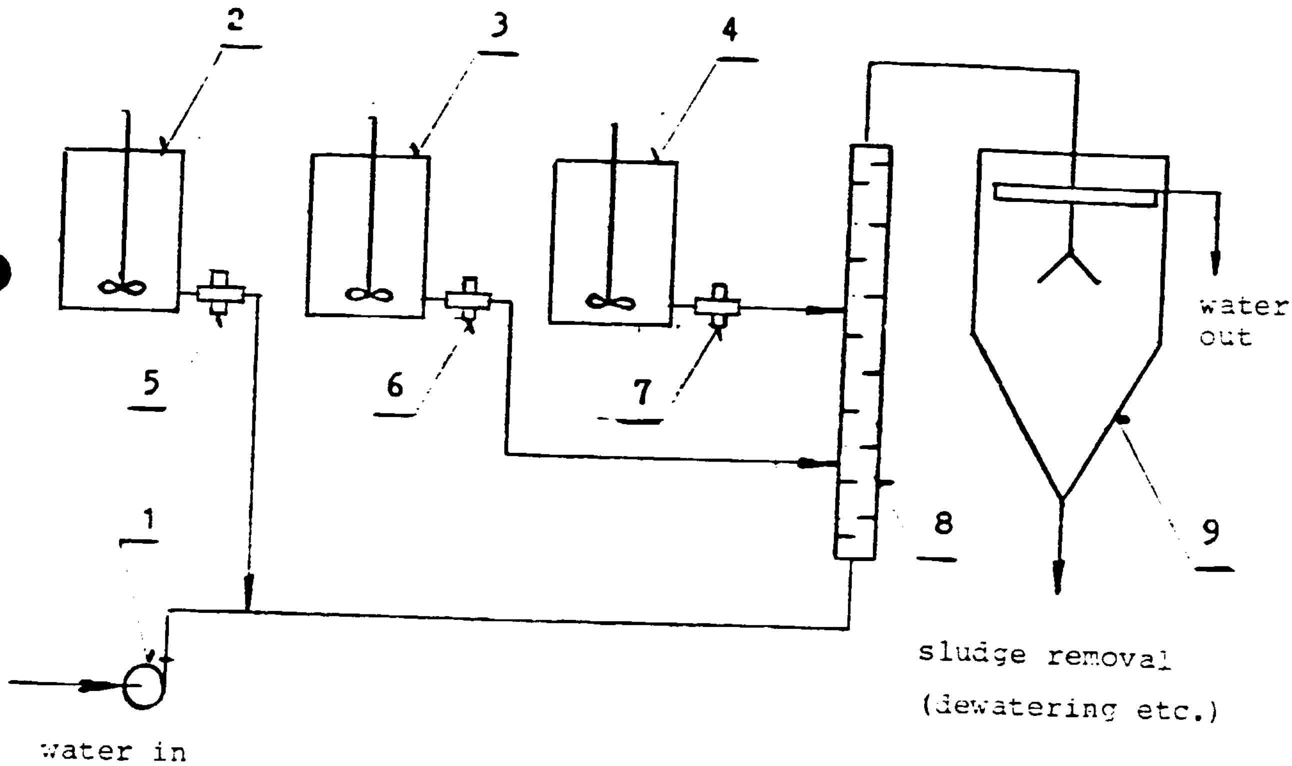
9) Electric Power: annual consumption 3 659 722 kWh

10) Consumption of raw materials and power per ton of absolutely dry finished product:

Crude ore	4 000 kg
Flocculation agent	the quantity will be determined after test run
Industrial water	2.73 m^3
Water steam	0.87 t
Electric power	43 kWh
Filter cloth	the quantity will be determined after test run

11) Total price of investment 4,833,000.00 Cl $

Annex 9 Technological scheme of the continuous treatment of wastewaters by means of specially modified bentonites



Legend:

1 - pump for wastewater transporting

2 - blunger and reservoir of bentonite suspension

3 - blunger and reservoir of neutralization agent

4 - blunger and reservoir of flocculant

5, 6, 7 -metering pumps

8 - mixer

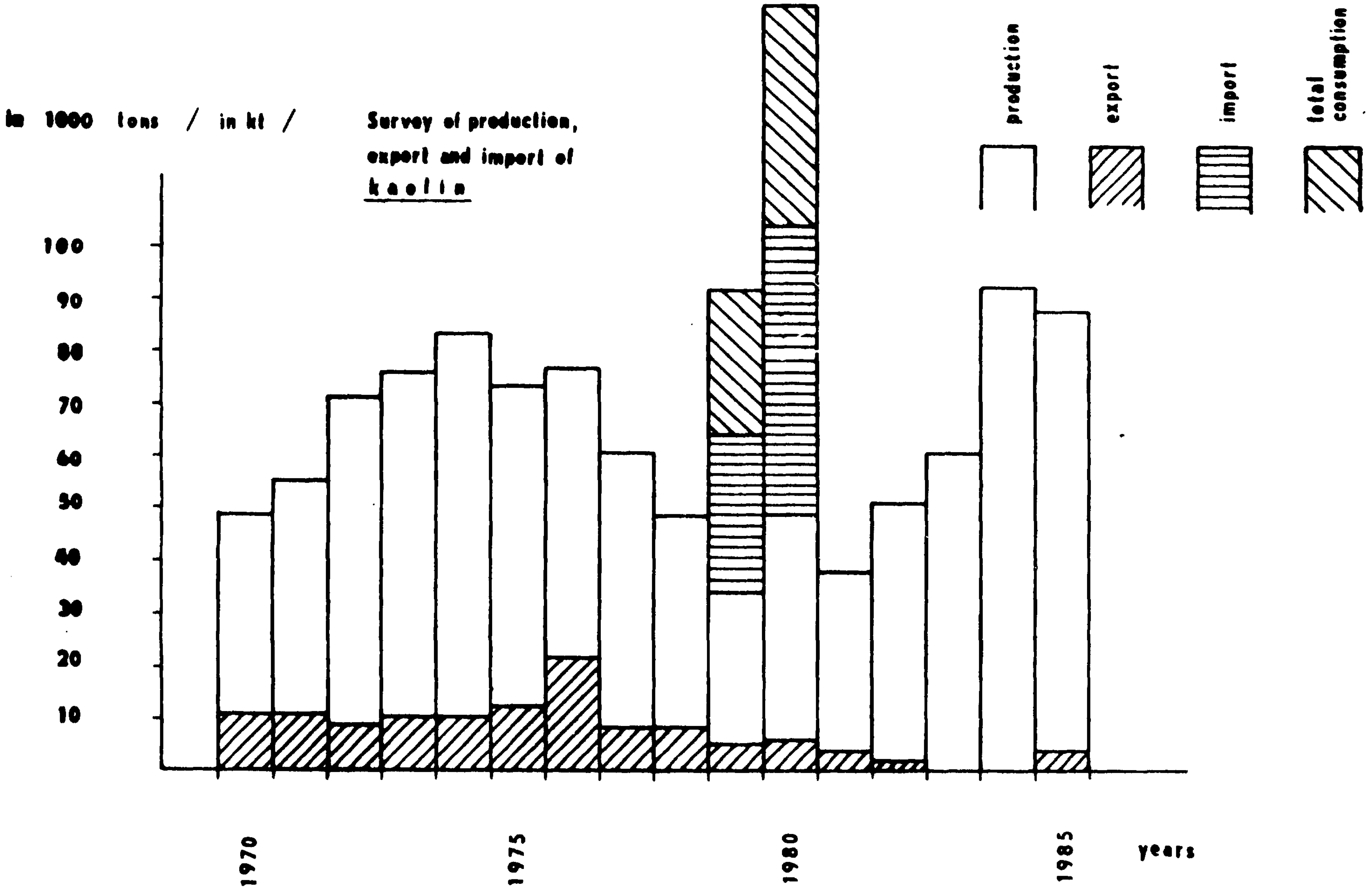
0 - settler

Annex 10

List of laboratory equipment - application of specially modified bentonites for wastewater treatment

1. Laboratory drier (max 200°C)
2. Analytical balance, weighing range 1 kg, readibility 0.1 mg
3. Analytical balance, weighing range 200 g m, readibility 0.1 mg
4. Chemical oxygen demand (COD) determination set
   - hot plate
   - Erlenmeyer flasks (250 ml)
   - coolers
5. Equipment for volumetric analysis
6. Equipment for filtration of the sludge (Buechner stopper, vacuum pump)
7. pH - meter
8. vibration (or ball) laboratory mill for dry grinding (volume about 1 kg)
9. Sieves - 2 mm and 0.315 mm
10. Laboratory stirrers, magnetic stirrers
11. Polarograph (for determination of heavy metals, if applicable)
12. Mixer
13. Laboratory refrigerator
14. Chemicals:
    - H_2SO_4, $K_2Cr_2O_7$, $(NH_4)_2$ $Fe(SO_4)_2$, KOH, Na_2CO_3, distilled water
    - organic flocculants (e.g. PRAESTOL)
15. Laboratory glass equipment
16. Sample flasks - PE or glass, 5 l

Annex 11



In 1000 tons / in kt /
Survey of production, export and import of kaolin
production
export
import
total consumption
100
90
80
70
60
50
40
30
20
10
1970
1975
1980
1985
years

Annex 12

a		b	c	d		e	f	g		h
1979	1	32 803			4	56 479	140 249	2 483	88 %	
	2	5 131	11 172	2 177	4	7 715	53 513	6 936	12 %	
	3	27 672			5	64 194	193 762		100 %	91 866
1980	1	48 399			4	92 274	315 275	3 417	88 %	
	2	5 594	16 302	2 914	4	12 482	78 509	6 290	12 %	
	3	42 805			5	104 756	393 784		100 %	147 561
1981	1	37 364								
	2	3 362	18 946	5 635						
	3	34 002								
1982	1	50 179								
	2	1 690	10 305	6 098						
	3	48 489								
1983	1	60 749								
	2	70	502	7 171						
	3	60 679								
1984	1	92 407								
	2	275	2 706	9 840						
	3	92 132								
1985	1	87 323								
	2	3 575	43 392	12 138						
	3	83 748								

Notes :

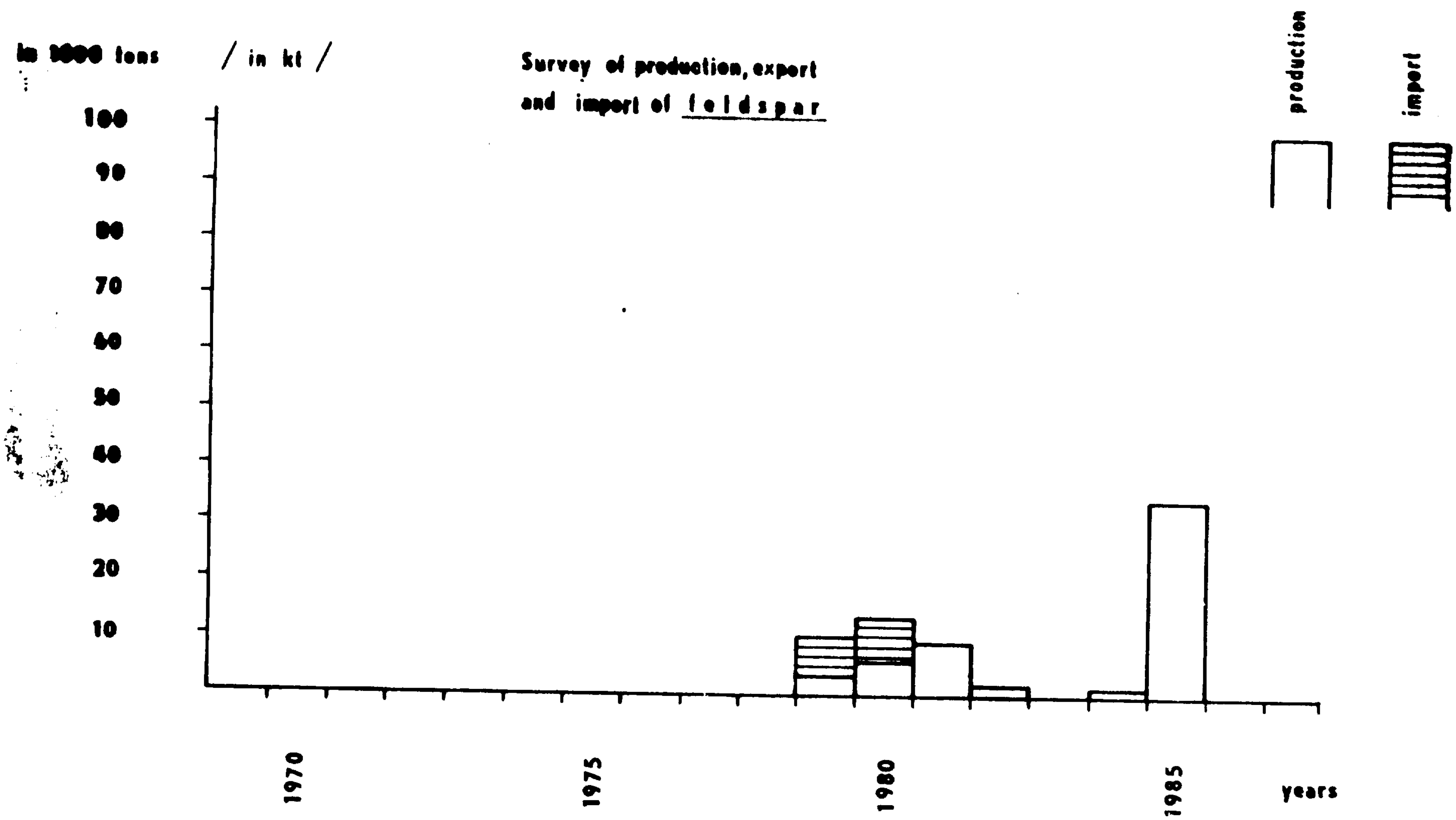
1	production	a	year
2	export	b	in tons
3	consumption	c	in 1000 DR
4	import	d	in DR/ton
5	total import	e	in tons
		f	in 1000 DR
		g	in DR/ton
		h	total consumption in tons

Survey of production, export and import of

kaolin

Annex 13

Survey of production, export and import of feldspar



Annex 14

a		b	c	d
1979	1	3 550		
	2	-		
	3	3 550		
1980	1	5 900		
	2	-		
	3	5 900		
1981	1	9 556		
	2	-		
	3	9 556		
1982	1	1 500		
	2	-		
	3	1 500		
1983	1	-		
	2	-		
	3	-		
1984	1	1 108		
	2	-		
	3	1 108		
1985	1	34 810		
	2	-		
	3	34 810		

	e	f	g	h
4	10 341	42 517	4 111	
5	10 341	42 517	4 111	13 891
4	13 908	66 979	4 816	
5	13 908	66 979	4 816	19 808

Notes :

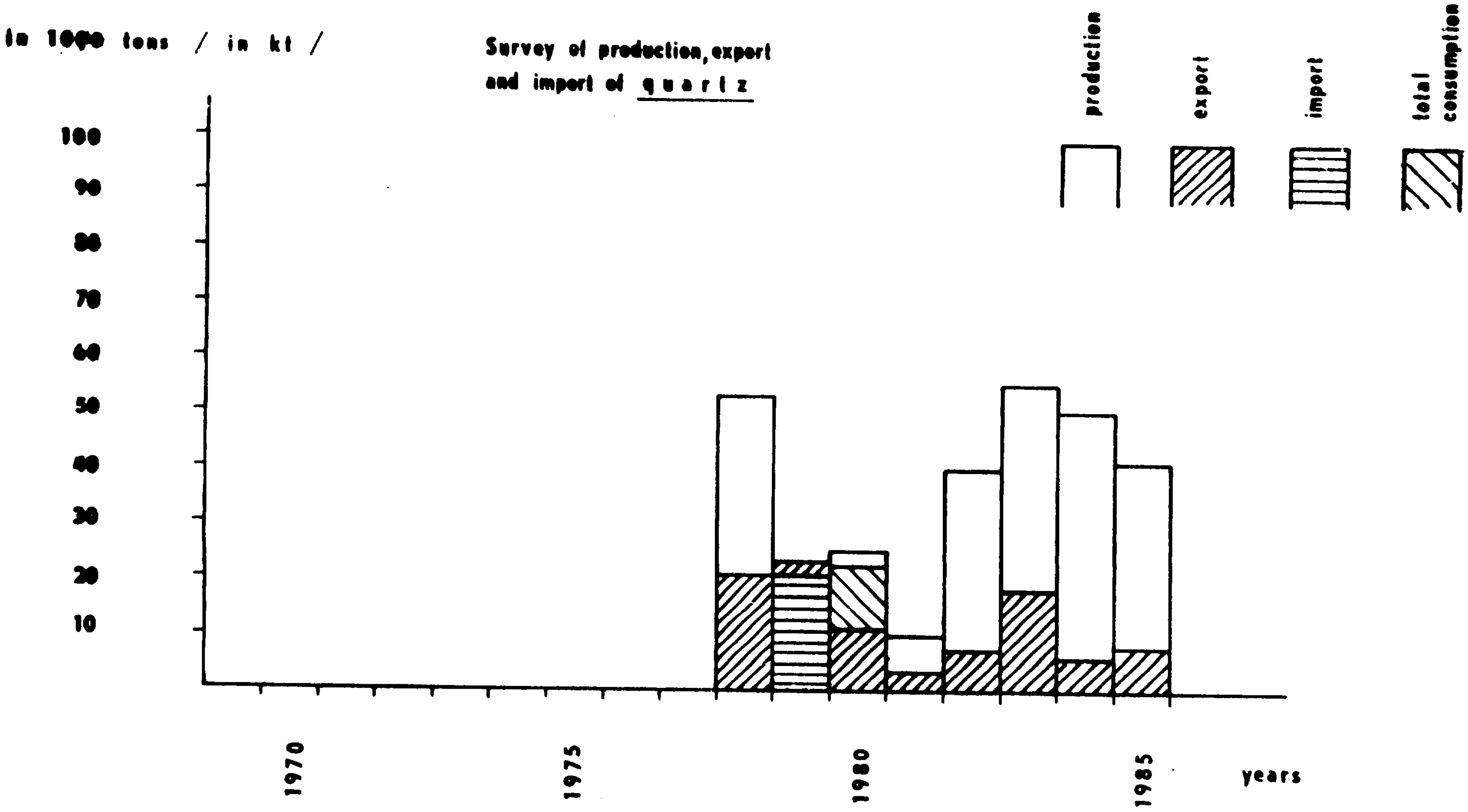
1 production
2 export
3 consumption
4 import
5 total import

a year
b in tons
c in 1000 DR
d in DR/ton
e in tons
f in 1000 DR
g in DR/ton
h total consumption in tons

Survey of production,export and import of

f e l d s p a r

Survey of production, export and import of quartz



Annex 16

a		b	c	d		e	f	g	h
1979	1	20 958			4	446	2 350	5 246	
	2	23 630	20 117	851	5	448	2 350	5 246	- 2 224
	3	- 2 672							
1980	1	25 049			4	36	478	13 278	
	2	11 662	13 850	1 188	5	36	478	13 278	23 423
	3	23 387							
1981	1	10 413							
	2	3 706	4 822	1 301					
	3	6 707							
1982	1	40 126							
	2	7 397	12 771	1 727					
	3	32 729							
1983	1	55 164							
	2	18 755	35 828	1 910					
	3	36 409							
1984	1	50 560							
	2	5 923	14 610	2 467					
	3	44 637							
1985	1	41 231							
	2	7 937	26 866	3 385					
	3	33 294							

Notes :

1	production	a	year
2	export	b	in tons
3	consumption	c	in 1000 DR
4	import	d	in DR/ton
5	total import	e	in tons
		f	in 1000 DR
		g	in DR/ton
		h	total consumption in tons

Survey of production, export and import of

q u a r t z

Annex 17 Selected Exporters and Importers of Montmorillonite Clays (000 t)

Export	1973	1974	1975	1976	1977	1978	1979	1980	1981
Germany F.R. of	31.6	37.3	32.9	44.3	30.5	25.0	26.3	29.8	24.0
Greece	316.7	296.9	336.4	381.6	381.1	331.7	272.2	339.7	N.A.
India	3.5	8.0	15.7	6.2	11.1	15.9	21.8	18.2	8.9
Italy	15.7	24.0	19.3	23.5	18.6	20.2	31.3	19.0	36.3
Netherlands	12.0	18.0	13.0	10.5	18.1	24.9	27.3	36.0	46.6
Spain	15.4	16.6	22.6	26.1	11.9	37.9	39.9	32.6	N.A.
UK	17.4	22.3	15.9	18.4	17.1	17.7	15.9	25.0	N.A.
USA	551.9	698.0	670.9	752.3	755.6	709.9	840.6	1012.4	882.9
Imports									
Australia	63.1	69.1	50.2	63.7	11.8	19.4	N.A.	N.A.	N.A.
Belgium	11.3	17.3	22.6	27.8	26.6	28.6	24.6	38.5	25.8
Brazil	19.3	17.7	13.1	14.0	16.2	14.4	21.6	13.2	N.A.
Canada	367.6	345.2	286.0	366.6	478.1	295.7	612.3	469.5	311.6
France	72.8	124.0	103.8	94.3	91.3	88.5	94.5	18.0	95.0
Germany F.R. of	33.8	107.0	43.5	93.3	77.5	45.9	66.8	78.0	77.2
Italy	25.9	26.8	23.4	42.5	64.6	54.7	29.9	55.4	25.4
Netherlands	42.8	38.4	46.4	35.4	38.3	58.7	64.8	68.9	63.2
UK	53.5	73.4	45.4	48.4	79.0	46.2	75.4	79.2	N.A.

Source: International Trade Statistics

Annex 18 FOB Values of Selected Exports of Bentonite and Fuller's Earth (US $/t)

		1975	1976	1977	1978	1979	1980	1981
Belgium	(bentonite)	82.6	73.9	80.4	91.7	109.9	108.7	93.8
France	(bentonite)	124.6	125.8	125.9	146.3	235.8	189.2	153.6
	(fuller's earth)	52.0	49.9	50.0	139.3	102.6	85.7	93.6
Germany	F.R. of (natural bentonite)	95.4	92.3	113.7	136.2	150.3	155.5	154.4
Greece	(crude bentonite)	12.7	12.7	13.7	16.4	17.2	15.2	-
	(processed bentonite)	18.8	17.3	19.6	19.3	22.7	26.3	-
Italy	(bentonite)	55.0	80.4	73.2	94.2	80.0	120.1	92.5
USA	(bentonite)	62.4	70.6	64.1	65.9	71.4	76.4	82.5
	(fuller's earth)	67.2	70.6	67.9	78.7	77.1	88.7	103.6

Source: International Trade Statistics

Annex 19

Field activity of UNIDO Technical Assistance Experts (Project DP/GRE/86/008, posts 11-01, 11-02,11-04)

Date	Post presence	Activity
4.6.	11-01, 11-02	Arrival - Athens
5.6.	-"-	IGME Athens
6.-7.6	-"-	Bauxite - Parnassos
8.-12.6	-"-	Lesvos island - kaolin
13.-15.6	-"-	IGME Athens, transfer to Salonica
16.6.	-"-	Transfer to Salonica
17.6.	-"-	IGME Branch Salonica, Kato Potamia-feldspars, Kilkis-quartz
	11-04	Arrival - Salonica
18.6.	all posts	Analipsi-metaarkose,MEVIOR, Agios Panteleimon-red clay
19.-20.6	-"-	Sithonia peninsula -granite
21.6.	-"-	Transfer to Xanthi
22.6.	-"-	IGME Branch Xanthi, PORCEL, Tholos - feldspars
23.6.	-"-	Transfer to Soufli, Ferres - zeolites
24.6.	-"-	Dikea - sands
	11-02	Departure for Athens
25.6.	11-01, 11-04	Metaxades - zeolites, transfer to Xanthi
	11-02	IGME Athens
26.6.	11-01, 11-04	Theotokato - arkoses
	11-02	IGME Athens
27.6.	11-01, 11-04	Theotokato - arkoses, transfer to Kassandra peninsula (Halkidiki)
	11-02	IGME Athens, preparation of terminal report
28.6	11-01, 11-04	Haniotis (kassandra) - sands, transfer to Athens
	11-02	Preparation of terminal report

Annex 19 cont.

29.6.	11-01, 11-04	Transfer to Athens
	11-02	Departure for Vienna
30.6.-6.7.	11-01, 11-04	IGME Athens, laboratories
7. - 9.7.	-"-	Milos island - bentonite, perlite, kaolin, illite, silica
10.-12.7.	-"-	IGME Athens - laboratories, preparation of terminal report
12.7.	11-04	Departure for Vienna
13.-31.7.	11-01	IGME Athens, preparation of terminal report
31.7.	11-01	Departure for Vienna

xxxxxxxxxx xxxxxxxxx

UNITED NATIONS

Annex 20 a

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

JOB DESCRIPTION

DP/GRE/86/008/11-01/J 13419

Post title:	Raw materials specialist
Duration:	Two (2) months
Date Required:	March 1987
Duty Station:	Athens and selected field areas as required
Duties:	In consultation with the National Project Director and the IGME scientific personnel the consultant shall:

1) Review existing geological data related to various area in Greece favoured with the existence of selected industrial minerals.
2) Evaluation and interpretation of the reviewed data in the local geological context of each area.
3) Visits to the selected areas and collection of representative samples for testing in the IGME laboratories and for sending abroad.
4) Training on the job of the IGME personnel.
5) Submission of a report containing major findings, conclusions and recommendations, for the integrated exploitation of the selected industrial minerals.

Qualifications:	Senior geologist with broad experience in the exploration and exploitation of industrial minerals.
Language:	English.

Contd...2

Applications and communications regarding this Job Description should be sent to:

Project Personnel Recruitment Section, Industrial Operations Division

UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. Box 300, Vienna, Austria

V - 33106

Project Objective: The project is designed to strengthen IGME's capability in the field of industrial minerals for the development of selected exploration projects leading to the integrated exploitation of industrial minerals.

Background information: Industrial minerals cover a major part of Greek mineral raw materials. The needs of the existing industry are to a great extent covered by imported raw materials. Therefore industrial minerals become a subject with first priority for the IGME research programme.

The assimilation of international experience in this field will provide the basis for the intensification of exploitation on local mineral raw materials.

Stepaney

Annex 20 b

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

JOB DESCRIPTION
DP/GRE/86/008/11-02/J13419

Post title:	Consultant in Mineral Processing of Industrial Minerals.
Duration:	One (1) month
Date required:	May 1987
Duty station:	Athens laboratories
Duties:	The consultant will assist the institute staff in the mineralogical processing and evaluation of Greek industrial minerals. 1) Review of existing data 2) Selection and preparation of samples 3) Determination of processing characteristics. Application of traditional processing methods to beneficiate industrial minerals. 4) Evaluation of the produced concentrates according to their marketability. 5) Training of the local staff in 3 and 4. 6) Economic assessment on the possibility of industrial exploitation. 7) Submission of a report containing observations conclusions and recommendations.
Qualifications:	Senior mineral processing engineer with experience in industrial minerals evaluation. Teaching experience desirable.
Language:	English or French.

.../2

Applications and communications regarding this Job Description should be sent to:

Project Personnel Recruitment Section, Industrial Operations Division
UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. Box 300, Vienna, Austria

V.81-33106

Project objective:

The project is designed to strengthen IGME's capability in the field of industrial minerals for the development of selected exploration projects leading to the integrated exploitation of industrial minerals.

Background information:

Industrial minerals cover a major part of Greek mineral raw materials. The needs of the existing industry are to a great extent covered by imported raw materials. Therefore industria minerals become a subject with first priority for the IGME research programme.

The assimilation of international experience in this fiel[illegible] provide the basis for the intensification of exploitation [illegible] local mineral raw materials.

Annex 20 c

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

JOB DESCRIPTION

DP/GRE/86/008/11-04/J13419

Post title: Consultant in up-grading of industrial minerals for non traditional uses.

Duration: One (1) month.

Date required: 15 June - 15 July 1987

Duty station: Athens Laboratories.

Duties: The consultant will assist the institute staff in the mineralogical processing and evaluation of Greek industrial mineral for non traditional uses.

1) Literature review.
2) Selection and preparation of samples.
3) Determination of mineralogy and application of new or traditional processing methods to evaluate industrial minerals for different uses.
4) Training of the staff to 3
5) Marketing of new products.
6) Economic assessment on the possibility of production of new products from known industrial minerals.

Qualifications: Senior up-grading engineer with experience in mineralogy and mineral processing as applied to the investigation of industrial minerals in not traditional uses.

Language: English or French.

.../2

Project Objective:

The project is designed to strengthen IGME's capability in the field of industrial minerals for the development of selected exploration projects leading to the integrate exploitation of industrial minerals.

Background information:

Industrial minerals cover a major part of Greek mineral raw materials. The needs of the existing industry are to a great extent covered by imported raw materials. Therefore industrial minerals becomes a subject with firs priority for the IGME research programme.

The assimilation of international experience in this fiel will provide the basis for the intensification of ex[illegible] a tion on local mineral raw materials.