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25 November 1985
English

DEVELOPMENT OF A BASIC INDUSTRY FOR THE PRODUCTION OF ALUMINA FROM INDIGENOUS ALUMINIFEROUS ORES SUCH AS ALUNITE AND BAUXITE

DP/IRA/84/002/11-05/31.8.A.

ISLAMIC REPUBLIC OF IRAN

Iran.

Technical Report : Exploration of Bauxite and Alunite

"Aluminium Raw Materials Programme" (ARMP)

Prepared for the Government of the Islamic Republic of Iran
by the United Nations Industrial Development Organization,
acting as executive agency for the
United Nations Development Programme

Based on the work of :

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1. ABSTRACT

In connection with the project DP/IRA/84/002/11-05/31.8.A. the consultant visited,during an extended mission (21.10.1985 - 24.11.1985),bauxite and alunite deposits in Iran now under exploration by "Aluminium Raw Materials Programme" (ARMP). During the last week a joint excursion to the alunite deposit Taykand-Haftsandough was undertaken with Dr.E.Balazs. Head of Metallurgical Industries Section UNIDO, ARMP senior members, and three experts from VAMI/Leningrad. VAMI is the contractor of a project entitled "Pilot Scale Investigation of Alunites" providing services relating to the project support (functional) study on "Investigation and Evaluation of Alunite Ore and Concentrate in Iran".

Subjects of the discussion were the

- methodology of sampling the alunite deposits
- selection of samples from the storage of the "Geological Survey of Iran (GSI)
- evaluation of the comprehensive data on alunite accumulated at the GSI
- repetition of sampling in the field for a characteristic sample
- preparation for taking a representative sample from a selected deposit.

The exploration of bauxite deposits in two regions in the Elburz Mountains could prove during 1985 the existence of the quantity of resources in R-2 and R-3 categories of the UN-classification, however, the quality of the bauxite is subeconomic. Therefore, further exploration has been discontinued for the time being in the Ganu and Shirin Abad-Siah Rudbar regions.

In the Jajarm region on the eastern spur of the Elburz Mountain Range, the exploration works could prove the existence of bauxite suitable for the production of alumina (Drillhole No.22). Therefore it was decided to intensify the geological survey and exploration.
The bauxitiferous area of Jajarm was divided into four sectors, and sector 1 was selected for thorough exploration in order to achieve results soonest possible.

A Master Bar Chart was elaborated, according to which it can be expected that at the end of 1986 characteristic bauxite samples will be drawn for technological investigations, followed by the examination of a representative sample.

It is advisable that the consultant will provide his services on a regular base during the next two years in addition to ad hoc missions of further experts to support the exploration and mine development programme of ARMP.

The intention is to finalize the two studies on alunite and bauxite simultaneously in order to proceed to a comparative study of the two feasibility studies for a decision on investment.

2. RECOMMENDATIONS

A summary with the following recommendations was prepared at the end of the mission and copies were distributed accordingly.

2.1 Bauxite

2.1.1. GANU region

- To finalize the drillings now under execution in the eastern sector
- One additional drilling was selected during a field trip in the western sector.
- In case this drillhole should indicate favourable results then from the same location a deeper drillhole is advisable.
- After finishing these exploration works, a last geological survey along the outcrop should be made in order to complete the maps for a final evaluation of the exploration works performed by establishing the mineral inventory.
- To discontinue further exploration.

2.1.2. SIAH RUDBAR and SHIRIN ABAD region

- To complete drillings now under execution.
- To drill a last hole west of section 15 and 16.
- To complete geological survey along the outcrop and within the drilled area. Special attention to be paid to the tectonic structure in this area.
- To evaluate and review all geological and exploration data available in the area for final report.

2.1.3. JAJARM region

The recommendations for this bauxitiferous region are compiled in the Master Bar Chart on page 22 of this report, in which chart the working period till the end of the exploration works required for an OPPORTUNITY study and PRE-FEASIBILITY study is

covered. It is envisaged to finalize the feasibility study during 1988 if the exploration and the technological tests are not discontinued at an earlier stage due to quality inhomogenity, expected mining cost for selective mining in open pit and underground or technological difficulties in processing this bauxite economically.
The approach to the feasibility study in several phases is shown in the Appendix, in Tables 6/I for bauxite and 6/II for alunite.

2.1.4. ZAGROS - KORDESTAN - YAZD- Bauxitiferous Areas

It is recommended to proceed to fact finding, review of reports and data and prepare a time and cost estimate for an exploration campaign.

2.1.5. Laboratory Equipment

Large quantities of samples from the bauxite (and also alunite) exploration workings will be processed in a laboratory sample preparation section. Therefore, a supplementary list of suitable equipment was selected to be purchased the soonest possible as up to now sample preparation was a bottle-neck in the progress of the work.

2.2 Alunite

2.2.1. SYRDAN - HASSANABAD Alunite Deposits

This area was closely studied by the Geological Survey of Iran (GSI) and a volumenous report has been made available to ARMP. Besides that,ARMP's subcontractor "MADANKAV" has recommended these deposits for further investigation as shown in their report (in Farsi language).
Due to this, an evaluation of the deposits and selection of samples can immediately commence by the team of VAMI, which arrived on Thursday, 14 November 1985 in Tehran according to their contract Nr. 85/12 (UNIDO Nr. RP/IRA/84/901 and RP/IRA/84/001, Activity Code RP/02/31.8 Annex E, Article C.1).

This is emphasized due to the verbally given conclusions of VAMI - after examination of samples received from Iran several years ago and recently from the Tajkand alunite deposit - that there exists a great similarity with the alunite of KIROVOBAD,USSR* and which is sited in the same geological zone and formation as the Iranian alunite deposits.

Consequently, it can be expected that there exists a still closer similarity of ore character within the area explored by GSI and now by ARMP and partially evaluated by their subcontractor "Madankav".

Sampling according to above mentioned contract with VAMI should start at SYRDAN (20 samples) and, time permitting, in HASSANABAD (20 samples). Samples may be selected from the existing storages at GSI or, in case these are not available, 20 new samples may be drawn from locations of the deposit such as the abandoned quarry and galleries as well as from two trenches.

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* The Kirovabad alumina plant is supplied with alunite from the Alunitdag deposit in Azerbaidzhan.

2.2.2. ZAJKAN - ZAJKANDY Alunite Area

Sampling as indicated under 2.2.1 i.e. from the storage of GSI - 20 samples.

2.2.3. TAJKAND - HAFTSANDOUGH Alunite Deposits

Due to favourable infra-structure, access to deposit, resources and open cast mining conditions, samples should be selected as indicated in 2.2.1. from the storages of GSI.
However, the report of GSI is still pending.

2.2.4. In order to utilize the large knowledge and information accumulated at GSI for the further development of the project, it is advisable to create an ALUNITE WORKING TEAM (AWT) consisting of GSI, ARMP, MADANKAV (and from time to time an independent consultant may be added).

The scope of work of AWT consists of office work to evaluate the data as well as field trips and repetition of sampling at 10 selected locations which had previously been sampled by GSI. One set of these samples should be sent to VAMI for determination of mineralogical composition and phase analysis. A further set of these samples is to be sent to the "Amir Kabir Technology University, Tehran, Department of Mining, and one set may be examined abroad by an independent institute or firm of high reputation.

2.2.5. As soon as the mission report of VAMI concerning their visit to Iran is available, further steps should carefully be deliberated, especially for the selection of further samples according to VAMI's contract.

2.2.6. Due to the unique knowledge and experience of VAMI in alunite beneficiation and processing to alumina and valuable by-products, it seems advisable to have, in a stepwise implementation of the feasibility study,

an access to their know-how by paying the requested know-how fees in installments of 10-20 % each.

2.2.7. Each phase of the project study should be negotiable (opportunity study - pre-feasibility - feasibility study).

2.3 Final Remarks

It is advisable that in the future all reports, documents etc. which are of interest to consultants, contractors etc, will be written in the working language (Enlish). This is foreseen in the Project Document IRA/85/003/A/01/37 as Government Inputs, Article G 1 (i), page 14).

A translation of the report of MADANKAV on the alunite project is required.

Note:

The Iranian bauxite and alunite projects are difficult ones in every respect and require special attention and care. It is recommended to approve the ARMP's request expressed to the consultant several times during his stay in Iran that he should follow up the development of these projects on a regular basis for a period of 2 years. These consultancy services for optimizing ARMP's projects could be provided in two weeks missions every 2-3 months permitting 1-2 weeks monthly in between the missions for homework.

Ad hoc missions of further UNIDO experts may be required additionally to support the projects.

3. INTRODUCTION

The alumina requirements of the Islamic Republic of Iran are likely to reach 600.000 - 800.000 tons per year in the early 1990s. To reach the above objectives, the Ministry of Mines and Metals set up an Aluminium Raw Materials Program (ARMP-Government Implementing Agency) in 1981 with the plans for:

a. Completing the geological and mining work necessary for producing the required samples of aluminiferous ores,
b. Establishing a testing laboratory,
c. Contracting further testing and feasibility studies for the production of alumina from alunite, bauxite and aluminosilicates to outside sources which have developed a commercial scale technology.

UNDP assistance is provided for the projects in order to help negotiate, supervise and fund the alunite and bauxite testings and feasibility studies. The United Nations Industrial Development Organization (UNIDO) is acting as Executing Agency in the Project IRA/85/003/A/01/37.

The Government inputs are:

675 million Rials in kind
(official rate of exchange: 1 US$ = 98.-RLS)
UNDP contribution: 3.000.000 US$
Duration: 3 years.

For pilot scale investigation of alunites, a subcontract has been agreed early in 1985 with "All-Union Research, Development and Design Institute of Aluminium, Magnesium and Electrode Industry (VAMI)" USSR (Subject: RP/IRA/84/001/901). A cooperation in the field of alumina projects was agreed in June 1985 between ARMP and Aluterv-FKI of Hungary.

The implementation of the testing laboratory project is under way, however, for legal reasons it was suspended after starting with the foundations of the buildings. It is expected that work can be resumed within the next months.

For establishing the technology to produce alumina from aluminosilicates, huge resources of which are occurring in Iran, an agreement has been signed with POLSERVICE for a pre-feasibility study. Three samples of 10 kg each have been forwarded in 1984. A preliminary report has been received from POLSERVICE at the beginning of 1985 with recommendations to proceed to a prefeasibility study.

The time schedule of ARMP for all above projects is shown in the following Table, on page 13.

The National "Geological Survey of Iran" (GSI) has investigated,for more than a decade, alunite deposits within the tertiary volcanic formation in the northwestern part of Iran.

The estimated resources (in all resource categories) of alunite in four main areas are:

GSI estimation	:	602 mill.tons
Alumiran-Madankav*	:	340 mill.tons

In addition to the bauxite occurrences known in the Zagros mountains, Yazd and Kordestan regions, ARMP has concentrated its prospecting and exploration activities in the Elburz Mountains where three bauxitiferous areas were investigated.

The R-3 resources according to the UN-"International Classification of Mineral Resources" (indicating exploration opportunities) were estimated by applying various mineralisation assumptions to be: 65-90 mill. tons.

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* Madankav is the subcontractor selected by ARMP for the preparation of a prefeasibility study and the selection of the most advantageous alunite deposit for the production of alumina from alunite.

Time table for bauxcite and alunite exploration /by ARMP/

Bauxcite /x= quarterof year/

	1984	1985	1986	1987	1988	1989	199o	1991	1992
1 Exploration of 3 areas	xx	xxxx							
2 Exploration of Zagros area			xxxx	xx					
3 Selection of supplies of technology and discussion		xxxx	xx						
4 Pilot testing of various bauxcite qualities			xx						
5 Feasibility Study Mining			xxx						
6 Feasibility Study for Alumina Plant 3oc.ooo /6oo.ooo/ tpy				xxxx					
7 Financing and /parallel/ engineering					xx				
8 Construction of Alumina Plant					xx	xxxx	xxxx	xxxx	
9 Development bauxcite mine and production /1 million tpy/					xx	xxxx	xxxx	xxxx	xxxx
1o Start production alumina 3oo.ooo tpy									xxxx

Alunite

1 Elaboration of establishment of exploration program and execution of work	x	x							
2 Selection of characteristic samples and sending for lab. testing to VAMI; mining feasibility study	xx								
3 Preparation of representative sample /VAMI/		xx							
4 Elaboration of establishment of technology and report on results from No.3.		xx	x						
5 Pilot scale test /basic eng./		xx							
6 Feasibility Study for alumina			xxxx						
7 Financing and engineering			x	xx					
8 Beginning of construction 1st line loo.ooo t alumina py				xx	xxxx	xxxx			
9 Start production of alumina							x		
1o Construction 2nd line of loo.ooo t alumina py							xx	xxxx	xx

In August 1984, two UNIDO consultants visited these prospecting and exploration areas of ARMP and submitted their recommendations for further exploration activities.

The review of the progress achieved is also subject of the mission of the consultant in addition to the duties of the consultant according to the job description which are:

> "The consultant will work in close co-operation with the Ministry of Mines and Metals - Aluminium Raw Materials Programme (ARMP) and will specifically be required to:
>
> 1. Assist in selecting samples of aluminium raw materials for testing, in order to establish their suitability for industrial-scale processing to alumina and aluminium;
> 2. Advise ARMP on the concept and preparation of mining ore including additional geological investigations and sampling required to be carried out.
>
> The expert will also be expected to prepare a report, setting out the findings of the mission and recommendations to the Government on further action which might be taken."

During the mission, the consultant had the opportunity to discuss with the staff members of ARMP the results of bauxite exploration achieved in three areas during the course of this year.

As all reports of ARMP and the three-monthly progress reports requested by the Ministry of Minerals and Metals are written in Farsi language, the discussion was restricted to explanations given by the ARMP members.

It was requested by the consultant to produce , in the future, copies of reports in English, which was agreed to be the working language during UNDP/UNIDO assistance according to the Project Document: IRA/85/003/A/01/37,Article G 1(i) (Government Inputs) page 14.

4. BAUXITE RESOURCES

A summary of earlier investigations for bauxite and alunite in the Islamic Republic of Iran is given in a previous technical report of the consultant DP/IRA/84/002/11-03/A dated 10 September 1984.*

According to the consultant's opinion, R-3 resources (UN-International Classification of Mineral Resources) can be estimated in three regions of the Elburz Mountains. These R-3 reserves indicate "exploration opportunities" for bauxitic deposits. Quantities of resources are known in ranges estimated upon geological probabilities. Qualities are known by preliminary sampling at some locations.

The R-3 resources were estimated at 65-90 mill.tons in three areas:

	Mill.t	Al_2O_3	SiO_2	Modul
1. Ganu	10-25	49.0%	14.4%	3.4
2. Siah-Rudbar-Shirin Abad	35	44.0%	18.0%	2.4
3. Jajarm	20-30	46.6%	14.4%	3.4

* E.Mack, I.Vörös, Technical Report: Bauxite and Alunite Mineral Commodity.

4.1 GANU REGION

During this year, construction of access roads, exploration by core drillings and sampling continued in the western and eastern sectors of the Ganu bauxite outcrop which has a total length of 11 km.

The sampling of the outcropping bauxite by preliminary pick samples continued in Sector 1 at 34 locations. 79 samples were taken, about 1 kg each!

A total length of 1.314 m core drillings were drilled at 12 locations and 42 samples drawn. The modul of this subeconomic bauxite is 0.87-0.89.

As it was not possible to obtain a copy of the geological map 1:50.000 of this area, the geological position of the Ganu bauxite outcrop is shortly described:

The bauxite occurs between the Triassic Elika-formation consisting of fairly carstified dolomite and covered by shale and sandstone of the Jurassic Shemshak formation. The strike of the outcropping bauxitiferous horizon is mainly SW-NE, turning to NNE in the very eastern part. The inclination is generally steep as shown in the 3 sections of the Appendix, Enclosures 3-5.

For the exploration, the total length of the outcrop is subdivided into 5 sectors.

Sector 1: This sector begins in the western part of the outcrop, near the Mahtab fault, and has a length of 1500m (Trenches 1-4). One core drilling has been finished and 1-2 further drillings have been recommended to be drilled for a better assessment of the quality of the bauxite in this sector. Additional pick-samples were drawn, during this year, from the bauxite outcrop and analysed,

separately for hard (higher quality) and soft (inferior quality) bauxite.

The main quality parameter of soft and hard bauxites are shown in the statistic tabulation of the Appendix, Table 2, and is summarized in the following table:

Type of bauxite	Number of samples	Determination	Contents %		
			SiO_2	Al_2O_3	Modul
hard bauxite	36	mean value	14.55	43.95	3.02
		standard deviation	±6.13	±4.79	
soft bauxite	44	mean value	23.50	40.42	1.72
		standard deviation	±5.88	±4.13	

Sector 2: begins at trench 4 and reaches to trench 8 with an outcrop of a length of 2.750m. No further exploration was performed during this year in this sector.

Sector 3: from trench 8 to trench 22, with 2.300m length of the outcrop. During the year, core drillings were performed at 8 locations, however, only subeconomic bauxite was found.
Boreholes BH 2.1 and BH 2.2 are typical for the quality encountered in this part of the Ganu region. The assays are shown in Table 3 of the Appendix. The geological section of Enclosures 2, 3, and 4 are typical for these parts of the deposit.

Sector 4: begins at trench 22. The sector is about 2.400m long. No exploration work was performed during this year due to obviously inferior quality of the bauxite in the outcrop.

Sector 5: The total length of this sector is 2.000m with insignificant bauxite occurrences. No exploration was performed in this sector.

Due to the low grade of the bauxite found by the core drillings, the resources in the Ganu region are "subeconomic" in R-1S, R-2S and R-3 categories.

It was decided to suspend further core drillings in the Ganu area after finishing a last drillhole in the central part of the western block.

The balance of 1700m of core drillings from a contract signed with a drilling contractor will be transferred to the Jajarm bauxitiferous area.

During the next progress report of ARMP, the explored "subeconomic" resources will be calculated.

It is recommended that the consultant will elaborate definitions and specifications which are required for this type of bauxite for the application of the UN-classification method.

After the evaluation of all existent data, it can be decided if the area must finally be abandoned or if further exploration may be justified at least in sector 2 of the Ganu region.

The use of this type of bauxite as a raw material for other processes than that of an alumina production should also be taken into consideration.

4.2 SIAH RUDBAR AND SHIRIN ABAD REGION

This region in the Elburz Mountain range is situated at an elevation of 700 - 1.700m. The area is geologically mapped at a scale 1:10.000 and 1:25.000. The footwall of the bauxite horizon consists of carstified dolomite of the Triassic Elika formation. The hanging wall is shale and sandstone of the Shemshak formation (Jura).

An access road to the drilling sites was built in 1985 and 6 drillings were performed about 1 km south of Shirin Abad with a total length of 83m.

7 samples were taken and analysed indicating a low-grade bauxite of the "subeconomic" category. The quality ranges are:

SiO_2	20-40%
Al_2O_3	30-42%
Fe_2O_3	6-27%
TiO_2	1.65-2.45%
MgO	0.6 -1.2%
CaO	0.2 -2.2%
L.o.I.	9.5 -12.2%

In addition to above assays, the mean value and standard deviation of 14 samples taken from borehole BH 6 shows a low grade ore ,too:

SiO_2	31.46%	$\pm$ 5.04
Al_2O_3	34.98%	$\pm$ 3.55
Modul	1.11	

Even on the premise that sampling, sample preparation and assays include an error of more than 10%, this bauxite is of a subeconomic grade. No control assays were performed.

Trenching and sampling continued during 1985 along the Shemshak-Elika formation boundaries west of the Qozloq River. Ore bodies of lenticular shape with low-grade bauxite were explored:

Trench 23	SiO_2	20-23%
	Al_2O_3	40-42%
Trench 24	SiO_2	8.3-25%
	Al_2O_3	35-49%

Assays from sections 17 and 18 indicate a bauxite quality with a modul of 2.5-7, while assays from section 26 show a bauxite quality with a modul of 2.0-9.

It was decided to discontinue further exploration by core drillings in this area but one drill hole, west of section 15 and 26, with a forecast depth of 90m.

A balance of about 370m core drillings are still available for the Siah Rudbar and Shirin Abad regions according to an agreement with a drilling contractor and may be transferred to the Jajarm exploration area, if funds permit this during the remaining part of the year.

The geological survey in this region of Shirin Abad and Siah Rudbar will be completed and recorded in the next progress report of ARMP to the Ministry of Mines and Metals including a calculation of the subeconomic resources.

For the calculation of the bauxite resources, the UN-"International Classification of Mineral Resources" should be applied,as mentioned on page .

4.3 JAJARM REGION

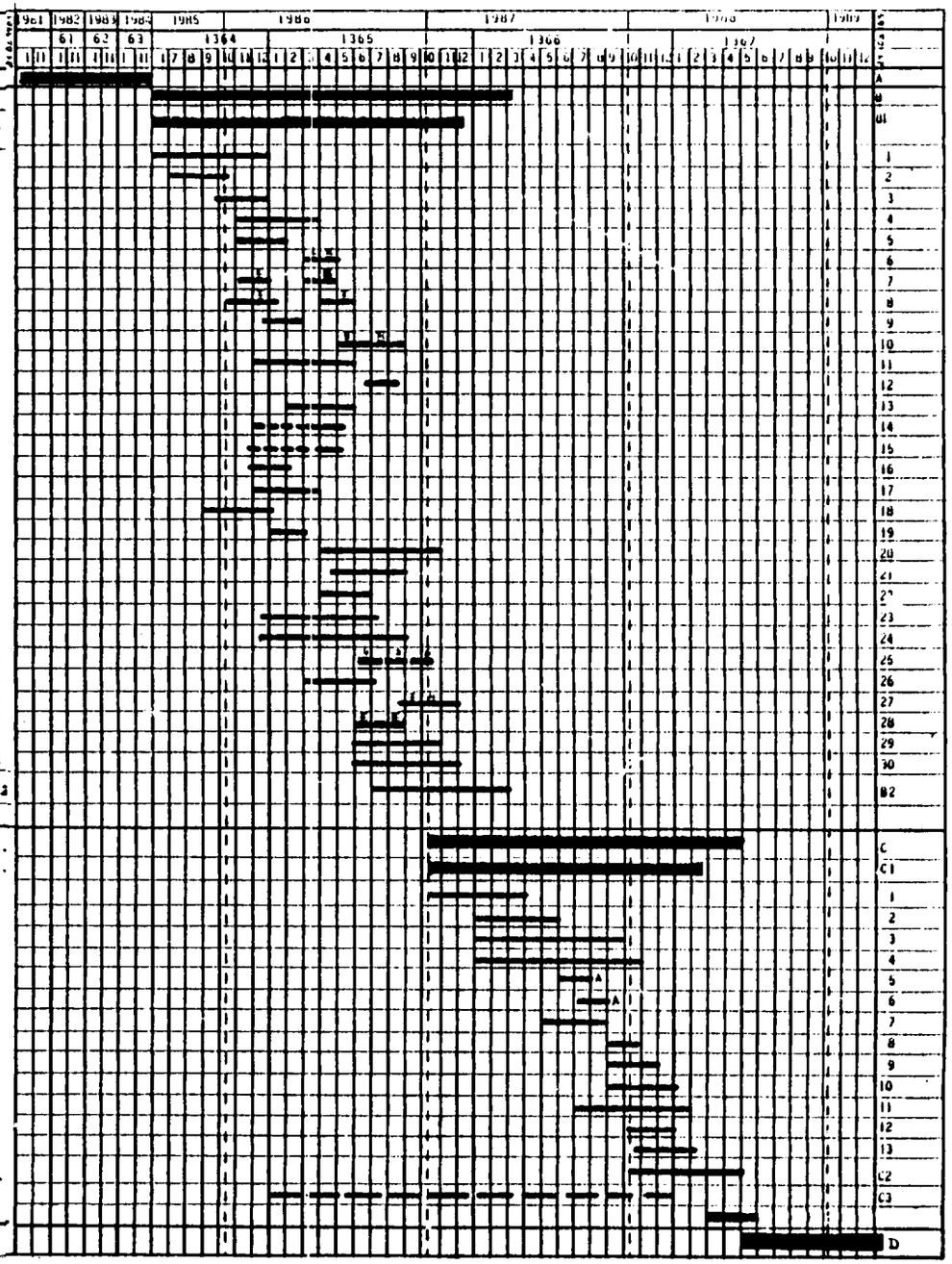
This region belongs to the eastern spur of the Elburz Mountain range. The Zoo Mountains, in which the bauxitiferous horizons occur, have an east-west elongation of 40 km , situated about 10 km north of the town of Jajarm. Jajarm, about 700 km east of Tehran, can be reached by car in 10-12 hours on a route north or south of the Elburz Mountain range. Jajarm has a railway station, 35 km south of the village on the railroad Tehran-Mashhad. (See index map, Enclosure 1 of the Appendix).

The bauxite horizon now under exploration is intercolating the Triassic, dolomitic Elika formation and the Jurassic Shemshak formation consisting of shales and sandstones. The geological situation of the bauxite horizon, findings of previous chemical, mineralogical and technological investigations of this bauxite type are summarized in the previous report of UNIDO-consultants and in reports by ARMP in Farsi language. The range of R-3 resources is estimated at 20-33 mill.tons. The aim of the present exploration campaign is to prove the existence of mineable resources, of a suitable quality of bauxite for improved and modified Bayer-autoclave digestion, tube digestion or lime soda sinter process technologies for the production of alumina from this type of bauxite.

The inhomogeneity of the bauxite, the marginal quality and the tectonic structure prevailing in the Zoo Mountain ridge request a well-adjusted development of exploration works, sampling, chemical and mineralogical examination and technological testing.

For this reason and in order not to waste money, a gradual approach is required, as is indicated in Table 6/I of the Appendix and in the Master Bar Chart on the next page. According to this, the feasibility study might be finalized 1988/89 if the project will not be abandoned at an earlier stage.

MASTER BAR CHART
"BAUXITE EXPLORATION PROJECT AND MINE FEASIBILITY STUDY, JAJARM AREA"



A.	PROJECT IDEA - Appraisal of Prospecting and Exploration on Bauxite in Elburz Mountains	A
B.	OPPORTUNITY STUDY FOR JAJARM BAUXITE DEPOSITS	B
B1.	NATURAL RESOURCES - Bauxite Exploration - Jajarm	B1
1	Appraisal of the bauxite deposits, evaluating data till 31.12.85, establishment of programme	1
2	Preparation of a survey plan layout,sector I-IV, scale 1:10,000 (or 20,000)for maps 1:5000,2000,1000(500)	2
3	Aerology, interpretation of aerial photographs 1:5000 (1:20,000) sector I	3
4	Aerology, sectors II and III	4
5	Generate topographical maps from rectified photoplan 1:5000 and 1:2000, sector I	5
6	Generate topographical maps as above for sectors II and III	6
7	Mark course of bauxite outcrop and tectonics (100-150m in hanging wall) in sector I and II	7
8	Survey by topographer of Nr. 7 for preparation of geological map 1:2000	8
9	Complete geological survey, sector I, scale 1:5000 and 1:2000	9
10	Complete geological survey, sectors II and III, scale 1:5000 (as per 7)	10
11	Prepare recording and management of data for EDP, trial run sector I	11
12	Generate geological map sector II, scale 1:2000 (as per 7-9) includ.tectonic structure	12
13	Supplementary topographical survey 1:2000, sector I, block 1-4	13
14	Purchase or leasing of exploration equipment(compressor, Kopra, drills, rails, etc.)	14
15	Permission for explosive magazine and erection	15
16	Purchase of movable housing for guard and personnel	16
17	Road construction to east part sector I and access to sectors II and II (Zoo-or Tagoei Valley)	17
18	Shallow core drillings, 50 m average depth (ca. 1000m) sector I block 4	18
19	Core drillings 50-200m depth (ca. 700m) sector I block 6	19
20	Shallow core drillings (2500m) sector II	20
21	Pitting and trenching, shallow precussive drillings sector I-III	21
22	Drift (7 m² section, 100 m) in deposit block 4, sector I and cross-cuts, 100 m	22
23	Tracing of mineralogical boundaries on outcrop and in drift, sector I and mapping	23
24	Complete channel and bulk sampling in sectors I,II (on outcrop,mineral-boundaries,mining boundaries	24
25	Preparation of a characteristic sample sector I, block 4	25
26	Prospecting for limestone and industrial water (Deregezy Valley etc) sampling for assays	26
27	Sampling for technological tests of bauxite, sector I, block 4 representative sample	27
28	Sampling for technological tests of bauxite, sectors II and III,characteristic samples	28
29	Selection of mining method	29
30	Computer assisted appraisal of mineral inventory sectors I-III for opportunity study	30
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2	Adit and/or drift (7 m² section, 500 m) sector I, block 2 and 6 and cross-cuts, 200m	2
3	Adit and/or drift (7 m² section, 700 m) sector II and III and cross-cuts 300 m	3
4	Core drillings 4000-5000 m in sectors I-III	4
5	Characteristic samples from A-horizon, technological evaluation	5
6	Exploration program for A-horizon (limited)	6
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9	Supplementary geological survey 1:2000, 1:1000 and 1:500 (underground)	9
10	Preparation of representative sample sectors II and III	10
11	Computer assisted appraisal of mineral inventory sector I-IV B-horizon and A-horizon	11
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13	Computer assisted underground mining study	13
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D.	TECHNO-ECONOMIC FEASIBILITY STUDY-Report and decision for next phase or abandon project	D.

In the preceding self-explanatory Master Bar Chart the key phases of exploration, sampling, testing, reviewing and decision making are shown.

During the opportunity study and at step 25, a characteristic bauxite sample or samples will be prepared in order to elaborate the most advantageous technology for this type(s) of bauxite. This might be done in the second half of 1986 at the earliest.

From an exploration and mining point of view, it is useless to have numerous samples examined by digestibility test before R-2 and partly R-1 resources can be calculated.

Based on chemical and mineralogical examination of bauxite samples, a preliminary mineral inventory can be established during step 11.

The opportunity study will indicate the viability of the project to produce economically alumina from Jajarm bauxite early in 1987. If this is the case and depending on the good quality of the deposit and technology involved, the next phase of a prefeasibility study can be envisaged immediately in 1987.

If the results of the opportunity study are exceptionally good and very encouraging, the decision may be taken to proceed directly to a techno-economic feasibility study in order to arrive at a final decision on the investment during 1988.

The consultant had the opportunity to discuss the draft of this Master Bar Chart with the management of ARMP and staff members. During a field excursion to Jajarm, the principles and methodology of sampling and sample preparation for the opportunity study were jointly agreed. It was suggested by ARMP and agreed by the consultant to provide consultancy services on a long-term base. The scope of work would comprise:

- Guidelines for the methodology of sampling recommended to be applied and for determining the distances of sampling (drilling, trenching, pitting) as well as quantities of material required for optimum results achievement.
  Manual calculation and evaluation methods will be used at the initial stage of mineral commodity appraisal.

- Guidance for the exploration of bauxite and specifically for the diasporic bauxite deposits in the Jajarm Mountain area in order to minimize exploration cost and to accelerate the appraisal of the mineral inventory.

- Specifications and guidance for the application of the United Nations "International Classification of Mineral Resources" in bauxite resources estimation.

- Recording and management of exploration and sampling data for the envisaged application of a computer assisted mineral appraisal and mine feasibility study.

- Activities and consultant services required by ARMP during the implementation of the works according to the schedule of the Master Bar Chart: "Bauxite Exploration and Mine Feasibility Study, Jajarm Area".

- Additional consultancy services and advice in connection with the work performed by ARMP's contractors Madankav, VAMI or others.

5. ALUNITE

The alunite deposits west of Quasvin at the western spur of the Elburz Mountains have been prospected by GSI for a long time (see Enclosure 2 of the Appendix).

Large and valuable information has been accumulated in their numerous reports.

The consulting firm "Madankav Eng.Co." was appointed by ARMP to select the most promising deposit for further consideration. A report was produced by Madankav concluding that the Syrdan-Hassan Abad alunite deposit should be given preference.
Due to lack of information - the report of GSI on the Taykand-Haftsandough alunite deposit is still pending - this most promising deposit was not included in Madankav's study.

ARMP arranged an excursion for the consultant to the Syrdan alunite deposit and together with the experts of VAMI/Leningrad to the Taykand-Haftsandough alunite deposit. An engineer of Madankav explained during a meeting at ARMP-offices the Madankav report, for which a translation into English is required.

In Table 4 of the Appendix, the alunite resources and grades according to the "Geological Survey of Iran"(GSI) and the report of the consulting firm "Madankav" are shown. This Table also displays an indication of mining cost and transportation distances from the mine to an assumed site of a beneficiation plant and an alumina plant.

A preliminary attempt of a two-dimensional statistical investigation of inhomogeneity of the alunite outcrop of the Syrdan alunite deposit was made with data available from the GSI-report which exists only in Farsi language. The analysis of numerous samples drawn by GSI in 4 shallow prospecting

trenches were used. The samples had been drawn mainly from the bottom of the trenches, in sections of 2-3m length.

Sample sequence :	from footwall to hanging wall
Distance between trench 1 and 4:	2500 m
Direction of outcrop :	NW - SE
Inclination of deposit:	N 25-35°
Azimut of trenches:	40-50°
Specific gravity of ore:	2.7 - 2.8 t/m³

The results are shown in Table 5 of the Appendix.

Explanation for Table 5:

n ... number of measurements or data

Σx ... sum of data $\sum_{i=1}^{n} x_i$

$\bar{x}$ ... arithmetic mean $\sum_{i=1}^{n} x_i/n$

σ^n ... standard deviation of population $\sqrt{\sum_{i=1}^{n} (x_i-\bar{x})^2/n}$

Σx^2 ... sum of square data $\sum_{i=1}^{n} x_i^2$

... standard deviation of sample from data shown $\sqrt{\sum_{i=1}^{n} (x_i-\bar{x})^2/(n-1)}$

From this evaluation derives that the alunite content within the deposit shows a really great fluctuation in the range of cut-off 30-35% alunite.

For an assessment of the alunite deposits it is advisable to create an "Alunite Working Team" (AWT) to evaluate all available information. The AWT should be formed by experts of the GSI, ARMP and Madankav and from time to time an independent

consultant may be added. (See Recommendation 2.2.4)

The opinion of the three experts from VAMI*, who arrived in Iran recently and who are engaged for three weeks exclu- ively with the alunite project, should carefully be taken into consideration for further exploration of the alunite deposits.

The alunite project is in every respect a difficult one. Due to certain problems and adverse circumstances, it was not possible for ARMP to proceed with the exploration of the Taykand-Haftsandough deposit according to a program established at the end of 1984.

Apart from the fact that about 1500 samples were taken by GSI during the course of last year and analysed abroad, the resources have not yet been calculated even in R-3 or R-2 categories.

Under the circumstances, the consultant recommends a subdivision of the total project as indicated in Table 6/II of the Appendix.

For each phase of the studies at least a master bar chart should be established, clearly showing the sequence of work to be done.

During this mission, the consultant had no ıe time to be occupied also with these technical and organizing details of the alunite project. It should be the subject of his further consultancy services for the ARMP programs.

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*VAMI/Leningrad-USSR was selected by ARMP/UNIDO as the contractor for a "Project Support (functional) Study on Investigation and Evaluation of Alunite ore and Concentrate in Iran."

A P P E N D I X

TABLE 1

List of UNDP, ARMP, VAMI and Other Senior Members met During Mission

At briefing and debriefing in the offices of the United Nations Development Program (UNDP), Avenue Gandhi, 43 Street Nr.3, Tel. 684-171, were present:

Dr. Krishan Singh, Resident Representative
Mohammed Farashuddin, Deputy Resid.Representative
Massoud Yahyazadeh, Programme Officer.

During the mission, the consultant had the opportunity of meeting, (during the field excursion and in the offices of ARMP, Gharani Ave, Bimeh Alley No.9, Tehran, Tel.833252-3, Telex: 212334 NISC-IR):

1. HASSANSADEH, Ebrahim, Managing Director of ARMP
2. SADRI, Hassan, Director of Exploration and Mining
3. DR. KHALILI, Halili, Analytic Chemist, Head of Labor.
4. BINAZADEH, Kheyrollah, Chief Geologist in charge of exploration and mining
5. MALEK-MOHAMMADI, Amanollah, Mining Eng.,Alunite Project
6. ASHRAF, Akbar, Mining Engineer
7. HEMATI, Gholamreza, Geologist
8. RAMEZANI, Mohammad, Geologist of Jajarm
9. CHEKAD, Abas, Chemical Engineer, Head of Alunite Project - Technology
10. SHAFAI, Mrs., Geologist of ARMP, Interpreter Farsi-Russian.

- Prof. Dr. ALINIA, Firous, Amir Kabir Technology University Hafez Ave, Tehran, Dpt.of Mining, Tel.6139304

- Dr. KASHANI, Fraidoon, Contractor for Core Drilling in Ganu and Jajarm Areas

All-Union Research, Development and Design Institute of
Aluminium, Magnesium and Electrode Industry (VAMI),USSR
Leningrad, V.O.Sredni Prospect 86. Tel. 2-175-241

- MIKHAILOV, Eugeni P., Chief Project Manager
- BASAKAKOV, Jury Petrovitch, Head of Techno-Economic Department
- BRONEVOJ, Vladislav Alexandrovitch, Mining Engineer - Geologist, Head of Geological Exploration Crew

TABLE 2

GANU BAUXITIFEROUS REGION

- Pick Sampling on the Outcrop, Sector 1 -

"SOFT BAUXITE"

SiO_2/%	Al_2O_3/%
CLEAR	CLEAR
STAT ON	*STAT ON*
25. SUM	36. SUM
26.5 SUM	38.8 SUM
23. SUM	40. SUM
22. SUM	37.76 SUM
26. SUM	39. SUM
20.6 SUM	39. SUM
26.5 SUM	39.68 SUM
22.16 SUM	40.5 SUM
28.06 SUM	38.5 SUM
28.4 SUM	34.92 SUM
37.5 SUM	34.6 SUM
13.5 SUM	39. SUM
30. SUM	34.8 SUM
28.14 SUM	37.12 SUM
23.44 SUM	38.5 SUM
36.5 SUM	35. SUM
29.44 SUM	40. SUM
23.2 SUM	41. SUM
23.6 SUM	42. SUM
29.5 SUM	36. SUM
28.5 SUM	36.92 SUM
11.55 SUM	50.64 SUM
20.7 SUM	39. SUM
29.1 SUM	37. SUM
23.6 SUM	38.12 SUM
15.1 SUM	44.2 SUM
19.94 SUM	40.2 SUM
22.6 SUM	39. SUM
12. SUM	48. SUM
25.9 SUM	37.6 SUM
19.2 SUM	40. SUM
29.1 SUM	48.08 SUM
24.3 SUM	39. SUM
21.1 SUM	41. SUM
26.6 SUM	43. SUM
26.7 SUM	42. SUM
13.4 SUM	47.28 SUM
13.3 SUM	49.88 SUM
15.9 SUM	44. SUM
21.05 SUM	43. SUM
23.5 SUM	41.3 SUM
16.6 SUM	50.2 SUM
27. SUM	39.3 SUM
24.6 SUM	37.8 SUM
44. n	44. n
1034.38 ΣX	1778.7 ΣX
25837.085 ΣX^2	72654.24 ΣX^2
23.508636 $\bar{x}$	40.425 $\bar{x}$
5.877966 σn	4.1294202 σn
5.9459217 $\sigma n-1$	4.1771608 $\sigma n-1$
STAT OFF	*STAT OFF*
CLEAR	CLEAR

Mean value

Standard Deviation

"HARD BAUXITE"

SiO_2/%	Al_2O_3/%
CLEAR	CLEAR
STAT ON	*STAT ON*
6.5 SUM	37.6 SUM
17.56 SUM	40.2 SUM
17. SUM	37.6 SUM
12.5 SUM	46. SUM
10.5 SUM	50. SUM
22. SUM	38.08 SUM
17.5 SUM	44. SUM
14. SUM	48.6 SUM
12.54 SUM	41.92 SUM
13.5 SUM	45.92 SUM
18.9 SUM	41.08 SUM
19.25 SUM	43. SUM
38. SUM	34.08 SUM
20.5 SUM	35.8 SUM
7.65 SUM	43. SUM
14.9 SUM	41.6 SUM
13.4 SUM	40. SUM
8. SUM	34.8 SUM
10.08 SUM	48.4 SUM
9. SUM	47. SUM
25. SUM	40.72 SUM
11.1 SUM	48. SUM
12.5 SUM	45.6 SUM
10.08 SUM	50. SUM
12.6 SUM	45.8 SUM
16.3 SUM	44.2 SUM
10.1 SUM	51.3 SUM
13.4 SUM	44. SUM
11.84 SUM	42.24 SUM
10.56 SUM	52.4 SUM
13.5 SUM	48. SUM
26. SUM	44.2 SUM
9.7 SUM	50. SUM
15.45 SUM	42. SUM
11.88 SUM	52. SUM
10.35 SUM	43. SUM
36. n	36. n
523.64 ΣX	1582.14 ΣX
8933.6616 ΣX^2	70360.418 ΣX^2
14.545556 $\bar{x}$	43.948333 $\bar{x}$
6.0484775 σn	4.7958371 σn
6.1342758 $\sigma n-1$	4.8638665 $\sigma n-1$
STAT OFF	*STAT OFF*
CLEAR	CLEAR

Modul $\frac{Al_2O_3}{SiO_2} = 1.72$

Mpdul $\frac{Al_2O_3}{SiO_2} = 3.02$

TABLE 3

GANU BAUXITIFEROUS REGION

- Assays From Core Drillings, Sector 3 -

- Subeconomic Bauxite Quality -

Borehole 2.1

SiO_2 %

```
CLEAR
*STAT ON*
    35.93 SUM
    35.07 SUM
     34.6 SUM
    31.44 SUM
    26.09 SUM
    31.92 SUM
     34.4 SUM
    33.93 SUM
    33.83 SUM
     34.4 SUM
    37.37 SUM
     34.6 SUM
    34.79 SUM
    37.37 SUM
    32.49 SUM
    35.74 SUM
      16. n
   543.97 ΣX
18601.997 ΣX²
33.998125 x̄          mean value
2.5985242 σn          standard deviation
2.6837443 σn-1
*STAT OFF*
CLEAR
```

Al_2O_3 %

```
CLEAR
*STAT ON*
    30.94 SUM
    30.43 SUM
    30.63 SUM
     28.3 SUM
    23.02 SUM
     28.5 SUM
    31.14 SUM
    30.63 SUM
    30.12 SUM
    29.82 SUM
    30.94 SUM
    29.92 SUM
    29.82 SUM
    31.55 SUM
    27.59 SUM
      15. n
   443.35 ΣX
29.556667 x̄
2.0535163 σn
      15. n
29.556667 x̄
    30.53 SUM
      16. n
   473.88 ΣX
14099.283 ΣX²
 29.6175 x̄           mean value
2.0022191 σn          standard deviation
 2.067883 σn-1
*STAT OFF*
CLEAR
```

Modul $\frac{Al_2O_3}{SiO_2}$ = 0.87

Borehole 8/2

SiO_2 %

```
CLEAR
*STAT ON*
    32.18 SUM
    29.04 SUM
    31.95 SUM
    31.13 SUM
    32.92 SUM
    31.18 SUM
    31.21 SUM
    28.01 SUM
    29.47 SUM
    28.33 SUM
    30.06 SUM
    37.19 SUM
    36.15 SUM
    37.66 SUM
    36.08 SUM
    32.88 SUM
     30.3 SUM
    35.13 SUM
    29.72 SUM
    32.39 SUM
    36.23 SUM
    36.91 SUM
      22. n
   716.12 ΣX
23508.583 ΣX²
32.550909 x̄           mean value
3.0017131 σn          standard deviation
3.0723513 σn-1
*STAT OFF*
CLEAR
```

Al_2O_3 %

```
CLEAR
*STAT ON*
    28.06 SUM
     27.4 SUM
    26.56 SUM
     27.5 SUM
    29.48 SUM
    29.86 SUM
    30.04 SUM
    29.38 SUM
    30.89 SUM
    27.78 SUM
     27.5 SUM
    30.42 SUM
    30.04 SUM
    31.36 SUM
    30.33 SUM
    28.57 SUM
    26.03 SUM
     29.1 SUM
    25.71 SUM
    28.16 SUM
    30.33 SUM
    30.42 SUM
      22. n
   635.97 ΣX
18440.027 ΣX²
28.907727 x̄           mean value
1.5894423 σn          standard deviation
1.6268461 σn-1
*STAT OFF*
CLEAR
```

Modul $\frac{Al_2O_3}{SiO_2}$ = 0.88

TABLE 4

ALUNITE RESOURCES AND GRADE ACCORDING TO "GEOLOGICAL SURVEY OF IRAN" (GSI) AND "MADANKAV"-STUDY (Farsi Language)

Area	Resources according to GSI, grade more than 30% alunite	Resources according to "Madankav" grade more than 35% alunite				
	mill.tons	mill.t.	Distance to Alumina Plant km	Average Grade %	Mine to benefic.plant km	Production cost/delivery/t benef.plant Rials
1. Hassan Abad	165	136	22	38.46	13	421
2. Syrdan	235	67.9	22	36.6	2	390.5
3. Zajkan	212	60.4		36.4	34	515
4. Zajcandy	165					
5. Yuzbashchai	853	76.3		40.5		
6. Taykand/Haftsandough	not available	not available				

* Official rate of exchange: 1 US$ = 98.- RLS

TABLE 5

Alunite Deposit SYRDAN

Calculation of mean and standard deviation of samples selected by GSI from four exploration trenches

Trench No.	Section Trench	Total Length m	Mineralised Length m	Number of Values n	ALUNITE CONTENT % Σx	Σx^2	$\bar{x}$	σ^n	σ^{n-1}	
1		195		40	656	11040	(16.4)	(2.0)	(2.6)	as SO_3
			(144)66	40			41.0	6.5	6.6	as alunite (factor 2-50 by GSI)
2		105	105	48	1300	41332	27.1	11.3	11.4	theoret.2.5875 pure
	1		22	10	365	13812	36.5	7.0	7.4	
	2		43	16	408	10979	25.5	5.9	6.1	
	3		12	6	238	9909	39.7	8.4	9.2	
	4		-	-	--	---	--	--	--	
	5		28	13	255	5943	19.6	8.5	8.8	
3		382								
	1+2		100	50	1523	50911	30.5	9.5	9.6	
	1		40	19	403	9388	21.2	6.5	6.8	
	2		60	31	1124	41643	36.2	5.4	5.5	
4		335								
	A		122	66	1819	55372	27.5	8.9	9.0	
	B		88	45	1396	45415	31.0	6.8	6.9	
	B_1		54	28	751	20685	26.8	4.4	4.5	
	B_2		34	17	643	24586	37.8	3.7	3.8	

GENERATION AND FLOW OF INFORMATION FOR TWO FEASIBILITY STUDIES ON BAUXITE AND ALUNITE
FOR "DEVELOPMENT OF ALUMINA INDUSTRY"- PROJECT NO.: DP/IRA/85/003/A/01/37

TABLE 6/I

EXECUTING AGENCY: UNIDO

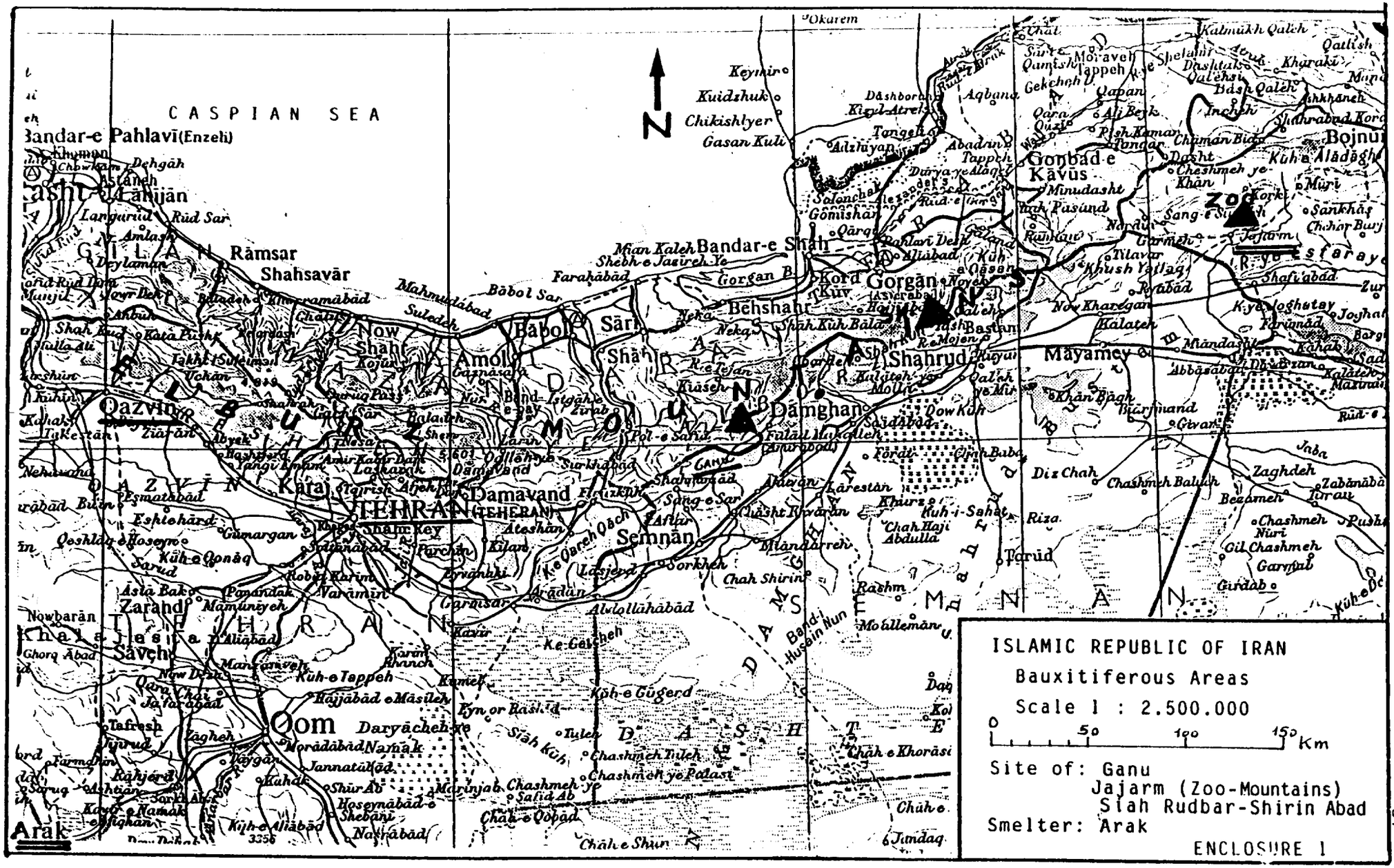
I - BAUXITE

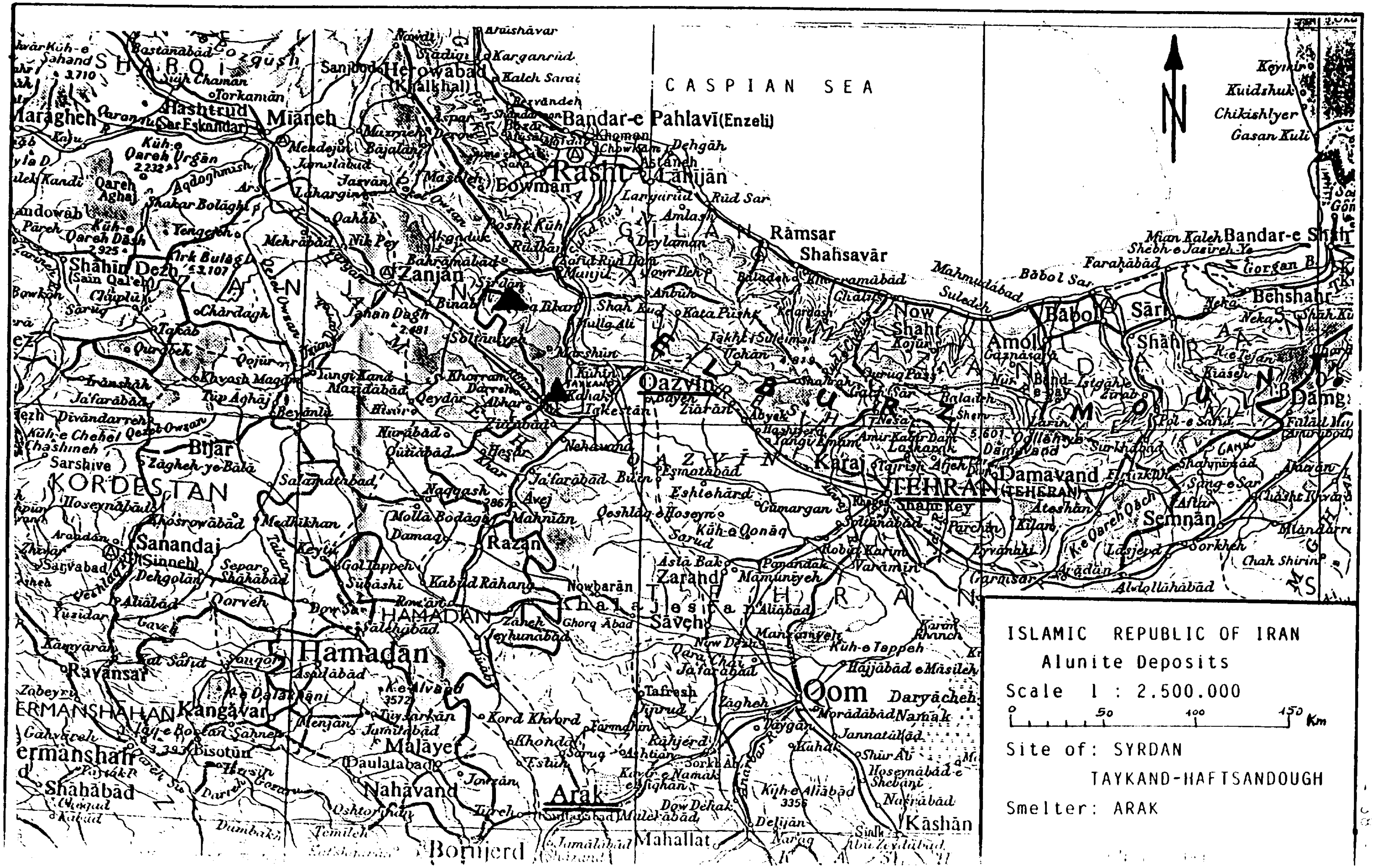
Proj. No.	Project Definition or name	Project No. assigned	Purpose - Aim - Result	Responsible Org. or Contractor	Duration Estimate	Fund Mill. $
A	PROJECT IDEA	-	Set up of ARMP (Aluminium Raw Material Programme)	Ministry of Mines and Metals	Since 1981	30.0 (spent 8.0)
B	OPPORTUNITY STUDY		Viability of project	UNIDO - ARMP		
B1	Natural Resources		Identific.bauxite deposits and resources/limestone	ARMP + consultant	1984-86	
B2	Technology Identification		Testing of representative sample and characteristic samples	Aluterv or others	1986-(87)	
C	PRE-FEASIBILITY STUDY		Decision for feas.study	UNIDO - ARMP	1986-87	
C1	Support Study: Mining Jajarm		Resources and reserves, quality	ARMP + consultant	1986-87	
C2	Support Study: Technology		Investigation on representative sample	Aluterv or others	1986-88	
C3	Support Study: mining other areas		Zagros, Yazd, Kordestan		1986-88	
D	TECHNO-ECONOMIC FEASIBILITY STUDY	IRA/85/003	Decision for Investment	UNIDO- ARMP	1987-89	UNDP 3.005 7.0(675 Rls)
D1	Mineral inventory eval.		Classific. of reserves	ARMP	1987	
D2	Mine planning for opt.size		Methods,capacity,cost, representative samples	ARMP	1987-88	
D3	Technology		Examination repres.sample	Aluterv or others	1987-89	

II - ALUNITE

TABLE 6 / II

Proj. No.	Project Definition or Name	Project No. assigned	Purpose - Aim - Result	Responsible Org. or contractor	Duration Estimate	Fund Mill.$
A	PROJECT IDEA		Set up of ARMP (Aluminium Raw Materials Programme)	Ministry of Mines and Metals	Since 1981	(see bauxite)
B	OPPORTUNITY STUDY					
B1	Natural resources		Identific.mining sites	Madankav-(GSI)	1984-85-86	
			Prepar.character.samples	VAMI-Madankav-ARMP	1986	0.1
B2	Technology	RP/IRA/84/001/901	Testing character.samples	VAMI	1985-86	0.5+0.29
B3	Marketing		Sale of by-products	Iran-Subcontractors	1986	0.03
B4	Alternative Processes for by-products		Consumption /use of by-products		1986	
C	PRE-FEASIBILITY STUDY					
C1	Support Study: Mining/ beneficiation		Resources and reserves,quality	Madankav	1985-86	
			Mining method,beneficiation,cost		1985-86	
			preparation representative sample	VAMI-Madankav	1986-(87)	
C2	Support study:Location					
C3	Support study:Technology		Investigation on repres.samples	VAMI	1986-(87)	
C4	S.St.By-Products and connected processes		Sale or usage of by-products		1986	
D	TECHNO-ECONOMIC FEASIBILITY STUDY	IRA/85/003	Decision for investment	VAMI-ARMP,Madankav	1987-88	(see bauxite)
D1	Comparative Study Bauxite/ Alunite		Exam.viability,preferences		1988-(89)	0.15
E	Monitoring Alunite Sub-contract	IRA/85/003			1985-88	0.10
F	Laboratory Equipment	IRA/85/003			1986	0.302+0.065


CASPIAN SEA
Bandar-e Pahlavī (Enzeli)
Rāmsar
Shahsavār
Bandar-e Shah
Gonbad-e Kāvūs
Bojnūrd
Behshahr
Shahrud
Māyamey
Qazvin
Damghan
Semnān
Damavand
TEHRAN
Zarand
Savch
Qom
Arak
ISLAMIC REPUBLIC OF IRAN
Bauxitiferous Areas
Scale 1 : 2.500.000
0 50 100 150 Km
Site of: Ganu
Jajarm (Zoo-Mountains)
Siah Rudbar-Shirin Abad
Smelter: Arak
ENCLOSURE 1

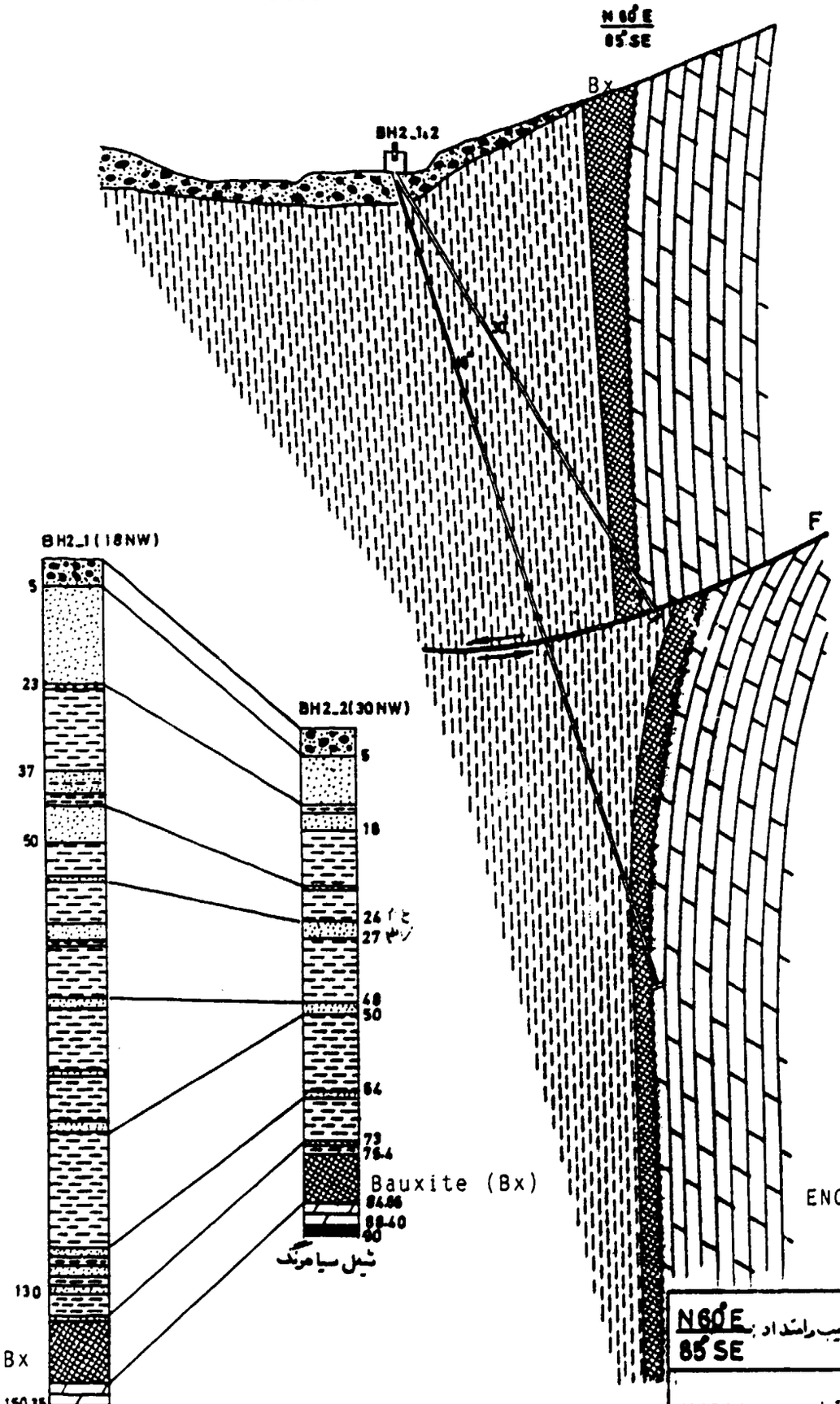

ISLAMIC REPUBLIC OF IRAN
Alunite Deposits
Scale 1 : 2.500.000
0 50 100 150 Km
Site of: SYRDAN
TAYKAND-HAFTSANDOUGH
Smelter: ARAK
CASPIAN SEA
Bandar-e Pahlavī(Enzeli)
Rasht
Lahijān
Rāmsar
Shahsavār
Zanjān
Qazvīn
TEHRAN
(TEHERAN)
Karaj
Damavand
Semnān
Bābol
Amol
Sārī
Behshahr
Bandar-e Shāh
Hamadān
Arāk
Qom
Kāshān
Sāveh
Malāyer
Nahāvand
Kangāvar
Sanandaj
Bijar
Mīāneh
Marāgheh
Hashtrud
Tafresh
Mahallat
KORDESTAN
HAMADAN
Borujerd

SE

NW

GANU Bauxitiferous Regions

Sector 3 Boreholes 2.1 and 2.2

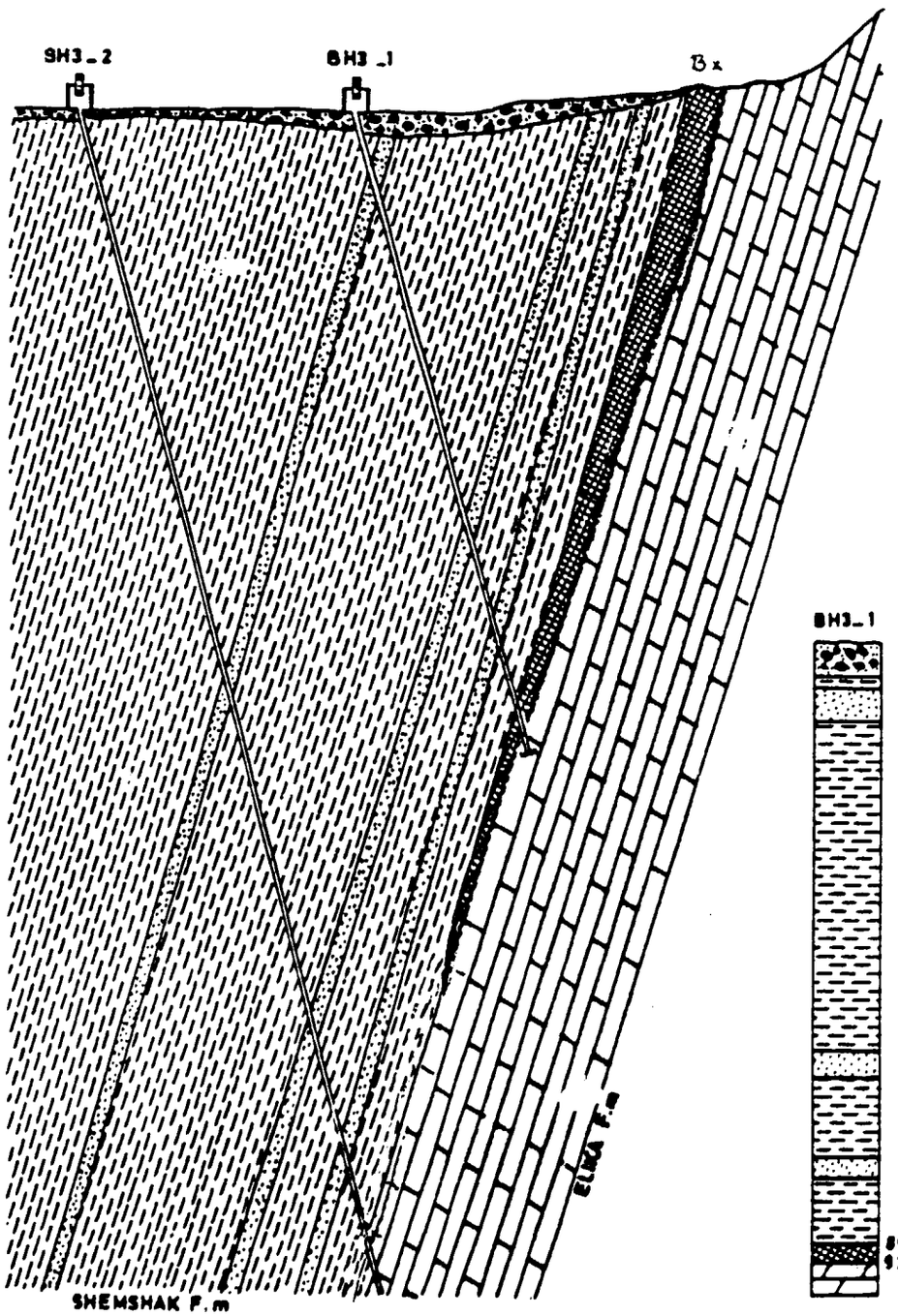


ENCLOSURE 3

N60°E / 85°SE شیب و امتداد	2 نام سکن / BH2_1 و 2 نام چاه
1:1000 مقیاس :	محل : گانو

GANU Bauxitiferous Region

SECTOR 3 : Boreholes 3.1 and 3.2



ENCLOSURE 4

شیب وامتداد:	شماره گمانه: 3 شماره چاه: BH3_1، 2
مقیاس : 1:1000	نقشه: گانو

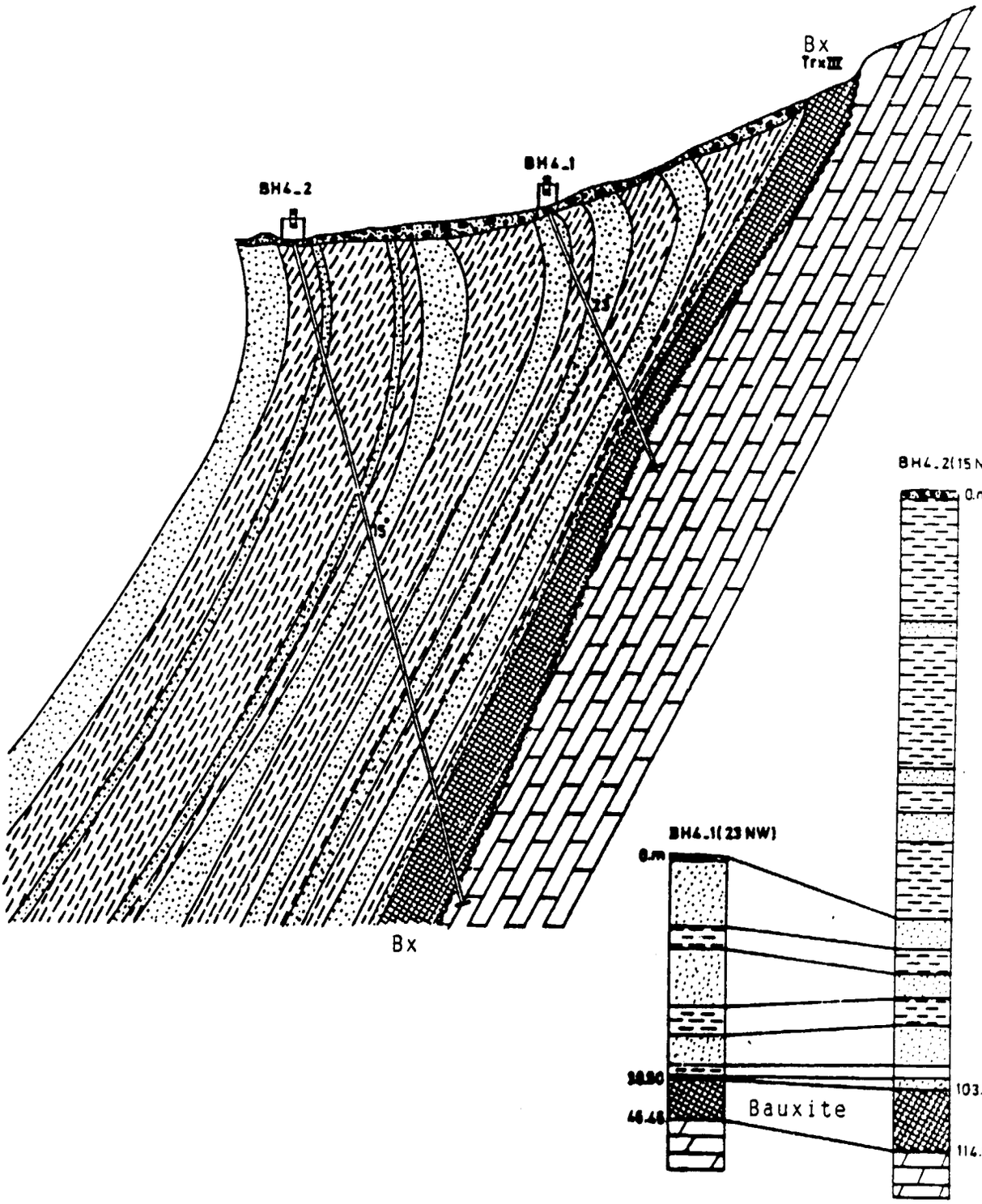
by K.Binazadeh, 1985

SE

GANU Bauxitiferous Region

Sector 3, Boreholes 4.1 and 4.2

NW



ENCLOSURE 5

شیب و امتداد :	نام گمانه : 4 نام چاه : BH4_1،2
مقیاس : 1:1000	محل : گانو

by K. Binazadeh, 1985

INTERNATIONAL CLASSIFICATION OF MINERAL RESOURCES (UN 1979)

ENCLOSURE 6

Classification categories: R / capital/: resources "in situ" of economic interest for the next 2-3 decades

r /lower case/: recoverable resources /reserves/ closely calculated for mineral supply.

R-1	R-2	R-3 occurrences
Encompasses the in situ resources in deposits that have been examined in sufficient detail, sizes and qualities known, technology established. Relevance of such estimates is the planning of mines. Error of estimation less than 50%.	Estimates of in situ resources that are associated with discovered deposits, quantities are preliminary and largely based upon broad geological knowledge, supported by measurements at some points. Estimation error above 50%. Estimates relevant for planning of further exploration for R-1 resources.	Undiscovered in situ resources that might exist based on geological extrapolation. R-3 indicate exploration opportunities, quantities known in ranges.
- reliable estimates -	- Preliminary estimates -	- tentative estimates -

R-1-E: Economically exploitable, believed to be workable with regard to thickness, depth, grade.

R-1-S: "Subeconomic, prefix "sub" denotes under, below, less than normal amount, contain small portions.

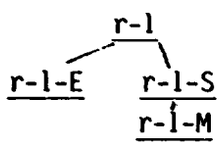
R-1-M: Marginally economic, a deposit near the lower limit of commercial workability which can be explitable in short due to economic and techn.changes.

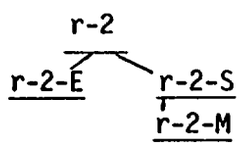
R-2-E

R-2-S

Not subdivided further

The "recoverable resources" are classified accordingly as r-1, r-2, r-3. The definition of recoverability and the point it will be measured in the exploration, mining and processing sequence must be established for each commodity.





r-3

not subdivided further

B I B L I O G R A P H Y

Selected list of references

1. BALKAY, B. and SAMIMI,N. /1972/: Present state of the search for bauxites in Iran.- GSI-GEOMINCO/Budapest, Hungary/ Report.

2. BULKAI,D. /1984/: Informative report on preliminary technological tests with Iranian diaspore-chamosite containing bauxites. - ALUTERV-FKI Report.- Budapest, Hungary.

3. Exploration of Zagros area /1978-79/. - GEOINDUSTRIA, Prague, Czechoslovakia.

4. NEMAT, L. and ZAINALOV, M. /1977/: Report of alunite prospection results in Iran. /In Pharsi, with summary in English/. GSI, Tehran.

5. SAMIMI,M. /1966/: Cretaceous bauxite, Zagros Mountains.

6. UN International Classification of Mineral Resources./1979/.

7. DOUGLAS,C. /1984/: Establishment of an aluminium raw materials testing laboratory. - UNIDO Technical report.

8. MACK.E.and VÖRÖS,I. /1984/: Bauxite and alunite mineral commodity.- UNIDO Technical report.

9. SOLYMAR,K. /1984/: Application of industrial scale technology for processing aluminoferous ores.- UNIDO Technical Report.