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Estimated Use of Explosives in the Mining Industries of Algeria, Iran, Iraq, and Libya

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Foreword

This work was performed under Memorandum of Agreement B291534 Between the Lawrence Livermore National Laboratory (LLNL) and the United States Bureau of Mines.

The Bureau of Mines authors are members of the Minerals Availability Field Office (MAFO) in Denver, CO, which uses an extensive network of information sources to develop and maintain the Minerals Availability database concerning mining and minerals properties worldwide.

This study was initiated and directed by F. Heuze at LLNL. A previous study on the same subject had been commissioned by LLNL from the Mining Journal Research Services (MJRS) in London, U.K. Its results were integrated into this report. MJRS is shown as one of the numerous sources which were used for this work. All sources are listed in the report.

This document is arranged in four sections, one for each country, in alphabetical order. The outline is the same for each country.

This work was supported by the LLNL Seismic Project under contract W-7405-ENG-48 with the U.S. Department of Energy. H. Patton was the Seismic Project Leader.

ALGERIA

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1.0 EXECUTIVE SUMMARY

This report was prepared under Memorandum of Agreement B291534 between Lawrence Livermore National Laboratory (LLNL) and the U.S. Bureau of Mines, Minerals Availability Field Office (MAFO). It provides LLNL information on the mining industry of Algeria, and quantitative information on the blasting potential of its mining industry. MAFO identified mining activities through the use of the Minerals Availability data base, its data collection and analytic capabilities, and an extensive network of information sources.

Algeria possesses a diverse but modest resource potential of metals and industrial minerals. The mining industry of Algeria is minor when compared to the mineral fuels industry (petroleum and natural gas), which accounted for almost all export earnings in 1993. Research activities resulted in the identification of 225 mineral properties. Most properties operate on a small scale and require minimal blasting. The blasting potential for 22 representative properties is reported. Only two operating mines have the potential to produce blasts of over 150 metric tons of ANFO equivalent at any given time as part of normal mining activities.

While Algeria is limited to using internally produced explosives or imports not restricted by trade policies of many countries, it possesses the technology and facilities to manufacture blasting agents and detonation systems suitable for mining applications. Most surface mines in Algeria utilize ammonium nitrate-fuel oil (ANFO) blasting agents. High explosives are used in a few small underground operations where geologic conditions and drilling characteristics require its use.

Mining is generally concentrated in the Atlas Mountains of northern Algeria. Underground mining is limited to small iron and lead/zinc operations with an individual maximum blasting event potential of less that 10 metric tons of ANFO equivalent. Surface mining and quarrying operations are generally on a larger scale. Only a few sites possess the capability to produce regularly scheduled

blasts in the 100-300 metric ton (ANFO equivalent) range. The largest producing mines are located close to the Tunisian border; monitoring of these sites from Tunisia should be possible.

1.1 Authority

This report was prepared under Memorandum of Agreement B291534 between Lawrence Livermore National Laboratory (LLNL) and the U.S. Bureau of Mines, Minerals Availability Field Office (MAFO).

1.2 Project Scope

As part of this agreement, MAFO is to identify mining activities in Algeria, Iran, Iraq, and Libya as they relate to monitoring/verifying compliance of the Comprehensive Test Ban Treaty. MAFO is to use the Minerals Availability data base, its data collection and analytic capabilities, and an extensive network of information sources to provide background information focusing on the use of explosives by the mining industry, which can cause false alarms during monitoring and hide blasting events.

Reports with accompanying figures and tables summarize location, type of mining method, commodity(ies), estimated frequency and size of mine blasts, operational status, and mine product distribution to foreign or internal markets for the specified countries.

Once country data were collected and verified, the explosive use at selected sites was evaluated. Focus was placed on locations that consume large quantities of conventional chemical explosives. Undeveloped sites and small scale mines, while included in Appendices A-C of this report, were not analyzed in terms of the site's anticipated use of explosives since mineral prospects generally make only small use of explosives and small mines (some of which are operated on an intermittent basis) are assumed to require minimal blasting application.

Based upon known site information (geological conditions, mine technology, production capacity, and current blasting practices), the blasting potential for significant mining sites was evaluated. Where site-specific data were not available,

available, estimates for representative, important properties were developed based upon accepted industry practice, knowledge of the Algerian mining industry, and regional geologic characteristics.

2.0 SOURCES OF INFORMATION

Data for this report were derived from published sources, unpublished documents, and personal communications through an extensive network of public and private contacts. Public sources of information are listed in Appendices A - C. Attempts were made to collect information at offices of agencies known to either possess this type of information or those believed to have an interest in such information.

Principal agencies contacted include, but were not limited to the U.S. Bureau of Mines, the U.S. Geological Survey, the U.S. State Department, Central Intelligence Agency, Defense Intelligence Agency, the United Nations, the World Bank, World Resource Institute, International Strategic Minerals Institute (ISMI). In addition, selected academic and industry contacts, explosives manufacturers and suppliers, and trade groups were contacted.

3.0 THE MINING INDUSTRY OF ALGERIA

Algeria possesses a diverse but modest resource potential of metals and industrial minerals. The mining industry of Algeria is minor when compared to the mineral fuels industry, the leading industrial sector. Only iron ore, mercury, and phosphate are produced on a scale to be considered important by world standards. Lead, zinc, and several industrial minerals are also produced, but production is not large on a worldwide basis. Other mineral resources include antimony, tungsten, manganese, copper, uranium, and gold. Algerian mineral production statistics for 1992 and 1993 are provided in Table 3.1.

Table 3.1--Estimated Mineral Production in Algeria, 1992 and 1993 (Metric tons)

Commodity(1)	1992 Production	1993 Production
METALS		
Cadmium, refined	75	75
Iron ore, gross weight	2,560,000	2,311,000
Lead concentrate, Pb content	1,200	1,538
Mercury	476	455
Silver	3.5	3.5
Zinc concentrate, Zn content	7,500	6,800
INDUSTRIAL MINERALS		
Barite, crude	51,150	47,232
Celestite	5,400	5,400
Cement, hydraulic	6,400,000	6,940,000
Clay, bentonite	25,000	20,823
Clay, Fuller's earth	4,550	3,229
Clay, kaolin	20,000	12,586
Diatomite	3,600	3,471
Gypsum	234,000	200,000
Lime, hydraulic	62,000	62,000
Phosphate rock	1,136,000	718,000
Salt	251,000	247,000
Sulfur, elemental	20,000	20,000

Source: U. S. Bureau of Mines. Minerals Yearbook, 1993.

(1) In addition to the commodities listed, small amounts of secondary aluminum, secondary lead, secondary copper, nitrogen, and caustic soda are produced. Petroleum and mineral fuels are excluded from this table.

The Algerian Government retains control over the mining and mineral processing industries since they were nationalized in 1966. A revised mining law was enacted in 1991 which allows some private involvement and foreign investment in the mining industry. Foreign investors can now form joint ventures and receive tax concessions as an incentive to improve exploration and production within the country. The Office de Recherche Géologique et Minières (ORGM) was created in 1991 to coordinate the various mining activities in Algeria[1].

Summaries of mineral site data are provided in Appendices A-C. Data on producing or developing mineral deposits, past producing properties, and prospects and undeveloped mineral occurrences are provided in tabular form. Location maps for each of the above categories of mineral property are also provided in Appendix Maps A-C.

3.1 Industrial Minerals

While Algeria possesses resource potential for a wide variety of minerals with industrial applications, production is relatively small and minerals are generally processed or marketed domestically. One Algerian phosphate producer is considered important on a world scale (Refer to section 3.5).

Barite is produced from a number of small mines, often found in association with lead and zinc sulfides. In some cases, lead/zinc production has ceased, while barite production continues. Barite production at an individual site rarely exceeds 10,000 tpy, and is often much smaller. Small quantities of cadmium are also produced as a byproduct of lead/zinc mining.

Construction cement production is derived from a number of sites in northern Algeria. Sites are typically located near market cities. The largest single producer reportedly has an operating capacity of 2,000,000 tpy; small by world standards.

[1] Europa Publications Ltd. The Middle East and North Africa 1994. 40th Edition. p. 262.

Current production is not sufficient to support domestic demand, so about 20% of Algerian cement is imported. Major investments are required to modernize and rehabilitate the industry to allow it to fulfill domestic market requirements. Cement production is Government owned and controlled. Open pit mining techniques with limited blasting of the limestone are employed.

Mining of kaolin and bentonite clays occurs at a few selected sites on a very small scale. Clay mining typically does not require significant blasting. Fuller's earth and diatomite are also recovered in small quantities.

Algeria possesses the potential to recover large quantities of salt, owing to its proximity to the Mediterranean Sea, its arid climate, and an abundance of a number of large saline lakes. While salt is recovered at a number of locations in northern Algeria, they are believed to be small scale surface operations. Salt brine is often pumped from the lake or evaporation basin to nearby processing facilities; blasting is not required. Gypsum is also available from extensive evaporite deposits near the Mediterranean. Only one operation is reported to produce gypsum. While some blasting is required, Algerian mining operations tend to be small, surface operations with limited blasting.

Algeria is one of few countries producing strontium. Production of celestite occurs at one known surface operation, producing approximately 5,400 tpy.

Sulfur is recovered principally as a refinery byproduct of petroleum. Primary sulfur, where recovered, is extracted by the Frasch process, in which hot water is injected through wells into sulfur-rich evaporites. Sulfur is melted and pumped out through the same wells for processing. Blasting is not required for this extraction technique.

3.2 Iron Ore

Algeria produces significant quantities of iron ore. Approximately 75% - 80% of production comes from the Djebel Ouenza and Bou Khadra mines in northeastern Algeria near the Tunisian border. Annual production at these two sites can reach 4 million mt, although production in recent years has ranged between 2.0 - 2.5 million tpy[2].

Ore containing 53% - 60% Fe is extracted by surface methods at Djebel Ouenza and underground methods at Bou Khadra. Average stripping ratio at Djebel Ouenza is 2:1, so almost 6 million tpy of overburden and 3 million tpy of ore require blasting at this large surface operation. Blasting requirements at Bou Khadra are much less than those of Djebel Ouenza. These two mines primarily supply the domestic market, with minor exports to Tunisia and Albania.

While a number of other mines recover iron ore in Algeria, production at these sites range from 120,000 tpy to 300,000 tpy of ore. Blasting requirements for these mines vary considerably depending upon mining method employed, but in all cases are considerably less than that of Djebel Ouenza.

Several plans have been put forward in recent years to develop the Ghara Djebilet iron deposit. A proposed production rate of 8 million tpy has been mentioned, but mining would require the construction of a 1400 km rail line. The development status of this deposit remains uncertain at this time.

3.3 Lead and Zinc

In recent years, Algerian production of lead/zinc ores has decreased as a result of declining ore grade, diminished reserves, and reduced exploration activity. Many small occurrences and past producing mine sites are scattered across northern Algeria. Several sites recently closed or switched to barite recovery, as lead/zinc reserves were depleted.

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[2] U. S. Bureau of Mines. Minerals Yearbook 1994 (preprint). Ch. on Algeria.

The main deposits of lead and zinc are at El Abed, on the Algerian-Moroccan frontier, and at Kherzet Youssef, in the Sétif region. While El Abed has the capacity to produce up to 350,000 tpy of ore by underground mining techniques, production was reduced by 120,000 tpy in 1991 as a result of ore structure and selectivity considerations[3].

The Kherzet Youssef mine ceased production in recent years. The underground workings were flooded in 1990, causing the mine to terminate production; it is presently unclear whether the mine will be able to reopen[3]. In 1990, reserves were reported to be nearing depletion, so without increased exploration it is doubtful whether the mine could resume production.

3.4 Mercury

Mercury production in Algeria is significant on a world scale, about 10% of world output, even though production volume is not large. Most mercury is produced in the Ismail/Am'Rasma mining area of northeastern Algeria. Ore with grades ranging from 0.5% - 1.4% Hg are mined by conventional surface mining methods to recover up to 30,000 tpy (Am'Rasma) and 26,000 tpy (Ismail) of mercury-bearing ore. At both locations, the ore is drilled and blasted with a reported powder factor of 0.1 kg/ton of mined material[4]. Ore is trucked to Azzaba for beneficiation, and the mercury produced is exported via the port of Annaba to Europe.

3.5 Phosphate

Most phosphate production presently comes from the Djebel Onk mining area in northeastern Algeria. Algerian phosphate is mined by surface methods at an average depth of 22.5m; the reported stripping ratio is approximately 1:1.

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[3] United Nations. Mission to Algeria: Aug. 27 - Oct. 19, 1993, F. J. Gauthier. Project ALG/87/013.

[4] U. S. Bureau of Mines. Minerals Yearbook 1994 (preprint). Ch. on Algeria.

The Djebel Onk mine handles 3 million tpy of overburden and 3 million tpy of phosphate-bearing material to produce up to 1.5 million tpy of processed P2O5. Approximately 30% of this phosphate is used domestically, and the bulk of the remaining material is exported to Europe, principally to France and Spain[5]. In past years, production rates were higher, and other market areas included Yugoslavia, Poland, Finland and Indonesia.

The mine is estimated to be the largest explosives consumer in Algeria, with explosive use of up to 307 mt of ANFO equivalent for blasting events. Algeria possesses other phosphate mineral resources, but lack of financing has hindered development of these sites.

3.6 Other minerals

Algeria possesses additional mineral resources of antimony, tungsten, manganese, copper, gold, and uranium. Recently announced development projects include development of uranium resources and two gold properties in the Hoggar Mountain region of Algeria. Development of these projects are dependent on improving site infrastructure, building regional transportation structures, and acquiring sufficient capital.

4.0 MINE-RELATED EXPLOSIVES USE

Almost all mines use explosives to fragment or loosen rock and consolidated material prior to excavation. Bulk or packaged explosives and blasting agents are detonated after emplacement in material to be excavated. Minor quantities of sachet and shaped charges may be used for secondary breakage and other special applications.

The type and amount of explosives used are influenced by the nature of the rock or ore, the mining methods employed, the production rate of the mine, the type and availability of explosives and detonation systems, hydrologic conditions, mining

[5] British Sulphur, Ltd. World Survey of Phosphate Deposits. 5th Edition, 1992, pp. 90-92.

equipment, drilling equipment, mine geometry, level of technical expertise, and external constraints such as the proximity of residences, availability of explosives, and available funding. At almost any mine, the size of each blast can vary significantly due to local conditions, production schedules, weather, etc.

Surface mines typically shoot much larger blasts than underground operations and tend to have higher production rates than underground mines. In addition, limitations of working room, limited free faces, ventilation requirements, and drilling limitations may constrain maximum blast sizes in underground mines.

Algeria is limited to internally produced explosives or imports from other allied Islamic countries. Currently the United States and other Western countries impose strict trade policies on the sale of military or dual use technology and equipment (including mining explosives and drilling rigs) to Algeria[6]. Industrial contacts, however, maintain that these restrictions do not represent a major impediment to Algeria's mining sector. Algeria has the military-related technology and facilities to manufacture blasting agents and detonation systems suitable for most mining applications.

Most Algerian mines use ammonium nitrate-fuel oil (ANFO) blasting agents. This includes some of the newer emulsion and/or aluminum boosted products presently available. ANFO systems are preferred in most mining applications due to their ease of manufacture, low cost, inherent safety, and bulk loading advantages. High explosives, however, would be preferable for small underground operations that use drill sizes that are below the critical diameter needed for emplacing ANFO blasting agents, under wet conditions, in methane-rich atmospheres, and conditions that require higher detonation velocities and/or convenience of packaged explosives.

[6] Mr. Steven Keshette, Algerian Desk Officer, U.S. State Department. Personal communication, April 5, 1995.

Blasting assumptions used in this report are based upon engineering judgment; explosive use can vary considerably as mining conditions change. ANFO consumption was assumed to be dependent upon mine production rate, average stripping ratio, specific gravity of the host rock, assumed powder factor limits, and mining method. In most cases, site-specific blasting information was unavailable. Consequently, estimates were based upon known or estimated production rates, mine geology, mining systems, and typical mining practices. Experience, engineering judgement, and available data were incorporated into calculations and estimates.

For each site, a stripping ratio (Quantity of overburden removed per mt of ore mined) and powder factor (Quantity of rock blasted per unit of ANFO blasting agent equivalent) limits were estimated. A range of ANFO consumption was calculated for both daily blasting requirements and for an assumed maximum blasting event. Daily ANFO requirements were estimated assuming a 215 day production schedule. Consumption estimates for all sites were calculated in a similar manner. The lower consumption value applies a minimum powder factor while the higher value assumes a maximum powder factor. Unlike daily consumption estimates, a maximum blasting event would not take place on a daily basis. For this study, it was assumed that a maximum blasting event could occur every 10 working days for a surface mine and every 5 working days for an underground mine. Such events are designed to account for such factors as blasting delays, geological irregularities, and mining method variations that require a higher ANFO consumption than the typical blasting event. Mine development or pillar extraction conditions, for example, often require larger blasts.

The following examples illustrate typical blasting calculations using the estimation procedure described above:

<u>Djebel Onk daily ANFO consumption lower limit (L):</u>

L = Production rate * [1 + (stripping ratio * specific gravity of ore + waste)] * [Low powder factor / 1000 (converts kg to mt)] / 215 (assumed operating days per year)

L = 3,000,000 * [1 + (4.0 * 2.5)] * [0.11 / 1000] / 215

L = 16.88   17 mt ANFO equivalent (Rounded to nearest unit)

Djebel Onk daily ANFO consumption higher limit (H):

H = Production rate * [1 + (stripping ratio * specific gravity of ore + waste)] * [High powder factor / 1000 (converts kg to mt)] / 215 (assumed operating days per year)

L = 3,000,000 * [1 + (4.0 * 2.5)] * [0.20 / 1000] / 215

L = 30.70   31 mt ANFO equivalent (Rounded to nearest unit)

Djebel Onk maximum blasting event ANFO consumption (M):

M = Production rate * [1 + (stripping ratio * specific gravity of ore + waste)] * [High powder factor / 1000 (converts kg to mt)] / 215 (assumed operating days per year) * maximum blast cycle time (working days between blasting events)

M = [3,000,000 * [1 + (4.0 * 2.5)] * [0.20 / 1000] / 215] * 10

M = 306.97   307 mt ANFO equivalent (Rounded to nearest unit)

Table 4.1 provides the corresponding blasting range estimates for the main Algerian mines identified in this study. Figure 4.1 shows site locations for the mines reported in table 4.1. Symbols reflect mine type (surface or underground) and maximum ANFO consumption for a given blasting event.

Table 4.1—Estimated Explosives Usage at the Main Algerian Mines Used in this Study in Order of Estimated ANFO Consumption

Mine	Latitude	Longitude	Product	Mine Type (1)	Production (Mmt/yr) (2)	Daily Consumption (mt ANFO) (3),(4) Low	Daily Consumption (mt ANFO) (3),(4) High	Maximum Blast Cycle Time (days) (5)	Maximum Blasting Event (mt ANFO)
Djebel Onk	N 34° 43'	E 8° 00'	Phosphate	S	3.000	17	31	10	307
Djebel Ouenza	N 35° 58'	E 8° 07'	Fe	S	2.800	13	18	10	180
Elma Laboid	N 35° 20'	E 8° 01'	Limestone	S	5.600	6	12	10	117
Oran	N 35° 40'	W 0° 36'	Limestone	S	2.900	3	6	10	61
El Asnam	N 36° 30'	E 1° 59'	Limestone	S	2.000	2	4	10	42
Batna	N 36° 56'	E 6° 46'	Limestone	S	1.000	1	2	10	21
Blida	N 36° 28'	E 2° 48'	Limestone	S	1.000	1	2	10	21
Constantine	N 36° 50'	E 6° 39'	Limestone	S	1.000	1	2	10	21
Setif	N 36° 10'	E 5° 35'	Limestone	S	1.000	1	2	10	21
Khanguet El Mouhad	N 35° 35'	E 8° 06'	Fe	S	0.300	1	2	10	19
Timezrit	N 36° 35'	E 4° 46'	Fe	S	0.300	1	2	10	19
Bou Khadra (Bou Khandra)	N 35° 46'	E 8° 03'	Fe	UG	1.000	1	2	5	8
Beni–Saf	N 35° 17'	W 1° 23'	Fe	S	0.120	1	1	10	8
Djebel Zaccar	N 36° 20'	E 2° 12'	Fe	UG	0.250	0	0	5	2
Bou Caid	N 35° 36'	E 1° 40'	Ba,Pb,Zn(6)	UG	0.350	0	0	5	2
El Abed	N 34° 31'	W 1° 41'	Pb,Zn	UG	0.350	0	0	5	2
Am'Rasma	N 36° 43'	E 7° 09'	Hg	S	0.030	0	0	10	2
Ismail (Taght)	N 36° 42'	E 7° 06'	Hg	S	0.030	0	0	10	2
Bendjerah	N 36° 20'	E 7° 40'	Marble	S	0.010	0	0	10	1
Bou Hanifia	N 35° 13'	E 0° 10'	Marble	S	0.010	0	0	10	1
Timagouine	N 21° 39'	E 4° 32'	U	UG	0.002	0	0	5	1

(1) S—Surface; UG—Underground
(2) Mmt/yr—Million metric tons per year.
(3) mt ANFO—Metric tons of Ammonium Nitrate/Fuel Oil blasting agent equivalent rounded to nearest whole unit.
(4) Assumed production schedule – 215 days/yr.
(5) Assumed maximum blasting cycle time for surface operation – 10 working days; underground operation – 5 working days.
(6) Operation currently only produces barite.

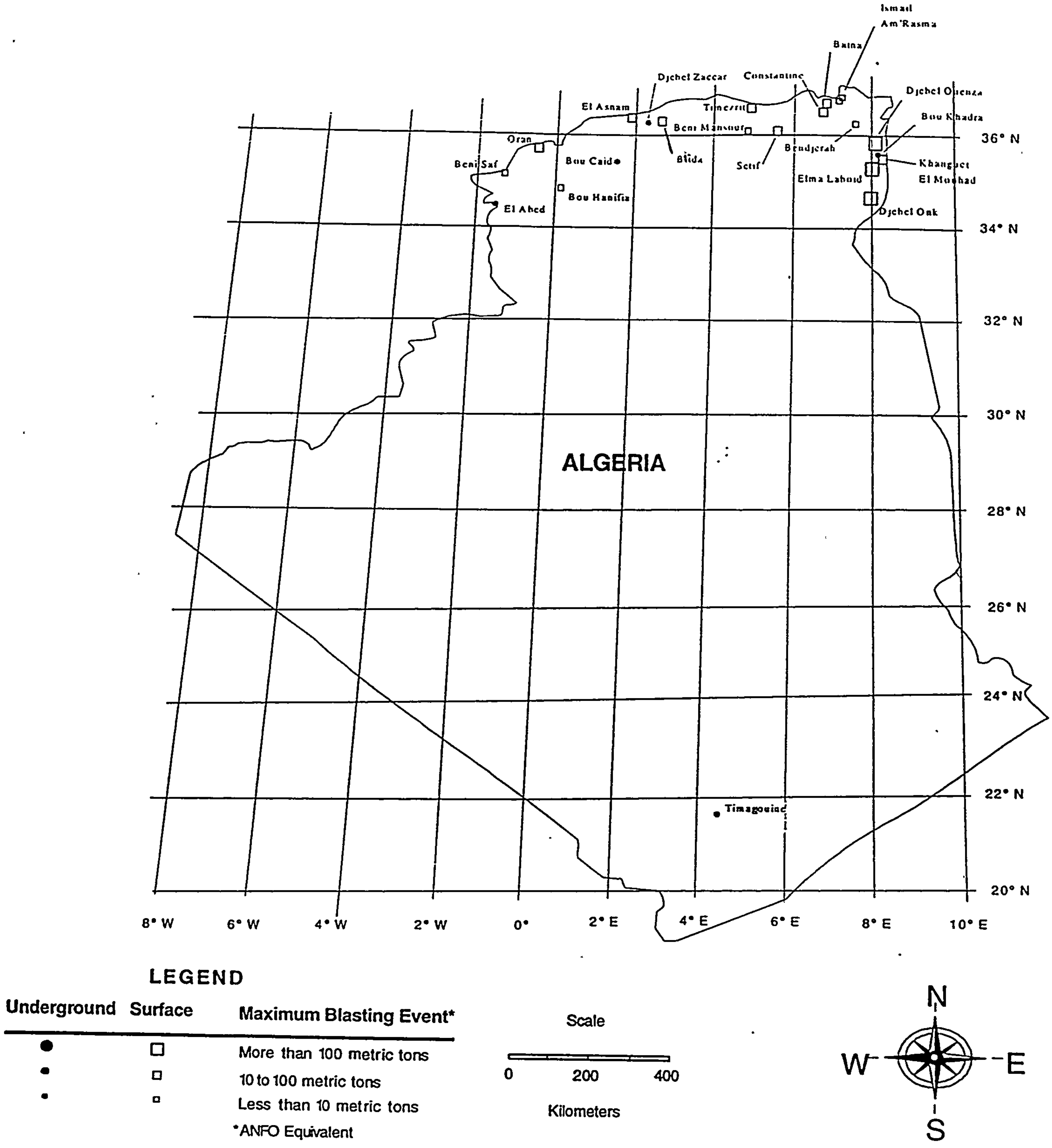

Figure 4.1--Selected Algerian Mines and Estimated Maximum Blasting Events

5.0 CONCLUSIONS

Mining primarily occurs in the Atlas Mountains of northern Algeria. Underground mining is limited to small iron and lead/zinc operations with a blasting potential of less that 10 metric tons of ANFO equivalent per event at an individual site. Surface mining and quarrying operations are generally on a larger scale. Quarrying operations are of moderate scale, generally located near larger cities in the north. It is likely that a blast detected outside of the well-defined mining region of northern Algeria would not be due to mining. In northern Algeria, maximum mine blasting events typically are in the 1-20 metric ton of ANFO equivalent range.

While only a few individual sites possess the capacity to produce regularly scheduled blasts in the 100-300 metric ton (ANFO equivalent) range, there are several areas where multiple surface mines are operating; it could be feasible to effectively conceal a nuclear test by excavating a deep test chamber in the midst of one of these areas. If a blast is detected in an area where mining occurs regularly from several sources, it may be difficult to detect. This could especially be true by decoupling the nuclear device in a large sealed cavern. Detonation of such a device during a surface mining blast event could further confuse the blasting signature.

The largest producing mines are located close to the Tunisian border.

APPENDICES

APPENDIX A: PRODUCING OR DEVELOPING MINERAL PROPERTIES IN ALGERIA

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
A 1	Colomb Behar–Kenadza	N 31° 30'	W 2° 30'	Bituminous Coal	21	General	Producer	Unknown	Domestic	Production estimated to be 7,000–15,000tpy in 1981–1990 Prod. peak in 1958 at 153,000tpy. Associated deposits shown on Appendix Map C.
A 1	Ksiksou	N 31° 20'	W 2° 20'	Bituminous Coal	21	General	Producer	Unknown	Domestic	See previous comments.
A 2	Beni–Saf	N 35° 17'	W 1° 23'	Fe	1,2,3,4,13, 14,19,21	Confirmed	Producer	Surface	Domestic	120,000tpy ore >100Mmt massive ore Producer in 1994
A 2	El Abed	N 34° 31'	W 1° 41'	Zn,Pb,Ag	1,4,6,7,8,13, 14,16,17,19,21	Confirmed	Producer	Underground	Domestic	Prod. 2000 tpd ore, 800 tpd conc. Room & pillar mining used. Block 100: 15Mmt @ 5% PbZn. Addl Res. 11Mmt @ 7% PbZn Plant proc. 476,000 tpy. Pit dim: 2000m x 75m x 6m
A 2	Kieselghur	N 35° 33'	W 1° 57'	Diatomite	18	General	Producer	Surface	Domestic	40 tpy prod. Reserves for 40 yr from 1993.
A 2	Maghnia	N 34° 50'	W 1° 45'	Bentonite	14,23	General	Producer	Surface	Domestic	--
A 3	Arzew	N 35° 42'	W 0° 19'	Salt	1,7,14	General	Producer	Surface	Domestic	--
A 3	Bou Hanifia	N 35° 13'	E 0° 10'	Marble	18	General	Producer	Surface	Domestic	Prod. 9800 tpy
A 3	Great Sebkha	N 35° 30'	W 0° 45'	Salt	7,14	General	Producer	Surface	Domestic	--
A 3	Mostaganem	N 35° 54'	E 0° 05'	Bentonite	14,23	General	Producer	Surface	Domestic	--
A 3	Oran	N 35° 40'	W 0° 36'	Cement	1,15,19	General	Producer	Surface	Domestic	Prod. 2.9Mmt from 3 plants
A 4	Blida	N 36° 28'	E 2° 48'	Cement	1,19	General	Producer	Surface	Domestic	Prod. 1Mmt
A 4	Bou Caid	N 35° 36'	E 1° 40'	Ba,Pb,Zn(4)	1,13	General	Producer	Underground	Domestic	Converted to Ba prod. in 1978

(1) Represents property or property grouping as defined on Appendix Map A.
(2) Complete list of data sources found at end of Appendix A.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) Deposit has produced only barite since 1978.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
A 4	El Asnam	N 36° 30'	E 1° 59'	Cement	1,19	General	Producer	Surface	Domestic	Prod. 2Mmt
A 4	Djebel Zaccar	N 36° 20'	E 2° 12'	Fe	1,2,3,4,5,21	General	Producer	Underground	Domestic	Prod. 250,000tpy ore >100Mmt massive ore Producer in 1994
A 4										
A 4	Medea	N 36° 15'	E 2° 45'	Gypsum	23	General	Producer	Surface	Domestic	--
A 4	Ouarsenis	N 35° 52'	E 1° 38'	Pb,Zn,Ba	1,7,13,14,19	General	Producer	Underground	Domestic	--
A 5	Algiers	N 36° 50'	E 3° 00'	Cement	15,19	General	Producer	Surface	Domestic	Cap: 500,000 tpy
A 5	Fej Hassen	N 36° 50'	E 3° 00'	Zn,Pb	19	General	Producer	Underground	Domestic	Reported to be producing.
A 6	Affensou	N 36° 40'	E 4° 14'	Ba	1,13,19	General	Producer	Surface	Unknown	Prod. reportedly began in 1979.
A 6	Beni Mansour	N 36° 22'	E 4° 46'	Sr	1,14,17	General	Producer	Surface	Domestic & Exported	Res: 2.6Mmt proven; Res: 2.5Mmt probable; Grade: 85.7% SrSO4
A 6	Bouira	N 36° 22'	E 3° 55'	Cement	15,19	General	Producer	Surface	Domestic	Cap: 1Mmt
A 6	Keddara	N 36° 37'	E 3° 29'	Ba,Pb	1,19	General	Producer	Surface	Unknown	Names: Zouggara, Tala Roumi, Ain-Sultane, Saddle
A 6	Mekla	N 36° 39'	E 4° 21'	Ba	1,13,14	General	Producer	Surface	Unknown	Limited data
A 6	Timezrit	N 36° 35'	E 4° 46'	Fe	1,2,3,4,11,21	General	Producer	Surface	Domestic	Prod. 150,000 – 300,000tpy ore Res: 4Mmt @ 53–56% Fe Producer in 1994.
A 7	Bou Soufa (Cavallo)	N 36° 45'	E 5° 35'	Cu,Pb,Zn	1	General	Producer	Underground	Domestic	Assoc. with Kherzet Youssef Current status uncertain
A 8	Setif	N 36° 10'	E 5° 35'	Cement	1,15,19	General	Producer	Surface	Domestic	Prod. 1Mmt
A 9	El Outaya	N 35° 03'	E 5° 36'	Salt	1,7,14	General	Producer	Surface	Domestic	--
A 10	Djebel Ichmoul	N 35° 17'	E 6° 30'	Pb,Zn	1,7,19	General	Producer	Underground	Domestic	Alt. name Easchmool. Developed in 1969. Res: 1.3Mmt @ 4% Pb

(1) Represents property or property grouping as defined on Appendix Map A.
(2) Complete list of data sources found at end of Appendix A.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
A 11	Tamazert	N 36° 49'	E 6° 14'	Kaolin	1,14	General	Producer	Surface	Domestic	Prod. 10,000 tpy in 1985. Ore to El Milia plt. 20 km away.
A 12	Am'Rasma(5)	N 36° 37'	E 7° 06'	Hg,Pb	1,16	Confirmed	Producer	Surface	Exported	A mining area of Ismail. Powder factor: 0.1 kg/t Fissure veins; pegmatite Cap: 140 tpd or 30,000 tpy Processed at Annaba, then exported to Europe
A 12	Batna	N 36° 56'	E 6° 46'	Cement	1,19	General	Producer	Surface	Domestic	Cap: 1Mmt
A 12	Constantine	N 36° 50'	E 6° 39'	Cement	1,19	General	Producer	Surface	Domestic	Cap: 1Mmt
A 12	Filfila	N 36° 53'	E 7° 07'	Marble	7	General	Producer	Surface	Domestic	Began prod. in 1969.
A 12	Guenicha(5)	N 36° 47'	E 7° 04'	Hg	1	General	Producer	Surface	Exported	A mining area of Ismail.
A 12	Ismail(5)	N 36° 42'	E 7° 06'	Hg	1,7,13,19,21	Confirmed	Producer	Surface	Exported	Res: 4.1Mmt @ 1.66% Hg. Also called Taght Ore/waste ratio 1:1. Cap: 120 tpd or 26,000 tpy; 215 d/y Powder factor: 0.1 kg/t Other zone: Tendak. Processed at Annaba, then exported to Europe.
A 12	Sidi Kamber	N 36° 43'	E 6° 35'	Ba,Pb,Zn(4)	1,7,13,14,19	Confirmed	Producer	Underground	Domestic	Converted to barite production. PbZn resource depleted.
A 13	Ain Mimoun	N 35° 51'	E 7° 07'	Ba	13,14	General	Producer	Surface	Unknown	--
A 13	Sidi Bouziane	N 35° 47'	E 6° 50'	Salt	7,14	General	Producer	Surface	Domestic	--
A 14	Ain Barbar	N 36° 59'	E 7° 34'	Zn,Cu,Pb	1,7,13,14,19	Confirmed	Producer	Underground	Domestic	--
A 14	Bendjerah	N 36° 20'	E 7° 40'	Marble	21	General	Producer	Surface	Domestic	1990 prod. was 9800 tpy.
A 14	Djebel Debagh	N 36° 31'	E 7° 28'	Kaolin	1,7,14	General	Producer	Surface	Domestic	Began in 1970 with reported life of about 20 yr.
A 14	Gerboun Lamri	N 36° 47'	E 7° 30'	Salt	7,14	General	Producer	Surface	Domestic	--

(1) Represents property or property grouping as defined on Appendix Map A.
(2) Complete list of data sources found at end of Appendix A.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) Deposit is currently producing only barite.
(5) The Ismail area includes the Ismail, Am'Rasma, and Guenicha deposits.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
A	15	Bou Khadra	N 35° 46'	E 8° 03'	Fe	1,4,14,19,21	Confirmed	Producer	Underground	Domestic, minor exp. Tunisia and Albania	Prod. 0.5Mmt−1.0Mmt in 1989. >100Mmt massive ore Res: 50Mmt (1979) Producer in 1994 Assoc. with Ouenza deposit.
A	15	Djebel Ouenza	N 35° 58'	E 8° 07'	Fe	1,2,3,4,7, 14,15,19,21	Confirmed	Producer	Surface	Domestic steel ind. Minor exp. to Tunisia and Albania	30km from Bou Khadra Res: 100Mmt (1989) Prod: 2.3−2.8 Mmt @ 53−60%Fe Producer in 1994. Supplies 75% of Algerian prod. 2:1 stripping ratio. Blasts ore and waste. Operates 2 (14 hr) sh/d. Open pit mining used. Pit area reportly 17 sq km. 300 d/yr schedule.
A	15	Elma Laboid	N 35° 20'	E 8° 01'	Cement	1	General	Unknown (6)	Surface	NAp(7)	Cap: 5.6Mmt Production status uncertain.
A	15	Khanguet El Mouhad	N 35° 35'	E 8° 06'	Fe	3,4,13,19	Confirmed	Producer	Surface	Domestic steel ind.	Prod: 0.15−0.3Mmt (1989).
A	16	Djebel Onk	N 34° 43'	E 8° 00'	Phosphate	1,4,7,9, 13,14,19	Confirmed	Producer	Surface	30% Domestic 70% Exported to France, Spain Past exports to Yugoslavia, Poland, Finland, and Indonesia.	Prod. 3Mmt phosrock. Res: 500Mmt @ 24.3−27.5%P2O5 Prod. began in 1960's. Prod. 1.2Mmt of processed P2O5. Mining area 3000 ha. Ave. ore depth 22.5m. 1:1 stripping ratio. Continuous schedule. Site covers 2100 sq km.
A	17	Djelfa	N 34° 43'	E 3° 14'	Cement	15,19	General	Producer	Surface	Domestic	Cap: 500,000 tpy
A	18	Timagouine	N 21° 39'	E 4° 32'	U	22,24	General	Deposit planned for devel.	NAp(7)	NAp(7)	Occurrence Prod. 1,800 tpy planned Res: 50,000 mt U (see Hoggar). Vein & stockworks in gneisses. Requires financing.
A	19	Laouni	N 20° 28'	E 5° 34'	W,Sn	4,13	General	Deposit planned for devel.	NAp	NAp	Occurrence Planned for development.

(1) Represents property or property grouping as defined on Appendix Map A.
(2) Complete list of data sources found at end of Appendix A.
(3) General − denotes limited data; Confirmed − denotes deposit information confirmed by several sources.
(6) While reported in one source to be a major producer, this property does not show up in other sources of information.
(7) NAp Not applicable; generally applied to deposits that have never produced or for which a mining or marketing plan has not been proposed.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
A	20	Ghara Djeblet	N 26° 46'	E 7° 20'	Fe	1,3,7,13,19	Confirmed	Deposit planned for devel.	Surface	Domestic, exported	Res: 1.4Bmt @ 49–54% Fe. Prod proposed at 8Mmt. 1400 km rail line required. Sedimentary, lenticular ore zone 50% exports to Europe planned. Dev. requires funding which has not been secured to date.
A	20	Michri Abdelaziz	N 26° 46'	E 7° 20'	Fe	1,11,13	General	Deposit planned for devel.	Surface		Res. 1.96 Bmt at 52–54% Fe. Adj. to Ghara Djebilet. Same status as Ghara Djebilet.
A	21	Amesmessa	N 23° 38'	E 8° 30'	Au	1,12,15,21	General	Deposit planned for devel.	Surface	NAp(7)	Planned to begin production in 1997 if financing secured. Res: 55,800 oz Au.
A	21	Tirek	N 23° 38'	E 8° 29'	Au	1,12,15,19,21	General	Deposit planned for devel.	Unknown	NA	Projected for 1997. Res: 161,800 oz Au. Needs funding. Lode gold deposit. Needs infrastructure to dev.

(1) Represents property or property grouping as defined on Appendix Map A.
(2) Complete list of data sources found at end of Appendix A.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(7) NAp Not applicable; generally applied to deposits that have never produced or for which a mining or marketing plan has not been proposed.

APPENDIX A: PUBLIC SOURCES OF INFORMATION

1. Mining Journal Research Service. Oct. 6, 1994, Report compiled for Lawrence Livermore National Laboratory.
2. Economic Geology. Vol. XXII, No. 6, Sept. – Oct. 1927, pp. 537–540.
3. Survey of World Iron Ore Resources. United Nations, New York, 1970, pp. 64–66.
4. U.S. Geological Survey. Mineral Resources Data System (MRDS), 1994.
5. Engineering & Mining Journal. May 14, 1927, Vol. 123, No. 20, pp. 803–804.
6. International Lead Zinc Industry Group (ILZIG). ILZIG World Directory. June 1988.
7. Mining Magazine. Aug. 1969, Vol. 121, No. 2, p. 126.
8. Pincock, Allen, & Holt, Inc. Profile Deposit Report, 1981.
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12. Mining Magazine. Aug. 1993, Vol. 169, No. 2, p. 64.
13. World Mines Register. 1981–82.
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15. U.S. Bureau of Mines. Minerals Yearbook 1994 (preprint).
16. United Nations. Mission to Algeria – Sept. 11 – Oct. 7, 1993, G. A. Tremblay. Project ALG/87/013.
17. United Nations. Mission to Algeria – Aug. 27 – Oct. 19, 1993, F. J. Gauthier. Project ALG/87/013.
18. United Nations. Mission to Algeria – Sept 10 – Oct. 7, 1993, Paul Girard. Project ALG/87/013.
19. U.S. Bureau of Mines. Minerals Availability Data Base, Dec. 1994.
20. Iron Age. Apr. 8, 1927, pp. 986–987.
21. Europa Publications Ltd. The Middle East and North Africa 1994. 40th Ed. Selected country chapters.
22. Cambridge Information and Research Services Ltd. World Directory of Energy Information. Vol. 2, 1994. Selected country profiles.
23. Mining Magazine. Aug. 1993, Vol. 169, No. 2, pp. 65–67.
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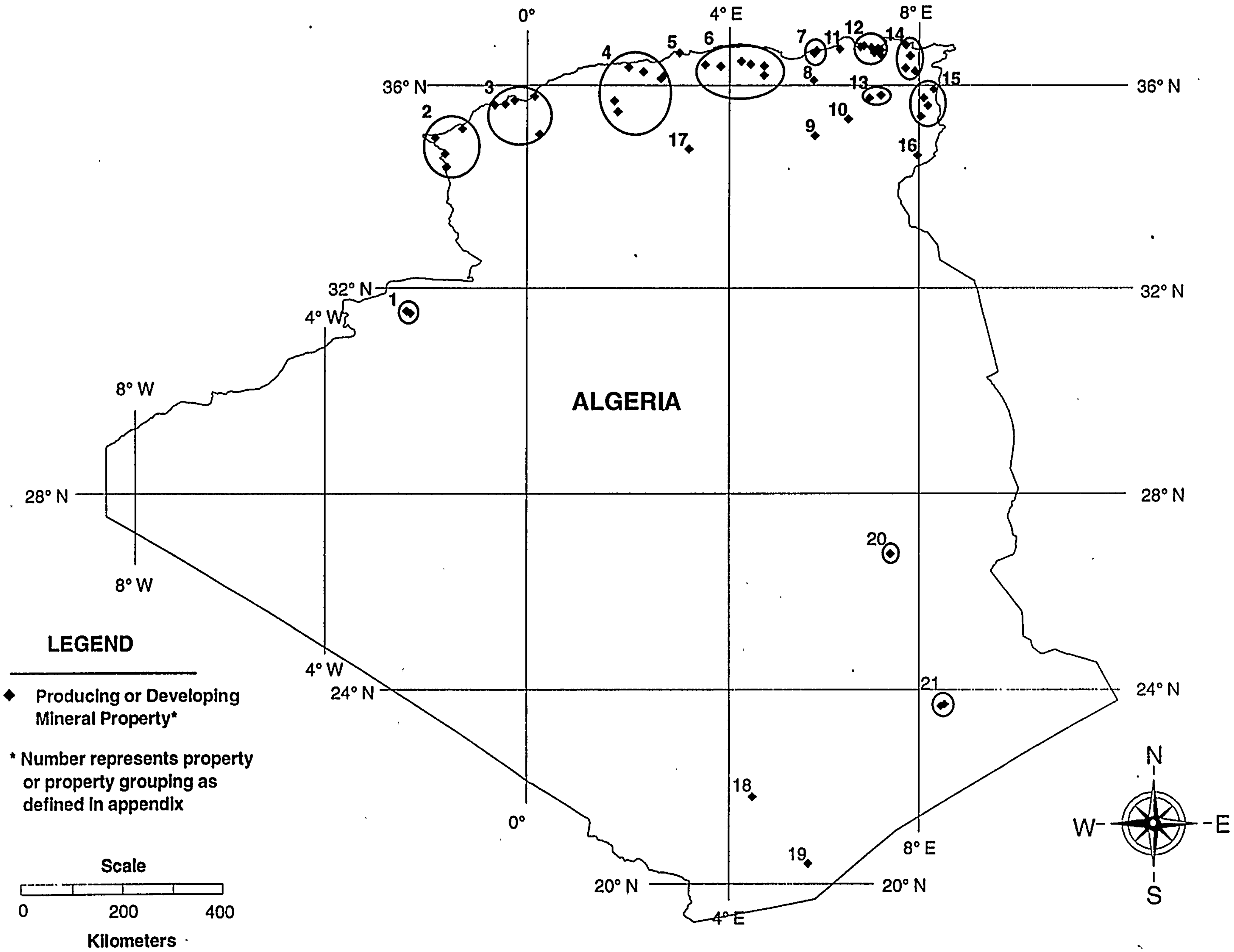

APPENDIX MAP A: PRODUCING OR DEVELOPING MINERAL PROPERTIES OF ALGERIA

APPENDIX B: PAST PRODUCING MINERAL PROPERTIES IN ALGERIA

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
B 1	Djebel Filaoucine	N 35° 01'	W 1° 37'	Pb,Zn	1,16	General	Past Producer	Surface	NAp(4)	--
B 1	Djebel Maasser	N 34° 57'	W 1° 46'	Pb,Zn	1	General	Past Producer	Surface	NAp	--
B 1	Ghar Rouban	N 34° 36'	W 1° 47'	Pb,Cu	1,7,18	Confirmed	Past Producer	NAp(4)	NAp	Old, small site.
B 1	Kristel	N 35° 49'	W 1° 20'	Fe	5	General	Past Producer	Surface	NAp	Very low grade. Production 1905–1915.
B 1	Maaziz	N 34° 53'	W 1° 48'	Pb,Zn	1,16	General	Past Producer	Surface	NAp	--
B 1	Tazout	N 35° 50'	W 0° 28'	Pb,Fe	1	General	Past Producer	NAp	NAp	--
B 2	Djebel Haddid	N 36° 29'	E 2° 16'	Fe,Cu	1,2,5	General	Past Producer	NAp	NAp	Near town of Cherchal.
B 2	Fondouk	N 36° 25'	E 2° 15'	Fe	5	General	Past Producer	Surface	NAp	Very low grade.
B 2	Rouina	N 36° 14'	E 1° 48'	Fe,As	1,2,5	General	Past Producer	NAp	NAp	100,000 tpy in 1927 @ 53% Fe.
B 2	Temoulga	N 36° 30'	E 2° 10'	Fe	5	General	Past Producer	Surface	NAp	Very low grade. Produced up to 50,000 tpy.
B 3	Ain Oudrer	N 35° 27'	E 2° 54'	Fe	5	General	Past Producer	Surface	NAp	Very low grade.
B 4	Beni Douala	N 36° 38'	E 4° 04'	Fe	1,3	General	Past Producer	Underground	NAp	>100Mmt massive ore.
B 4	Bou Saada	N 35° 13'	E 4° 10'	Phosphate	19	General	Past Producer	Surface	NAp	--
B 4	El Maden	N 36° 36'	E 3° 17'	Fe,Cu	1,2,5	General	Past Producer	NAp	NAp	Prod. began 1898. Prod. 50,000 tpy @ 47% Fe

(1) Represents property or property grouping as defined on Appendix Map B.
(2) Complete list of data sources found at end of Appendix B.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) NAp Not applicable; past producing operations have no current markets.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
B	4	Palestro	N 36° 34'	E 3° 36'	Ba	19	General	Past Producer	Surface	NAp(4)	Incl. in regional cap. given in Rivet deposit.
B	4	Rivet	N 36° 37'	E 3° 14'	Ba	19	General	Past Producer	Surface	NAp	Producer in 1965, no info. since. Regional cap: 34,000 tpy ore.
B	4	Sakamody	N 36° 30'	E 3° 18'	Zn,Pb	1,7	General	Past Producer	Unknown	NAp	--
B	4	St. Paul	N 36° 41'	E 3° 23'	Ba	19	General	Past Producer	Surface	NAp	Producer in 1965. Included in regional cap.
B	4	St. Pierre	N 36° 41'	E 3° 23'	Ba	19	General	Past Producer	Surface	NAp	Producer in 1965. Incl. in regional cap.
B	5	Affalou	N 36° 30'	E 4° 40'	Fe	5	General	Past Producer	Surface	NAp	Small output.
B	5	Beni–Felkai	N 36° 30'	E 4° 40'	Fe	5	General	Past Producer	Surface	NAp	Small output.
B	5	Bordj Redir	N 35° 54'	E 4° 54'	Phosphate	19	General	Past Producer	Surf/ug	NAp	--
B	5	Djebel Gustar	N 36° 01'	E 5° 33'	Zn,Pb,Cu	1,7	General	Past Producer	Unknown	NAp	--
B	5	Kherzet Youssef	N 35° 46'	E 5° 36'	Zn,Pb, Ag,Cu	1,6,7,16, 17,19,21	Confirmed	Past Producer	Underground	NAp	Also called Cavallo. Res: 1) 0.2Mmt @ 9% Zn, 2.5% Pb; 2) 1Mmt @ 17.7% Zn, 3.2% Pb Prod. began June 1981. Deposit to be exhausted by 2000. Closed mid–1990 due to flooding. Perm. closed as of 1994. Prod. 10,000 tpy Zn, 4,000 tpy Pb
B	5	M'zaita	N 35° 55'	E 5° 01'	Phosphate	1,4,7,9,19	Confirmed	Past Producer	Underground	NAp	Production ceased 1958. Res: 25–30Mmt @ 23–28% P2O5. Dim: 4500m by 3000m. Avg. thickness 2.3m. Avg. depth 150m.
B	6	Ain Bou Hamada	N 35° 22'	E 6° 41'	Zn,Pb	1,7	General	Past Producer	Unknown	NAp	--

(1) Represents property or property grouping as defined on Appendix Map B.
(2) Complete list of data sources found at end of Appendix B.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) NAp Not applicable; past producing operations have no current markets.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
B 6	Chellala	N 35° 37'	E 6° 08'	Zn,Pb	1,7	General	Past Producer	Unknown	NAp(4)	--
B 6	Tioun Kenine	N 35° 33'	E 6° 16'	Zn,Pb	1,16	General	Past Producer	Underground	NAp	Prod. bet. 1899–1930. Incl. Ain Boukda.
B 7	Ain Ben Merouane	N 36° 53'	E 7° 06'	Fe,Cu	1	General	Past Producer	Unknown	NAp	--
B 7	Amarko	N 36° 15'	E 7° 08'	Zn	10	General	Past Producer	Unknown	NAp	Past producer.
B 7	Bou Douka	N 36° 45'	E 6° 24'	Zn,Pb,Cu	1,7,16,17	Confirmed	Past Producer	Underground	NAp	Prod. between 1910–1955. Reserves: 3.8 Mmt @ 1.04% Pb, 5.87% Zn, and 0.34% Cu.
B 7	Hammam N'Rails	N 36° 20'	E 7° 39'	Zn,Sb	1	General	Past Producer	Unknown	NAp	--
B 7	Karezas	N 36° 48'	E 7° 39'	W,As	1	General	Past Producer	Unknown	NAp	--
B 7	Marouania	N 36° 53'	E 7° 08'	Fe	5	General	Past Producer	Surface	NAp	Surface ore depleted. UG mining required.
B 7	M'Cid Aiaba	N 36° 35'	E 6° 22'	Pb,Zn	1	General	Past Producer	Unknown	NAp	--
B 7	Sidi Marouf	N 36° 34'	E 6° 28'	Fe	7,20	General	Past Producer	Surface	NAp	--
B 8	El Ouasta	N 36° 09'	E 8° 17'	Zn	1,7	General	Past Producer	Unknown	NAp	--
B 9	Djebel Kouif	N 35° 30'	E 8° 20'	Phosphate	1,4,7,9,13, 14,15,19	Confirmed	Past Producer	Underground	NAp	Mine closed in 1970s.

(1) Represents property or property grouping as defined on Appendix Map B.
(2) Complete list of data sources found at end of Appendix B.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) NAp Not applicable; past producing operations have no current markets.

APPENDIX B: PUBLIC SOURCES OF INFORMATION

1. Mining Journal Research Service. Oct. 6, 1994, Report compiled for Lawrence Livermore National Laboratory.
2. Economic Geology. Vol. XXII, No. 6, Sept. – Oct. 1927, pp. 537–540.
3. Survey of World Iron Ore Resources. United Nations, New York, 1970, pp. 64–66.
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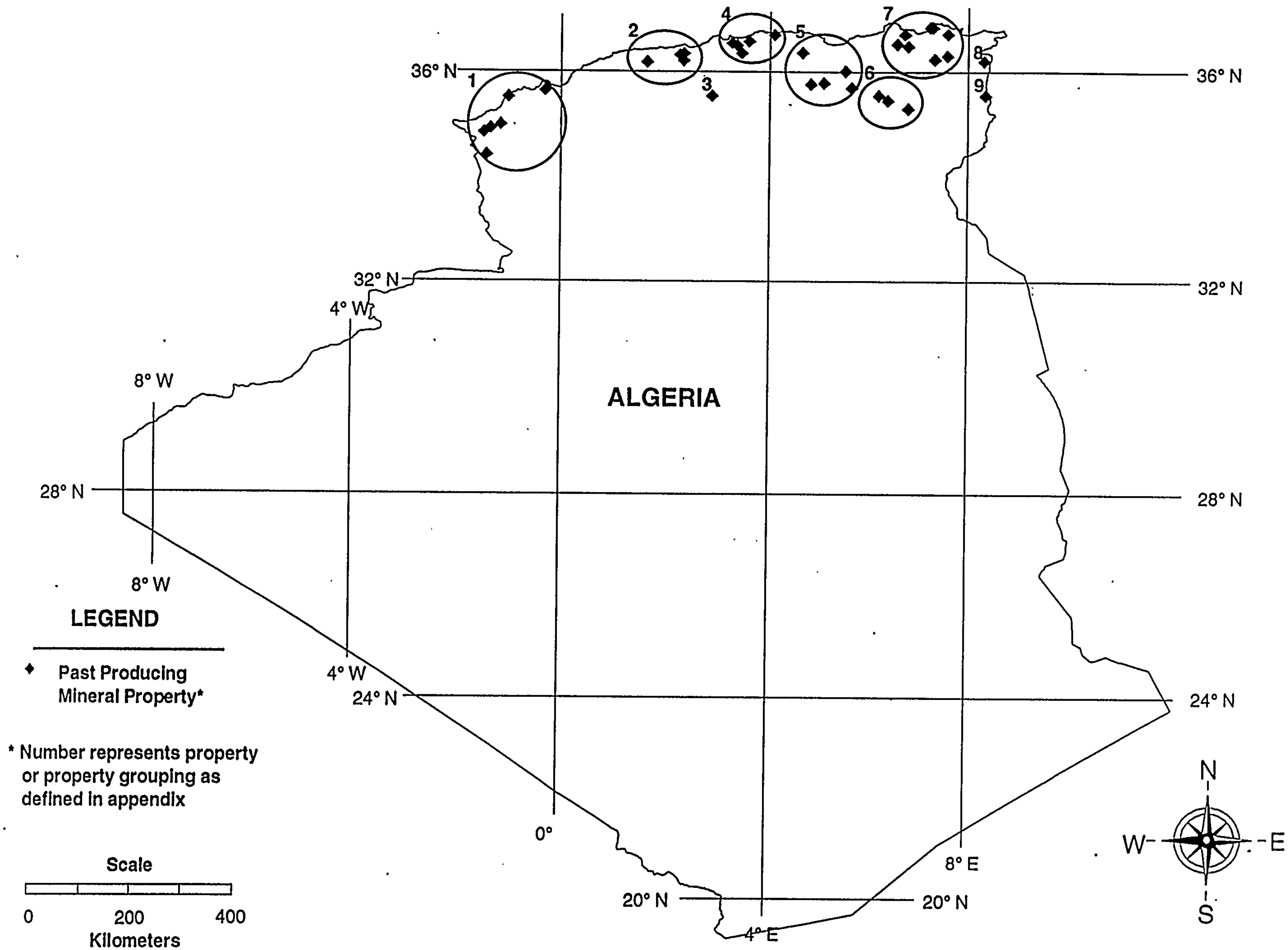

APPENDIX MAP B: PAST PRODUCING MINERAL PROPERTIES OF ALGERIA

APPENDIX C: PROSPECTS AND UNDEVELOPED MINERAL PROPERTIES IN ALGERIA

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C 1	Djebel Guettara	N 30° 06'	W 3° 10'	Mn,As	4,7,19	General	Deposit	Surface	NAp(4)	Occurrence Stratiform Exp. Pros.
C 2	Sebabna	N 35° 02'	W 2° 06'	Fe,Mn	5	General	Deposit	Surface	NAp	Occurrence
C 3	Colomb Behar–Kenadza	N 31° 30'	W 2° 30'	Bituminous Coal	21	General	Deposit	Unknown	NAp	Deposits reported to be adjacent to producing area.
C 3	Ksiksou	N 31° 20'	W 2° 20'	Bituminous Coal	21	General	Deposit	Unknown	NAp	See previous comments.
C 4	Ain Djeraoua	N 34° 38'	W 1° 41'	Mn,Fe	1	General	Deposit	Unknown	NAp	--
C 4	Deglen	N 34° 35'	W 1° 44'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C 5	Djebel Slissen	N 34° 48'	W 1° 04'	Fe,Mn	1	General	Deposit	Unknown	NAp	--
C 5	Djebel Toulla	N 35° 36'	W 1° 06'	Cu,Ni	1	General	Deposit	Unknown	NAp	--
C 5	M'Sirda	N 35° 00'	W 1° 00'	Pb,Zn	16	General	Deposit	Unknown	NAp	Occurrence
C 6	Ain Sefra	N 32° 45'	W 0° 35'	Cu	1	General	Deposit	Unknown	NAp	--
C 6	Garet Deba	N 32° 47'	W 0° 40'	Cu	16	General	Deposit	Unknown	NAp	Occurrence
C 6	Ras El Guenatis	N 33° 30'	E 0° 10'	Zn,Pb,F	16,18	General	Deposit	Unknown	NAp	Occurrence Reserves: 3.2 Mmt @ 3.5% Zn, 1.8% Pb, and 12.4% F.
C 6	Teniet El Rhnem	N 32° 56'	W 0° 10'	Cu	16	General	Deposit	Unknown	NAp	Occurrence
C 7	Ben Alane	N 35° 49'	E 0° 40'	Salt	1	General	Deposit	Surface	NAp	--
C 7	Djebel Modzbab	N 34° 56'	E 0° 20'	Cu,Au	16	General	Deposit	Unknown	NAp	Occurrence
C 7	Kalna	N 35° 09'	E 0° 42'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C 7	Khenifer	N 34° 54'	E 0° 22'	Pb,Zn,Ba	16	General	Deposit	Unknown	NAp	Occurrence
C 7	Oued Zeboundj	N 34° 49'	E 0° 08'	Pb,V	1,16	General	Deposit	Unknown	NAp	May be same occurrence as Saida.

(1) Represents property or property grouping as defined on Appendix Map C.
(2) Complete list of data sources found at end of Appendix C.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C 7	Saida	N 34° 45'	E 0° 05'	Pb,Zn	4,7	General	Deposit	Unknown	NAp(4)	Occurrence
C 7	Takhemaret	N 35° 10'	E 0° 39'	Pb,Zn	16	General	Deposit	Unknown	NAp	Occurrence
C 8	Brezina	N 33° 17'	E 1° 33'	Mn	1	General	Deposit	Unknown	NAp	--
C 8	Forthassa	N 32° 51'	E 1° 18'	Cu	1	General	Deposit	Unknown	NAp	--
C 9	Ain Melaz	N 35° 21'	W 0° 41'	Pb,Zn	1,16	General	Deposit	Unknown	NAp	--
C 9	Trezel	N 34° 50'	E 1° 35'	Pb,Zn	7	General	Deposit	Unknown	NAp	Occurrence
C 10	Bou Khendar	N 36° 28'	E 1° 21'	Cu,As	1	General	Deposit	Unknown	NAp	--
C 10	Breira	N 36° 28'	E 1° 36'	Fe,Cu	1	General	Deposit	Unknown	NAp	--
C 10	Djahamama	N 36° 13'	E 1° 49'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C 10	Koudiat Hallounda	N 35° 55'	E 2° 15'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C 10	Larhat	N 36° 32'	E 1° 49'	Fe	1	General	Deposit	Unknown	NAp	--
C 11	Ain Maden	N 36° 49'	E 2° 59'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C 11	Bou Zega	N 36° 36'	E 3° 26'	Ba	19	General	Deposit	Surface	NAp	Incl. in regional capacity.
C 11	Bouarous	N 36° 37'	E 3° 20'	Au	17	General	Deposit	Surface	NAp	Occurrence
C 11	Chabat Kahat	N 36° 08'	E 3° 10'	Ba,Pb	1	General	Deposit	Unknown	NAp	--
C 11	Djebel Ahmed	N 36° 32'	E 3° 16'	Hg	1	General	Deposit	Unknown	NAp	--
C 11	Guerrouma	N 36° 31'	E 3° 28'	Pb,Zn	1,7	General	Deposit	Unknown	NAp	--
C 11	La Bouzaria	N 36° 40'	E 3° 00'	Pb,Pt	4	General	Deposit	Unknown	NAp	Occurrence Vein Deposit
C 11	Le Soummah	N 36° 30'	E 2° 56'	Fe	1	General	Deposit	Unknown	NAp	--
C 11	Mozaia	N 36° 21'	E 2° 42'	Cu,Fe	1	General	Deposit	Unknown	NAp	--
C 11	Nador Chair	N 36° 31'	E 3° 30'	Zn,Pb	1	General	Deposit	Unknown	NAp	--

(1) Represents property or property grouping as defined on Appendix Map C.
(2) Complete list of data sources found at end of Appendix C.
(3) General -- denotes limited data; Confirmed -- denotes deposit information confirmed by several sources.
(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C	11	Oued Merdja	N 36° 23'	E 2° 47'	Cu,Fe	1	General	Deposit	Unknown	NAp(4)	--
C	12	Tizi N'Taga	N 35° 27'	E 3° 04'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C	13	Djelfa	N 34° 40'	E 3° 14'	Salt	1	General	Deposit	Surface	NAp	--
C	14	Azrou N'Bechar	N 36° 44'	E 4° 05'	Pb,Zn	19	General	Deposit	Underground	NAp	Prospect 200 Mmt @ 6% Zn. Ore at 250m depth.
C	14	Bou Mahni	N 36° 35'	E 3° 54'	Ba, Pb	1	General	Deposit	Unknown	NAp	--
C	14	Oued Amizour	N 36° 50'	E 4° 00'	Zn,Pb	17	General	Deposit	Unknown	NAp	Occurrence Reserves: 33.54 Mmt @ 5.51%Zn and 1.12% Pb.
C	14	Sidi Ali Bou Nab	N 36° 42'	E 3° 51'	Kaolin	1	General	Deposit	Surface	NAp	--
C	14	Timizar	N 36° 43'	E 4° 03'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C	14	Tizi Bouali	N 36° 38'	E 4° 16'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C	15	Abanker	N 21° 00'	E 4° 00'	U	22	General	Deposit	Unknown	NAp	Prod. at 1,800 tpy planned in Hoggar Mtns. Depends upon financing.
C	15	Daira	N 21° 10'	E 4° 10'	U	22	General	Deposit	Unknown	NAp	Prod. of 1,800 tpy planned in Hoggar Mtns. Depends upon financing.
C	16	Arak Canyon	N 22° 40'	E 4° 30'	Pt	4	General	Deposit	Surface	NAp	Placer
C	16	Silet	N 22° 40'	E 4° 30'	Pt	4	General	Deposit	Surface	NAp	Placer
C	17	Hoggar	N 23° 00'	E 5° 00'	Pt,U	4,13	General	Deposit	Unknown	NAp	Occurrence Magmatic Res: 50,000 t contained U.
C	18	Afoural	N 35° 45'	E 5° 46'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C	18	Ain Kahla	N 35° 45'	E 5° 17'	Pb,Zn	7,16	General	Deposit	Unknown	NAp	Occurrence
C	18	Ain Rouh	N 36° 20'	E 5° 11'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C	18	Amaden	N 36° 43'	E 4° 57'	Pb,Ag	1,7,16	General	Deposit	Unknown	NAp	Occurrence

(1) Represents property or property grouping as defined on Appendix Map C.
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(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C 18	Beni Segoual	N 36° 38'	E 5° 24'	Zn,Pb	1,7,16	General	Deposit	Unknown	NAp(4)	Occurrence
C 18	Bou Amrane	N 36° 42'	E 5° 02'	Fe,Cu	1	General	Deposit	Unknown	NAp	--
C 18	Bou Kdema	N 36° 19'	E 5° 04'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C 18	Bou Klama	N 36° 44'	E 5° 01'	Pb,Ba	1	General	Deposit	Unknown	NAp	--
C 18	Bouich	N 35° 43'	E 5° 13'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C 18	Boukdema	N 36° 40'	E 5° 00'	Pb,Zn	16,17	General	Deposit	Unknown	NAp	Occurrence Reserves: 10 Mmt @ 4.5% Zn and 1.5% Pb.
C 18	Bra Demah	N 36° 31'	E 5° 16'	Cu	1	General	Deposit	Unknown	NAp	--
C 18	Chabet El Hamra	N 35° 30'	E 5° 40'	Zn	16,17	General	Deposit	Unknown	NAp	Occurrence Reserves: 5.0 Mmt @ 4.5% Zn.
C 18	Chouf Ameur	N 35° 42'	E 5° 44'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C 18	Djebel Haoumar	N 35° 44'	E 5° 22'	Zn	1	General	Deposit	Unknown	NAp	--
C 18	Djebel Soubella	N 35° 43'	E 5° 12'	Pb,Zn	7	General	Deposit	Unknown	NAp	Occurrence
C 18	Djebel Z'Dim	N 36° 02'	E 5° 13'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C 18	Dra Sfa	N 35° 50'	E 5° 26'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C 18	Guemel	N 36° 00'	E 5° 21'	Salt	1	General	Deposit	Surface	NAp	--
C 18	Guergour	N 36° 20'	E 5° 05'	Pb,Zn	7	General	Deposit	Unknown	NAp	Occurrence Inc. Ain Roua, Kef Semmah, Djebel Anini, Baukedema.
C 18	Kef Aoumar	N 35° 45'	E 5° 30'	Pb,Zn	16	General	Deposit	Unknown	NAp	Occurrence
C 18	Kef Semmah	N 36° 15'	E 5° 07'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C 18	Merouana	N 35° 35'	E 5° 45'	Pb,Zn	7	General	Deposit	Unknown	NAp	Occurrence
C 18	Tadergount	N 36° 33'	E 5° 17'	Cu	1	General	Deposit	Unknown	NAp	--
C 19	Achab Tiri	N 36° 28'	E 6° 26'	Zn,Pb,Ag	17	General	Deposit	Unknown	NAp	Occurrence

(1) Represents property or property grouping as defined on Appendix Map C.
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(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C	19	Ain Kerma	N 36° 27'	E 6° 28'	Sb,Zn	1	General	Deposit	Unknown	NAp(4)	--
C	19	Beni Bel	N 36° 53'	E 6° 10'	Sn,W	1	General	Deposit	Unknown	NAp	--
C	19	Bir Beni Salah	N 36° 52'	E 6° 32'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C	19	Bou Djoudoun	N 36° 41'	E 6° 17'	Cu	1	General	Deposit	Unknown	NAp	--
C	19	Chekfa	N 36° 42'	E 5° 52'	Kaolin	1	General	Deposit	Surface	NAp	--
C	19	Djebel Aougueb	N 36° 16'	E 6° 23'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C	19	Djebel Felten	N 36° 13'	E 6° 27'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C	19	Djendeli	N 35° 40'	E 6° 33'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C	19	Kef Chernia	N 37° 02'	E 6° 32'	Cu,Pb	1	General	Deposit	Unknown	NAp	--
C	19	Koudiat Stah	N 36° 22'	E 5° 54'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C	19	Koudiat Toaba	N 36° 45'	E 6° 31'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C	19	L'Achaiches	N 36° 40'	E 6° 21'	Cu	1	General	Deposit	Unknown	NAp	--
C	19	Oued Bibi	N 36° 57'	E 6° 45'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C	19	Oued Oudina	N 36° 54'	E 6° 43'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C	19	Tamanart	N 37° 05'	E 6° 29'	Cu	1	General	Deposit	Unknown	NAp	--
C	20	Djebel Bouari	N 35° 30'	E 6° 10'	Fe	21	General	Deposit	Unknown	NAp	Discovered in 1975.
C	20	Djebel Takhapbi	N 35° 38'	E 6° 14'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C	20	Menkouch Hadjar	N 35° 38'	E 6° 16'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C	20	Taghit	N 35° 12'	E 6° 09'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C	21	Ain Babouche	N 35° 07'	E 7° 39'	Fe	1,3,11	General	Deposit	Unknown	NAp	Res: 12Mmt @ 47–52% Fe. High silica. >100Mmt bedded ore.
C	21	Bekkaria	N 35° 23'	E 8° 15'	Zn	1	General	Deposit	Unknown	NAp	--
C	21	Bou Djabeur	N 35° 54'	E 7° 56'	Zn	1	General	Deposit	Unknown	NAp	--

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(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C 21	Bou Jabber	N 35° 44'	E 8° 14'	Zn,Pb	1,17	General	Deposit	Unknown	NAp(4)	Grade is 1.5–6% Pb, 0.1–3% Zn. Expl. occurred 1967–74.
C 21	Djebel Dyr	N 35° 31'	E 8° 09'	Phosphate	1	General	Deposit	Surface	NAp	--
C 21	Djebel Hammimat	N 35° 59'	E 7° 12'	Sb,Zn	1	General	Deposit	Unknown	NAp	--
C 21	Djebel Tarraguelt	N 35° 52'	E 7° 37'	Pb,Zn	7	General	Deposit	Unknown	NAp	Occurrence
C 21	Hadjar Souda	N 35° 54'	E 7° 27'	Sb,Hg	1	General	Deposit	Unknown	NAp	--
C 21	Hizab	N 35° 44'	E 7° 01'	Ba	1	General	Deposit	Surface	NAp	--
C 21	Kef Rakma	N 35° 54'	E 7° 52'	Zn	1	General	Deposit	Unknown	NAp	--
C 21	Mesloula	N 35° 52'	E 7° 50'	Pb,Cu	1	Confirmed	Deposit	Unknown	NAp	Ore disseminated in limestone.
C 21	Tizi Ala	N 35° 23'	E 6° 56'	Cu,Hg	1	General	Deposit	Unknown	NAp	--
C 22	Ain Arka	N 36° 07'	E 7° 09'	Zn	1	General	Deposit	Unknown	NAp	--
C 22	Ain Mokra	N 36° 52'	E 7° 28'	Fe	1	General	Deposit	Unknown	NAp	--
C 22	Bou Maiza	N 37° 02'	E 7° 28'	Fe	1	General	Deposit	Unknown	NAp	--
C 22	Djebel Taya	N 36° 30'	E 7° 07'	Sb,Zn	1	General	Deposit	Unknown	NAp	--
C 22	El Gouhdi	N 36° 41'	E 7° 02'	Au	16,17	General	Deposit	Surface	NAp	Placer
C 22	Kef Djelja	N 36° 55'	E 7° 42'	As	1	General	Deposit	Unknown	NAp	--
C 23	Djebel Berda	N 36° 17'	E 8° 11'	Zn,Pb	1,7	General	Deposit	Unknown	NAp	--
C 23	El Kanga	N 36° 23'	E 8° 14'	Cu,Ag	1	General	Deposit	Unknown	NAp	--
C 23	El Kecherida	N 36° 20'	E 8° 12'	Pb,Zn	1	General	Deposit	Unknown	NAp	--
C 23	Oued Mougas	N 36° 20'	E 8° 16'	Zn,Pb	1	General	Deposit	Unknown	NAp	--
C 24	Kef Oum Theboul	N 36° 53'	E 8° 35'	Zn,Cu	1,7,14,17	Confirmed	Deposit	Unknown	NAp	Reserves: 2.79 Mmt @ 2.38% Cu, 1.23% Zn, and 0.46% Pb. Explored 1977–81. Vein deposit.

(1) Represents property or property grouping as defined on Appendix Map C.
(2) Complete list of data sources found at end of Appendix C.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.

APPENDIX C: PUBLIC SOURCES OF INFORMATION

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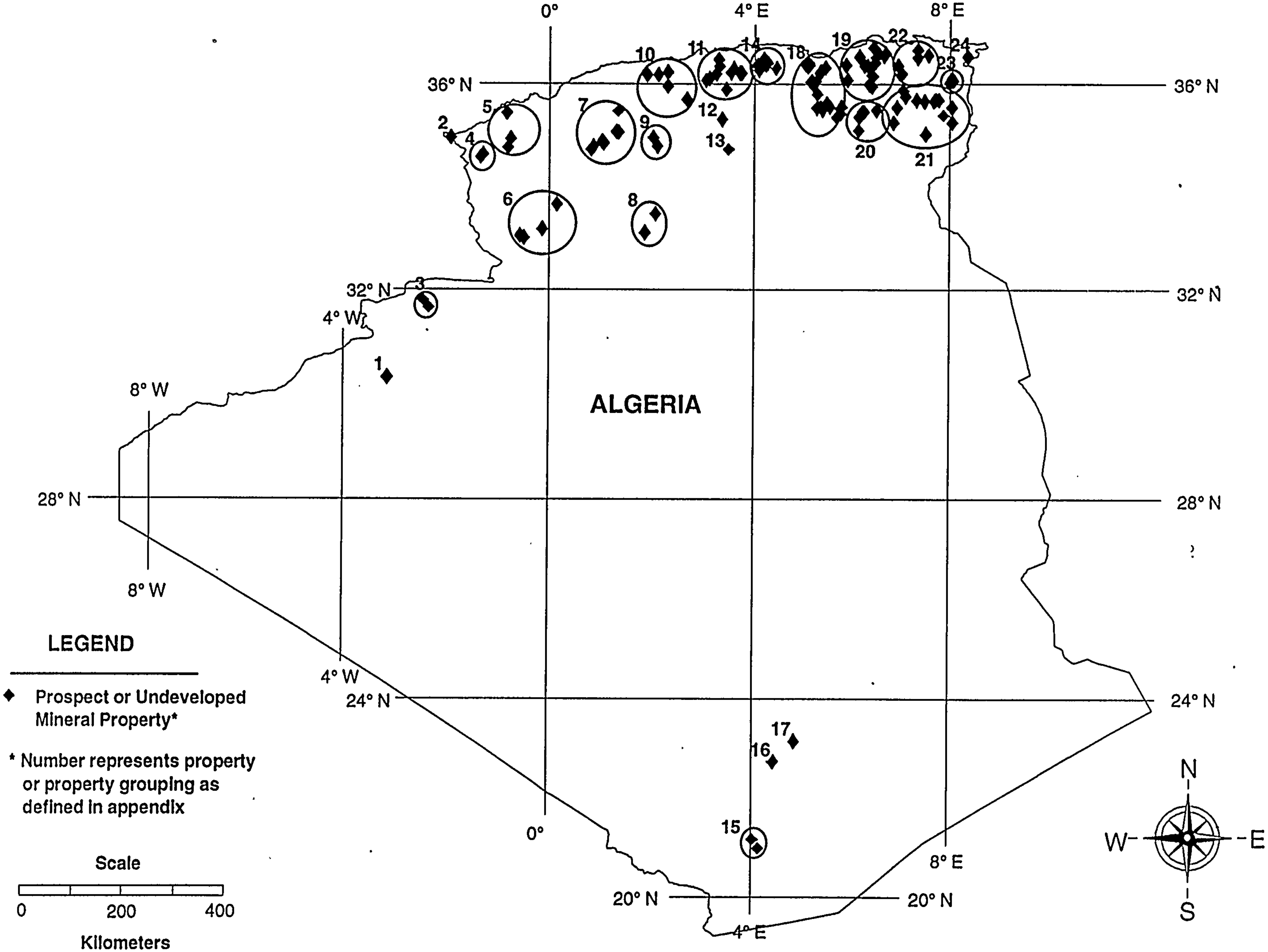

APPENDIX MAP C: PROSPECTS AND UNDEVELOPED MINERAL PROPERTIES OF ALGERIA

IRAN

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FIGURES

1.0 EXECUTIVE SUMMARY

This report was prepared under Memorandum of Agreement B291534 between Lawrence Livermore National Laboratory (LLNL) and the U.S. Bureau of Mines, Minerals Availability Field Office (MAFO). It provides LLNL information on the mining industry of Iran, and quantitative information on the blasting potential of its mining industry. MAFO identified mining activities through the use of the Minerals Availability data base, its data collection and analytic capabilities, and an extensive network of information sources.

While mineral fuels account for a large share of Iran's income, the minerals industry is also significant. Since the 1600's, Iran has produced significant quantities of iron ore, coal, copper, lead/zinc, and chromium to support its heavy industry. The Sar Cheshmeh deposit is a world class copper producer. Iran also is a producer of numerous industrial and construction materials. Mining is conducted in virtually all regions of the country, with the greatest concentration of sites in the mountainous regions of central Iran. Research activities resulted in the identification of 437 mineral properties. Most properties operate on a small scale and require minimal blasting.

Iran is prohibited by U. S. law from receiving U.S. mining equipment or supplies. Such restrictions do not appear to represent a major impediment to Iran's mining sector. Iran has the military-related technology and facilities to manufacture blasting agents and detonation systems suitable for most mining applications. Based upon available data, the blasting potential for 32 properties has been estimated. Blasting is generally conducted on a small scale, but may occur frequently where mine geology requires explosive use. Underground mining is limited to small coal and base metal deposits with an individual maximum blasting event potential of less than 10 metric tons of ANFO equivalent. Surface mining and quarrying operations are generally on a larger scale, but only a few sites possess the capacity to produce regularly scheduled blasts in the 100-300 metric ton (ANFO equivalent) range.

1.1 Authority

This report was prepared under Memorandum of Agreement B291534 between Lawrence Livermore National Laboratory (LLNL) and the U.S. Bureau of Mines, Minerals Availability Field Office (MAFO).

1.2 Project Scope

As part of this agreement, MAFO is to identify mining activities in Algeria, Iran, Iraq, and Libya as they relate to monitoring/verifying compliance of the Comprehensive Test Ban Treaty. MAFO is to use the Minerals Availability data base, its data collection and analytic capabilities, and an extensive network of information sources to provide background information focusing on the use of explosives by the mining industry, which can cause false alarms during monitoring and hide blasting events.

Reports with accompanying figures and tables summarize location, type of mining method, commodity(ies), estimated frequency and size of mine blasts, operational status, and mine product distribution to foreign or internal markets for the specified countries.

Once country data were collected and verified, the explosive use at selected sites was evaluated. Focus was placed on a limited number of larger operations, or those reported to have potential for short-term development. Undeveloped sites and small scale mines, while included in Appendices A-C of this report, were not analyzed in terms of the site's anticipated use of explosives since mineral prospects generally make only small use of explosives and small mines (some of which are operated on an intermittent basis) are assumed to require minimal blasting application.

Based upon known site information (geological conditions, mine technology, production capacity, and current blasting practices), the blasting potential for

significant mining sites was evaluated. Where site-specific data were not available, estimates for representative, important properties were developed based upon accepted industry practice, knowledge of the Iranian mining industry, and regional geologic characteristics.

2.0 SOURCES OF INFORMATION

Data for this report were derived from published sources, unpublished documents, and personal communications through an extensive network of public and private contacts. Public sources of information are listed in Appendices A - C. Attempts were made to collect information at offices of agencies known to either possess this type of information or those believed to have an interest in such information.

Principal agencies contacted include, but were not limited to the U.S. Bureau of Mines, the U.S. Geological Survey, the U.S. State Department, Central Intelligence Agency, Defense Intelligence Agency, the United Nations, the World Bank, World Resource Institute, and International Strategic Minerals Institute (ISMI). In addition, selected academic and industry contacts, explosives manufacturers and suppliers, and trade groups were contacted.

3.0 THE MINING INDUSTRY OF IRAN

While the oil and gas industry provided 76% of Iran's foreign exchange in 1994[1], its mining industry is significant. Iran reportedly produced over 40 different minerals[1]. The majority of the sites are small scale pits or quarries.

Mining was an expanding sector of the Iranian economy in 1994. The Government considers mining to be of high priority, and is in the process of implementing regulations that would ensure that the country would continue to develop its own

[1] U. S. Bureau of Mines. Minerals Yearbook 1994. Ch. on the Mineral Industry of Iran, by M. M. Heydari.

resources to meet domestic needs and to minimize mineral imports. The mining sector contributed more than 4% of the gross national product in 1994; the Government set a target to increase its contribution to 10% by 2000.

The Mining Act of 1983 and subsequent amendments regulate mineral ownership and production procedures. In Iran, the oil & gas and energy sectors are State owned, as well as the larger metal and non-metal mines. Recent provisions have relaxed private investment constraints and encouraged private ownership and development of smaller mines and sources of construction raw materials. As a result, many new mining developments are planned for Iran. Financing for such projects are provided both by the Government, through the Ministry of Mines and Metals (MMM), and private sources, both foreign and domestic. The Ministry has authority to issue 5-year mining and exploration permits at low royalty rates.

Since the 1600's, Iran has relied on domestic sources of raw materials (iron ore and coal) to support its domestic steel industry. It also is known to possess significant quantities of copper, lead/zinc and chromium ore. The Sar Cheshmeh deposit is a world class copper producer. Iran also is a producer of a variety of industrial minerals and construction materials. Significant resources of gypsum, manganese, celestite, magnesite, barite, bentonite and kaolin clays, and sodium sulfate are found in Iran. Salt, limestone, pumice, marble, and sand and gravel are also produced in Iran. Table 3.1 provides Iranian mineral production statistics for 1993 and 1994.

Iran has large areas where mineral exploration is limited. Until the 1970's, when foreign companies were first allowed to conduct exploration activities within Iran, little was known in the West about Iranian mineral resources, except for documented ancient mining areas along Persian trade routes. Since the 1970's, however, much exploration work has been done to develop such sites as Sar Cheshmeh, a world class copper mine.

Table 3.1--Estimated Mineral production in Iran, 1993 and 1994 (Metric tons)

Commodity (1)	1993 Production	1994 Production
METALS		
Aluminum, primary ingot	90,000	116,000
Bauxite ore, gross weight	100,000	100,000
Chromium concentrate, gross weight	130,000	129,000
Copper ore, gross weight	10,800,000	12,100,000
Gold ore, Au content (kg)	417	723
Iron ore, gross weight	9,870,000	8,690,000
Lead concentrate, gross weight	50,000	60,000
Manganese ore, gross weight	108,000	75,000
Molybdenum concentrate, gross weight	1,700	1,700
Silver ore, Ag content (kg)	60,000	60,000
Zinc concentrate, gross weight	180,000	220,000
INDUSTRIAL MINERALS		
Asbestos concentrate	90,000	80,000
Barite, crude	105,000	225,000
Cement, hydraulic	18,000,000	20,000,000
Clay, bauxite and refractory	220,000	220,000
Clay, bentonite	85,000	84,000
Clay, industrial	250,000	250,000
Clay, kaolin	452,000	450,000
Feldspar	25,000	30,000
Fluorspar	10,000	10,000
Gemstones, turquoise (kg)	5,000	5,000
Gypsum	8,600	8,430
Industrial sand & gravel	932,000	950,000
Lime	650,000	650,000
Magnesium, magnetite	40,000	65,000
Mica	8,000	8,000
Pumice and related volcanic materials	185,000	200,000
Salt	720,000	1,050,000
Stone	34,758	38,670
Strontium, celestite	20,000	20,000
Sulfate, alum	12,000	12,000
Sulfate, sodium	280,000	280,000
Sulfur	800,000	880,000
Talc	18,000	27,000

Source: U. S. Bureau of Mines. Minerals Yearbook, 1994.

(1) In addition to the commodities listed, small amounts of arsenic, boron, diatomite, perlite, and caustic soda are produced. Petroleum and mineral fuels are excluded from this table.

Summaries of mineral site data are provided in Appendices A-C. Data on producing or developing mineral deposits, past producing areas, and prospects and undeveloped mineral occurrences are provided in tabular form. Location maps for each of the above categories of mineral property are also provided in Appendix Maps A-C.

3.1 Chromium

Chromite was first discovered in Iran in 1940. Reported chromium reserves are estimated between 5-7 Mmt from ophiolites in central and southern Iran[2]. Mineral production is controlled primarily by the Faryab Mining and Chrome Smelting Co. (Faryab), a state-owned entity. Chromium ore feeds a ferrochromium smelter near Bandar Abbas, completed in 1994. Ferrochrome produced by Faryab primarily feeds domestic demand, with minor shipments to the Far East. The first shipment of Iranian high-carbon ferrochrome to Japan was scheduled for 1995.

Production occurs from both surface and underground operations. The largest producer of chromite is the Faryab operation near Bandar Abbas, which produces between 300,000-500,000 tpy of ore by both surface and underground methods. The Mir Mahmoud and Esfandaghheh mines produce in the 100,000-150,000 tpy range. The Chesmehbidouh mine is typical of a smaller chromite producer, recovering approximately 20,000 tpy of ore using underground methods. While the largest mines are highly mechanized, additional production comes from small mines utilizing older, less-mechanized technology. Blasting is carried out using conventional hand-held drills and charged with ammonium nitrate-fuel oil (ANFO) explosives. Blasts are small but often frequent.

3.2 Copper

Although copper was one of the earliest minerals recovered in Iran, little was known of Iranian copper mineral potential until recently. The discovery of the Sar Cheshmeh

[2] J. Amuzegar. Iran: An Economic Profile. The Middle East Institute, Washington, D. C., 1977, p. 8.

and other copper deposits during the early 1970's increased known Iranian copper reserves from approximately 6 million metric tons to over 1.6 billion metric tons[3]. Copper mineralization occurs as primary copper in Tertiary volcanics in central Iran and as polymetallic occurrences in northwestern and central Iran. The most important copper bearing area is the Kerman region. This region includes the Sar Cheshmeh deposit, the largest producing mine in Iran. The reported mine production rate is 14 million tpy of ore, recovering copper, gold, silver, and molybdenum from a resource that may exceed 1.2 billion metric tons.

In addition to the Sar Cheshmeh surface operation, the only other significant copper producer is the Qal'eh Zari underground mine in eastern Iran, although new mines are being developed at Meydouk (northwest of Sar Cheshmeh in Kerman province) and Sungun (northwestern iran). Production at these sites is expected to range from 1-5 million tpy. Over 330 copper occurrences are reported to have been identified in Iran.

The Sar Cheshmeh operation consists of a two eight-hour shift schedule mining 12.5m pit benches. Blasting occurs on a regular basis, generally on a 9.5m by 7.5m pattern. Estimated daily ANFO consumption ranges from 7-11 metric tons of ANFO equivalent, with an estimated maximum blasting event of up to 105 mt ANFO.

3.3 Gold

Gold production in Iran is not large, produced mainly as a byproduct of its copper operations. A number of small gold deposits occur in the vicinity of Mouteh, in central Iran. Production capacity of the region is approximately 500 tpd of ore, small on a world scale. Ore is currently mined by open pit methods, with a reported stripping ratio of 1:6 ore to waste[1]. Blasting is small scale, accomplished using

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[3] J. Amuzegan. Iran: An Economic Profile. The Middle East Institute, Washington, D. C., 1977, p. 8.

Europa Publications, Ltd. The Middle East and North Africa 1994. Fortieth Ed., p. 411.

conventional ANFO explosives. Iranian gold is processed domestically at two processing facilities at Sar Cheshmeh and Mouteh.

With an increasing interest in developing self sufficiency in raw materials, there is a corresponding interest in developing additional domestic gold resources. A number of projects have been proposed, and increased exploration work is planned. To date, however, it appears that future gold resource potential in Iran is not significant.

3.4 Iron

Iron ore exploration and production has increased in recent years in order to meet a fast growing domestic steel manufacturing industry, which has increased production of direct reduced iron by at least a factor of ten since 1990[1]. Iron ore production has increased by a factor of three for the period 1990-1994, and it is expected to rise even further as new mine production comes on line in the mid-1990s.

Iran has four main iron producing areas. The reported 2 billion metric tons of resources at these four sites are planned for development or expansion. Iran's largest producer at present is the Choghart mine in central Iran, which has a current output capacity of 4.5 million tpy of mill concentrate. The Gol-E-Gohar mine in southern Iran began operations in 1994 with an initial production capacity of 2.7 million tpy of concentrate, rising to 5 Mmt by 1997. Feasibility and pre-engineering studies are presently being carried out for a planned expansion at the Sangan iron mine near Afghanistan. Planned production is for 3.4 million tpy of concentrate from this site. The Chadormalou mine near Yazd is scheduled to come on line in 1998 with a initial production capacity of 5 million tpy of concentrate.

Iron ores in Iran occur in schists and gneisses covered by Tertiary sands of up to 100m in thickness. This Kiruna-type ore is generally mined by surface methods using 15m benches. Blasting of ore is likely to occur on a daily basis; blasting of overburden is normally not required, as the overburden is mainly unconsolidated sands. The larger operations have the potential for a maximum blasting event in the 84-326 metric ton of ANFO equivalent range, assuming blasting of both ore and overburden is required. This estimate would reflect an exceptional event; most blasts should be significantly smaller in scale.

All of Iran's iron mines feed steel plants at Mobarakeh and Ahwaz. Iran has a national objective of creating a larger domestic value-added steel industry and making this industry more competitive for export by developing its domestic iron ore industry[1]. The state-owned National Iranian Steel Company (NISCO), under the direction of MMM, owns and operates all major iron mines, concentrators, and steel plants.

3.5 Lead/zinc

Lead and zinc deposits have a wide regional distribution, but major mines are found primarily in northwestern and central Iran near the cities of Zanjan, Yazd, and Isfahan (Esfahan). The Angouran mine southwest of Zanjan is considered to be the largest lead/zinc mine in the Middle East. It is medium size on a world scale based upon its reported production capacity of 900 tpd of mill feed. Other significant Iranian lead/zinc deposits fall in the 75-540 tpd of feed. A large number of small underground lead and zinc mines have gone out of production in the last decade, as larger, more cost effective mines have begun production[4]. Many of these mines still contain ore and could resume mining if metals prices increased; such mines are often in close proximity and possess the capability to hide small scale blasting.

Lead/zinc ore is most often found associated with other sulfide minerals in sedimentary rocks. Mining is conducted using both surface and underground methods, depending upon ore depth and geology. Because lead/zinc mining in Iran has been conducted on a small scale for centuries, most older operations are being

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[4] Bassir, S. H. Role of Mining in the National Economy of Iran. Presentation at Unidentified Conference, 1989.

worked by underground methods such as cut & fill or sublevel caving; recent discovery areas are generally being worked by open pit methods. The amount of blasting that is required is variable. At the Angouran mine, the ore is relatively friable, so blasting is infrequent in spite of an overburden to ore ratio of 10:1. Where the ore occurs in more competent rock, regular and more frequent blasting is required.

With one exception, lead/zinc ore is processed at local concentrators, then the lead and zinc concentrates are exported. Principal export destinations are Russia, Germany, North Korea, and Japan. Lead concentrate from the Angouran mine is now sent to a new on-site lead smelter which came on stream in 1992.

3.6 Industrial minerals

Iran produces a wide variety of industrial minerals and materials. Products include cement, various industrial clays, construction and building stone, gypsum, salt, and phosphate. Iran is particularly well known for its turquoise, which has been mined on a small scale for centuries. One of the world's largest sources of strontium (the mineral celestite) is found in the northwestern part of the Dasht-e-Kavir salt desert, with proven reserves of 1.8 million metric tons of celestite. Iran is the world's third largest producer of gypsum, with extensive deposits in the Dasht-e-Kavir region. Iran's bauxite and refractory clays are important feed sources for Iran's growing ceramics industry. Iran also produces small quantities of asbestos, barite, boron, feldspar, fluorite, magnesite, mica, sodium compounds, and talc. Phosphate resources in Iran consist of low grade sedimentary ore averaging 10% P_2O_5.

Demand for cement increased after the Iran-Iraq war, for the purpose of reconstruction of industrial and transportation facilities and new projects. More than 20 plants were reported to be either under construction or planned for future construction[1]. Like other countries in the region, Iran possesses suitable limestone raw material for cement production at various locations close to major cities or potential sites of construction. Information is limited on specific sites, but most are believed to be small, with production capacities less that 2,500 tpd. Open pit mining techniques with limited blasting are employed.

Iran has extensive deposits of various types of dimension stone. In recent years, the Government has promoted expansion of this industry, in an attempt to earn export revenues for the country. Focus has been placed on the development of export markets for granite, marble, onyx, and travertine. Information is limited on specific sites. Conventional quarrying methods with limited blasting are used at larger operations; smaller operations are believed to employ non-mechanized methods which do not require blasting.

3.7 Coal

Coal deposits in Iran are located beneath a 3,600 square kilometer area covering the Kerman region and Elborz Mountains. Like iron mines, all mines are operated by NISCO and provide coking coal to steel plants at Mobarakeh and Ahwaz. NISCO's total production from these two regions in 1993 was 1.4 million metric tons[1]. In addition, there are about 15 other small coal mines, operated by co-operatives, in the Zagros Mountains, near Shahroud, and the Elburz Mountains northwest of Tehran. These small mines produce about 280,000 tpy of coking and heating coal for local demand. In 1994, domestic mines supplied about 65% of the coking coal requirements of the domestic steel industry, the remainder was imported[1].

Development of a large underground mine at Tabas is planned with a total capacity of 3.5 million tpy to supplement domestic production. Planned mining would consist of 3-5 longwalls, each capable of producing 2,500 tpd. Development of this operation, however, would necessitate construction of extensive infrastructure costing an estimated $400 million. Due to lack of sufficient foreign exchange, the Government has expressed concern about the project and is hesitant to proceed at this time.

Mining of coal is done by both surface and underground methods. Production techniques are not well known, but are assumed to be similar to those used by neighboring countries. Mechanized technology such as longwall methods do not require large quantities of blasting. A maximum blasting event is estimated to require less than 10 metric tons of ANFO equivalent.

3.7 Other minerals

Iran could benefit from additional mineral exploration. Occurrences of antimony, bauxite, borax, cobalt, magnesium, manganese, salt, sulfur, talc, tin, tungsten, turquoise, uranium, and various materials with industrial uses have been noted, but production is small. Of special note are uranium deposits near Saghand and bauxite deposits near Jajarm, both of which are planned for production to satisfy domestic needs.

4.0 MINE-RELATED EXPLOSIVES USE

Almost all mines use explosives to fragment or loosen rock and consolidated material prior to excavation. Bulk or packaged explosives and blasting agents are detonated after emplacement in material to be excavated. Minor quantities of sachet and shaped charges may be used for secondary breakage and other special applications.

The type and amount of explosives used are influenced by the nature of the rock or ore, the mining methods employed, the production rate of the mine, the type and availability of explosives and detonation systems, hydrologic conditions, mining equipment, drilling equipment, mine geometry, level of technical expertise, and external constraints such as the proximity of residences, availability of explosives, and available funding. At almost any mine, the size of each blast can vary significantly due to local conditions, production schedules, weather, etc.

Surface mines typically shoot much larger blasts than underground operations and tend to have higher production rates than underground mines. In addition, limitations of working room, limited free faces, ventilation requirements, and drilling limitations may constrain maximum blast sizes in underground mines.

While there are presently no United Nations economic sanctions imposed on Iran, the United States maintains sanctions on the exportation of any goods or services to Iran[5]. As a result, Iran is prohibited by U.S. law from receiving any U. S. mining equipment or explosive materials. There are reports that Iran has been able to receive such supplies from Europe and Japan. In addition, Iran has been able to acquire substantial quantities of needed supplies and explosive materials from Dubai. Iran has the military-related technology and facilities to manufacture blasting agents and detonation systems suitable for most mining applications[6]. Consequently, these restrictions do not appear to represent a major impediment to Iran's mining sector.

Most Iranian mines use ammonium nitrate-fuel oil (ANFO) blasting agents. This includes some of the newer emulsion and/or aluminum boosted products presently available. ANFO systems are preferred in most mining applications due to their ease of manufacture, low cost, inherent safety, and bulk loading advantages. High explosives, however, would be preferable for small underground operations that use drill sizes that are below the critical diameter needed for emplacing ANFO blasting agents, under wet conditions, in methane-rich atmospheres, and conditions that require higher detonation velocities and/or convenience of packaged explosives.

Blasting assumptions used in this report are based upon engineering judgment; explosive use can vary considerably as mining conditions change. ANFO consumption was assumed to be dependent upon mine production rate, average stripping ratio, specific gravity of the host rock, assumed powder factor limits, and

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[5] M. M. Heydari, U.S. Bureau of Mines, personnel communication, 7/10/95.

U.S. Department of the Treasury, Office of Foreign Assets Control, press release, 6/29/95.

[6] M. M. Heydari, U. S. Bureau of Mines, personnel communication, 7/13/95.

mining method. In most cases, site-specific blasting information was unavailable. Consequently, estimates were based upon known or estimated production rates, mine geology, mining systems, and typical mining practices. Experience, engineering judgement, and available data were incorporated into calculations and estimates.

For each site, a stripping ratio (Quantity of overburden removed per mt of ore mined) and powder factor (Quantity of rock blasted per unit of ANFO blasting agent equivalent) limits were estimated. A range of ANFO consumption was calculated for both daily blasting requirements and for an assumed maximum blasting event. With the exception of Sar Cheshmeh, where mining is reported to occur on a 350 day/year basis, daily ANFO requirements were estimated assuming a 215 day production schedule. Consumption estimates for all sites were calculated in a similar manner. The lower consumption value applies a minimum powder factor while the higher value assumes a maximum powder factor. Unlike daily consumption estimates, a maximum blasting event would not take place on a daily basis. For this study, it was assumed that a maximum blasting event could occur every 10 working days for a surface mine and every 5 working days for an underground mine. Such events are designed to account for such factors as blasting delays, geological irregularities, and mining method variations that require a higher ANFO consumption than the typical blasting event. Mine development or pillar extraction conditions, for example, often require larger blasts.

The following examples illustrate typical blasting calculations using the estimation procedure described above:

<u>Sar Cheshmeh daily ANFO consumption lower limit (L):</u>

L = Production rate * [1 + (stripping ratio * specific gravity of ore + waste)] * [Low powder factor / 1000 (converts kg to mt)] / 350 (assumed operating days per year for this site)

L = 14,000,000 * [1 + (0.22 * 2.45)] * [0.12 / 1000] / 350

L = 7.39   7 mt ANFO equivalent (Rounded to nearest unit)

Sar Cheshmeh daily ANFO consumption higher limit (H):

H = Production rate * [1 + (stripping ratio * specific gravity of ore + waste)] * [High powder factor / 1000 (converts kg to mt)] / 350 (assumed operating days per year)

L = 14,000,000 * [1 + (0.22 * 2.45)] * [0.17 / 1000] / 350

L = 10.54   11 mt ANFO equivalent (Rounded to nearest unit)

Sar Cheshmeh maximum blasting event ANFO consumption (M):

M = Production rate * [1 + (stripping ratio * specific gravity of ore + waste)] * [High powder factor / 1000 (converts kg to mt)] / 350 (assumed operating days per year) * maximum blast cycle time (working days between blasting events)

M = [14,000,000 * [1 + (0.22 * 2.45)] * [0.17 / 1000] / 350] * 10

M = 105.40   105 mt ANFO equivalent (Rounded to nearest unit)

Table 4.1 provides the corresponding blasting range estimates for principal Iranian mines identified in this study. Figure 4.1 shows site locations for the mines reported in table 4.1. Symbols reflect mine type (surface or underground) and maximum ANFO consumption for a given blasting event.

Table 4.1--Estimated Explosives Usage at the Main Iranian Mines Used in this Study in Order of Estimated ANFO Consumption

Mine	Latitude	Longitude	Primary Product	Mine Type (1)	Production (Mmt/yr) (2)	Daily Consumption (mt ANFO) (3),(4) Low	High	Maximum Blast Cycle Time (days) (5)	Maximum Blasting Event (mt ANFO)
Chadormalou(6)	N 32° 18'	E 55° 28'	Iron	S	5.000	24	33	10	326
Gol-e-Gohar	N 29° 08'	E 55° 21'	Iron	S	2.700	20	27	10	269
Meydouk(6)	N 30° 22'	E 55° 28'	Copper	S	5.000	10	14	10	138
Sangan	N 34° 23'	E 60° 15'	Iron	S	3.400	8	11	10	111
Sar Cheshmeh	N 29° 57'	E 55° 54'	Copper	S	14.000	7	11	10	105
Choghart	N 31° 42'	E 55° 28'	Iron	S	4.500	6	8	10	84
Sungun(6)	N 38° 41'	E 46° 43'	Copper	S	1.000	6	7	10	69
Faryab	N 27° 32'	E 57° 19'	Chromium	S	0.500	2	3	10	32
Mehdiabad(7)	N 31° 45'	E 55° 48'	Zinc/Lead	S	0.540	2	3	10	30
Semnan Gatchs	N 35° 27'	E 53° 30'	Gypsum	S	3.000	0.8	1.5	10	15
Neiriz	N 35° 45'	E 51° 05'	Stone	S	3.000	0.1	1.4	10	14
Emarat	N 33° 51'	E 49° 43'	Lead/Zinc	S	0.300	0.8	1.2	10	12
Angouran	N 36° 39'	E 47° 20'	Lead/Zinc	S	0.900	0.7	1.1	10	11
Ravanj(7)	N 34° 10'	E 50° 45'	Lead/Barite	UG/S	0.620	1.0	1.0	NAp	10
Irankouh(7)	N 32° 30'	E 51° 10'	Lead/Zinc	UG	0.540	1.0	1.8	5	9
Tabas(6)	N 33° 36'	E 56° 55'	Coal	UG	3.500	0.9	1.7	5	9
Yazd area	N 31° 53'	E 54° 22'	Limestone	S	0.800	0.4	0.7	10	7
Mashad area	N 36° 18'	E 59° 36'	Limestone	S	0.600	0.3	0.6	10	6
Mir Mahmoud(7)	N 36° 32'	E 55° 12'	Chromium	S/UG	0.150	0.0	1.0	NAp	6
Mouteh	N 33° 41'	E 50° 42'	Gold	S	0.110	0.3	0.5	10	5
Hamadan area	N 34° 48'	E 48° 30'	Limestone	S	0.500	0.3	0.5	10	5
Bijar	N 35° 52'	E 47° 36'	Limestone	S	0.500	0.3	0.5	10	5
QalehZari	N 31° 50'	E 59° 00'	Copper	UG	0.500	0.4	0.5	5	3
Koushk	N 31° 45'	E 55° 46'	Lead/Zinc	UG	0.450	0.2	0.3	5	2
Ahangaran(7)	N 34° 22'	E 49° 15	Lead/Zinc	S/UG	0.075	0.03	0.05	NAp	2
Pabedana	N 31° 11'	E 56° 29'	Coal	UG	0.500	0.13	0.24	5	1
Babnizou	N 30° 18'	E 57° 05'	Coal	UG	0.500	0.13	0.24	5	1
Chesmehbidou	N 29° 50'	E 53° 50'	Chromium	UG	0.020	0.01	0.02	5	1
Esfandagheh	N 28° 38'	E 57° 12'	Chromium	UG	0.100	0.07	0.09	5	1
Elborz area	N 36° 05'	E 53° 55'	Coal	UG	0.400	0.10	0.20	5	1
Dasht-e-Kavir	N 35° 00'	E 54° 10'	Celestite	S	0.020	0.01	0.02	10	1
Nakhlak	N 33° 34'	E 53° 49'	Lead	UG	0.065	0.03	0.04	5	1

NAp Not applicable as site uses both surface and underground methods. A weighted averaged maximum blast cycle is used for calculations.
(1) S--Surface; UG--Underground
(2) Mmt/yr--Million metric tons per year
(3) mt ANFO--Metric tons of Ammonium Nitrate/Fuel Oil blasting agent equivalent. Estimate based on equations reported on pages 14,15.
(4) Assumed production schedule for all sites is 215 days/yr except for Sar Cheshmeh.
(5) Assumed maximum blasting cycle time for surface operation - 10 working days; underground operation - 5 working days.
(6) Site is currently being developed for production.
(7) Site uses both surface and underground methods. Weighted averages used for calculation purposes.

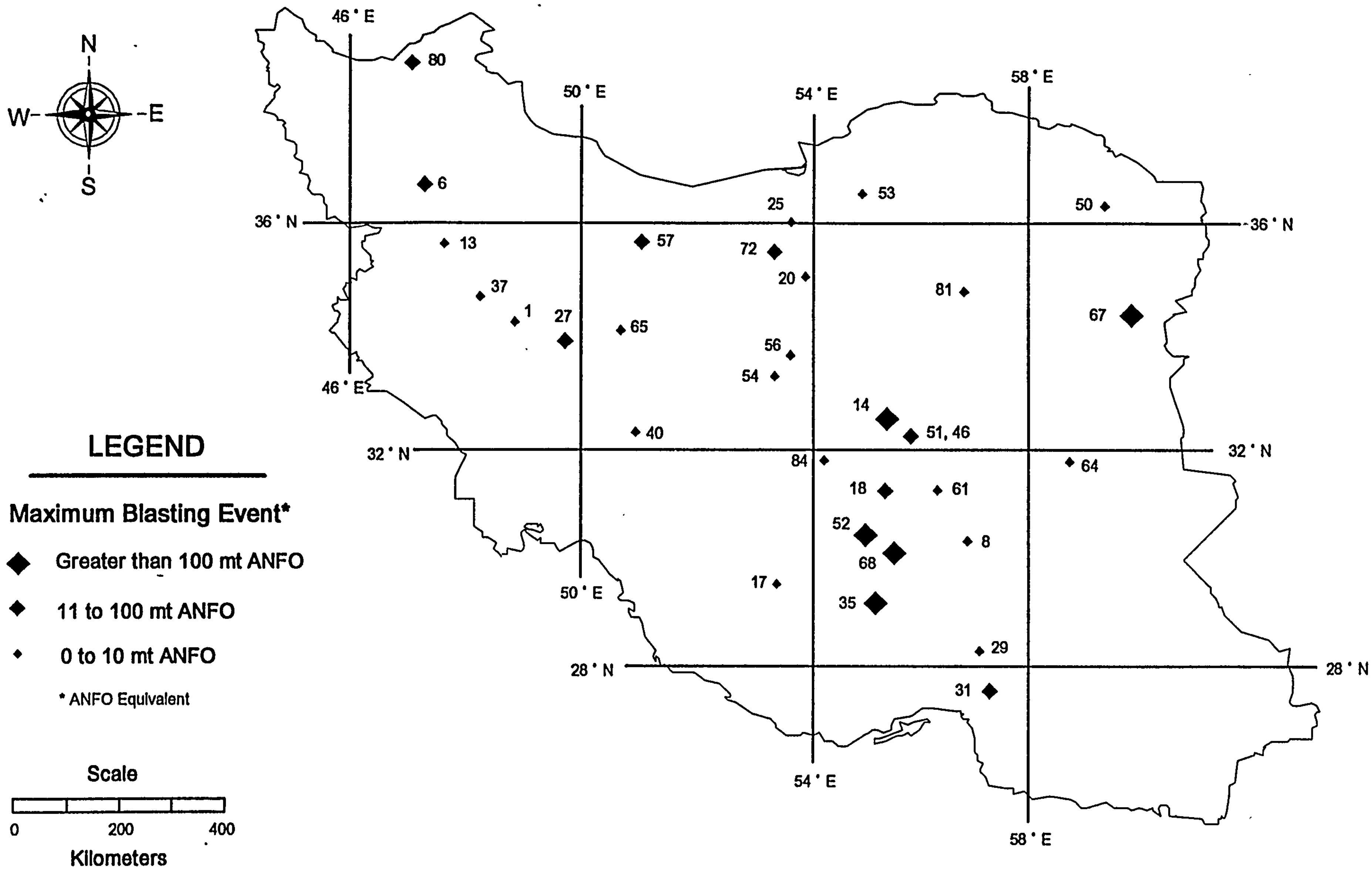

Figure 4.1 -- Estimated explosives usage at the main Iranian mines used in this study in order of estimated ANFO consumption

5.0 CONCLUSIONS

The production of minerals in Iran is an important, expanding industry. While mining occurs throughout Iran, major producing regions appear to be concentrated in the mountainous regions of northern Iran near Tehran and central Iran between Qom and Kerman. The greatest amount of blasting occurs in the Kerman region of south-central Iran.

Underground mining is limited to small coal and base metal deposits with an individual maximum blasting event potential of less than 10 metric tons of ANFO equivalent. While individual mine blasting potential is small, there are areas where old underground workings are numerous and could support a nuclear test of moderate size. The lead/zinc mining area near Bafq is one such area. Mine workings in this area are generally accessed by adits and shafts rarely exceeding 100m, indicating a relatively shallow ore depth. Blasting detected below such a depth are probably not related to legitimate mining operations.

Surface mining and quarrying operations generally occur on a larger scale, but only a few sites possess the capacity to produce regularly scheduled blasts in the 100-300 metric ton (ANFO equivalent) range. Quarrying operations rarely require extensive blasting. The largest blasts are associated with open pit iron mines and copper operations at Sar Cheshmeh and Meydouk (developing). Because overburden at some sites consists of unconsolidated material, large scale blasting is generally not required. A blast in the 100-300 metric ton ANFO equivilent range is thought to be an exceptional event. Regular blasts in this range should be viewed with caution.

APPENDIX

APPENDIX A: PRODUCING AND DEVELOPING MINERAL PROPERTIES IN IRAN

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
	1 Ahangaran	N 34° 22'	E 49° 15'	Lead Zinc	1,26,30,31,57	General	Producer	Surf./UG	Concentrate exported	Capacity 5kt Pb. Expansion to 10kt Pb planned. Host rock ls, ss, sh.
B	2 Allah	N 36° 03'	E 53° 53'	Iron	31	General	Producer	Unknown	Unknown	Prod. in 1984; Current status uncertain. Probable res. in 1984 100,000 mt @ 50% hematite/magnetite.
	3 Amirieh Amerieh Zereski	N 33° 32'	E 50° 07'	Lead Zinc	1,30,31	General	Producer	Unknown	Unknown	--
	4 Anarak Naklak	N 33° 33'	E 53° 45'	Lead Zinc	1,24	General	Producer	Underground	Unknown	Prod. est. at 100,000 tpy.
	5 Anarek district	N 33° 19'	E 53° 43'	Ni,Co,Cu,Pb,S, Asbestos, Mn	38,46	General	Producer	Surf/UG	Unknown	Late 1800s. Includes Talmessee,Meskoni deposits.
	6 Angouran Anguran Angooran	N 36° 39'	E 47° 20'	Lead Zinc	1,11,13,22,24,27,30, 31,35,49,56,57,58	Confirmed	Producer	S/UG	Exported to Russia, Europe, N. Korea, Angouran smelter	1990 prod: 11kt Pb, 35kt Zn. 1992 exp. to 17kt Pb, 59kt Zn. Considered to be largest Pb/Zn mine in Middle East. Prod: 0.5-0.9 Mmt ore. Res: 22Mmt. Host rocks: decomposed Ls. Severe weather impacts prod. Ore friable, blasting minimal. Smelter on-line 1992. Prod: OP-2kt ore, 20kt waste/day. UG-2kt ore per day using blasthole drills.
	7 Ardakan	N 32° 19'	E 54° 13'	Lead Zinc	1	General	Producer	Underground	Unknown	--
C	8 Babnizou Babenizu	N 30° 18'	E 57° 05'	Coal	9,57	General	Producer	Underground	Domestic	Location near Kerman. Part of Kerman district.
C	9 Badamu	N 30° 36'	E 56° 30'	Coal	27	General	Producer	Unknown	Unknown	Res(1974) 51Mmt.

(1) Represents property or property grouping as defined on Appendix Maps A-C.
(2) Complete list of data sources found at end of appendix.
(3) General -- denotes limited data; Confirmed -- denotes deposit information confirmed by several sources.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C	10	Bafq District Koushk Zardu Pahna Kuoshke	N 31° 45'	E 55° 47'	Lead Zinc	1,10,20,22,24,26,27, 30,31,35,49,56,57	Confirmed	Producer	Underground	Domestic	Also known as Koushk mine. Bafq comprised of 3 orebodies, Koushk, Zardu, & Pahnu. Some Fe is present. Largest area Pb/Zn deposit. Fine grained stratiform beds of sulfides. Mill processes 400 tpd. Conc. grade 20% Pb/Zn. Prod: 0.3-0.5Mmt ore, to prod 6.5kt Pb; 30kt Zn conc.
	11	Bandan	N 34° 00'	E 56° 00'	Asbestos	10	General	Producer	Unknown	Unknown	Specific location unknown.
C	12	Bidkhun	N 30° 45'	E 56° 53'	Coal	Unpublished	General	Producer	Unknown	Unknown	--
	13	Bijar	N 35° 52'	E 47° 36'	Cement	31	General	Producer	Surface	Domestic	Prod: 2300 tpd.
C	14	Chadormalou Chandor-Malu Chadormaloo Tschador-Malu Tchadormalou	N 32° 18'	E 55° 28'	Iron	1,7,10,11,27,31, 44,57	Confirmed	Developing	Surface	Mobarakeh	Planned startup in 1998 @ 5Mmt conc. per yr. Res: 400Mmt @ 67% Fe.
C	15	Chahar Gombad	N 29° 34'	E 56° 11'	Copper	1,13,27	General	Producer	Underground	Domestic	1973 Res: 3Mmt @ 1.7% Cu.
	16	Chah Hezar	N 28° 40'	E 58° 20'	Iron	31	General	Producer	Surface	Domestic	Producer in 1990.
	17	Chesmehbidouh Kbajeh Jamaly	N 29° 50'	E 53° 50'	Chromium	1,24,31,56	Confirmed	Producer	Underground	Unknown	20,000 tpy ore. Cap: (1990) 6,000 tpy chromite.
C	18	Choghart Tchogart Mount Chogart Tchogart Ma'dan-e Choghart Tschogart Bafq district	N 31° 42'	E 55° 28'	Iron Manganese	1,7,27,28,31,34, 39,45,56,57	Confirmed	Producer	Surface	To Isfahan Mobarakeh	Operating in 1994. Largest Iranian Fe producer in 1994. Prod: 4.2Mmt Fe ore + 1.5Mmt conc (66% Fe). Choghart and adjacent Se-Chahun mine have +300Mmt combined reserves with output of approx. 4.5Mt/a lumpy ore. Res: (1993) 200mmt @ 56-60% iron. 540km rail to steel plt.
	19	Damanjala	N 35° 22'	E 56° 24'	Copper	46	General	Producer	Surf/Underground	Domestic	Small producer in 1960s.
	20	Dasht-e-Kavir	N 35° 00'	E 54° 10'	Strontium	31	General	Producer	Surface	Exported.	Location approximate.
C	21	Deh-E-Shotoran	N 29° 28'	E 55° 44'	Boron	1	General	Producer	Unknown	Domestic	Prod. 100 mt in 1943. Current prod. uncertain.

(1) Represents property or property grouping as defined on Appendix Maps A-C.
(2) Complete list of data sources found at end of appendix.
(3) General -- denotes limited data; Confirmed -- denotes deposit information confirmed by several sources.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C	22	Deh Poshten	N 30° 46'	E 57° 00'	Coal	Unpublished	General	Producer	Unknown	Unknown	--
B	23	Domghan-Sharud	N 36° 24'	E 54° 45'	Coal	27	General	Producer	Surface	Unknown	Status uncertain.
A	24	Duna Douna	N 36° 10'	E 51° 19'	Lead Zinc	1,56,57	General	Producer	Underground	Concentrate exported	--
B	25	Elborz	N 36° 05'	E 53° 55'	Coal	1,10,34,57	General	Producer	Underground	Unknown	Prod (2 mines): 400,000 tpy. Medium quality coking coal. Elborz & Kerman prod. 1.4Mmt in 1993, equiv. to 725,000 t washed coal.
B	26	Elburz Mountains Alborz Reshteh-ye Kuhha-ye	N 36° 00'	E 53° 00'	Coal Iron	38	General	Producer	Underground	Unknown	Late 1800s.
	27	Emarat	N 33° 51'	E 49° 43'	Lead Zinc	1,26,31,57	General	Producer	Surface	Concentrate exported	1992: Expanded to 3.2kt Pb, 12kt Zn. 1992 prod: 1.2kt Pb, 6kt Zn.
	28	Esfordi	N 31° 48'	E 54° 30'	Apatite	57	General	Producer	Surface	Domestic	Location approximate.
	29	Esfandagheh Abdasht	N 28° 38'	E 57° 12'	Chromium	1,11,27,36	General	Producer	Underground	Unknown	Prod: 100,000 tpy ore. Res: 5Mmt ore. Esfandagheh & Faryab produce 100,000 t/y lumpy ore grading 48-50% Cr2O3. Chromite cap. (1990) 25,000 tpy. Res: 5Mmt ore.
C	30	Eshkil	N 30° 50'	E 56° 59'	Coal	Unpublished	General	Producer	Unknown	Unknown	3 mining areas.
	31	Faryab Haryab Shahriar Amir Shahin Cargah Sohrab	N 27° 32'	E 57° 19'	Chromium	1,11,24,31,36	General	Producer	Surface	Unknown	300,000-500,000 tpy ore. 85% of Iranian production. Esfandagheh & Faryab prod. 100,000 t/y lumpy ore grading 48-50% Cr2O3. Chrome cap. (1990) 40,000 tpy Res: 5Mmt.
	32	Galt and Saloor	N 36° 13'	E 57° 38'	Chromium	1	General	Producer	Unknown	Unknown	--
A	33	Qachsar	N 36° 12'	E 50° 45'	Coal	27	General	Producer	Surface	Unknown	Status uncertain.
C	34	Gasdaru	N 30° 10'	E 56° 30'	Iron	31	General	Producer	Unknown	Domestic	Producer in 1984. Res: (1984) 500,000 mt @ 40-50% ilmenite/magnetite.

(1) Represents property or property grouping as defined on Appendix Maps A-C.
(2) Complete list of data sources found at end of appendix.
(3) General -- denotes limited data; Confirmed -- denotes deposit information confirmed by several sources.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C	35	Gol-E-Gohar Gor-el-Gohar Goli Gohar Gol-Gohar Golgohar Gole-Gohar	N 29° 08'	E 55° 21'	Iron	1,10,19,31,34, 36,45,57	Confirmed	Producer	Surf./UG	Mobarakeh	320km rail to steel plt. Res: (1994) 180Mmt @ 60% Fe. Prod. began Mar. 1994. Host rock: Schists & gneisses Overburden 100m of sand. Prod: 25Mmt ore yields 2.5Mmt conc. rising to 5Mmt/a in 1997. Conc. railed 1,000km to plant.
B	36	Gorgan	N 36° 42'	E 54° 15'	Coal	27	General	Producer	Surface	Unknown	Status uncertain.
	37	Hamadan area	N 34° 48'	E 48° 30'	Cement	31	General	Producer	Surface	Domestic	Prod: 2300 tpd.
C	38	Hodjedk	N 31° 06'	E 57° 00'	Coal	27	General	Producer	Unknown	Unknown	Res(1974) 48.5Mmt.
	39	Hormoz	N 27° 04'	E 56° 28'	Iron	28	General	Producer	Surface	Exported	Ochre Fe content of 25-45%.
	40	Irankouh Irankuh	N 32° 30'	E 51° 10'	Lead Zinc	1,11,24,26,31	General	Producer	Surf./UG	Concentrate exported	Prod: 0.5-1.0Mmt ore. Conc prod. 5kt Pb, 25kt Zn.
	41	Jajarm	N 36° 58'	E 56° 27'	Bauxite	13,57	General	Developing	Surface	Domestic refinery	1994 Res: 19Mmt @ 41-69% Al2O3. 100kmt stocked in 1994.
A	42	Karaj	N 35° 41'	E 50° 30'	Coal	27	General	Producer	Surface	Unknown	Status uncertain.
C	43	Kerman	N 30° 15'	E 57° 10'	Coal	1,57	General	Producer	Surf./UG	Domestic	Prod: 1.4M tpy. Elborz & Kerman prod. 1.4Mmt in 1993, equiv. to 725,000 t washed coal.
	44	Khvaf	N 34° 34'	E 60° 08'	Iron	Unpublished	General	Producer	Unknown	Unknown	--
	45	Khorassan district Korasan	N 36° 13'	E 57° 38'	Chromium	36	General	Producer	Unknown	Unknown	--
C	46	Koushk Kuoshke Kuchke Kushk	N 31° 45'	E 55° 46'	Lead Zinc	1,10,19,20,22,24, 26,27,30,31,56,57	Confirmed	Producer	Underground	Concentrate exported	Also part of Bafq district. Bafq comprised of 3 orebodies, Koushk, Zardu, & Pahnu. Res(1974): 3Mmt @ 21% Zn Smelter planned. Prod: 650 tpd ore. Mined by UG using longhole blasting.
	47	Kuh Sorkh	N 27° 35'	E 57° 35'	Chromium	31,56	General	Producer	Unknown	Unknown	Chrome cap. (1990) 5,000 tpy.
C	48	Mansurabad	N 31° 18'	E 56° 01'	Lead Zinc	10	General	Producer	Unknown	Domestic	--

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MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
	49 Maragah	N 37° 36'	E 46° 00'	Coal	27	General	Producer	Surface	Unknown	Status uncertain.
	50 Mashad area	N 36° 18'	E 59° 36'	Cement	31	General	Producer	Surface	Domestic	Location est. as town center. Prod: 2400 tpd.
C	51 Mehdiabad Calamine	N 31° 45'	E 55° 48'	Zinc Lead Copper Silver	1,24,26,27,30, 41,46,56,58	General	Developing(4)	Surf./UG	Domestic	Future mining of low grade ore by open pit or selected underground mining. Mining stopped in 1959. Mining rate 12-15 kmt/yr. Res:(1974) 24Mmt @ 2.9%Pb, 6.1% Zn, 10% Cu. New mine planned 5kt,25kt Pb/Zn in mid 1990s.
C	52 Meydouk Meyduk Meiduk Meduk	N 30° 22'	E 55° 28'	Copper Gold	1,11,25,27,31,36, 46,57	General	Developing	Surface	Domestic Foreign	Cap: 3-5Mmt ore. Res. 50-125Mmt, 1.1% Cu, Dev. work started in 1993. Cap. cost $300M mine & conc.
B	53 Mir Mahmoud	N 36° 32'	E 55° 12'	Chromium	24,31	General	Producer	Surf./UG	Unknown	Chromite cap. (1990) 10,000 tpy. Prod: 150,000 tpy ore. Grade: 48% Cr2O3 2.63-3.15 Cr/Fe.
	54 Mouteh Muteh Muteh district	N 33° 41'	E 50° 42'	Gold	1,4,11,36,57	General	Producer	Surf./UG	Domestic	Prod: 100,000 tpy ore Cap.to prod. 500kg/y Au. Prod. 417 kg Au in 93. Res(1993):5.1Mmt @ 3-4g/t Au. Production began Feb. 1993. Sites include Chah Bagh, Chah Khatur, Dastar Cheshmeh, Chahar-khaton, and Seniedeh. Chahar-khaton largest deposit w/ 50% of area resource. Res. of 5.1Mmt @ 4g/mtAu for area. Min. & proc. cost est. $32/t ore. Current mining open pit. Strip ratio: 1:6 ore:waste.
	55 Nakhjir	N 34° 32'	E 52° 35'	Strontium	1	General	Producer	Surface	Russia Japan	Bedded celestite ave. 3m thick. Res: 500 st @ 91% SrSO4.
	56 Nakhlak Naklak	N 33° 34'	E 53° 49'	Lead Silver Zinc	11,27,30,31,56,57	General	Producer	Underground	Concentrate exported	Host rock: Ls Stope width range from 1.5-7m. Cut & fill used in 1965. Cap. 300 tpd ore; 20 tpd conc. Res(1974)100kmt @10-15% Pb.
A	57 Neiriz	N 35° 45'	E 51° 05'	Stone	1	General	Producer	Surface	Domestic	Prod: 1-3Mmt.

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(4) Site was a producer until 1959. It is currently being re-developed for operation in mid-1990s.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
	58	Neyzar	N 35° 55'	E 58° 36'	Iron	31,56	General	Producer	Surface	Unknown	Producer in 1984. Res: (1984) 300,000 mt @ 50% hematite.
	59	Niaeband	N 32° 32'	E 58° 02'	Lead Zinc	30	General	Producer	Underground	Unknown	Shrinkage stoping used in 1960. Current status uncertain. Host rock: rhyolite/andesite.
	60	Niasar Niassar Kashan	N 34° 04'	E 51° 10'	Iron Copper	1,13,28,56	General	Producer	Unknown	Unknown	Producer in 1984. Res: (1984) 250,000 mt @ 45-56% hematite/magnetite.
C	61	Pabedana	N 31° 11'	E 56° 29'	Coal	57	General	Producer	Underground	Domestic	Area mines supplied 65% of domestic needs in 1994.
C	62	Pahnu	N 31° 45'	E 55° 47'	Lead Zinc	20	General	Producer	Unknown	Unknown	Bafq comprised of 3 orebodies, Koushk, Zardu, & Pahnu.
	63	Qoen	N 33° 44'	E 59° 11'	Cement	31	General	Producer	Surface	Domestic	Location est. as town center.
	64	Qal'eh Zari Ghaleh Zari Birjand	N 31° 50'	E 59° 00'	Copper Gold	1,11,25,27,31, 56,57	General	Producer	Underground	Sar Chesmeh	Res: (1993) 1.8 Mmt sulfide ore 2-4% Cu,2-3g/mt Au 15-20g/mt Ag. Prod: 30 tpd conc. trucked to Sar Chesmeh. Host rock: tuff and lavas. 1991 prod: 5,301mt Cu conc. conc. 23% Cu, 600g/t Ag, and 25g/t Au. Res (1995): 1.5Mmt @ 3.2% Cu. Cap (1995): 7,000 tpy Cu conc.
	65	Ravanj Ravange	N 34° 10'	E 50° 45'	Lead Barite	1,26,27,30,31, 49,56,57	General	Producer	Surf./UG	Concentrate exported	Prod: 200 tpd ore to mill. Conc. prod. 4.5kt Pb. Ore lenses in ls. Res:(1974) 950kmt @ 6% Pb. UG mine uses sublevel caving. Prod: UG-240 tpd Ba,300 tpd Pb. OP-300 tpd ore,1900 tpd waste.
A	66	Rudbar Gasran	N 35° 36'	E 51° 23'	Coal	27	General	Producer	Surface	Unknown	Status uncertain.
	67	Sangan	N 34° 23'	E 60° 15'	Iron	1,7,31,56,57	General	Producer	Surface	Mobarakeh Ahwaz	Opened 1993. Res: (1992) 160Mmt @ 49% magnetite. Prod: 3.4M tpy ore. Sedimentary host rocks.

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MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
C	68	Sar Cheshmeh Sar Chesmeh Sarcheshmeh Sar-Cheshmeh	N 29° 57'	E 55° 54'	Copper Silver Gold Molybdenum	1,19,22,24,25,27, 31,34,36,46, 52,56,57	Confirmed	Producer	Surface	1/2 exported	Prod: 14Mmt ore. Plans for expansion announced. Cap: 140,000 tpy Cu (1994). 1993 output near 110,000 mt. 1/2 output for export. Prod: 60,000 tpy Cu;9,000 kg Ag; 2,800 kg Au, 600mt Mo Res: 115Mmt @ 1.2% Cu. Host rock: andesite , Schedule: 2 sh/d; 8 hr/sh. Blast pattern: 9.5m x 7.5m. Exp. to be financed by exports to China.
	69	Saroor Forumad	N 35° 46'	E 59° 36'	Chromium	31	General	Producer	Unknown	Domestic	Chromite cap. (1990) 6,000 tpy.
C	70	Se-Chahun	N 31° 23'	E 56° 28'	Iron	57	General	Producer	Surface	Mobarakeh To Isfahan	Similar mining as Chogart. Conc. sent to local plant. Choghart and adjacent Se-Chahun mine have +300Mmt combined reserves with output of approx. 4.5Mt/a lumpy ore.
B	71	Semnan	N 35° 33'	E 53° 24'	Cement	31	General	Producer	Surface	Domestic	Location est. as town center.
B	72	Semnan Gatchs Semnan, region	N 35° 27'	E 53° 30'	Gypsum	1,36	General	Producer	Surface	Unknown	Prod: 1-3M tpy ore. World's 3rd largest gypsum producer.
	73	Shah Kuh	N 32° 30'	E 51° 35'	Zinc Lead	1,13,27,30,56	General	Producer	Surf./UG	Smelted in Europe, Russia.	Host rock: Ls Open cut/modified room & pillar. Res(1974) 4.5Mmt @ 20% Zn, 3% Pb.
	74	Shah-Ali Baglu	N 37° 16'	E 48° 17'	Lead Zinc	1,30,56	General	Producer	Underground	Unknown	Developing in 1965.
	75	Shahroud	N 33° 05'	E 49° 11'	Cement	31	General	Producer	Surface	Domestic	Location est. as town center.
B	76	Shahrud Froumud	N 36° 23'	E 54° 50'	Chromium	24,31	General	Producer	Underground	Unknown	Chromite cap. (1990) 2,000 tpy.
	77	Shamsabad	N 33° 54'	E 49° 46'	Iron Lead Zinc Copper	1,27,28,31,34, 45,56	General	Producer	Unknown	Unknown	Res. in 1984 48Mmt @ 40-50% ilmenite/magnetite. Formed by replacement of ls.
	78	Shiekhab	N 35° 00'	E 53° 00'	Iron	31	General	Producer	Unknown	Unknown	Producer in 1984. Prob. res. in 1984 500,000 mt @ 45-55% hematite/magnetite. Current status uncertain.

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MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
79	Semirom (Simirum)	N 31° 25'	E 51° 34'	Clay Kaolin	13,27	General	Producer	Surface	Domestic	Refractory clays 1973 Prod. 350 tpy.
80	Sungun Songoon Sangun	N 38° 41'	E 46° 43'	Copper Molybdenum Gold	1,11,27,31,46, 56,57	General	Developing	Surface	Export	Receiving foreign investment. Cu porphyry. Res. +100Mmt at 1% Cu Avg. 0.7% Cu; hi grade 1.5% Cu.
81	Tabas	N 33° 36'	E 56° 55'	Coal	1,57	General	Developing	Underground	To feed Mobarakeh plt	Prod: 3.5M tpy. Res: 525Mmt. Current design-3 longwalls @ 2,500mt/d with expansion to 5 longwalls. Total cost est. at $400M. Ext. infrastructure required.
82	Taknar I and II	N 35° 19'	E 57° 48'	Copper Lead, Zinc	27,46	General	Producer	Underground	Unknown	Res(1974) 50kt @ 2% Cu.
83	Torbat-Jam	N 35° 32'	E 60° 56'	Coal	27	General	Producer	Surface	Domestic	10kmt per year.
84	Yazd	N 31° 53'	E 54° 22'	Cement	31	General	Developing	Surface	Domestic	Startup planned for 1995. Prod: 3600 tpd. Location est. is town center.
85	Zanjan	N 36° 36'	E 48° 30'	Coal	27	General	Producer	Surface	Unknown	Status uncertain.
C 86	Zardu	N 31° 45'	E 55° 47'	Lead Zinc	20	General	Producer	Unknown	Unknown	Bafq comprised of 3 orebodies, Koushk, Zardu, & Pahnu.
87	Zehabad Zahbad	N 36° 22'	E 49° 32'	Lead Zinc Copper	1,13,27,30,56	General	Producer	Underground	Domestic	1973 prod. 100 tpd. Cut & fill used in 1965. Host rock: rhyolite Res(1974) 140kmt @ 10% Zn, 5% Pb, 0.3% Cu.
B 88	Zirab	N 36° 24'	E 52° 53'	Coal	27	General	Producer	Surface	Unknown	Status uncertain.

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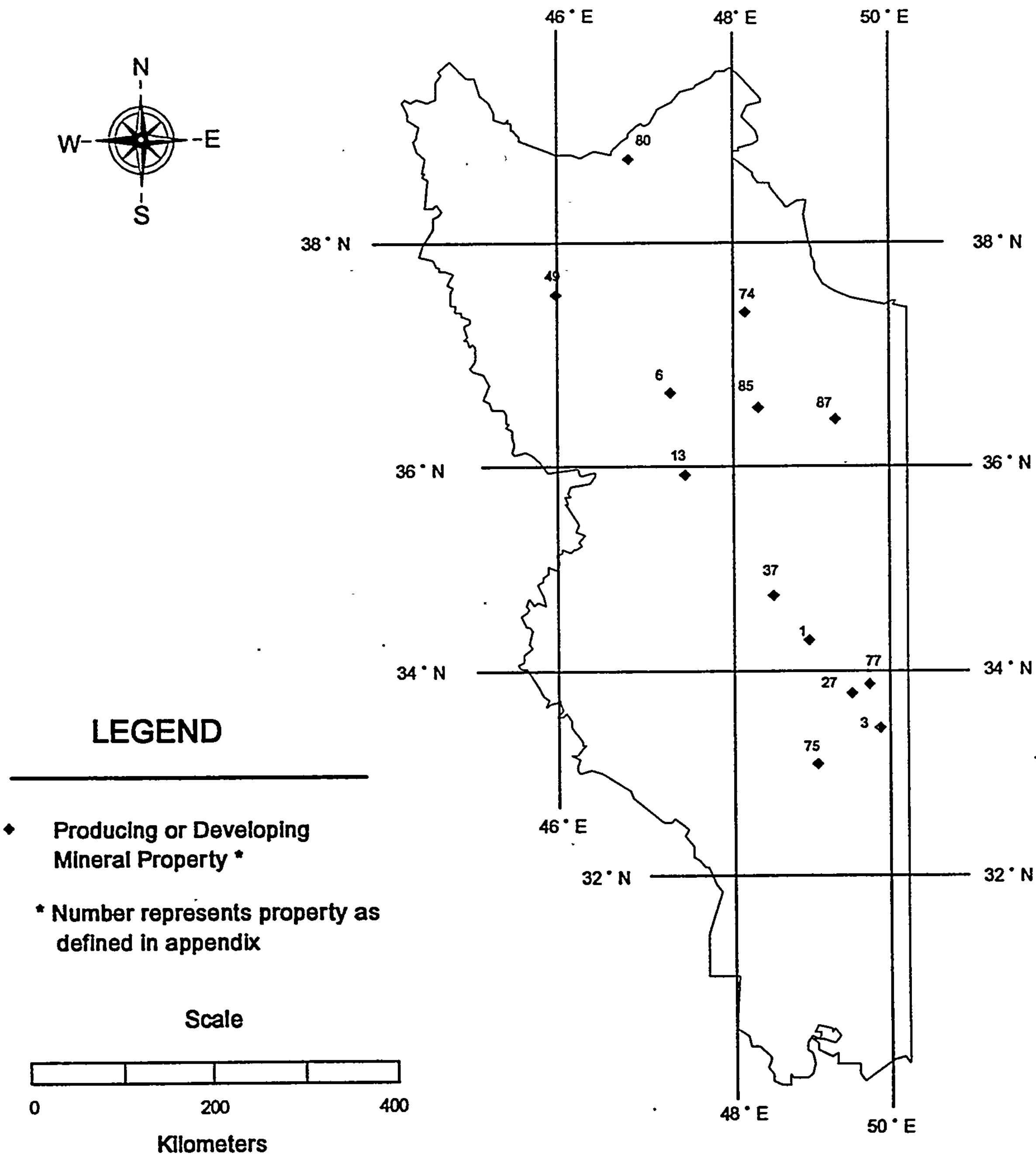
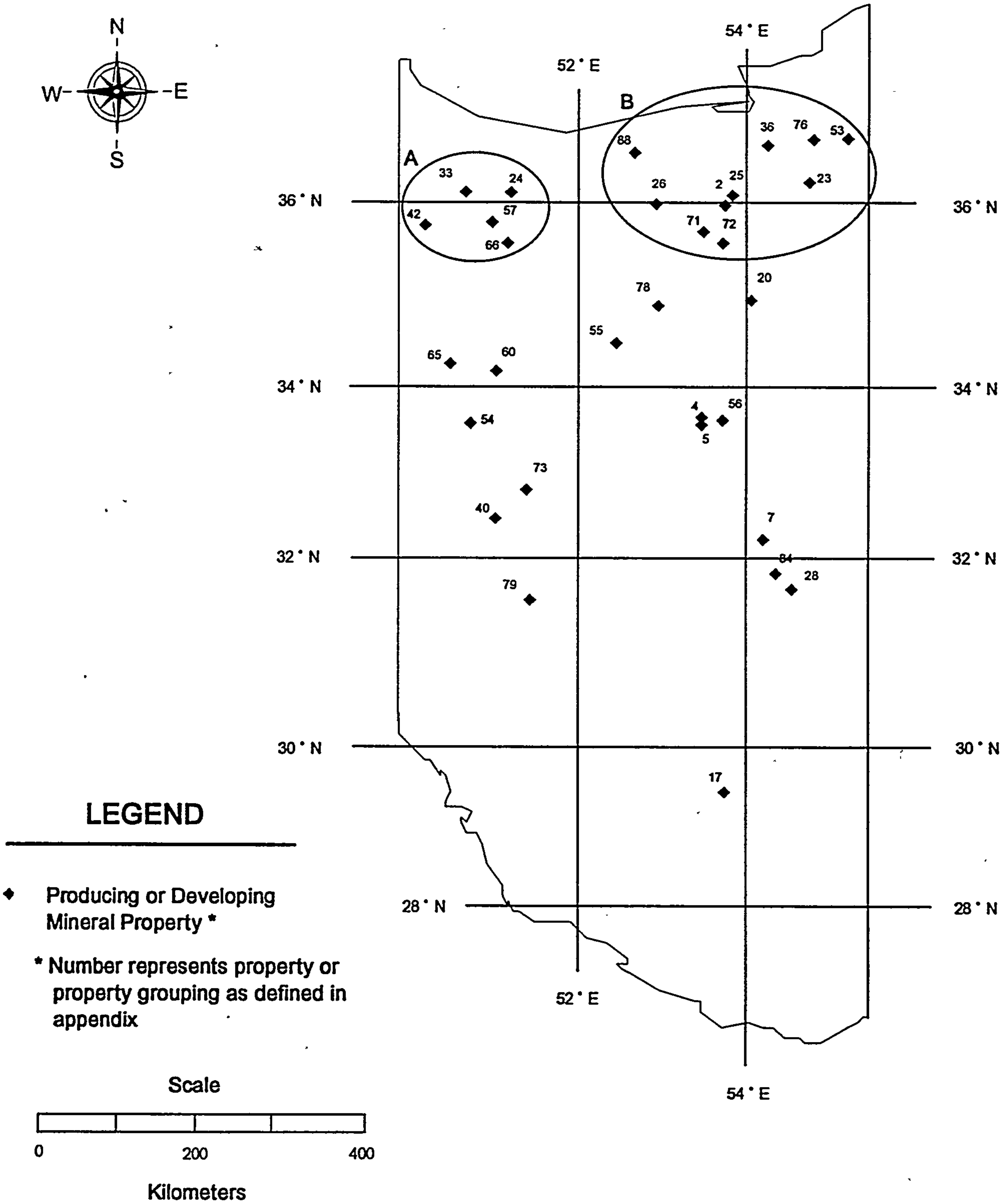
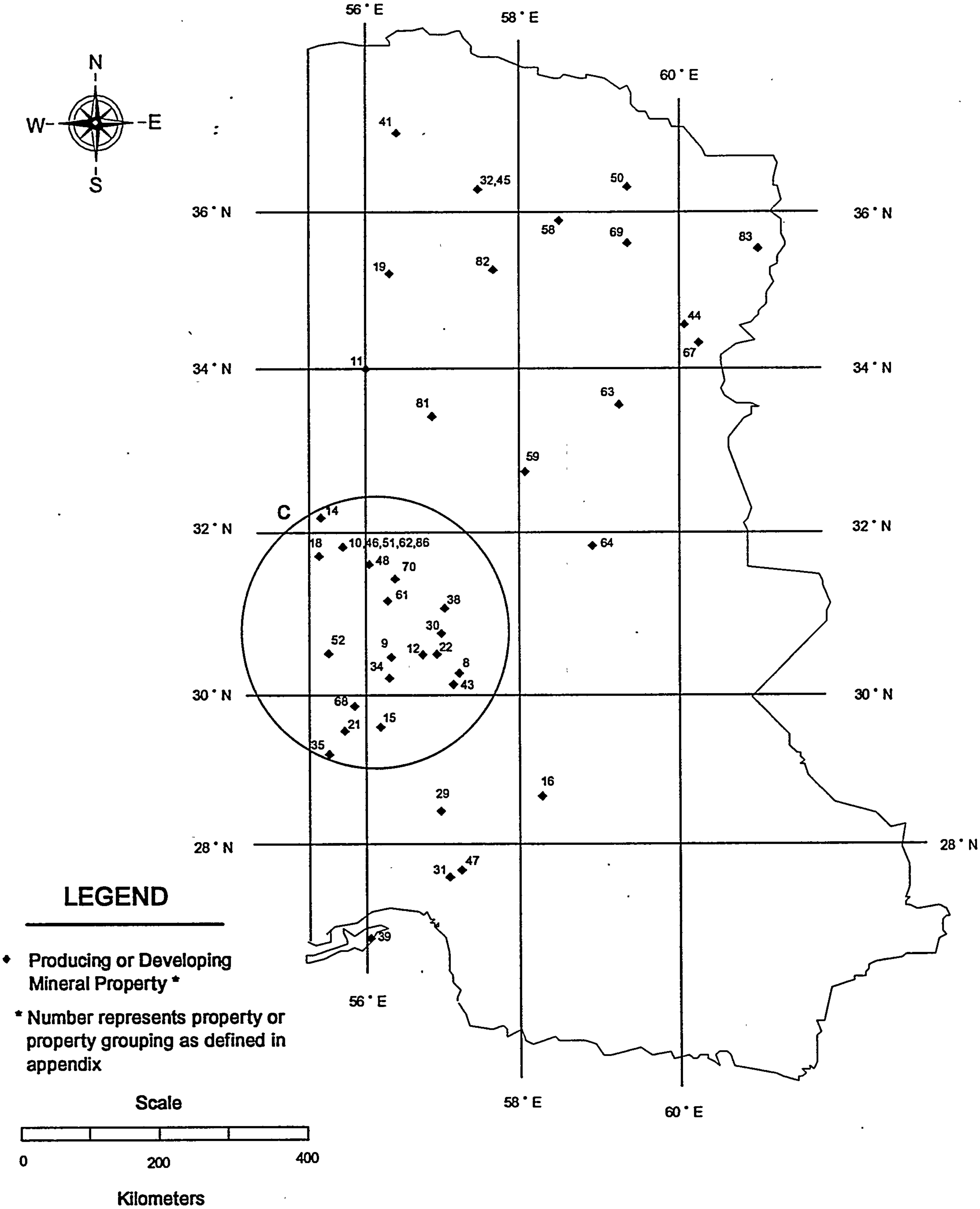


APPENDIX MAP A: PRODUCING OR DEVELOPING MINERAL PROPERTIES OF WESTERN IRAN



APPENDIX MAP B: PRODUCING OR DEVELOPING MINERAL PROPERTIES OF CENTRAL IRAN



APPENDIX MAP C: PRODUCING OR DEVELOPING MINERAL PROPERTIES OF EASTERN IRAN

APPENDIX B: PAST PRODUCING MINERAL PROPERTIES IN IRAN

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
K	1	Ad-Dasht	N 27° 25'	E 57° 07'	Chromium	1,27	General	Past Producer	Underground	Intermittant production.
E	2	Abdoorryzak Abdourryzak	N 36° 29'	E 58° 22'	Turquoise	36	General	Past Producer	Underground	Old workings.
D	3	Ahvanoc Ahwanu	N 36° 22'	E 54° 05'	Lead Zinc	30	General	Past Producer	Underground	--
A	4	Aigheleseh Igeliseh	N 36° 27'	E 47° 34'	Copper Lead,Zinc	1,30	General	Past Producer	Underground	Produced 6 tpd in the 1960s.
A	5	Ak Derreh	N 36° 40'	E 48° 00'	Mercury	38	General	Past Producer	Unknown	Late 1880s. West of Zanjan.
K	6	Amir	N 27° 32'	E 57° 00'	Chromium	27	General	Past Producer	Unknown	Res(1974) 1Mmt @ 48% Cr2O3.
G	7	Anjireh-Tiran Anjireh	N 32° 45'	E 51° 07'	Zinc Lead	1,27,30,56	General	Past Producer	Underground	Operated in 1965. Current status uncertain. Ore in limestone veins.
H	8	Ashin	N 33° 20'	E 53° 44'	Boron	1	General	Past Producer	Surface	Playa salts.
F	9	Ashtian	N 34° 27'	E 49° 22'	Lead Barite	1,27	General	Past Producer	Unknown	--
	10	Baluchestan	N 28° 30'	E 60° 30'	Chromium	30	General	Past Producer	Unknown	--
E	11	Batau	N 35° 22'	E 57° 57'	Copper	38	General	Past Producer	Unknown	Late 1800s. Location approximate.
A	12	Baychehbagh Baeychbag	N 37° 06'	E 47° 07'	Copper Lead,Zinc	1,27,46	General	Past Producer	Underground	Res: 100,000 mt @ 2% Cu.
I	13	Bazergun	N 30° 23'	E 57° 04'	Coal	38	General	Past Producer	Unknown	Late 1800s. Location approximate.
	14	Biarjumand district Bairjomand	N 36° 06'	E 55° 49'	Copper	38	General	Past Producer	Unknown	Late 1800s.
	15	Chah Sorb	N 34° 04'	E 56° 40'	Lead	27,30	General	Past Producer	Underground	Operated in 1965. 1960 prod. 50 tpd. Stoping used.

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MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
E	16	Chund	N 35° 55'	E 57° 42'	Copper	38	General	Past Producer	Surface	Late 1800s. Area contains 2 other mines Homai & Nehru. Paghaleh is in the Jagatai (Joghatay) hills.
	17	Dahaneh Siah	N 35° 09'	E 47° 08'	Copper	38,46	General	Past Producer	Unknown	Late 1800s. Recent prod: 1938-1940.
D	18	Damghan	N 36° 13'	E 54° 04'	Lead	38	General	Past Producer	Unknown	Late 1800s.
F	19	Dareh Noghreh Dahrenogreh	N 33° 33'	E 50° 00'	Lead Zinc	1,27,30	General	Past Producer	Unknown	Res(1974) 100kmt @ 10% Pb.
H	20	Darehzanjir	N 31° 50'	E 54° 15'	Lead Zinc	30	General	Past Producer	Underground	Closed in 1958.
	21	Dehkharegan Dehkhvareqan Azar Shahr	N 37° 45'	E 45° 59'	Marble	38	General	Past Producer	Unknown	Late 1800s.
D	22	Dehmollah	N 36° 17'	E 54° 46'	Gold Copper	18	General	Past Producer	Unknown	--
C	23	Delaazian	N 35° 26'	E 53° 25'	Sulfur	1,53	General	Past Producer	Unknown	Part of Semnan district. Grade of ore 50% S. Ore occurs 7-14m depth.
E	24	Dooletaly	N 36° 44'	E 58° 22'	Salt	18	General	Past Producer	Underground	Location approximate.
H	25	Faiziabad	N 32° 54'	E 53° 00'	Lead	30	General	Past Producer	Underground	Limited workings.
G	26	Fasakhod Changarzeh Fassakhood	N 33° 17'	E 51° 55'	Lead, Zinc Barite	1,27,30	General	Past Producer	Unknown	Exploration workings exist. Res:(1974) 50kmt @ 5-6% Pb.
	27	Feridan district Feridun Fereydun	N 34° 08'	E 47° 48'	Iron	38	General	Past Producer	Unknown	Late 1800s.
E	28	Firizi Farizi	N 36° 30'	E 58° 57'	Coal	38	General	Past Producer	Unknown	Late 1880s.
B	29	Freshend	N 36° 04'	E 50° 35'	Coal	38	General	Past Producer	Unknown	Late 1800s.
H	30	Gardanehshir Gardanshir	N 33° 02'	E 52° 26'	Lead Zinc	1,30	General	Past Producer	Surf./UG	Small production.

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MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
I	31	Ghoghart	N 31° 44'	E 55° 47'	Iron	19	General	Past Producer	Unknown	--
E	32	Goor Sefid	N 36° 29'	E 58° 22'	Turquoise	18	General	Past Producer	Underground	--
I	33	Gujar	N 31° 32'	E 56° 30'	Asbestos	38	General	Past Producer	Unknown	Late 1800s.
I	34	Gujar Gujur Gujahr	N 31° 32'	E 56° 30'	Lead Zinc	9	General	Past Producer	Underground	Prod. sm. amt. of Pb,Zn in 1980. Cap: 30 tpd ore. Mined by sub-level caving.
A	35	Gurkhani Gurkhanek Qurkhaneh	N 36° 41'	E 49° 18'	Copper	38	General	Past Producer	Unknown	Full of water in late 1800s.
H	36	Haftal Aghadan	N 32° 25'	E 53° 14'	Lead Zinc	27	General	Past Producer	Unknown	--
	37	Hamadan	N 34° 48'	E 48° 30'	Antimony	19	General	Past Producer	Unknown	--
	38	Hamadan	N 34° 55'	E 48° 46'	Tin	17	General	Past Producer	Unknown	--
I	39	Heruzeh Heruz Haruz-e Sofla	N 30° 44'	E 57° 02'	Manganese	38	General	Past Producer	Unknown	Late 1800s.
B	40	Hiv	N 36° 03'	E 50° 40'	Coal	38	General	Past Producer	Unknown	Late 1800s. 1888 output 9000t.
E	41	Homai Homa'i	N 35° 52'	E 58° 55'	Copper	38	General	Past Producer	Unknown	Late 1800s.
F	42	Hosseinabad Hassanabad	N 33° 32'	E 49° 48'	Lead Zinc Copper	21,27,30	General	Past Producer	Underground	1968 prod 300 tpd. Ore in ls. Conc grade: 75% Pb; 60% Zn. Res:(1974) 250kmt @ 10% Pb, 5% Zn, 0.1-0.9% Cu.
D	43	Hyrcania region Mazanderan region Gorgan region	N 37° 00'	E 54° 30'	Iron	38	General	Past Producer	Unknown	Late 1600s
	44	Istakhr	N 29° 57'	E 52° 55'	Iron Mercury	17	General	Past Producer	Unknown	Old workings.

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MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
	45	Jabal Bariz	N 28° 45'	E 58° 50'	Iron	17	General	Past Producer	Unknown	Old workings.
E	46	Kafir Kafir Qal'eh	N 35° 53'	E 59° 25'	Rock Salt	38	General	Past Producer	Surface	Late 1800s.
	47	Kaladasht	N 36° 30'	E 51° 23'	Lead	1,27	General	Past Producer	Unknown	--
G	48	Kalik	N 33° 55'	E 51° 00'	Iron	28	General	Past Producer	Unknown	Sm. amounts prod. in 1960s. Incl. Sarvian, Abbya, Kalik sites.
	49	Kamarij Kamaraj	N 29° 37'	E 51° 29'	Rock salt	38	General	Past Producer	Surface	Late 1800s.
A	50	Karadagh Mountains Gore Kara-Dag Mtns Qareh Dagh Mtns	N 36° 51'	E 48° 27'	Copper Iron	38	General	Past Producer	Unknown	--
A	51	Kazvin Qazvin	N 36° 16'	E 50° 00'	Alum Coal	27,38	General	Past Producer	Surface	Late 1800s.
E	52	Kemeri-Khaki	N 36° 29'	E 58° 22'	Turquoise	18	General	Past Producer	Underground	--
K	53	Kerman	N 28° 07'	E 57° 14'	Chromium	36	General	Past Producer	Surface/UG	--
E	54	Kharydji	N 36° 29'	E 58° 22'	Turquoise	18	General	Past Producer	Underground	--
A	55	Kiz Kapan	N 36° 45'	E 48° 00'	Mercury	38	General	Past Producer	Unknown	Late 1800s. Location approximate.
H	56	Kuhberan district	N 31° 38'	E 53° 30'	Coal	38	General	Past Producer	Unknown	Late 1800s.
G	57	Kuhrud Qohrud	N 33° 40'	E 51° 25'	Copper Iron	38	General	Past Producer	Unknown	Late 1800s.
G	58	Kum	N 34° 39'	E 50° 54'	Potassium nitrate	38	General	Past Producer	Underground	Late 1800s.
L	59	Laft	N 26° 54'	E 55° 46'	Salt	38	General	Past Producer	Surface	Late 1600s.
F	60	Lakan Lakan district	N 33° 40'	E 49° 43'	Lead Zinc	1,21,27,30,56	General	Temp. closure	Surf./UG	Mine reported closed 1984. Host rock: Ls, sh. Mining dates to Roman times. In 1950s, open cut used. 1956 started UG mining. 1954, prod. 11kt ore @ 65% Pb yielded 7.1kt Pb conc. No mining from 1959-68.

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(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
C	61	Lasgird	N 35° 24'	E 53° 04'	Rock Salt	38	General	Past Producer	Surface	Late 1800s.
G	62	Marvand	N 33° 32'	E 51° 28'	Lead Zinc	27	General	Past Producer	Unknown	--
H	63	Masreh Masr	N 34° 04'	E 54° 48'	Rock Salt	38	General	Past Producer	Surface	Late 1800s.
	64	Mazraeh Maazraah	N 38° 36'	E 47° 03'	Copper Molybdenum Gold	1,13,27,46	General	Past Producer	Unknown	Expl. work done in 1973. Res: 300,000 mt @ 1.5% Cu.
H	65	Mehrjard	N 32° 15'	E 53° 30'	Lead Zinc	27,30	General	Past Producer	Unknown	Res: 45Mmt@ 7% cutoff(Pb+Zn).
E	66	Meshed Mashad	N 36° 18'	E 59° 36'	Copper	38	General	Past Producer	Underground	Late 1800s. Mine located 5 mi. from Meshed.
H	67	Meskani	N 33° 20'	E 53° 27'	Copper	27,46	General	Past Producer	Unknown	Res:(1974) 5Mmt @ 0.5% Cu.
	68	Naij	N 36° 28'	E 52° 21'	Iron	38	General	Past Producer	Unknown	Late 1800s.
E	69	Nehru	N 35° 52'	E 58° 55'	Copper	38	General	Past Producer	Underground	Late 1800s.
L	70	Nemekdan	N 26° 50'	E 56° 00'	Rock Salt	38	General	Past Producer	Surface	Late 1800s. Annual exports of 1,500t/y. Cliffs 200-300 ft. high.
E	71	Neyshabur	N 36° 12'	E 58° 50'	Turquoise	13,18	General	Past Producer	Underground	Exploration 1972-73. At village of Madene.
	72	Nowbaran	N 35° 13'	E 49° 30'	Barite	1,27	General	Past Producer	Unknown	--
E	73	Nukan	N 36° 33'	E 59° 17'	Gold Silver Lead,Zinc	17	General	Past Producer	Unknown	Ancient workings.
	74	Ozbak-kuh Osbakkuh	N 34° 39'	E 57° 07'	Lead Zinc	13,27,30	General	Past Producer	Underground	Recovered both Pb and Zn. Cut & fill used 1965. Host rock: Ls & dolomite
L	75	Ormuz (Island) Jazireh-ye Hormoz	N 27° 04'	E 56° 28'	Rock Salt	38	General	Past Producer	Surface	Late 1800s.

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MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
E	76	Paghaleh	N 36° 32'	E 57° 13'	Copper	38	General	Past Producer	Unknown	Late 1800s. Paghaleh is in the Jagatai hills
	77	Parpa	N 29° 10'	E 53° 57'	Iron	38	General	Past Producer	Unknown	Late 1800s. Extensive workings.
A	78	Rashidabad	N 37° 04'	E 48° 26'	Copper Lead	1,27,46	General	Past Producer	Unknown	Grade reported to be 2.7% Cu. Res:(1963) 1200mt.
K	79	Reza	N 27° 20'	E 57° 05'	Chromium	27	General	Past Producer	Unknown	--
	80	Robat-e-Khan	N 33° 21'	E 56° 02'	Bauxite	13	General	Past Producer	Surface	Hi-Al kaolin clay with high silica. Res: estimated at 0.7Mmt. Used at Aminabad military smelter in 1973.
J	81	Rudun Rudin	N 30° 22'	E 55° 24'	Naphtha	38	General	Past Producer	Surface	Late 1800s.
	82	Sahik	N 29° 28'	E 54° 06'	Iron	17	General	Past Producer	Unknown	--
L	83	Salakh	N 26° 41'	E 55° 42'	Naphtha	38	General	Past Producer	Surface	Late 1600s. On Qesm Island.
	84	Sari	N 36° 34'	E 53° 04'	Copper	38	General	Past Producer	Unknown	Late 1600s.
E	85	Sebzewar Sabzawar Sebzevar	N 36° 13'	E 57° 42'	Lead Manganese	27,38	General	Past Producer	Unknown	Late 1800s.
	86	Seh Changi	N 32° 31'	E 58° 03'	Lead Zinc	13,27	General	Past Producer	Underground	Opened in 1963. 5-6% Pb,Zn.
E	87	Seh Chelangi	N 36° 17'	E 57° 44'	Copper Lead, Zinc	46	General	Past Producer	Unknown	Operated 1950-1958.
C	88	Semnan	N 35° 33'	E 53° 24'	Sulfur	38,53	General	Past producer	Surface	Late 1800s. Native sulfur.
K	89	Shahin	N 27° 25'	E 57° 29'	Chromium	27	General	Past Producer	Unknown	--
E	90	Shahi-perdar	N 36° 29'	E 58° 22'	Turquoise	18	General	Past Producer	Underground	--
G	91	Shahrokh	N 34° 24'	E 51° 03'	Manganese	1,24,27	General	Past Producer	Unknown	Associated with volcanics. Res(1966) 20kmt @32-34% Mn.
K	92	Shariar	N 27° 18'	E 57° 05'	Chromium	27	General	Past Producer	Unknown	Res(1974)1.1Mmt @51% Cr2O3.

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MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
J	93	Kavir-e Namak-e Sirjan	N 29° 25'	E 55° 25'	Borax	38	General	Past Producer	Surface	Late 1800s. On edge of salt flat.
G	94	Sherifabad	N 34° 12'	E 51° 10'	Copper	27,46	General	Past Producer	Unknown	Res: 25kmt @ 3% Cu.
	95	Shemsek Shemshak district	N 36° 00'	E 51° 30'	Coal Phosphate	12,38	General	Past Producer	Surface	Late 1800s.
	96	Shiz Saqqez	N 36° 14'	E 46° 16'	Gold	17	General	Past Producer	Unknown	--
H	97	Siahkuh	N 32° 47'	E 53° 55'	Lead Zinc	27,30	General	Past Producer	Underground	35 tpd in 1965. Current status uncertain.
K	98	Soghan	N 28° 26'	E 57° 07'	Chromium	27	General	Past Producer	Unknown	Res(1974) 150kmt.
K	99	Solo	N 28° 37'	E 57° 11'	Chromium	27	General	Past Producer	Unknown	--
	100	Tabriz	N 38° 05'	E 46° 18'	Coal	27,38	General	Past Producer	Underground	Late 1800s.
J	101	Tajkuh Tajkoo	N 30° 20'	E 55° 27'	Lead Zinc	9,26,30	General	Past Producer	Underground	Old workings. Prod. in 1980.
H	102	Talmessi	N 33° 25'	E 53° 29'	Copper	46	General	Past Producer	Unknown	--
J	103	Tang-i-Mo-iAspan	N 29° 52'	E 55° 45'	Lead Copper	38	General	Past Producer	Unknown	Late 1800s.
I	104	Tarz	N 31° 10'	E 56° 42'	Lead Zinc	26,27,30	General	Past Producer	Underground	Total prod. to 1965 is 1100 mt. Cap: 50 tpd. Mined by sub-level caving.
A	105	Tash	N 37° 22'	E 49° 35'	Alum	38	General	Past Producer	Surface	Late 1800s.
H	106	Tchah Heriseh Charisseh	N 32° 57'	E 52° 18'	Lead Zinc	30	General	Past Producer	Surface	Mining ended in 1965.
E	107	Tonkar	N 36° 13'	E 57° 38'	Boron	24	General	Past Producer	Surface	Sporatic, small production. Lacustrine playa.
E	108	Turshiz area	N 35° 46'	E 58° 15'	Copper	38	General	Past Producer	Unknown	Late 1800s. Area between Soltanabad (N3623 E5802) and Kashmar (N3514 E5828).
H	109	Turun Pusht Turan Posht	N 31° 32'	E 53° 52'	Marble	38	General	Past Producer	Surface	Late 1800s.

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MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
E	110	Tus	N 36° 33'	E 59° 17'	Turquoise Malachite	17	General	Past Producer	Unknown	--
H	111	Yezd Kathah	N 31° 48'	E 54° 13'	Zinc Lead	17,38	General	Past Producer	Unknown	Late 1800s. Yadz was called Kathah in early times. Lead mine was in the area.
F	112	Zardeh Kuh (Mtn Range) Zard Kuh (Mtn)	N 32° 55'	E 49° 55'	Mercury	38	General	Past Producer	Unknown	Late 1800s.
I	113	Zirakan	N 31° 59'	E 55° 33'	Lead Zinc	30	General	Past Producer	Surf./UG	Ore in stopes est. at 200,000 mt.

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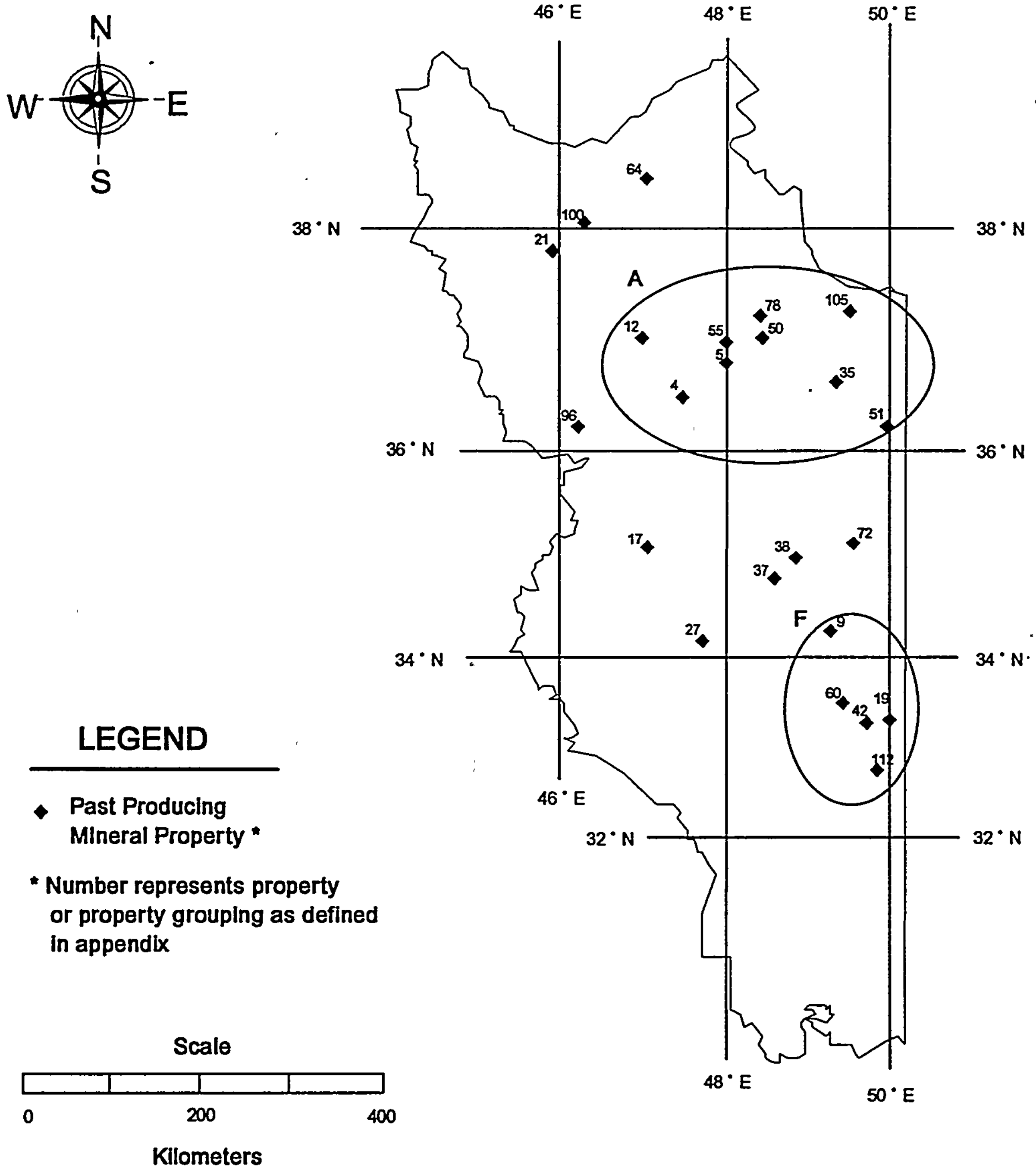
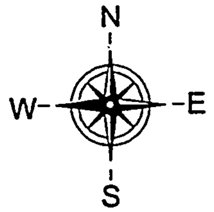
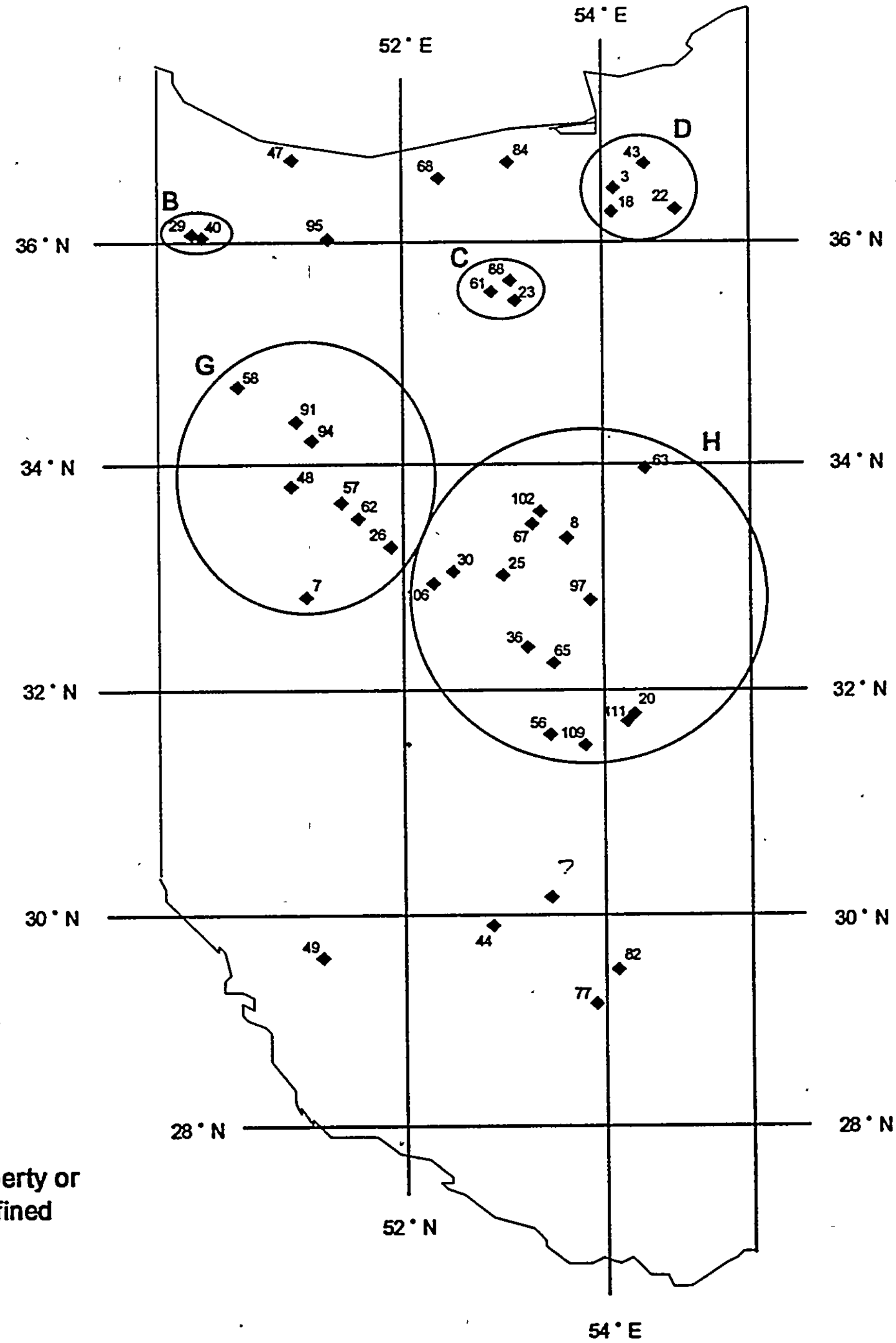


APPENDIX MAP D: PAST PRODUCING MINERAL PROPERTIES OF WESTERN IRAN





LEGEND

◆ Past Producing Mineral Property *

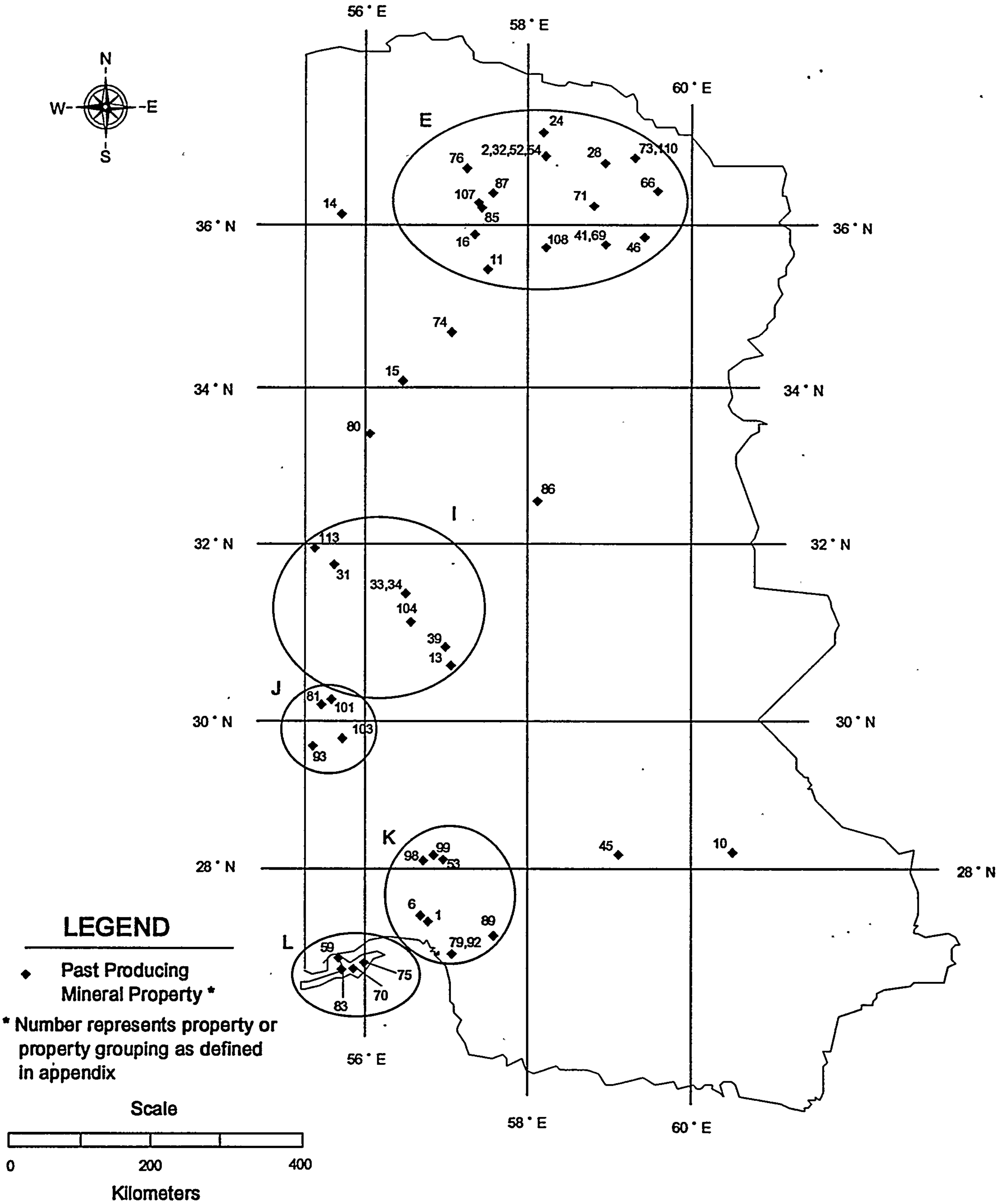
* Number represents property or property grouping as defined in appendix

Scale

0 200 400

Kilometers

APPENDIX MAP E: PAST PRODUCING MINERAL PROPERTIES OF CENTRAL IRAN



APPENDIX F: PAST PRODUCING MINERAL PROPERTIES OF EASTERN IRAN

APPENDIX C: PROSPECTS AND UNDEVELOPED MINERAL PROPERTIES IN IRAN

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
A	90	Hassu Kuchak	N 39° 20'	E 44° 50'	Phosphate	1	General	Deposit	Unknown	--
B	115	Khoy	N 38° 27'	E 44° 45'	Chromium	1	General	Deposit	Unknown	--
B	116	Khoy	N 38° 12'	E 44° 58'	Asbestos	1	General	Deposit	Unknown	--
B	155	Queshagh-Yasdikhan	N 38° 22'	E 44° 44'	Copper	1	General	Deposit	Unknown	--
B	193	Tamtameh Cave	N 38° 20'	E 44° 50'	Cave	5	General	Site	Underground	13 mi. NW of Lake Reza'iyek.
C	11	Andab-Jadid	N 38° 19'	E 47° 19'	Copper Lead	1	General	Deposit	Unknown	--
C	13	Anjert	N 38° 33'	E 47° 10'	Copper Molybdenum	1	General	Deposit	Unknown	--
C	19	Aynelu	N 38° 45'	E 46° 50'	Copper	1,27	General	Deposit	Unknown	0.25-2.0% Cu.
C	28	Barzgar	N 38° 22'	E 46° 47'	Copper	1	General	Deposit	Unknown	--
C	74	Garadareth	N 38° 46'	E 46° 22'	Copper Molybdenum	1	General	Deposit	Unknown	--
C	84	Gowdal Goudal	N 38° 39'	E 47° 10'	Copper	1,27,46	General	Deposit	Unknown	Res: 10,000 mt @ 1.0-1.5% Cu.
C	85	Gumusholan	N 38° 29'	E 46° 48'	Copper Molybdenum	1	General	Deposit	Unknown	--
C	97	Juban	N 38° 29'	E 46° 55'	Zinc Copper	1	General	Deposit	Unknown	--
C	151	Qarachilar	N 38° 47'	E 46° 30'	Copper Molybdenum	1	General	Deposit	Unknown	--
C	164	Sabalan	N 38° 15'	E 47° 47'	Sulfur	1	General	Deposit	Surface	--
C	208	Valilu	N 38° 24'	E 46° 53'	Arsenic	1	General	Deposit	Unknown	--
C	211	Varzaqan	N 38° 10'	E 47° 18'	Arsenic	1	General	Deposit	Unknown	--
C	218	Zandabad	N 38° 30'	E 47° 09'	Copper Molybdenum	1	General	Deposit	Unknown	--

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(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.

MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
C	228	Zaylik	N 38° 42'	E 46° 15'	Bauxite	1	General	Deposit	Surface	--
C	229	Zaylik-E-Ahar	N 38° 27'	E 47° 20'	Bauxite	1	General	Deposit	Surface	--
C	230	Zaylik-E-Moshkin	N 38° 30'	E 47° 30'	Bauxite	1	General	Deposit	Surface	--
C	233	Zonuz	N 38° 33'	E 46° 00'	Kaolin	1	General	Deposit	Surface	--
D	7	Aghdarreh	N 36° 42'	E 47° 02'	Gold	43,46	General	Deposit	Unknown	--
D	14	Aqdareh	N 36° 37'	E 46° 56'	Antimony	1	General	Deposit	Unknown	--
D	20	Ayqaleshi	N 36° 36'	E 47° 12'	Lead Zinc	1	General	Deposit	Unknown	--
D	38	Bukan	N 36° 31'	E 46° 12'	Bauxite	13	General	Deposit	Surface	Exposed over 40km length. Max. thickness 10m.
D	82	Gopi Baba Ali	N 36° 57'	E 45° 55'	Bauxite	1	General	Deposit	Surface	--
D	111	Kharaju	N 37° 20'	E 46° 27'	Copper	1	General	Deposit	Unknown	--
D	150	Qarachaman	N 37° 29'	E 47° 46'	Pyrite	1	General	Deposit	Surface	--
D	179	Shekterabad	N 37° 20'	E 47° 32'	Copper	1	General	Deposit	Unknown	--
D	190	Takab	N 36° 30'	E 47° 03'	Gold	57	General	Deposit	Surface	Exploration planned.
D	197	Turkomanchal Turkmanchal Toraman city	N 37° 35'	E 47° 23'	Copper	38	General	Deposit	Unknown	1810 information. Sheikh der Aband district near Turkomanchal.
D	206	Uzundareh	N 37° 30'	E 48° 02'	Lead Zinc	1	General	Deposit	Unknown	--
D	225	Zarshuran Zarshouran River	N 36° 40'	E 47° 27'	Gold	1,57	General	Deposit	Surface	--
D	231	Zereshlu	N 37° 20'	E 47° 10'	Copper Silver	1	General	Deposit	Unknown	--
E	15	Arjin	N 36° 29'	E 49° 10'	Iron	1	General	Deposit	Unknown	--
E	27	Barikab	N 36° 12'	E 49° 22'	Lead Zinc	1,27	General	Deposit	Unknown	--

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MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
E 35	Bivarzin	N 36° 39'	E 49° 42'	Lead	1	General	Deposit	Unknown	--
E 46	Chizeh	N 36° 47'	E 49° 21'	Copper	1,27	General	Deposit	Surface	Res(1974) 100kmt.
E 54	Dastak	N 37° 22'	E 50° 05'	Titanium	1	General	Deposit	Unknown	--
E 59	Dizejin	N 36° 38'	E 49° 13'	Copper Gold	1	General	Deposit	Unknown	--
E 68	Esmailabad	N 36° 40'	E 49° 00'	Copper	1	General	Deposit	Unknown	--
E 92	Hosseinabad	N 36° 39'	E 48° 13'	Barite	1	General	Deposit	Unknown	--
E 103	Kalarud	N 36° 56'	E 48° 29'	Copper	1	General	Deposit	Unknown	--
E 107	Khalkhal	N 37° 30'	E 48° 30'	Copper	1	General	Deposit	Surface	--
E 110	Khanghardash	N 36° 46'	E 48° 40'	Iron	1	General	Deposit	Unknown	--
E 112	Kharaqan	N 35° 29'	E 49° 50'	Copper	1	General	Deposit	Unknown	--
E 132	Lubenjardeh	N 36° 50'	E 48° 48'	Copper	1	General	Deposit	Unknown	--
E 137	Mulla Ali	N 36° 40'	E 49° 19'	Bauxite	1	General	Deposit	Surface	--
E 149	Qara Tikan	N 36° 40'	E 49° 29'	Bauxite	1	General	Deposit	Surface	--
E 156	Queshlagh	N 36° 40'	E 48° 52'	Copper	1	General	Deposit	Unknown	--
E 158	Razan	N 35° 30'	E 49° 19'	Copper Lead, Zinc	1	General	Deposit	Unknown	--
E 168	Sangrud	N 36° 58'	E 49° 53'	Lead	1	General	Deposit	Unknown	--
E 173	Senjedeh	N 37° 20'	E 48° 17'	Lead Zinc	1	General	Deposit	Unknown	--
E 174	Shahboulagh	N 36° 46'	E 48° 57'	Iron	1	General	Deposit	Unknown	--
E 181	Shilander	N 37° 00'	E 48° 32'	Lead Copper	1	General	Deposit	Unknown	--
E 192	Talequan	N 37° 01'	E 49° 25'	Feldspar Copper	10,48	General	Deposit	Surface	Res: Reported to be 500,000mt.

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E	214 Yamashkan	N 36° 47'	E 49° 32'	Copper	1	General	Deposit	Unknown	--
E	219 Zanjan	N 36° 20'	E 48° 20'	Iron	1,28	General	Deposit	Unknown	Res: 1Mmt @ 48% Fe. Ore in limestone.
E	220 Zanjan	N 36° 40'	E 48° 29'	Phosphate	12	General	Deposit	Surface	--
E	223 Zarinkhani	N 36° 32'	E 49° 42'	Copper	1,46	General	Deposit	Unknown	Res: 1000 mt @ 8% Cu.
E	227 Zaykan	N 36° 23'	E 49° 21'	Bauxite	1	General	Deposit	Surface	--
F	22 Bagarlu	N 35° 18'	E 48° 00'	Antimony	1	General	Deposit	Unknown	--
F	33 Bisitun Cave	N 34° 23'	E 47° 26'	NAp	5	General	Cave	Underground	--
F	182 Shirvaneh	N 34° 44'	E 47° 00'	Copper	1	General	Deposit	Unknown	--
G	8 Ahmad-Rowghant	N 34° 09'	E 49° 01'	Iron	28	General	Deposit	Unknown	Ore is hematite in schist. Res: 10Mmt @ 40% Fe.
G	16 Astaneh	N 33° 53'	E 49° 26'	Gold	1,57	General	Deposit	Surface	Exploration planned.
G	21 Babagholeh Babaghale	N 33° 40'	E 50° 02'	Lead Zinc	1,30	General	Deposit	Unknown	--
G	40 Chamanak	N 34° 44'	E 49° 54'	Barite	1	General	Deposit	Unknown	--
G	52 Darreh-Ahmadkan	N 33° 49'	E 49° 53'	Lead Zinc	27	General	Deposit	Unknown	--
G	53 Darreh Zar	N 33° 34'	E 48° 38'	Copper	13	General	Deposit	Unknown	Location approximate. 1973 Res: 30Mmt @ 1% Cu.
G	93 Hossienabad	N 33° 46'	E 49° 06'	Tungsten Gold	1	General	Deposit	Unknown	--
G	113 Khomein	N 33° 38'	E 50° 04'	Copper	49	General	Deposit	Unknown	--
G	114 Khoramabad	N 33° 38'	E 48° 40'	Chromium	1	General	Deposit	Unknown	--
G	159 Reskan	N 34° 22'	E 49° 14'	Lead	1	General	Deposit	Unknown	--
G	160 Revesht	N 33° 42'	E 49° 15'	Tungsten Gold Copper	1,27	General	Deposit	Surface	--

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G 162	Robat	N 33° 56'	E 50° 02'	Lead	1	General	Deposit	Unknown	--
G 167	Saki	N 34° 02'	E 49° 58'	Lead Zinc	1,30	General	Deposit	Unknown	--
G 207	Vafez	N 34° 39'	E 49° 58'	Copper	1	General	Deposit	Unknown	--
H 60	Dokuh	N 32° 50'	E 48° 28'	Sulfur	1	General	Deposit	Unknown	--
H 119	Kuhdasht	N 33 ° 11'	E 47° 38'	Sulfur	1	General	Deposit	Surface	--
H 135	Malavi	N 32° 49'	E 47° 52'	Sulfur	1	General	Deposit	Surface	--
I 36	Bonebrahe	N 32° 38'	E 49° 21'	Sulfur	1	General	Deposit	Unknown	--
I 94	Idhaj Izeh	N 31° 50'	E 49° 52'	Salts	17	General	Deposit	Surface	--
I 122	Kuh-E-Pabdeh	N 32° 28'	E 49° 48'	Phosphorus	1	General	Deposit	Surface	--
I 157	Ramhormoz Ram Hormus	N 31° 16'	E 49° 36'	Phosphate	12	General	Deposit	Surface	--
J 55	Dawrak	N 30° 49'	E 48° 53'	Sulfur	37	General	Deposit	Unknown	--
K 5	Abiek	N 36° 03'	E 50° 36'	Coal	38	General	Deposit	Unknown	Late 1800s. Coord. determined from map. Output in 1888 was 2000mt.
K 10	Alborz	N 36° 15'	E 50° 28'	Lead	1,30	General	Deposit	Unknown	--
K 31	Bibishahr-Ranu	N 35° 34'	E 51° 32'	Lead	1	General	Deposit	Unknown	--
K 45	Cherarlu	N 36° 22'	E 50° 20'	Copper	1	General	Deposit	Surface	--
K 47	Dalir Delir	N 36° 21'	E 51° 08'	Phosphate	12,55	General	Deposit	Surface	Res: 23Mmt @ 12% P2O5.
K 63	Dorvan Sanj	N 35° 59'	E 51° 02'	Copper Molybdenum	1	General	Deposit	Unknown	--
K 66	Elikah	N 36° 10'	E 51° 19'	Lead	1,27,31,56	General	Deposit	Underground	--
K 76	Geirud	N 36° 19'	E 51° 12'	Phosphate	27	General	Deposit	Surface	--

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K 89	Halalabad	N 36° 23'	E 50° 28'	Copper	1	General	Deposit	Unknown	--
K 96	Jaru	N 35° 35'	E 50° 45'	Copper	1,27	General	Deposit	Unknown	Res:(1974) 9kmt @ 3-8% Cu.
K 127	Lak	N 35° 38'	E 50° 25'	Lead Zinc	1	General	Deposit	Unknown	--
K 143	Nowbaran Sira	N 36° 12'	E 50° 56'	Barite	1	General	Deposit	Unknown	--
K 147	Pasqaleh Pasgalaeh	N 35° 50'	E 51° 33'	Zinc, Lead Copper Gold	1,46	General	Deposit	Unknown	--
K 163	Robat Karim	N 35° 28'	E 51° 05'	Manganese	1,24,27,32	General	Deposit	Unknown	Ore zone 100m by 8m. Res:(1981) 500,000mt @ 30% Mn
K 180	Shemshak Jelrud	N 35° 53'	E 51° 38'	Phosphate	1,13	General	Deposit	Surface	Res: 12Mmt @ 22.3% P2O5
L 4	Ab-E-Garm	N 35° 46'	E 53° 02'	Zinc Lead	1	General	Deposit	Unknown	--
L 9	Akuhi	N 35° 52'	E 52° 32'	Lead	1	General	Deposit	Unknown	--
L 18	Alwan-i Kaif Aivan-i-Kaif Eyvanekey	N 35° 20'	E 52° 04'	Salt	38	General	Deposit	Surface	Late 1800s.
L 48	Damavand	N 35° 48'	E 52° 22'	Copper	1	General	Deposit	Unknown	--
L 56	Deh Nemek	N 35° 15'	E 52° 44'	Rock Salt	38	General	Deposit	Surface	Late 1800s.
L 65	Elburz Mountains	N 35° 40'	E 52° 20'	Phosphate	55	General	Deposit	Surface	Phosphorite bed 75cm thick. Grade is 20% P2O5.
L 70	Firuzkuh	N 35° 54'	E 52° 48'	Copper	1	General	Deposit	Unknown	--
L 71	Firozkuh	N 35° 54'	E 52° 48'	Phosphate	12,27	General	Deposit	Surface	--
L 124	Kuh-E-Sorkh	N 35° 23'	E 53° 10'	Sulfur	1	General	Deposit	Surface	--
L 129	Lalun	N 35° 42'	E 52° 00'	Phosphate	27	General	Deposit	Surface	--
L 131	Lareskan	N 35° 48'	E 53° 58'	Lead Zinc	1	General	Deposit	Unknown	--

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(2) Complete list of data sources found at end of appendix.
(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
L 131	Lareskan	N 35° 48'	E 53° 58'	Lead Zinc	1	General	Deposit	Unknown	--
L 161	Rezaabad	N 35° 53'	E 53° 25'	Iron	1	General	Deposit	Unknown	--
L 169	Sarbisheh	N 36° 08'	E 53° 25'	Lead Zinc	1	General	Deposit	Unknown	1992 prod: 83,000 tpy contained Cu.
L 172	Semnan	N 35° 40'	E 53° 27'	Iron	1,28	General	Deposit	Unknown	Pyrite-rich magnetite. Includes Towyeh, Darwar sites. Grade: 30-55% Fe.
L 185	Siahkuh	N 34° 34'	E 52° 41'	Strontium	1	General	Deposit	Unknown	--
L 186	Siahkuh	N 34° 49'	E 52° 17'	Barite	1	General	Deposit	Surface	--
L 198	Tuyehdarva Tuyehdarvar	N 36° 02'	E 53° 39'	Lead Zinc	1,30	General	Deposit	Unknown	--
L 199	Tuyhassi	N 36° 06'	E 53° 42'	Lead Zinc	1	General	Deposit	Unknown	--
L 224	Zarkouh	N 35° 40'	E 53° 40'	Gold	57	General	Deposit	Surface	Exploration planned.
L 226	Zarvan	N 35° 52'	E 52° 59'	Zinc Lead	1	General	Deposit	Unknown	--
M 30	Beit Cace Ghar-i-Kamarband	N 36° 43'	E 53° 28'	NAp	5	General	Cave	NAp	--
N 202	Unnamed	N 37° 34'	E 53° 55'	Coal	11	General	Deposit	Surface	--
O 136	Mazanderan region	N 37° 00'	E 54° 30'	Naphtha	38,58	General	Deposit	Surface	Late 1600s.
O 175	Shahrud	N 36° 23'	E 54° 50'	Phosphate	12	General	Deposit	Surface	--
O 203	Unnamed	N 36° 50'	E 54° 46'	Coal	11	General	Deposit	Surface	--
P 195	Torud	N 35° 26'	E 55° 07'	Copper	13	General	Deposit	Unknown	Cu anomalies reported.
Q 25	Baqeroq	N 33° 47'	E 54° 06'	Copper	27	General	Deposit	Unknown	--
R 17	Ateshkuh	N 33° 47'	E 50° 32'	Lead Barite	1	General	Deposit	Unknown	--
R 34	Bitan	N 34° 23'	E 50° 50'	Barite	1	General	Deposit	Unknown	--

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(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
R 37	Boz	N 33° 12'	E 52° 32'	Manganese	1,24,27	General	Deposit	Unknown	Replacement of porphyry.
R 62	Dorreh	N 33° 55'	E 51° 21'	Barite	42	General	Deposit	Surface	Res: 1.67Mmt @ +72% BaSO4. Sm. amounts of Pb, Zn, and Cu.
R 79	Golestan	N 34° 41'	E 50° 24'	Lead,Zinc Copper	1	General	Deposit	Unknown	--
R 102	Kajarab	N 34° 41'	E 50° 10'	Iron	1,28	General	Deposit	Unknown	Res: 20Mmt @ 35% Fe.
R 105	Kamsar	N 33° 50'	E 51° 09'	Iron	28,38	General	Deposit	Unknown	--
R 125	Kul-E-R	N 33° 16'	E 52° 40'	Copper	1	General	Deposit	Unknown	--
R 140	Natanz	N 33° 38'	E 51° 40'	Kaolin	1	General	Deposit	Surface	
R 148	Qamsar	N 33° 48'	E 51° 36'	Cobalt Copper	1	General	Deposit	Unknown	--
R 154	Qomsheh	N 33° 05'	E 51° 58'	Lead Iron	1	General	Deposit	Unknown	--
R 187	Sirjend	N 35° 09'	E 50° 12'	Copper	1	General	Deposit	Unknown	--
R 188	Soh	N 33° 22'	E 51° 36'	Lead Zinc	1	General	Deposit	Unknown	--
R 191	Takhtechaman	N 35° 04'	E 50° 37'	Copper	1,27	General	Deposit	Unknown	--
R 194	Tarkin	N 33° 31'	E 51° 58'	Copper	1	General	Deposit	Unknown	--
R 200	Udeh	N 33° 32'	E 51° 51'	Molybdenum	1	General	Deposit	Unknown	--
R 209	Vardeh	N 35° 12'	E 50° 14'	Barite	1	General	Deposit	Surface	--
R 210	Varun	N 34° 02'	E 50° 31'	Lead	1	General	Deposit	Unknown	--
R 212	Veshnoveh	N 34° 13'	E 51° 00'	Copper	1	General	Deposit	Unknown	--
R 217	Zalibolagh	N 35° 09'	E 50° 52'	Copper	1	General	Deposit	Unknown	--
S 23	Baghbadran	N 32° 26'	E 51° 08'	Lead Zinc	1	General	Deposit	Unknown	--

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(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
S	50 Dareh Bid	N 32° 45'	E 51° 00'	Lead Zinc	1	General	Deposit	Unknown	--
S	69 Faridan	N 32° 59'	E 50° 24'	Iron	28	General	Deposit	Unknown	--
S	80 Golharan	N 32° 56'	E 50° 50'	Lead Zinc	1	General	Deposit	Unknown	--
S	81 Golpayegan	N 33° 27'	E 50° 17'	Lead Zinc	11	General	Deposit	Unknown	--
S	83 Gosruyeh	N 31° 55'	E 51° 49'	Lead Zinc	1,27	General	Deposit	Unknown	--
S	86 Gushfil	N 32° 25'	E 51° 49'	Lead Zinc	1	General	Deposit	Unknown	--
S	87 Gushkalat Gouskhalat	N 33° 07'	E 50° 43'	Lead Zinc	1,30	General	Deposit	Unknown	--
S	91 Hazarbisheh	N 33° 24'	E 50° 28'	Lead Zinc	1	General	Deposit	Unknown	--
S	98 Kacha East	N 32° 22'	E 51° 17'	Lead Zinc	1	General	Deposit	Unknown	--
S	99 Kacha West	N 32° 27'	E 51° 11'	Lead Zinc	1	General	Deposit	Unknown	--
S	109 Khaneh Sormeh	N 32° 43'	E 51° 17'	Lead Zinc	1,30	General	Unknown	Surf./UG	Ore replaces ls. 20 tpd in 1965. Current status unknown.
S	213 Vijin	N 32° 51'	E 51° 12'	Lead Zinc	1	General	Deposit	Unknown	--
T	12 Andakhan Ardakan	N 32° 19'	E 54° 13'	Molybdenum	1	General	Unknown	Underground	Host rock is limestone. Producer in 1965.
T	117 Khut	N 31° 50'	E 53° 49'	Copper	1,34	General	Deposit	Unknown	--
T	141 Nayin	N 32° 52'	E 53° 20'	Silver	17	General	Deposit	Unknown	1966 Info
T	142 Nodushan	N 32° 03'	E 53° 33'	Iron	51	General	Deposit	Unknown	Res: 20Mmt.

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MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
T	170	Sebarz	N 33° 10'	E 53° 39'	Copper	27	General	Deposit	Unknown	1% Cu.
T	189	Taft	N 31° 42'	E 54° 07'	Lead Zinc	27	General	Deposit	Unknown	--
T	215	Yazd	N 31° 48'	E 54° 13'	Bauxite	13	General	Deposit	Surface	District reserves 15Mmt. Metamorphosed to diaspore.
U	2	Abbaghkordieh Abbaghcordieh	N 31° 25'	E 50° 10'	Lead Zinc	30	General	Unknown	Underground	Produced 70 tpy in 1964. Ore in limestone.
U	29	Behbehan	N 30° 35'	E 50° 14'	Bauxite Phosphate	12,13	General	Deposit	Surface	--
U	42	Charam	N 30° 45'	E 50° 44'	Phosphate	58	General	Deposit	Surface	Res: 400Mmt of low grade ore.
U	61	Do-Polan	N 31° 46'	E 50° 49'	Kaolin Bauxite	1,13	General	Deposit	Surface	Lens between limestones.
U	64	Doshmanziary	N 30° 10'	E 51° 40'	Sulfur	53	General	Deposit	Surface	Res: 3.5Mmt.
U	73	Gachsaran	N 30° 12'	E 50° 47'	Phosphate	12	General	Deposit	Surface	--
U	106	Keykas	N 30° 35'	E 50° 40'	Sulfur	1	General	Deposit	Surface	--
U	108	Khanegah	N 31° 01'	E 51° 18'	Copper	1,56	General	Deposit	Unknown	--
U	128	Lakak	N 30° 57'	E 50° 09'	Strontium	1	General	Deposit	Unknown	--
U	134	Madan	N 31° 39'	E 51° 00'	Copper Cobalt	1	General	Deposit	Unknown	--
U	171	Semirom	N 31° 16'	E 51° 25'	Coal	Unpublished	General	Unknown	Unknown	Status uncertain.
U	178	Sheikhabil	N 30° 50'	E 51° 04'	Phosphate	1,13	General	Deposit	Surface	--
U	216	Zagros Mountains	N 30° 00'	E 51° 30'	Phosphate	55	General	Deposit	Surface	Res: 240Mmt @ 8.25% P2O5. Host rocks are sedimentary.
V	41	Chamessi	N 30° 20'	E 55° 07'	Copper Zinc,Lead	30,46	General	Deposit	Underground	--
V	44	Chehel Kureh	N 30° 10'	E 54° 58'	Copper Lead,Zinc	1,27	General	Deposit	Surface	--

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MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
V	78 God-E-Kolvar	N 30° 34'	E 54° 54'	Copper	27	General	Deposit	Unknown	Res(1974) 26Mmt @ 0.46-0.71% Cu.
V	95 Iju	N 30° 30'	E 54° 52'	Copper	27	General	Deposit	Unknown	--
V	126 Lachar	N 30° 25'	E 55° 04'	Copper	36,46	General	Deposit	Underground	--
V	176 Shehr-I-Babek	N 30° 07'	E 55° 07'	Copper	49	General	Deposit	Unknown	--
W	1 Ab-band	N 28° 57'	E 54° 24'	Manganese	13,24,27	General	Deposit	Unknown	Res: 100,000mt @ 25% Mn.
W	49 Darab Darabjird	N 28° 34'	E 54° 31'	Salt	17	General	Deposit	Surface	Multiple salts.
W	77 Ghuri	N 29° 31'	E 54° 29'	Salt	38	General	Deposit	Surface	Late 1600s
W	152 Qatruyeh Kutruh Kadru	N 29° 09'	E 54° 43'	Iron	17	General	Deposit	Unknown	--
X	3 Abbasabad	N 36° 21'	E 56° 23'	Copper	1,13,27	General	Deposit	Unknown	Low grade disseminated Cu. Res:(1974) 1.5Mmt @ 1.5% Cu.
Y	6 Ab-I-Kat	N 36° 31'	E 59° 08'	Coal	38	General	Deposit	Unknown	Late 1880s.
Y	133 Mashhad	N 36° 10'	E 59° 28'	Copper	13,50	General	Deposit	Unknown	Exploration work in 1970's. Res: 5Mmt.
Z	144 Now Deh	N 35° 28'	E 57° 17'	Copper	27	General	Deposit	Unknown	--
AA	196 Turbat-I-Halderi area Torbat-e Heydariyeh	N 35° 16'	E 59° 13'	Copper	38	General	Deposit	Unknown	Late 1800s.
BB	204 Unnamed	N 35° 58'	E 60° 58'	Coal	11	General	Deposit	Surface	--
BB	205 Unnamed	N 35° 21'	E 61° 02'	Coal	11	General	Deposit	Surface	--
CC	201 Unnamed	N 33° 24'	E 55° 26'	Coal	11	General	Deposit	Surface	--
DD	75 Gazu	N 33° 08'	E 57° 21'	Iron Copper	23,27	General	Deposit	Surface	0.01-2.4% Cu.
EE	32 Birjand	N 32° 53'	E 59° 13'	Alunite Magnesium	10	General	Deposit	Surface	Location approximate.

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MAP KEY (1)		NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
FF	104	Kaleh Zirl district	N 32° 10'	E 59° 50'	Copper Lead Manganese Turquoise	38	General	Deposit	Unknown	Old workings are extensive.
GG	26	Barbara	N 31° 45'	E 55° 33'	Iron	27,28	General	Deposit	Unknown	Res: 1.7Mmt @ 37% Fe.
GG	39	Chah Mileh	N 31° 37'	E 56° 00'	Lead Zinc	27	General	Deposit	Unknown	--
GG	43	Bafq	N 31° 36'	E 55° 24'	Iron	11,13,34	General	Deposit	Surface	Res: 13Mmt @ 1.12% Cu. Ore to 100m depth.
GG	67	Esfordi	N 31° 35'	E 55° 40'	Phosphate	12	General	Deposit	Surface	Probable reserves +8.5MMt.
GG	118	Kolah-Siyah	N 31° 46'	E 55° 46'	Iron	28	General	Deposit	Unknown	Res: 2.5Mmt @ 55% Fe.
GG	138	Narikan	N 31° 44'	E 55° 48'	Iron	27,28	General	Deposit	Unknown	Res: 12Mmt.
GG	165	Saghand	N 32° 18'	E 55° 31'	Uranium	58	General	Unknown	Unknown	Status unconfirmed
GG	166	Saghand	N 32° 04'	E 55° 33'	Iron	28	General	Deposit	Unknown	Res: Est. at 28Mmt @ 60% Fe.
GG	232	Zinjan	N 32° 30'	E 56° 00'	Copper Lead	38	General	Deposit	Unknown	--
HH	58	Deh Taki Deh Taqi Hizumi Pass	N 30° 42'	E 57° 01'	Coal	38	General	Deposit	Unknown	Late 1800s.
HH	221	Zarand	N 30° 49'	E 56° 36'	Coal	Unpublished	General	Deposit	Unknown	--
HH	222	Zarand East	N 30° 46'	E 56° 44'	Coal	Unpublished	General	Deposit	Unknown	--
II	24	Baluchestan district	N 28° 30'	E 60° 30'	Uranium	8	General	Deposit	Unknown	Several deposits in area.
II	88	Haij Kosteh	N 29° 39'	E 60° 55'	Copper	27	General	Deposit	Unknown	--
II	139	Nassagh-e-purchangi	N 30° 30'	E 59° 58'	Copper	13	General	Deposit	Unknown	Res: 3Mmt @ 3.8% Cu, 5.5% Pb+Zn.
II	183	Shorkuh	N 29° 39'	E 60° 55'	Copper	27	General	Deposit	Unknown	--
II	184	Showeh	N 29° 31'	E 60° 07'	Copper	27	General	Deposit	Unknown	0.4-0.8% Cu.

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MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	COMMENTS
JJ 57	Deh Siahan	N 29° 54'	E 56° 05'	Copper	27	General	Deposit	Unknown	Res(1974) 1000 mt @ 5% Cu.
JJ 123	Kuh-E-Panj	N 29° 49'	E 56° 10'	Copper	27	General	Deposit	Unknown	Res(1974) 1.1Mmt @ 1.5% Cu.
JJ 145	Palangi	N 30° 18'	E 55° 36'	Copper	27,46	General	Deposit	Surface	0.7-3.1% Cu.
KK 51	Dargaz	N 27° 50'	E 57° 57'	Iron	46	General	Deposit	Unknown	2-12% Fe in ilmenite.
KK 101	Kahnuj	N 27° 58'	E 57° 45'	Titanium	10	General	Deposit	Surface	Res: 2Mmt.
KK 120	Kuh-E-Hanzer	N 29° 01'	E 57° 25'	Copper	27	General	Deposit	Unknown	--
KK 121	Kuh-E-Lalezar	N 29° 05'	E 56° 47'	Copper	27	General	Deposit	Unknown	Res(1974) 4Mmt @ 0.4% Cu.
KK 146	Panegeen	N 29° 20'	E 57° 08'	Copper	27	General	Deposit	Unknown	--
KK 177	Sheikali	N 28° 05'	E 56° 56'	Copper	27	General	Deposit	Unknown	7.2% Cu.
LL 72	Forour	N 26° 40'	E 55° 53'	Iron	28	General	Deposit	Unknown	Res: 0.5Mmt @ 55% Fe.
LL 100	Kahmir	N 26° 57'	E 55° 36'	Gypsum Potash Sulfur	38,53	General	Deposit	Surface	Late 1800s. Expl. 1970-71.
LL 130	Larak	N 26° 52'	E 56° 22'	Iron	28	General	Deposit	Unknown	Res: 3Mmt @ 25-57% Fe.
LL 153	Qeshm	N 26° 53'	E 56° 08'	Iron	28	General	Deposit	Surface	Res: 1Mmt.

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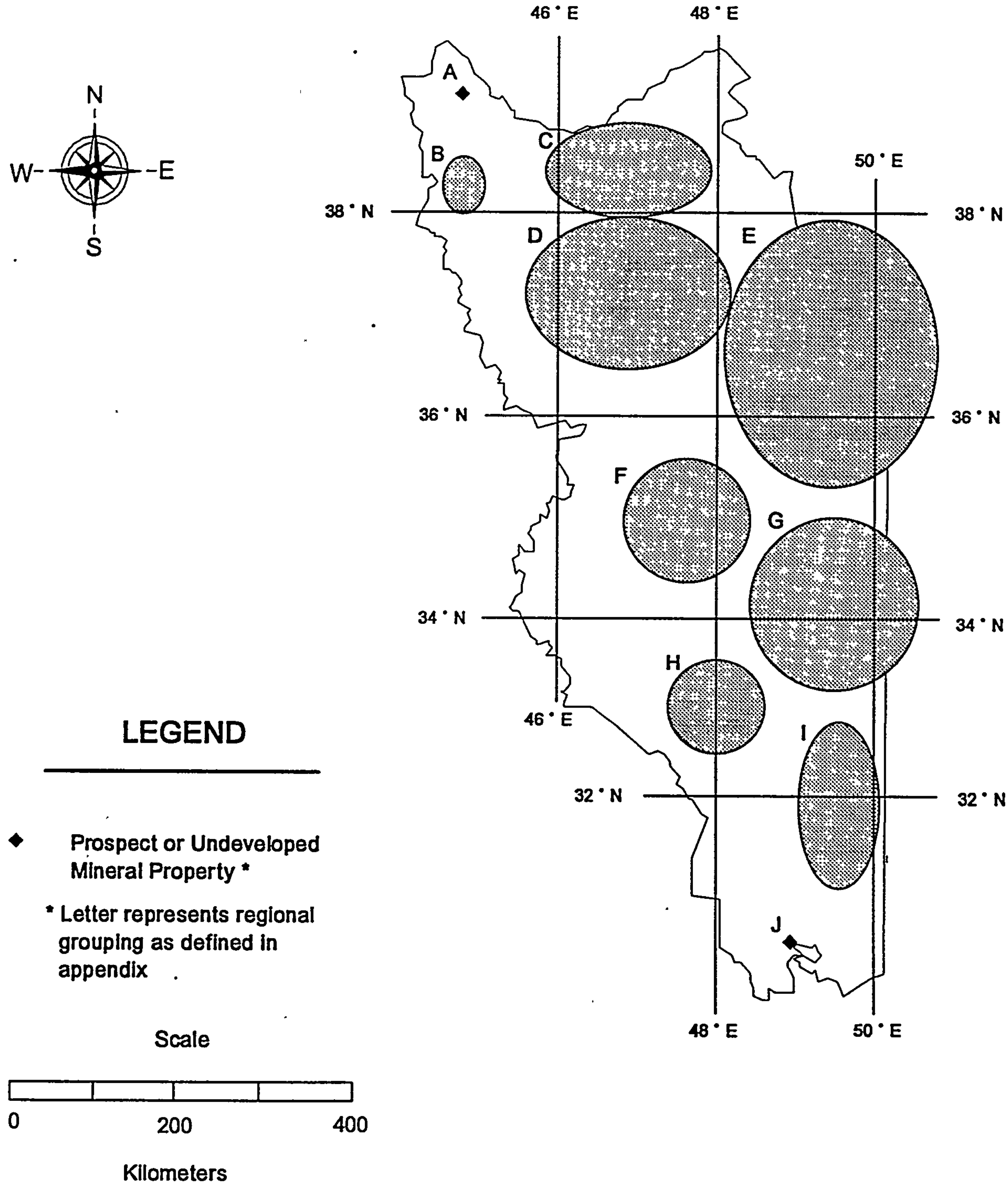
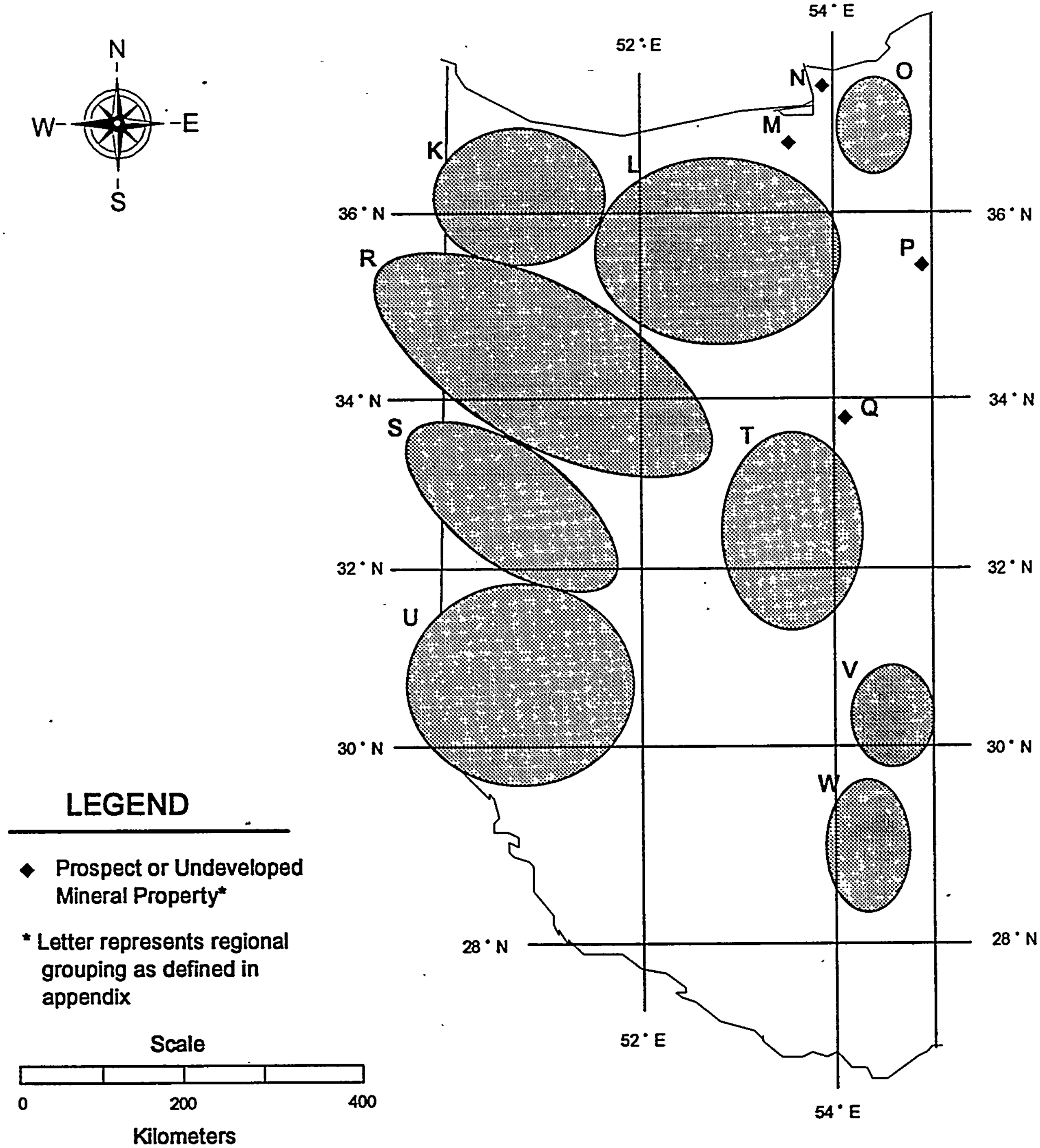
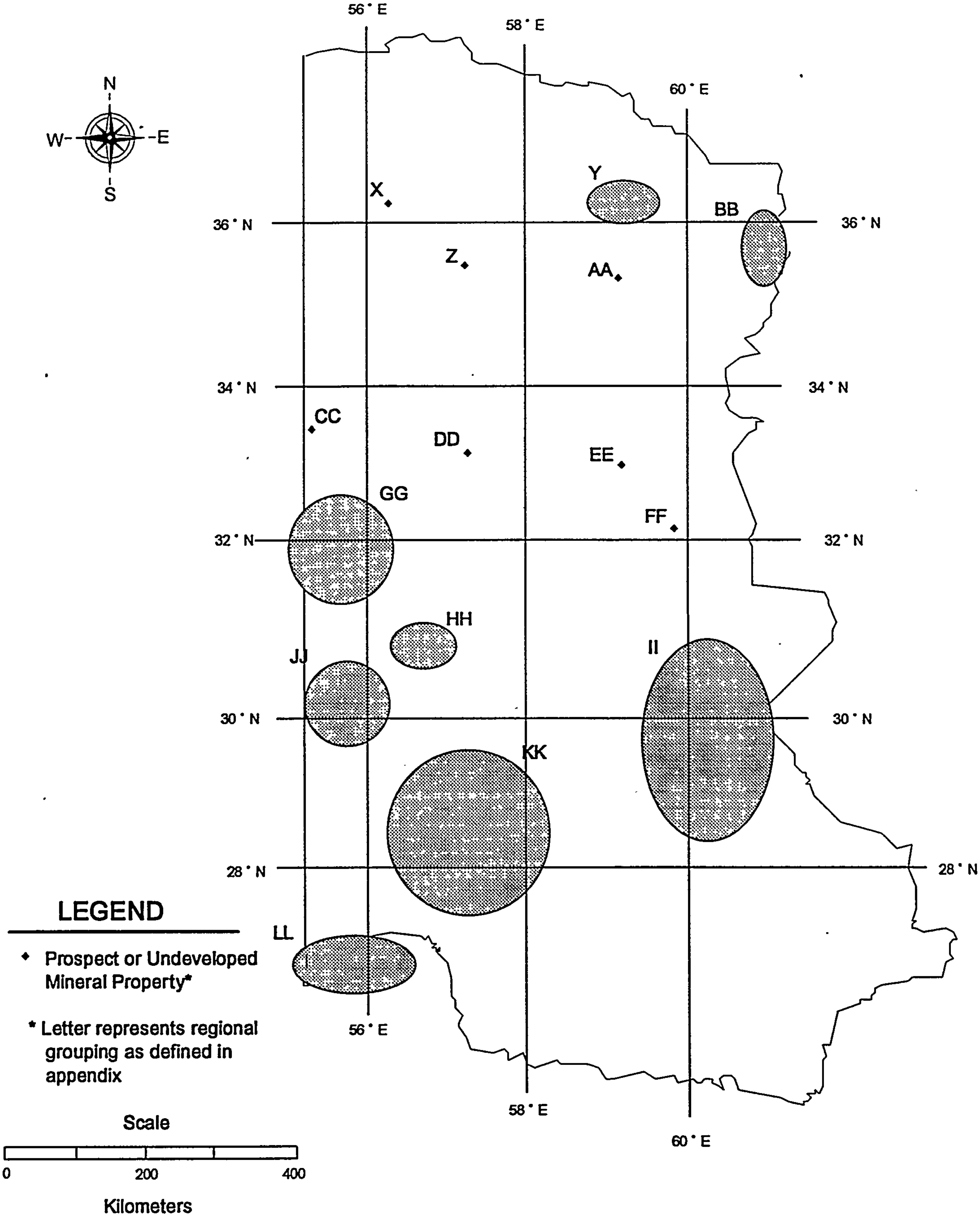


APPENDIX MAP G: PROSPECTS AND UNDEVELOPED MINERAL PROPERTIES OF WESTERN IRAN



APPENDIX MAP H: PROSPECTS AND UNDEVELOPED MINERAL PROPERTIES OF CENTRAL IRAN



APPENDIX MAP I: PROSPECTS AND UNDEVELOPED MINERAL PROPERTIES OF EASTERN IRAN

APPENDIX: PUBLIC SOURCES OF INFORMATION

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IRAQ

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TABLES

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1.0 EXECUTIVE SUMMARY

This report was prepared under Memorandum of Agreement B291534 between Lawrence Livermore National Laboratory (LLNL) and the U.S. Bureau of Mines, Minerals Availability Field Office (MAFO). It provides LLNL information on the mining industry of Iraq, and quantitative information on the blasting potential of its mining industry. MAFO identified mining activities through the use of the Minerals Availability data base, its data collection and analytic capabilities, and an extensive network of information sources.

While hydrocarbon production is the most important industry in Iraq, mining of sulfur, derived from both native sulfur and as a byproduct of petroleum and natural gas processing, phosphate, and cement is important to Iraq's economy. Mineral industry production was severely affected by the 1991 Gulf War, both as a result of direct bombing and destruction of infrastructure and supply points, and the ensuing United Nations trade embargo. Research activities resulted in the identification of 47 mineral properties. Most properties operate on a small scale and require minimal blasting. The blasting potential for 11 properties is reported.

While Iraq is limited to using internally produced explosives and technology, it possesses the raw materials, technology and facilities to manufacture blasting agents and detonation systems suitable for mining applications. The mining industry most commonly uses ammonium nitrate-fuel oil (ANFO)-based blasting agents. Blasting is generally small scale and occurs infrequently. Iraqi mineral production is mainly industrial minerals which do not require significant blasting. Estimates for daily ANFO consumption rarely exceed 25 metric tons of ANFO equivalent. The largest operation in Iraq, the Akashat phosphate mine, has an estimated maximum blasting event of 41 mt of ANFO equivalent.

1.1 Authority

This report was prepared under Memorandum of Agreement B291534 between Lawrence Livermore National Laboratory (LLNL) and the U.S. Bureau of Mines, Minerals Availability Field Office (MAFO).

1.2 Project Scope

As part of this agreement, MAFO is to identify mining activities in Algeria, Iran, Iraq, and Libya as they relate to monitoring/verifying compliance of the Comprehensive Test Ban Treaty. MAFO is to use the Minerals Availability data base, its data collection and analytic capabilities, and an extensive network of information sources to provide background information focusing on the use of explosives by the mining industry, which can cause false alarms during monitoring and hide blasting events.

Reports with accompanying figures and tables summarize location, type of mining method, commodity(ies), estimated frequency and size of mine blasts, operational status, and mine product distribution to foreign or internal markets for the specified countries.

Once country data were collected and verified, the explosive use at selected sites was evaluated. Focus was placed on a limited number of larger operations, or those reported to have potential for short-term development. Undeveloped sites and small scale mines, while included in Appendices A-B of this report, were not analyzed in terms of the site's anticipated use of explosives since mineral prospects generally make only small use of explosives and small mines (some of which are operated on an intermittent basis) are assumed to require minimal blasting application.

Based upon known site information (geological conditions, mine technology, production capacity, and current blasting practices), the blasting potential for

significant mining sites was evaluated. Where site-specific data were not available, estimates for representative, important properties were developed based upon accepted industry practice, knowledge of the Iraqi mining industry, and regional geologic characteristics.

2.0 SOURCES OF INFORMATION

Data for this report were derived from published sources, unpublished documents, and personal communications through an extensive network of public and private contacts. Public sources of information are listed at the end of Appendix B. Attempts were made to collect information at offices of agencies known to either possess this type of information or those believed to have an interest in such information.

Principal agencies contacted include, but were not limited to the U.S. Bureau of Mines, the U.S. Geological Survey, the U.S. State Department, Central Intelligence Agency, Defense Intelligence Agency, the United Nations, the World Bank, World Resource Institute, International Strategic Minerals Institute (ISMI). In addition, selected academic and industry contacts, explosives manufacturers and suppliers, and trade groups were contacted.

3.0 THE MINING INDUSTRY OF IRAQ

Until the 1970s, Iraq had few large industries apart from the petroleum industry. In recent years, greater priority has been given to industrial development. Today, while petroleum retains its key role in the Iraqi economy, it provides only a fraction of the 95% of national export revenue it generated prior to the Gulf War[1]. Production of sulfur, cement, phosphate, and urea are also important to Iraq's economy. Government reports indicate that by the end of 1993, mineral production capacity in several sectors had almost regained that of pre-1991 levels, although focus had been

[1] U.S. Bureau of Mines. The Mineral Industry of Iraq. Ch. in Minerals Yearbook 1993, by L. E. Antonides.

shifted from exports to domestic consumption. Production for export, however, continued to be limited severely by a continued United Nations embargo on any trade not required for humanitarian needs[2].

Iraq continues to be a significant producer of sulfur, derived from both native sulfur and as a byproduct of petroleum and natural gas processing, phosphate, and cement. Mineral industry production was severely affected by the 1991 Gulf War, both as a result of direct bombing and destruction of infrastructure and supply points. The economy continues to be hampered by the United Nations embargo, which requires storage of production surpluses above domestic consumption. At the present time, all exports are covert in nature; regional production must be estimated.

Only two Iraqi mines are considered major on a world scale. The Akashat phosphate mine had the capacity to produce up to 3.4M tpy of phosphate ore (1.2M tpy concentrate) prior to the war; current estimated production is less than 1M tpy of concentrate. The Mishraq sulfur mine reportedly had a capacity of 1M tpy in 1989, but is currently operating between 400,000 and 800,000 mt per year, depending on the source of information[3]. There are seven cement plants each with a limestone grinding capacity equal to or greater than 2M tpy. Other cement plants in Iraq are of a smaller scale. Iraqi mineral production estimates for 1992 and 1993 are provided in table 3.1.

The Government of Iraq retains ownership of the major mineral producing companies. Exploration is also Government controlled. Natural resources are owned by the State. In 1988, responsibility for all civilian and military industry was placed under

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[2] Ms. Jan Brown. Economic Sanctions Program Officer. U. S. Department of the Treasury. Personal communication, August 10, 1995.

[3] The 400,000 tpy production figure comes from Mining Annual Review - 1994. Iraq chapter. The 800,000 tpy figure comes from the U.S. Bureau of Mines 1993 Minerals Yearbook.

Table 3.1 -- Estimated Mineral Production in Iraq, 1992 and 1993 (Metric tons)

Commodity (1)	1992 Production	1993 Production
Cement, hydraulic	10,000,000	12,000,000
Gypsum (2)	380,000	450,000
Nitrogen: N content of ammonia	200,000	500,000
Phosphate rock, beneficiated	900,000	1,000,000
Salt	250,000	300,000
Sulfur, elemental:		
Native, Frasch	500,000	800,000
Byproduct of petroleum and natural gas	100,000	200,000

(1) In addition to the commodities listed, the following were also produced: limestone for cement (about 1.3 mt/mt of finished cement), lime and construction stone, miscellaneous construction materials (clay, sand & gravel, stone) uranium and fluorine compounds from phosphate rock processing, and various industrial sands and clays. Crude steel production is not reported here.

(2) Gypsum estimated for cement manufacture only; additional quantities are undoubtedly produced for construction applications.

the control of a single Ministry of Industry, Minerals, and Military Industrialization[4]. Government ownership was retained following the 1991 Gulf War.

All foreign trade was disrupted as a consequence of the Gulf War and the resultant U. N. embargo. Iraqi nonfuel exports in 1989 were principally sulfur, phosphate, chemical fertilizers, and petrochemicals. Principal trading partners prior to the war were the United States, Japan, Jordan, France, India, and the U.S.S.R. As a result of the war and ensuing embargo, production has shifted to rebuilding the national economy and feeding the domestic population; hence, production of cement, sulfur and phosphate is continuing at approximately the pre-war rate to supply domestic needs.

Summaries of mineral site data are provided in Appendices A-B. Data on producing sites, prospects, and undeveloped mineral occurrences are provided in tabular form. Maps showing mineral property locations are also provided in Appendix Maps A-B.

3.1 Sulfur

Sulfur is recovered from naturally occurring deposits and as a byproduct of petroleum and natural gas production. Production of sulfur and sulfuric acid was a priority prior to the war in 1991 because much of the output was exported, providing Iraq with needed revenue. Mining of sulfur began at Mishraq, south of Mosul, in 1973. Reserves at Mishraq are reported to be the largest in the world, according to the Iraqi Government[4]. Capacity was expanded until the late 1980s, reaching 1.4M tpy. In the late 1980s, Japan was providing technology to increase sulfur exports 30 percent from the 1987 level of 500,000 tpy, and increase sulfuric acid production by 10 percent annually. Iraq was also attempting to increase the rate of sulfur recovery as a byproduct of petroleum from the 1987 level of 90 percent[5]. Prior to 1991,

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[4] Europa Publications Limited. The Middle East and North Africa 1994. 40th Ed. Ch. on Iraq, p. 460.

[5] Library of Congress. Iraq - A Country Study. May. 1988, p. 149.

sulfur was exported to Jordan and Egypt. Presently, production is estimated to be running at about 60% of capacity, principally supplying the domestic fertilizer industry.

Native sulfur is found in extensive evaporite deposits between Mosul and Al Fat'ha. Sulfur occurs in cavities, fissures, and pores of limestones of the Lower Fars formation. Most sulfur is recovered by the Frasch process, in which water, pumped from the nearby Tigris River, is softened, cleaned, and heated to 180°C, then pumped into the ore bearing formation. Sulfur is dissolved in the heated solution, then pumped out of the ground and treated. At Mishraq, part of the sulfur is extracted by open pit mining using shovels and draglines. Apart from some limestone areas, little blasting is required.

Blasting is not required as part of the normal Frasch process. It should be noted, however, that hydraulic fracturing of the host rock, in order to increase rock permeability, has been used both in the sulfur and oil and gas industries of Iraq. Fracturing occurs when a sand-water mixture is pumped into the rock under pressure. An area that has been impregnated in such a manner requires a considerably smaller quantity of explosives to blast a given volume of rock than an untreated area.

Sources indicate that testing was conducted in the 1960s and 1970s to determine the benefit of using a combination of blasting and hydraulic fracturing to increase rock breakage. If that process is still used at Mishraq, it would be reasonable to expect the blasting signature to be different from a typical blasting signature of limestone.

Two plants have recovered sulfur as a byproduct from petroleum and natural gas.

The plant at Kirkuk (north-central Iraq) has the capacity to recover approximately 200,000 tpy of sulfur as a byproduct of natural gas with a H_2S content of 7-8%. The extraction plant at Baiji (central Iraq) also has the capacity to extract approximately 200,000 tpy of sulfur as a byproduct from oil and gas operations. Both plants sustained war damage; it is not known at what level these plants are currently operating.

3.2 Phosphate

Phosphate has been produced at the Akashat mine in western Iraq (near the Syrian border) since 1982. Ore is transported 3 km to an on-site crusher, then shipped by rail to the Al Qaim fertilizer plant approximately 150 km northeast of the mine. Ore occurs in two phosphate bearing horizons, each approximately 10m thick. Overburden averages 10.5m; the two beds are separated by a 10m bed of limestone. Ore averages 20-25% P_2O_5. Blasting is required; a stripping ratio of 1:1 has been reported for each bed. Open pit mining using draglines, power shovels, and front end loaders is employed. Mine production capacity has achieved up to 3.4Mmt of ore, producing 1.2M tpy of beneficiated phosphate rock. Reported 1993 production in Iraq was 1M tpy of beneficiated phosphate rock at the Al Qaim plant. Phosphate rock resources are large and grades are in the 20% to 30% P_2O_5 range, but many prospective areas have yet to be explored fully.

All phosphate ore is treated at the Al Qaim plant. After plant construction in 1984, Iraq became self-sufficient in fertilizer production. Approximately 64% of plant production of 1,140,000 mt was exported in 1989. The plant was scheduled for expansion prior to the Gulf War, and was targeted during the war. The Al Qaim plant was damaged, but the extent of damage has not been documented. By 1993, however, the plant was reported to be operating at a 1M tpy level. Approximately 85% of available capacity is producing phosphate for the domestic fertilizer industry. With the current embargo on exports from Iraq, it is not known how much excess material is being stockpiled for future export.

3.3 Cement

Cement production in Iraq in 1993 reportedly had regained the 1989 level of 12M tpy as the country attempted to rebuild from the Gulf War. Production is designed to meet the needs of the domestic construction industry. Several cement plants near Baghdad were damaged or destroyed in 1991. Current plant operating levels are such that the industry was able to produce at the 1989 level.

Most cement production is centered in northern Iraq around Mosul and in central Iraq between Baghdad and Samawa. Iraq has seven cement plants that are operating at or above the 2M tpy of kiln capacity; moderate by world standards. The largest facility is at Samawa, about 230 km south of Baghdad. Since a typical cement plant requires approximately 1.3 mt of limestone to produce 1 mt of cement, a 2M tpy plant would typically consume 2.6M tpy of limestone from nearby deposits.

As with the other countries in the Middle East, limestone extraction is generally conducted at small scale open pit operations requiring minimal blasting. For the purpose of this study, it is assumed that each cement plant listed in the appendices is fed from nearby limestone deposits. Specific information on limestone occurrences is not available. In addition to the seven plants mentioned above, Iraq also has a number of smaller plants supplying domestic needs.

During the 1980s, Iraq exported significant quantities of cement, although the majority of cement production was for domestic purposes. Principal trade partners were Egypt, India, Brazil, Yemen, the U.S.S.R. and Spain. With the present need to rebuild after the 1991 war, Iraq has focused production on supplying the domestic construction industry. With the trade embargo firmly in place, it can be expected that about 95% of production is used domestically[6].

[6] L. E. Antonides, U. S. Bureau of Mines Commodity Specialist, Washington, D.C. Personal communication, 8/9/95.

3.4 Other minerals

Iraq also produces small quantities of gypsum, nitrogen, urea, and salt for domestic use. Production is considered small on a world scale. While little is known of Iraq's future mineral potential, it is assumed that resources remain largely untapped. They have not been developed as they are not outstanding in terms of quantity or quality, they are located in remote regions with little developed infrastructure, and the Government currently lacks international capital and markets. Production is limited, small scale, technologically simple, and is marketed locally. Blasting is generally not required or is considered insignificant.

4.0 MINE-RELATED EXPLOSIVES USE

Almost all mines use explosives to fragment or loosen rock and consolidated material prior to excavation. Bulk or packaged explosives and blasting agents are detonated after emplacement in material to be excavated. Minor quantities of sachet and shaped charges may be used for secondary breakage and other special applications.

The type and amount of explosives used are influenced by the nature of the rock or ore, the mining methods employed, the production rate of the mine, the type and availability of explosives and detonation systems, hydrologic conditions, mining equipment, drilling equipment, mine geometry, level of technical expertise, and external constraints such as the proximity of residences, availability of explosives, and available funding. At almost any mine, the size of each blast can vary significantly due to local conditions, production schedules, weather, etc.

Surface mines typically shoot much larger blasts than underground operations and tend to have higher production rates than underground mines. In addition, limitations of working room, limited free faces, ventilation requirements, and drilling limitations may constrain maximum blast sizes in underground mines.

Iraq is limited to internally produced explosives, but has ample raw materials to produce what it needs. Currently the United States and other United Nation countries impose a total commercial and financial trade ban on Iraq[2]. While these restrictions have limited recent industrial development, export markets, and acquisition of foreign capital, they do not appear to represent an impediment to Iraq's mining sector. As the recent Gulf War demonstrated, Iraq has the military-related technology and facilities to manufacture blasting agents and detonation systems suitable for most mining applications.

Where blasting is required, most Iraqi mines use ammonium nitrate-fuel oil (ANFO) blasting agents. This may include some of the newer emulsion and/or aluminum boosted products presently available. ANFO systems are preferred in most mining applications due to their ease of manufacture, low cost, inherent safety, and bulk loading advantages. High explosives, however, would be preferable for small underground operations that use drill sizes that are below the critical diameter needed for emplacing ANFO blasting agents, or under wet conditions, in methane-rich atmospheres, and conditions that require higher detonation velocities and/or convenience of packaged explosives.

Blasting assumptions used in this report are based upon engineering judgment; explosive use can vary considerably as mining conditions change. ANFO consumption was assumed to be dependent upon mine production rate, average stripping ratio, specific gravity of the host rock, assumed powder factor limits, and mining method. Only a small number of mines in Iraq require blasting. In most cases, site-specific blasting information was unavailable. Consequently, estimates were based upon known or estimated production rates, mine geology, mining systems, and typical mining practices. Experience, engineering judgement, and available data were incorporated into calculations and estimates.

For each site, a stripping ratio (Quantity of overburden removed per mt of ore mined) and powder factor (Quantity of rock blasted per unit of ANFO blasting agent equivalent) limits were estimated. A range of ANFO consumption was calculated for both daily blasting requirements and for an assumed maximum blasting event. Daily ANFO requirements were estimated assuming a 215 day production schedule, with exception of the Akashat mine, which is believed to operate on a 330 day schedule. Consumption estimates for all sites were calculated in a similar manner. The lower consumption value applies a minimum powder factor while the higher value assumes a maximum powder factor. Unlike daily consumption estimates, a maximum blasting event would not take place on a daily basis. For this study, it was assumed that a maximum blasting event could occur every 10 working days for a surface mine and every 5 working days for an underground mine. Such events are designed to account for such factors as blasting delays, geological irregularities, and mining method variations that require a higher ANFO consumption than the typical blasting event. Mine development or pillar extraction conditions, for example, often require larger blasts.

The following examples illustrate typical blasting calculations using the estimation procedure described above:

<u>Akashat ANFO consumption lower limit (L):</u>

L = Production rate * [1 + (stripping ratio * specific gravity of waste)] * [Low powder factor / 1000 (converts kg to mt)] / Operating days per year

L = 3,400,000 * [1 + (0.4 * 2.5)] * [0.11 / 1000] / 330

L = 2.27   2 mt ANFO equivalent (Rounded to nearest unit)

<u>Akashat ANFO consumption higher limit (H):</u>

H = Production rate * [1 + (stripping ratio * specific gravity of waste)] * [High powder factor / 1000 (converts kg to mt)] / Operating days per year

L = 3,400,000 * [1 + (0.4 * 2.5)] * [0.20 / 1000] / 330

L = 4.12   4 mt ANFO equivalent (Rounded to nearest unit)

Akashat maximum blasting event ANFO consumption (M):

M = Production rate * [1 + (stripping ratio * specific gravity of waste)] * [High powder factor / 1000 (converts kg to mt)] / Operating days per year * maximum blast cycle time (working days between blasting events)

M = [3,400,000 * [1 + (0.4 * 2.5)] * [0.20 / 1000] / 330] * 10

M = 41.21   41 mt ANFO equivalent (Rounded to nearest unit)

Table 4.1 provides the corresponding blasting range estimates for the main Iraqi mines identified in this study. The two principal mining sites, the Akashat phosphate mine and the Mishraq sulfur mine, are both considered surface mines for this analysis. The Akashat employs typical open pit mining techniques and requires blasting of both ore and overburden. A maximum blasting event of 41 mt of ANFO equivalent has been estimated.

The Mishraq mine is mined partially by the Frasch process, which is an auger mining method typically not requiring blasting. The Iraqis are reported using a variation on this method which includes selected blasting and Frasch drilling. An area that has been impregnated in such a manner requires a considerably smaller quantity of explosives to blast a given volume of rock than an untreated area. For this reason, limited explosive usage has been assumed for this site. A maximum blasting event of 17 mt of ANFO equivalent has been estimated. Blasting requirements for both principal mining sites are considered small scale, based on world standards.

The explosive potential required at limestone quarries in Iraq is also considered small on a world scale. The range of a typical blasting event for the larger Iraqi sites is 20-40 mt of ANFO equivalent.

Table 4.1–Estimated Explosives Usage at the Main Iraqi Mines Used in this Study in Order of Estimated ANFO Consumption

Mine	Latitude	Longitude	Primary Product	Mine Type (1)	Production (Mmt/yr) (2)	Daily Consumption (mt ANFO) (3 (4) Low	High	Maximum Blast Cycle Time (days) (5)	Maximum Blasting Event (mt ANFO)
Akashat	N 33° 40'	E 39° 55'	Phosphate	S	3.400	2	4	10	41
Samawa	N 31° 12'	E 45° 00'	Limestone	S	4.100	2	4	10	38
Sinjar	N 36° 22'	E 42° 00'	Limestone	S	2.640	1	2	10	25
Tasluja	N 35° 35'	E 45° 23'	Limestone	S	2.640	1	2	5	25
Karbala	N 32° 45'	E 44° 17'	Limestone	S	2.640	1	2	10	25
Kubaysah	N 33° 35'	E 42° 37'	Limestone	S	2.340	1	2	10	22
Al Tamin	N 35° 26'	E 44° 11'	Limestone	S	2.340	1	2	10	22
Kufa	N 32° 00'	E 44° 25'	Limestone	S	2.220	1	2	10.	21
Badoosh	N 36° 30'	E 43° 20'	Limestone	S	1.900	1	2	10	18
Mishraq (4)	N 36° 00'	E 43° 20'	Sulfur	S	1.400	1	2	10	17
Al Qaim	N 34° 23'	E 41° 05'	Limestone	S	1.320	0.7	1.2	10	12

(1) S–Surface
(2) Mmt/yr–Million metric tons per year
(3) mt ANFO–Metric tons of Ammonium Nitrate/Fuel Oil blasting agent equivalent
(4) Only small amount of ore is mined by surface methods; most ore recovered by Frasch process, which normally does not require blasting.

5.0 CONCLUSIONS

The mining industry of Iraq recovers industrial minerals from sedimentary host rocks usually requiring a limited amount of blasting. The largest Maximum Blasting Event in Iraq should be on the order of 40 mt ANFO equivalent. Should events greater that this be detected, they are most likely not due to mining.

APPENDICES

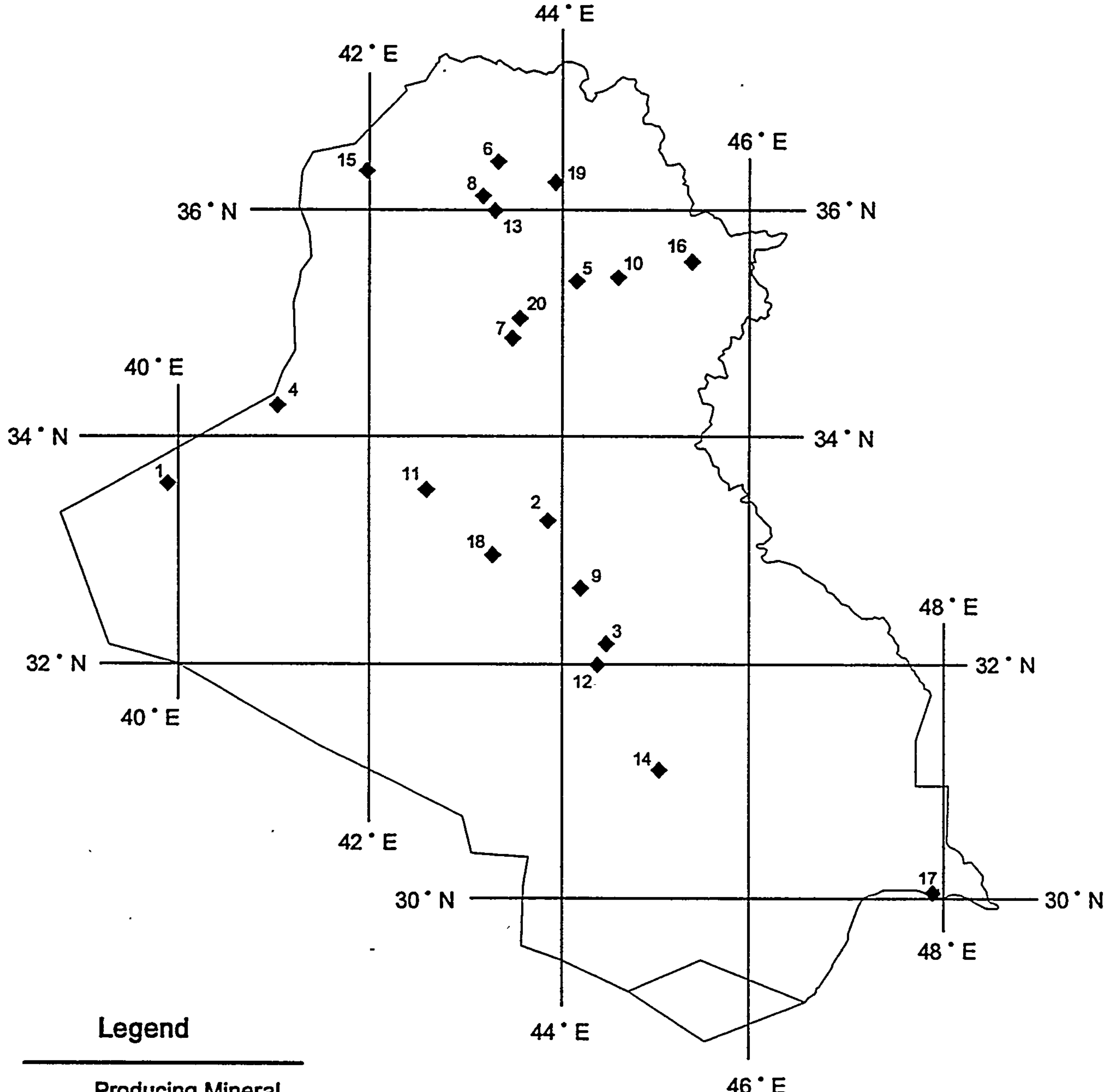
APPENDIX A: PRODUCING MINERAL PROPERTIES IN IRAQ

MAP KEY	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES	DATA REFIANCE	STATUS	MINE TYPE	MARKETS	COMMENTS
1.	Akashat (Akashatt)	N 33° 40'	E 39° 55'	Phosphate	1,5,6,8,9,13,16,17	Confirmed	Producer	Surface	64% exported In 1989.	3.5M tpy crude ore. 1.2M tpy beneficiated phosphate rock. Ore depth 10.5m. Limestone overburden. Opened In 1981. Res: 450Mmt @ 21% P2O5 (1981). Ore transported 3km to crusher, then shipped 150km by rail to Al Qalm. Ore mined from 2 beds, each 10m thick. Top bed mined first, then lower bed mined. Both overburden and ore require blasting. Each of two pits mined by 25m benches. Overburden removed by 8 cu. yd. dragline. Ore by shovels or front-end loaders. Stripping ratio approx.1:1 waste:ore for each bed.
2.	Al Falluja	N 33° 22'	E 43° 53'	Cement	18	General	Producer	Surface	Domestic	Ls cap: 290,000 tpy. Kiln cap: 240,000 tpy. Second plant closed after 1991. Began operations 1975.
3.	Al Kufah	N 32° 10'	E 44° 33'	Salt	19,21	General	Producer	Surface	Domestic	Prod: Est. to be 300,000 tpy.
4.	Al Qaim Al Khaim	N 34° 23'	E 41° 05'	Cement Fertilizer	8,9,17	General	Producer	Surface	Exported	Ls cap: 1.32M tpy. Kiln cap: 1.0M tpy. Began operations in 1988.
5.	Al Tamin	N 35° 26'	E 44° 11'	Cement	18	General	Producer	Surface	Domestic	Ls cap: 2.34M tpy. Kiln cap: 2.0M tpy. Began operations in 1984.
6.	Badoosh	N 36° 30'	E 43° 20'	Cement	22	General	Producer	Surface	Domestic	Ls cap: 1.9M tpy. Kiln cap: 1.9M tpy. Began operations in 1978.
7.	Baiji	N 34° 56'	E 43° 29'	Sulfur	4	General	Producer	Well	Domestic Exported	200,000 tpy extraction plant.
20.	Fatha Makhul	N 35° 06'	E 43° 30'	Sulfur	1,4	General	Producer	Surface	Unknown	Near Mishraq Open-pit methods
8.	Hamman al'Alil	N 36° 10'	E 43° 12'	Cement	18	General	Producer	Surface	Domestic	Ls cap: 690,000 tpy. Kiln cap: 640,000 tpy. Began operations 1963.

(1) Represents property or property grouping as defined on Appendix Map A.
(2) Complete list of data sources found at end of appendix.
(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.

MAP KEY	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES	DATA REFIANCE	STATUS	MINE TYPE	MARKETS	COMMENTS
9.	Karbala Hindiyah	N 32° 45'	E 44° 17'	Cement	1,18	General	Producer	Surface	Exported to Spain 1989.	Ls cap: 2.64M tpy. Kiln cap: 2.0M tpy. Began operation 1984.
10.	Kirkuk	N 35° 28'	E 44° 28'	Natural gas Sulfur	4,8	General	Temp. closure	Well	Domestic Exported	150,000 tpy extraction plant. Closed due to war damage. Res: 25-30 Mmt @ 7-8% H2S (1971).
11.	Kubaysah Kubaisa	N 33° 35'	E 42° 37'	Cement	18	General	Producer	Surface	Domestic	Ls cap: 2.34M tpy. Kiln cap: 2.0M tpy. Began operations 1983.
12.	Kufa	N 32° 00'	E 44° 25'	Cement	18	General	Producer	Surface	Domestic	Operation has two plants. Total ls cap: 2.22M tpy. Total kiln cap: 1.97M tpy. Plant 1 began in 1974; plant 2 in 1977.
13.	Mishraq Ash Shurah	N 36° 00'	E 43° 20'	Sulfur	1,4,8,9,13,14,17	Confirmed	Producer	Surface	85% exported in 1988 Processed at Al Qaim plt. 50,000 mt to Jordan. Exp. to Egypt	In 1993, estimated production was 800,000 tpy. Site bombed in Gulf War Mining method: open-pit & Frasch process. Prod. 1.4M tpy if bituminous phosphates included. Location 40km from Mosul. Res: 245Mmt @ 21.65% S (1985). Operation began 1973.
14.	Samawa	N 31° 12'	E 45° 00'	Cement	18	General	Producer	Surface	Exported to Spain 1989.	Site consists of two plants. Total ls cap: 4.14M tpy. Total kiln cap: 3.35M tpy. Plant 1 began in 1957; plant 2 in 1986.
15.	Sinjar	N 36° 22'	E 42° 00'	Cement	8,18	General	Producer	Surface	Domestic	Ls cap: 2.64M tpy. Kiln cap: 2.0M tpy. Began operation in 1985.
16.	Tasluja	N 35° 35'	E 45° 23'	Cement	22	General	Producer	Surface	Domestic	Ls cap: 2.64M tpy. Kiln cap: 2.0M tpy. Began operations in 1984.
17.	Umm Qasr	N 30° 02'	E 47° 56'	Cement	18	General	Producer	Surface	Exported to Brazil, North Yemen 1989.	Ls cap: 450,000 tpy. Kiln cap: 450,000 tpy. Began operations in 1987.
18.	Unnamed	N 33° 00'	E 43° 20'	Gypsum	19,21	Gypsum	Producer	Surface	Domestic	Cap: Est. to be 300,000 tpy.
19.	Unnamed	N 36° 18'	E 43° 58'	Gypsum	19,21	Gypsum	Producer	Surface	Domestic	Cap: Est. to be 300,000 tpy.

(1) Represents property or property grouping as defined on Appendix Map A.
(2) Complete list of data sources found at end of appendix.
(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.



Legend

◆ Producing Mineral Property*

* Number represents property as defined in Appendix A.

Scale

0 100 200 300

Kilometers

N

W- -E

S

Appendix Map A: Producing Mineral Properties of Iraq

APPENDIX B: PROSPECTS AND UNDEVELOPED MINERAL PROPERTIES IN IRAQ

MAP KEY	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES	DATA REFIANCE	STATUS	MINE TYPE	MARKETS	COMMENTS
C	21. Ari	N 37° 05'	E 44° 35'	Copper	1	General	Deposit	Unknown	NAp(4)	Site not confirmed.
	22. Asnawa	N 35° 37'	E 45° 48'	Iron	1	General	Deposit	Surface	NAp	Ore reportedly high in magnetite.
C	23. Bard-I-Zard	N 36° 44'	E 44° 48'	Chromium	1	General	Deposit	Unknown	NAp	Site not confirmed.
	24. Berzanik	N 37° 20'	E 42° 48'	Lead Zinc	1	General	Deposit	Unknown	NAp	Site not confirmed.
C	25. Derband	N 36° 45'	E 44° 52'	Iron	1	General	Deposit	Surface	NAp	Ore reportedly high in magnetite.
	26. Duri	N 37° 12'	E 43° 27'	Lead Zinc	1	General	Deposit	Unknown	NAp	Site not confirmed.
A	27. Ga'Ara 1	N 33° 33'	E 40° 38'	Iron	1,6	General	Deposit	Surface	NAp	Regional res. 2.6Mmt @ 35% Fe.
A	28. Ga'Ara 2	N 33° 17'	E 40° 46'	Iron	1,6	General	Deposit	Surface	NAp	Regional res. 2.6Mmt @ 35% Fe.
	29. Gara Mtns	N 37° 00'	E 43° 50'	Uranium	1	General	Unknown	Underground	NAp	Site not confirmed.
C	30. Hero	N 36° 07'	E 45° 15'	Copper	1	General	Deposit	Unknown	NAp	Site not confirmed.
A	31. Hussayniya Husseiniat	N 33° 17'	E 40° 56'	Iron	6,15	General	Deposit	Surf./UG	NAp	Res: 25Mmt @ 25% Fe, 32% SiO2. Minor prod. has occured, but ore reportedly too poor to be economic.
B	32. Jawan	N 35° 58'	E 42° 59'	Sulfur	4	General	Deposit	Surface	NAp	Deposit est. at 10 sq. km surface area.
C	33. Jebel Kalandur	N 36° 45'	E 44° 29'	Copper	1	General	Deposit	Unknown	NAp	Site not confirmed.
	34. Kani-Mangi	N 35° 38'	E 45° 53'	Chromium	1	General	Deposit	Unknown	NAp	Site not confirmed.
C	35. Konjrin	N 35° 54'	E 45° 23'	Copper	1	General	Deposit	Unknown	NAp	Site not confirmed.
B	36. Lazzage Lazzaqa	N 36° 13'	E 43° 10'	Sulfur	1,4	General	Deposit	Surface	NAp	--
C	37. Marapasta	N 36° 30'	E 45° 03'	Zinc Lead	1	General	Deposit	Unknown	NAp	Site not confirmed.
A	38. Marbat	N 33° 40'	E 40° 17'	Phosphate	6,8	General	Deposit	Surface	NAp	Near the Akashat Mine.

(1) Represents property or property grouping as defined on Appendix Map B.
(2) Complete list of data sources found at end of appendix.
(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.
(4) NAp - Not applicable; prospects and undeveloped deposits have no current markets.

MAP KEY	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES	DATA REFIANCE	STATUS	MINE TYPE	MARKETS	COMMENTS
	39. Mishaw	N 35° 46'	E 46° 16'	Copper	1	General	Deposit	Unknown	NAp	Site not confirmed.
B	40. Qalian	N 36° 08'	E 43° 14'	Sulfur	4	General	Deposit	Surface	NAp	4-26% S between 28-180m.
C	41. Qandil	N 36° 37'	E 44° 54'	Copper	1	General	Deposit	Unknown	NAp	Site not confirmed.
B	42. Qasab	N 35° 49'	E 43° 19'	Sulfur	4	General	Deposit	Surface	NAp	Three zones between 37-87m.
C	43. Qulqula	N 35° 56'	E 44° 46'	Manganese	1	General	Deposit	Unknown	NAp	Site not confirmed.
	44. Serguza	N 37° 12'	E 43° 31'	Lead Zinc	1	General	Deposit	Unknown	NAp	Site not confirmed.
C	45. Sersshiw	N 35° 57'	N 45° 29'	Asbestos	1	General	Deposit	Unknown	NAp	Site not confirmed.
C	46. Sheina Sheikhan	N 36° 47'	E 44° 35'	Chromium	1	General	Deposit	Unknown	NAp	Site not confirmed.
C	47. Spidarah	N 36° 32'	E 44° 53'	Copper	1	General	Deposit	Unknown	NAp	Site not confirmed.

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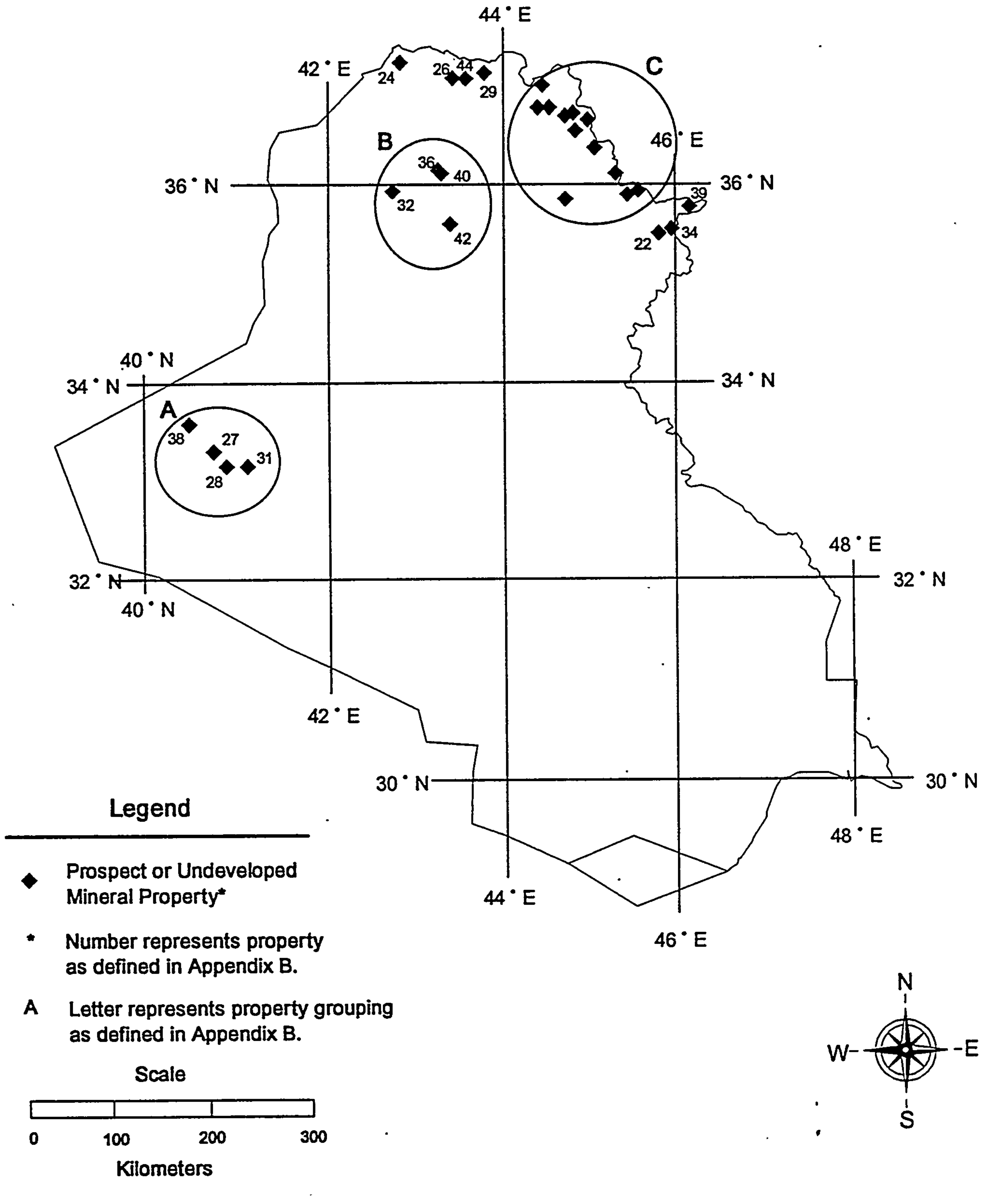
(1) Represents property or property grouping as defined on Appendix Map B.
(2) Complete list of data sources found at end of appendix.
(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.
(4) NAp - Not applicable; prospects and undeveloped deposits have no current markets.



Appendix Map B: Prospects and Undeveloped Mineral Properties of Iraq

APPENDIX: PUBLIC SOURCES OF INFORMATION

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4. British Sulphur, Ltd. World Survey of Sulphur Resources. 3rd Ed., 1985, pp. 181-184.
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15. United Nations. Report on Mission - Iraq. Mar. 31, - Apr. 7, 1979, by J. W. E. Van de Graaff.
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17. U. S. Bureau of Mines. Minerals Availability Data Base, June 1995.
18. U. S. Bureau of Mines. The Mineral Industry of Iraq. G. A. Morgan. Ch. in Minerals Yearbook 1989, Vol. III, pp. 25-28.
19. U. S. Bureau of Mines. The Mineral Industry of Iraq. L. E. Antonides. Ch. in Minerals Yearbook 1991, Vol. III, pp. 31-32.
20. U. S. Bureau of Mines. Sulfur. Ch. in Mineral Commodity Summaries. Jan. 1995, p. 167.
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LIBYA

Table of Contents

1.0 EXECUTIVE SUMMARY

This report was prepared under Memorandum of Agreement B291534 between Lawrence Livermore National Laboratory (LLNL) and the U.S. Bureau of Mines, Minerals Availability Field Office (MAFO). It provides LLNL information on the mining industry of Libya, and quantitative information on the blasting potential of its mining industry. MAFO identified mining activities through the use of the Minerals Availability data base, its data collection and analytic capabilities, and an extensive network of information sources.

Apart from hydrocarbons, mineral production in Libya is negligible. Mining activity is currently confined to salt harvesting from coastal areas, quarrying of clay, gypsum, and limestone, and cement and ammonia production. Research activities resulted in the identification of 61 mineral properties. Most properties operate on a small scale and require minimal blasting. The blasting potential for 5 properties is reported.

Libya is limited to using internally produced explosives or imports not restricted by trade policies. While it possesses the technology and facilities to manufacture blasting agents and detonation systems suitable for mining applications, acquisition of needed raw materials is hindered by trade and transport restrictions. The mining industry most commonly uses ammonium nitrate-fuel oil (ANFO)-based blasting agents.

Blasting is generally small scale and occurs infrequently. Libyan mineral production is mainly industrial minerals which do not require significant blasting. Estimates for daily ANFO consumption rarely exceed 10 metric tons of ANFO equivalent. Even if the Wadi Ash Shatti iron deposit were to be developed, estimated ANFO consumption for a maximum blasting event would not exceed 60 mt ANFO equivalent.

1.1 Authority

This report was prepared under Memorandum of Agreement B291534 between Lawrence Livermore National Laboratory (LLNL) and the U.S. Bureau of Mines, Minerals Availability Field Office (MAFO).

1.2 Project Scope

As part of this agreement, MAFO is to identify mining activities in Algeria, Iran, Iraq, and Libya as they relate to monitoring/verifying compliance of the Comprehensive Test Ban Treaty. MAFO is to use the Minerals Availability data base, its data collection and analytic capabilities, and an extensive network of information sources to provide background information focusing on the use of explosives by the mining industry, which can cause false alarms during monitoring and hide blasting events.

Reports with accompanying figures and tables summarize location, type of mining method, commodity(ies), estimated frequency and size of mine blasts, operational status, and mine product distribution to foreign or internal markets for the specified countries.

Once country data were collected and verified, the explosive use at selected sites was evaluated. Focus was placed on a limited number of larger operations, or those reported to have potential for short-term development. Undeveloped sites and small scale mines, while included in Appendices A-B of this report, were not analyzed in terms of the site's anticipated use of explosives since mineral prospects generally make only small use of explosives and small mines (some of which are operated on an intermittent basis) are assumed to require minimal blasting application.

Based upon known site information (geological conditions, mine technology, production capacity, and current blasting practices), the blasting potential for

significant mining sites was evaluated. Where site-specific data were not available, estimates for representative, important properties were developed based upon accepted industry practice, knowledge of the Libyan mining industry, and regional geologic characteristics.

2.0 SOURCES OF INFORMATION

Data for this report were derived from published sources, unpublished documents, and personal communications through an extensive network of public and private contacts. Public sources of information are listed in Appendices A - B. Attempts were made to collect information at offices of agencies known to either possess this type of information or those believed to have an interest in such information.

Principal agencies contacted include, but were not limited to the U.S. Bureau of Mines, the U.S. Geological Survey, the U.S. State Department, Central Intelligence Agency, Defense Intelligence Agency, the United Nations, the World Bank, World Resource Institute, International Strategic Minerals Institute (ISMI). In addition, selected academic and industry contacts, explosives manufacturers and suppliers, and trade groups were contacted.

3.0 THE MINING INDUSTRY OF LIBYA

Libya is not rich in mineral resources. Like other Middle Eastern countries, Libya's economy is maintained largely by mineral fuels production. Crude oil accounted for more than 95% of Libyan exports prior to the U.N. embargo of 1993[1]. Major trading partners at that time were Italy, Germany, and Spain. Partially as a result of the embargo and current low oil prices[2], current mining activity in Libya is limited. Plans for reviving the economy include two projects of note. The Great Man-Made River project is intended to transport artesian water from the Fezzan region in

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[1] U.S. Bureau of Mines. Minerals Yearbook 1993. Ch. on Libya.

[2] Mr. David Fetter, Libyan Desk Officer, U.S. State Department. Personal communication, May 15, 1995.

western Libya to coastal Libya. While this is not a mining project, blasting will be necessary to construct the 1900 km pipeline for this huge undertaking. Additional production of industrial minerals and cement will be required to support this project.

Plans also call for an expansion to the Misurata steel complex on the northern coast of Libya. The plant began production in 1989 using imported iron ore, and is reported to be currently operating at about 2/3 of its current 1.2M tpy steel production capacity. Most of the steel is exported to Egypt. Expansion plans call for the construction of a 650,000 tpy direct reduction plant. The majority of the new production would be shipped to Italy and Spain. If funding can be secured, plans also call for the construction of a 900 km railway to be built, linking the Wadi Ash Shatti iron ore deposits in the Fezzan region to Misurata. Such a construction project is also expected to require blasting in some areas of the route.

Current mining activity is confined to salt harvesting from coastal areas, quarrying of clay, gypsum, limestone, building stone, and scattered cement and ammonia production. Production is not large on a worldwide basis, and is mainly used for domestic purposes. Libya also possesses small resources of phosphate rock, manganese, barite, celestite, sulfur and alum. Libyan mineral production statistics for 1992 and 1993 are provided in Table 3.1.

The Libyan Government retains control over the mining and mineral processing industries. Generally, petroleum exploration and production sharing, along with any proposed mining activities, are governed by the Fiscal Provisions, Revenue, and Financial Law of 1977. In 1988, this legislation was revised allowing exploration costs to be recovered from output with development costs to be split equally between the foreign operator and Libyan interests[3]. Countries with mining

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[3] U.S. Bureau of Mines. Minerals Yearbook 1993. Ch. on Libya.

Table 3.1—Estimated Mineral Production in Libya, 1992 and 1993 (Metric tons)

Commodity(1)	1992 Production	1993(e) Production
Cement, hydraulic	2,300,000	2,300,000
Gypsum	180,000	180,000
Iron and steel:		
Direct–reduced iron	850,000	944,000
Crude steel	822,000	920,000
Lime, hydraulic	260,000	260,000
Nitrogen: N content of ammonia	347,000	350,000
Salt	12,000	12,000
Sulfur: Byproduct of petroleum	14,000	14,000

Source: U. S. Bureau of Mines. Minerals Yearbook, 1993.

(e) Estimated
(1) In addition to the commodities listed, a variety of construction stone, brick, and tile was produced. Petroleum and mineral fuels are excluded from this table.

interests in Libya include Benin, Ethiopia, Ghana, Guinea, Jordan, and Mauritania. In addition, other trading partners include Italy, Germany, and Spain, which have traditionally relied heavily on Libyan oil.

At present, there are a number of trade sanctions in effect against Libya that impact the mining industry[4]. All commercial or financial transactions with the United States are currently prohibited. In addition, the United Nations resolutions of 1993 call for the ban of oil-related equipment, aviation restrictions, the curtailment of arms and military equipment sales to Libya, and the freezing of certain Libyan assets. Such restrictions have had an impact on foreign investment within the country and Libya's ability to maintain a mining exploration and development program.

Summaries of mineral site data are provided in Appendices A-B. Data on producing or developing mineral deposits, and prospects and undeveloped mineral occurrences are provided in tabular form. Location maps for each of the above categories of mineral property are also provided in Appendix Maps A-B.

3.1 Industrial Minerals

Libya is poorly endowed with mineral resources, but does possess modest amounts of nonmetallic minerals--notably gypsum, salts, potash, building and ornamental stone, limestone and other materials for portland cement. Libya also has some trona, silica sand, sulfur, alum, phosphate rock, clays, barite, celestite, and kaolin. Resources remain largely untapped due to lack of international capital investment and markets along with high development costs. Production is limited, on a small scale, and marketed locally.

Cement is produced in three areas of Libya near the market cities of Tripoli, Bengasi, and Derna. The largest single producer reportedly has an operating capacity of

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[4] Mr. David Fetter, Libyan Desk Officer, U.S. State Department. Personal communication. May 15, 1995.

1,500,000 tpy; small by world standards. Recent development projects such as the Great Manmade River Project provide increased demand for cement, which is imported in large quantities. Production has been recently expanded but is still not sufficient to meet domestic demand and runs well below industry capacity. Like most industry in Libya, cement production is Government owned and controlled. Open pit mining techniques with limited blasting of the limestone are employed.

Gypsum resources are found at small, scattered deposits near population centers in Tripolitania and Cyrenaica. The Danish company FLOTEC was awarded a contract in 1985 to construct a gypsum plant and export terminal near Tripoli[5]. Approximately 200,000 - 300,000 tpy of gypsum is to be supplied by Yafran area deposits; the gypsum is designated for export to Europe. The sedimentary ore requires small scale blasting.

Lime and stone production in Libya also comes from scattered deposits near Tripoli Derna, and Bengasi. The Qarqarish (Gargaresh) sandstone, which extends for long distances along the Mediterranean coast, has long been quarried for building stone. The Azizia limestone and Bengasi limestone are also used for building stone, as they are easily cut and shaped. This material is also suitable for the manufacture of cement, if mixed with selected clays which are abundant locally. In many cases, the rock is quarried by non-mechanized methods, using rock saws and hand-held picks. Such operations do not require blasting. Larger operations are assumed to blast on a limited basis.

Libya possesses the potential to recover significant quantities of salt from both large salt flats (sebchas), lagoonal deposits along the Mediterranean, and interior basins, where salts have accumulated by means of meteoric waters and subsequent evaporation. Salt, potash, and gypsum are recovered at a number of sites; most of which are small scale surface operations. Sebchas are found in the vicinity of Tripoli

[5] Europa Publications, Ltd. The Middle East and North Africa 1994. 40th Ed. P. 663.

and Bengasi, and along the western coast of the Gulf of Sirte. Interior basins are primarily located in the Fezzan desert region southwest of Edri and Sebha. In both regions, the salt brines are allowed to evaporate, crystallized salts are harvested, and transported to nearby processing facilities or directly to markets; blasting is not required.

Sulfur is recovered principally as a refinery byproduct of petroleum. Colloidal and fumarolic sulfur is also recoverable from some areas. Sulfur recovery does not require blasting.

3.2 Iron Ore

Libya produces steel from one plant at Misurata, but to date the plant has received feed from imported iron ores. Plans call for the development of the iron ore deposits at Wadi Ash Shatti to supply domestic feed for the plant, but capital to construct a 900km rail line to the plant needs to be acquired before production could begin. The deposit consists of 140m of interbedded sandstones overlain by approximately 10m of overburden.[6] The deposit is reported to contain over 3.5 billion metric tons of ore above 35% Fe[6], with a proven reserve of 420 million metric tons at 55% Fe[7]. Ore would be mined by surface methods. A production rate of 2.4 million tpy would be required to supply the expanding steel plant at Misurata. An average stripping ratio of 1.2:1 waste to ore has been assumed for calculation purposes in this report. A number of other iron deposits exist in Libya, but these are much smaller in scale.

3.3 Other minerals

Libya also possesses some additional mineral resources of trona, silica sand, alum, phosphate rock, clays, barite, celestite, and kaolin. Resources remain largely untapped as they are not outstanding in terms of quantity or quality or because of

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[6] M. J. Salem and M. T. Busrewil. The Geology of Libya. Vol. III, Academic Press, 1980, pp. 1019-1043.

[7] Mining Magazine. April 1981. pp. 320-322.

their site remoteness and lack of international capital and markets. Production is limited, small scale, technologically simple, and is marketed locally. Blasting is generally not required or insignificant.

4.0 MINE-RELATED EXPLOSIVES USE

Almost all mines use explosives to fragment or loosen rock and consolidated material prior to excavation. Bulk or packaged explosives and blasting agents are detonated after emplacement in material to be excavated. Minor quantities of sachet and shaped charges may be used for secondary breakage and other special applications.

The type and amount of explosives used are influenced by the nature of the rock or ore, the mining methods employed, the production rate of the mine, the type and availability of explosives and detonation systems, hydrologic conditions, mining equipment, drilling equipment, mine geometry, level of technical expertise, and external constraints such as the proximity of residences, availability of explosives, and available funding. At almost any mine, the size of each blast can vary significantly due to local conditions, production schedules, weather, etc.

Surface mines typically shoot much larger blasts than underground operations and tend to have higher production rates than underground mines. In addition, limitations of working room, limited free faces, ventilation requirements, and drilling limitations may constrain maximum blast sizes in underground mines.

Libya is limited to internally produced explosives or imports from other allied Islamic countries. Currently the United States and other Western countries impose a commercial/financial trade ban on Libya[8]. It appears that restrictions have limited recent industrial development in Libya; but they do not appear to represent an unsurmountable impediment to Libya's mining sector. Libya has the military-related

[8] Mr. David Fetter, Libyan Desk Officer, U.S. State Department. Personal communication, May 15, 1995.

technology and facilities to manufacture blasting agents and detonation systems suitable for most mining applications.

Where blasting is required, most Libyan mines use ammonium nitrate-fuel oil (ANFO) blasting agents. This may include some of the newer emulsion and/or aluminum boosted products presently available. ANFO systems are preferred in most mining applications due to their ease of manufacture, low cost, inherent safety, and bulk loading advantages. High explosives, however, would be preferable for small underground operations that use drill sizes that are below the critical diameter needed for emplacing ANFO blasting agents, or under wet conditions, in methane-rich atmospheres, and conditions that require higher detonation velocities and/or convenience of packaged explosives. Such explosives are more difficult to acquire as a result of current sanctions.

Blasting assumptions used in this report are based upon engineering judgment; explosive use can vary considerably as mining conditions change. ANFO consumption was assumed to be dependent upon mine production rate, average stripping ratio, specific gravity of the host rock, assumed powder factor limits, and mining method. Only a small number of mines in Libya require blasting. In most cases, site-specific blasting information was unavailable. Consequently, estimates were based upon known or estimated production rates, mine geology, mining systems, and typical mining practices. Experience, engineering judgement, and available data were incorporated into calculations and estimates.

For each site, a stripping ratio (Quantity of overburden removed per mt of ore mined) and powder factor (Quantity of rock blasted per unit of ANFO blasting agent equivalent) limits were estimated. A range of ANFO consumption was calculated for both daily blasting requirements and for an assumed maximum blasting event. Daily ANFO requirements were estimated assuming a 215 day production schedule. Consumption estimates for all sites were calculated in a similar manner. The lower consumption value applies a minimum powder factor while the higher value assumes a maximum powder factor. Unlike daily consumption estimates, a maximum blasting event would not take place on a daily basis. For this study, it was assumed that a maximum blasting event could occur every 10 working days for a surface mine and every 5 working days for an underground mine. Such events are designed to account for such factors as blasting delays, geological irregularities, and mining method variations that require a higher ANFO consumption than the typical blasting event. Mine development or pillar extraction conditions, for example, often require larger blasts.

The following examples illustrate typical blasting calculations using the estimation procedure described above:

<u>Wadi Ash Shatti ANFO consumption lower limit (L):</u>

L = Production rate * [1 + (stripping ratio * specific gravity of waste)] * [Low powder factor / 1000 (converts kg to mt)] / 215 (assumed operating days per year)

L = 2,800,000 * [1 + (0.48 * 2.5)] * [0.17 / 1000] / 215

L = 4.87 5 mt ANFO equivalent (Rounded to nearest unit)

<u>Wadi Ash Shatti ANFO consumption higher limit (H):</u>

H = Production rate * [1 + (stripping ratio * specific gravity of waste)] * [High powder factor / 1000 (converts kg to mt)] / 215 (assumed operating days per year)

L = 2,800,000 * [1 + (0.48 * 2.5)] * [0.23 / 1000] / 215

L = 6.59 7 mt ANFO equivalent (Rounded to nearest unit)

<u>Wadi Ash Shatti maximum blasting event ANFO consumption (M):</u>

M = Production rate * [1 + (stripping ratio * specific gravity of waste)] * [High powder factor / 1000 (converts kg to mt)] / 215 (assumed operating days per year) * maximum blast cycle time (working days between blasting events)

M = [2,800,000 * [1 + (0.48 * 2.5)] * [0.23 / 1000] / 215] * 10

M = 65.90 66 mt ANFO equivalent (Rounded to nearest unit)

Table 4.1 provides the corresponding blasting range estimates for the main Libyan mines identified in this study.

Table 4.1--Estimated Explosives Usage at the Main Libyan Mines Used in this Study in Order of Estimated ANFO Consumption

Mine	Latitude	Longitude	Product	Mine Type (1)	Production (Mmt/yr) (2)	Daily Consumption (mt ANFO) (3),(4)		Maximum Blast Cycle Time (days) (5)	Maximum Blasting Event (mt ANFO)
						Low	High		
Wadi Ash Shatti	N 27° 26'	E 14° 13'	Fe	S	2.800	5	7	10	66
Bengasi	N 32° 05'	E 20° 20'	Limestone	S	1.500	2	3	10	31
Homs	N 35° 20'	E 8° 01'	Limestone	S	1.400	2	3	10	29
Derna	N 32° 40'	E 22° 40'	Limestone	S	1.000	1	2	10	21
Bi'r Ghanam – Yafran	N 32° 16'	E 12° 34'	Gypsum	S	0.180	0.207	0.377	10	4

(1) S--Surface; UG--Underground
(2) Mmt/yr--Million metric tons per year.
(3) mt ANFO--Metric tons of Ammonium Nitrate/Fuel Oil blasting agent equivalent rounded to nearest whole unit.
(4) Assumed production schedule – 215 days/yr.
(5) Assumed maximum blasting cycle time for surface operation – 10 working days; underground operation – 5 working days.

5.0 CONCLUSIONS

Mining primarily occurs in the Fezzan desert and northern Libya near the towns of Tripoli and Bengasi. Underground mining is absent. Surface mining and quarrying operations generally operate on a small scale serving domestic needs. It is likely that a blast detected in Libya requiring more than 30 metric ton of ANFO equivalent would not be due to mining. Blasts from producing sites are infrequent and would typically use less than 30 metric tons of ANFO equivalent for a maximum blasting event. The only mining site with significant blast potential is the Wadi Ash Shatti site, which has not yet been fully developed.

APPENDICES

APPENDIX A: PRODUCING OR DEVELOPING MINERAL PROPERTIES IN LIBYA

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
A 1	Al Qawasim	N 32° 10'	E 13° 00'	Kaolin	18	General	Producer	Surface	Domestic	Bed 1m thick. Clay used for pottery.
A 1	Azizia	N 32° 27'	E 12° 50'	Cement	16	General	Producer	Surface	Domestic	Ornamental stone, road ballast, and concrete aggregate. Maximum thickness 50m.
A 1	Bi'r al Ghanam–Yafran	N 32° 16'	E 12° 34'	Gypsum Sulfur	16	Confirmed	Producer	Surface	Domestic	Location given for Block 1 reserves. Block 1: 63Mmt, 54m thick (1959). Block 2: 31Mmt, 26m thick (1959). Block 3: 91Mmt, 50m thick (1959). Total res.: 79,700Mmt (1959). $CaSO_4.2H_2O$ content +80%
A 1	Gargaresh	N 32° 52'	E 12° 58'	Cement	16,18	General	Producer	Surface	Domestic(5)	Building stone. Can be used as cement feed if mixed with other clays. Multiple quarries. In 1970, rock mined by hand methods. Limestone extends along coast. Overburden 0–4m. Largest Libyan source of stone. Thickness reaches 40m.
A 1	Homs	N 32° 45'	E 14° 08'	Limestone Clay Cement	16,18,21	General	Producer	Surface	Domestic Europe	Limestone and clays. Several plants in area. Capacity 1.4M tpy.
A 1	Mellaha	N 32° 54'	E 13° 20'	Salt	16	General	Producer	Surface	Domestic	Evaporite basin covers 12 ha. Brines evaporate, salts scraped off, piled, then sent to markets. Capacity up to 30,000 tpy.
A 2	Sebcha Kebirah	N 30° 14'	E 18° 50'	Sulfur	5,16	General	Producer	Surface	Domestic	Colloidal sulfur in salt in bed 15–30 cm thick Max. prod. 200 tpy @ 50% S.

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(1) Represents property or property grouping as defined on Appendix Map A.
(2) Complete list of data sources found at end of Appendix A.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.
(5) The bulk of cement produced is used in domestic markets. Some may be supplied to neighboring countries, but specific trade data is lacking.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
A 3	Marada	N 29° 17'	E 19° 13'	Potash Magnesium Salt	4,6,16	Confirmed	Developing	Surface	Domestic	125km south of El Agheila. Area of 150 sq. km. Shallow evaporite basin. Brine has conc. of 20.45% Na, 13.05% K, 2.28% Mg at center, decreasing at edges. Exp. work in 1939 by Italians. Res. of 15 sq. km. area 1.6Mmt @ 40% K2O and 7.5Mmt MgCl2. Drilling conducted in 1961. Proposed for 10,000 tpa K2O op.
A 4	Bengasi	N 32° 05'	E 20° 20'	Cement Limestone	16,21	General	Producer	Surface	Domestic	Building stone. Cap: 1.5M tpy.
A 4	Bengasi	N 32° 05'	E 20° 04'	Salt	16	General	Producer	Surface	Domestic	Evaporite basin.
A 5	Derna	N 32° 40'	E 22° 40'	Cement Limestone	8,21	General	Producer	Surface	Domestic	Capacity to 1M tpy.
A 6	El Haruj el Aswad	N 27° 25'	E 17° 15'	Sulfur	5,16	General	Producer	Surface	Domestic	Fumarolic sulfur grading 5.6% S. Intermittant, small scale production.
A 7	Wadi Ash Shatti	N 27° 26'	E 14° 13'	Iron	1,2,3,7,9, 12,16,18, 22	Confirmed	Developing	Surface	Misurata (6) Plt. pellets to India, Indonesia, Mauritania, & Brazil	Preliminary exploration in 1950's. Development delayed in 1987. Res: 420Mmt @ 55% Fe. Resource: 2Bt @ 30–50% Fe & 1.6Bt at lower grades. Proposed cap: 7.6Mt (1992 est.) Would need to produce 2.4M tpy to feed Misurata plt. at planned capacity 900km rail line needed.
A 8	Sardalas	N 25° 50'	E 10° 32'	Alum Kaolin	16,18	General	Producer	Surface	Domestic	Pods 20–30m in evaporites. Alum crust scraped off and used locally in tanning. Blasting not required. Prod. probably < 10tpy. Deposit explored in 1970's.
A 9	Ghat	N 24° 54'	E 10° 11'	Salt	16	General	Producer	Surface	Domestic	Mined intermittantly by crude methods for table salt.

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(1) Represents property or property grouping as defined on Appendix Map A.
(2) Complete list of data sources found at end of Appendix A.
(3) General – denotes limited data; Confirmed – denotes deposit information confirmed by several sources.
(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.
(5) The bulk of cement produced is used in domestic markets. Some may be supplied to neighboring countries, but specific trade data is lacking.
(6) Deposit planned for development to feed the Misurata plant, which currently receives all feed from imported sources. Iron pellets from the plant exported to India, Indonesia, Mauritania, and Brazil.

APPENDIX A: PUBLIC SOURCES OF INFORMATION

1. Mining Journal Research Service. Oct. 6, 1994. Report compiled for Lawrence Livermore National Laboratory.
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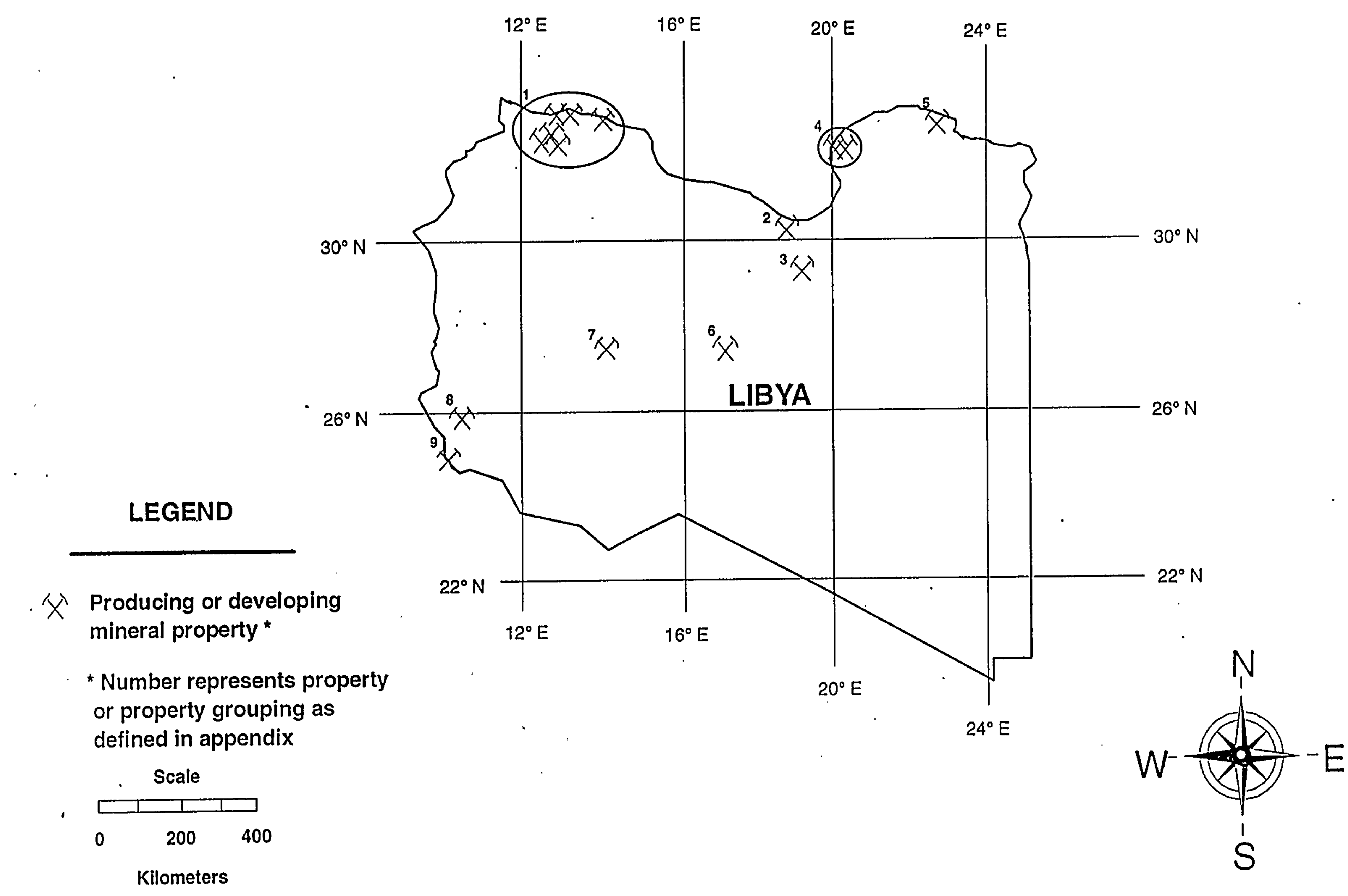

APPENDIX MAP A: PRODUCING OR DEVELOPING MINERAL PROPERTIES OF LIBYA

APPENDIX B: PROSPECTS AND UNDEVELOPED MINERAL PROPERTIES IN LIBYA

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
B 1	Abu Ghaylan	N 32° 16'	E 12° 30'	Bentonite	16,18	General	Deposit	Surface	NAp(4)	Ancient pit. Clays suitable for ceramics.
B 1	Glado-Glosc	N 31° 58'	E 11° 50'	Silica sand	16	General	Deposit	Surface	NAp	Sandstone is 10-40m thick.
B 1	Jabal	N 31° 55'	E 11° 40'	Iron	16	General	Deposit	Surface	NAp	Sandstone beds @ <25% Fe. Fe zones <2m wide, 50m long.
B 1	Mizda	N 31° 25'	E 12° 50'	Gypsum	16	General	Deposit	Surface	NAp	Occurrence
B 1	Nalut	N 31° 50'	E 11° 00'	Gypsum	16	General	Deposit	Surface	NAp	Occurrence
B 1	Pisida	N 33° 05'	E 11° 40'	Salt Potash Magnesium	16	General	Deposit	Surface	NAp	Covers 50 sq. km in Libya. Salt crust 3-10cm thick, and mixed salt layer of 30cm.
B 1	Shecshuk	N 32° 01'	E 12° 00'	Lignite	16	General	Deposit	Surface	NAp	Occurrence
B 1	Ulad Mahmud	N 31° 52'	E 11° 07'	Magnesium	16	General	Deposit	Surface	NAp	Lenses in limestone. Ore zone 3-4m by 1m.
B 1	Wadi Urari	N 31° 55'	E 11° 35'	Manganese Iron	1,16	General	Deposit	Surface	NAp	Zone 75m by 60m by 30m. Replacement in limestone.
B 1	Yifran	N 32° 04'	E 12° 30'	Kaolin	18	General	Deposit	Surface	NAp	--
B 2	Al Khums	N 32° 42'	E 13° 55'	Kaolin	18	General	Deposit	Surface	NAp	Bed thickness 0.5-0.7m. Clay suitable for stoneware.
B 2	Al Kussabat	N 32° 35'	E 14° 03'	Lignite	16	General	Deposit	Surface	NAp	Carbonaceous clay.
B 2	Beni Ulid	N 31° 40'	E 14° 25'	Celestite	16	General	Deposit	Surface	NAp	Mineral noted in area.
B 2	Beni Ulid-Wadi Soffegin	N 31° 45'	E 14° 25'	Phosphate	16	General	Deposit	Unknown	NAp	Thickness up to 10m.
B 2	Bu Nujaym	N 30° 36'	E 15° 23'	Gypsum	16	General	Deposit	Surface	NAp	Occurrence
B 2	Tauorga	N 31° 55'	E 15° 12'	Salt Potash Magnesium	16	General	Deposit	Surface	NAp	Covers up to 1000 sq. km.
B 2	Wadi Soffegin	N 31° 32'	E 14° 25'	Celestite Gypsum	16	General	Deposit	Surface	NAp	Beds and lenses up to 10cm thick in shale and marls.

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(1) Represents property or property grouping as defined on Appendix Map B.
(2) Complete list of data sources found at end of Appendix B.
(3) General - denotes limited data; Confirmed - denotes deposit information confirmed by several sources.
(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
B 3	Suknah	N 29° 10'	E 16° 00'	Clays	18	General	Deposit	Surface	NAp(4)	--
B 4	El Haderiat	N 28° 10'	E 18° 37'	Celestite	16	General	Deposit	Surface	NAp	Region of celestite-filled cavities 20-60cm in diameter.
B 4	Unnamed	N 28° 55'	E 18° 13'	Sulfur	16	General	Deposit	Surface	NAp	Occurrence
B 5	Agedabia	N 30° 36'	E 19° 55'	Salt Potash	16	General	Deposit	Surface	NAp	Occurrence
B 5	El Agheila	N 30° 17'	E 19° 34'	Salt Potash	16	General	Deposit	Surface	NAp	Occurrence
B 5	Unnamed	N 30° 12'	E 18° 45'	Salt Potash	16	General	Deposit	Surface	NAp	Occurrence
B 6	Unnamed	N 29° 05'	E 21° 35'	Salt Potash	16	General	Deposit	Surface	NAp	Occurrence
B 7	Al Bayda	N 32° 45'	E 21° 42'	Clays	18	General	Deposit	Surface	NAp	Clay suitable for cement production.
B 8	Shiggah	N 32° 15'	E 23° 02'	Salt Potash	16	General	Deposit	Surface	NAp	Occurrence
B 8	Umm ar Rizam	N 32° 20'	E 23° 00'	Clays	18	General	Deposit	Surface	NAp	Clay could be used for cement production.
B 9	Giarabutio	N 29° 40'	E 24° 40'	Salt Potash	16	General	Deposit	Surface	NAp	Occurrence
B 10	Al Jawi	N 24° 12'	E 23° 15'	Salt Potash	16	General	Deposit	Surface	NAp	Occurrence
B 11	Jabal El Haruj al Aswad	N 26° 30'	E 17° 10'	Iron	16	General	Deposit	Surface	NAp	Sandstone beds up to 45% Fe. Max. thickness 8m.
B 11	Tmassah	N 26° 20'	E 15° 48'	Trona	16	General	Deposit	Surface	NAp	Occurrence
B 11	Waw al Kabir	N 25° 41'	E 16° 45'	Trona	16	General	Deposit	Surface	NAp	Occurrence
B 11	Waw al Kabir	N 25° 17'	E 16° 42'	Salt Potash	16	General	Deposit	Surface	NAp	Occurrence
B 11	Waw an Namus	N 24° 55'	E 17° 43'	Trona	16	General	Deposit	Surface	NAp	Occurrence
B 11	Waw an Namus	N 24° 50'	E 17° 44'	Sulfur	16	General	Deposit	Surface	NAp	Occurrence
B 12	Gatrun	N 24° 56'	E 14° 35'	Trona	16	General	Deposit	Surface	NAp	Occurrence

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(4) NAp Not applicable; prospects and undeveloped deposits have no current markets.

MAP KEY (1)	NAME	COORDINATES LAT.	LONG.	COMMODITY(IES)	DATA SOURCES (2)	DATA RELIANCE (3)	STATUS	MINE TYPE	MARKETS	COMMENTS
B 12	Madrusali	N 24° 50'	E 14° 32'	Salt Potash	16	General	Deposit	Surface	NAp(4)	Occurrence
B 13	Brach	N 27° 35'	E 14° 23'	Manganese	1,16	General	Deposit	Surface	NAp	Also called Birak. Occurs in fractures 5–15 cm.
B 13	Edri	N 27° 30'	E 13° 12'	Sulfur Potash Salt	5,16	General	Deposit	Surface	NAp	Fumarolic sulfur grading 5.6% S. Salt covers area of 35km. Deposit crust 40cm, mixed salts 30cm, and brine 60cm.
B 13	Nashnusha	N 26° 55'	E 13° 27'	Trona	16	General	Deposit	Surface	NAp	Occurrence
B 13	Sebha	N 27° 10'	E 14° 30'	Kaolin	16,18	General	Deposit	Surface	NAp	Clays suitable for ceramics or brick making.
B 13	Ubari	N 26° 33'	E 12° 55'	Lignite	16	General	Deposit			Occurrence Bed 15–30cm thick.
B 13	Wadi Ash Shatti	N 27° 26'	E 14° 13'	Kaolin	18	General	Deposit	Surface	NAp	Clay suitable for ceramics, bricks.
B 13	Wadi el Aglal	N 26° 30'	E 13° 20'	Iron	19	General	Deposit	Surface	NAp	Veins of hematite.
B 13	Wadi es Scaltti	N 27° 34'	E 13° 10'	Iron	19	General	Deposit	Surface	NAp	Veins of hematite.
B 14	Ghat	N 24° 58'	E 10° 07'	Lignite	16	General	Deposit	Surface	NAp	Occurrence Bed 90cm thick.

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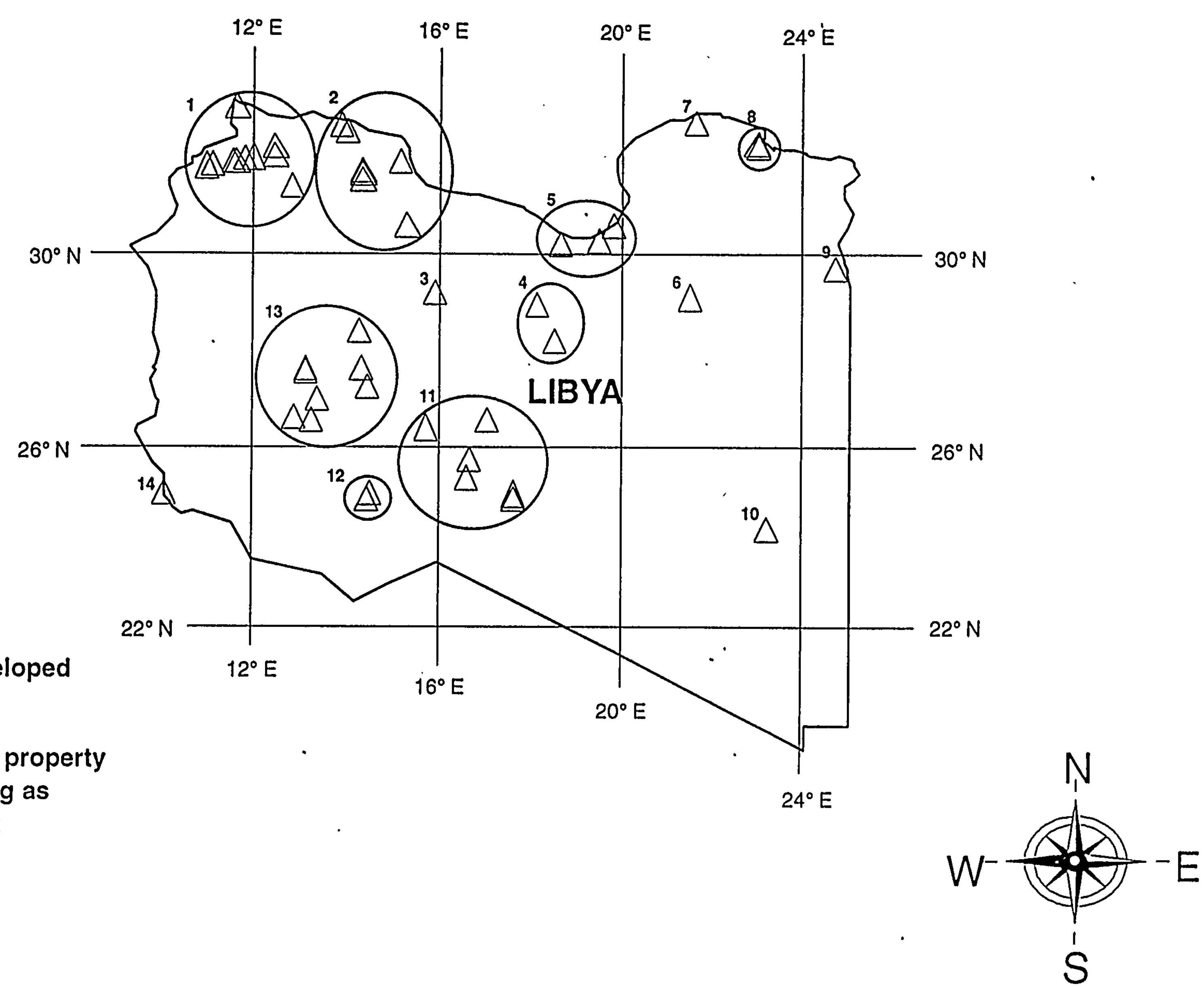

LEGEND

△ Prospect or Undeveloped Mineral Property*

* Number represents property or property grouping as defined in appendix

Scale

0 200 400

Kilometers

APPENDIX MAP B: PROSPECTS AND UNDEVELOPED MINERAL PROPERTIES OF LIBYA

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