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# DEVELOPMENT OF ENGINEERING AND COST DATA FOR FOR IGAN ANTIMONY AND BARITE PROPERTIES

Contract J0225017  
Brown & Root Development, Inc.

**OFR 53-85**

BUREAU OF MINES  
UNITED STATES DEPARTMENT OF THE INTERIOR



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## DISCLAIMER

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines or the U. S. Government.

## FOREWORD

This report was prepared by Brown & Root Development, Inc. of Houston, Texas, under USBM Contract Number J0225017. The contract was initiated under the Minerals Data Analysis Program. It was administered under the technical direction of Intermountain Field Operations Center with Alan G. Hite acting as Technical Project Officer. Mickey Lechuga was the contract administrator for the Bureau of Mines. This report is a summary of the work recently completed as a part of this contract during the period October 1982 to September 1984. This report was submitted by the authors on October 29, 1984.

Joseph S. Coffman of the Minerals Availability Field Office served as acting Technical Project Officer when Mr. Hite was unavailable.

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## INTRODUCTION

According to Bureau of Mines Information Circular IC 8887, the General Accounting Office has recommended that the United States Department of the Interior, Bureau of Mines (USBM) recognize the Minerals Availability System (MAS) as a priority program. This has led to the formation of the Division of Minerals Availability. The stated mission of this group is to collect current engineering and economic information on world non-fuel mineral deposits that represent at least eighty-five (85) percent of the production of selected critical commodities.

To comply with this mandate, USBM's MAS required detailed information on literally hundreds of mineral properties. Such data could not be collected under existing in-house research methods where foreign properties were concerned. Therefore, USBM hired consultants for collecting such data on thirty-three (33) mineral commodities determined to be of critical importance to the United States. Barite and antimony were two of the commodities in this group.

On September 30, 1982, a contract (Contract No. J0225017) was awarded to Brown & Root Development, Inc. (BARDI) of Houston, Texas to collect and evaluate pertinent data for sixteen (16) antimony and twenty-two (22) barite deposits in twenty (20) market economy countries. BARDI, as the main contractor, was responsible for the barite portion of the study, as well as the total performance on the contract. Mineral Systems Inc. (MSI) of Stamford, Connecticut, as subcontractor, was responsible for the antimony profile reports. The contract was subsequently extended to include three (3) more antimony and eleven (11) more barite deposits. An extension was also awarded to prepare a composite report on the central (non-mine site) barite grinding mills.

This report summarizes the work performed over the life of the contract, October 1982 to September 1984.

## SUMMARY

Fifty-two (52) profile reports on antimony and barite companies, mines and/or deposits (C/M/D's) in the market economy countries, exclusive of the United States, were prepared and submitted to the USBM. Several of the profile reports pertained to more than one deposit.

A breakdown of all reports submitted in fulfillment of the contract is as follows:

- o Profile reports on nineteen (19) antimony C/M/D's
- o Profile reports on thirty-three (33) barite C/M/D's
- o A barite grinding mill report
- o A final report
- o Monthly technical progress reports

Information for profile reports was obtained from published sources, personal communication, correspondence and field trips to operations. A detailed listing of this information, as taken from the contract, is shown in Schedule A. Nineteen of the twenty countries and seventy-five (75) percent of the C/M/D's were visited for personal observation and data collection. Responsible personnel in each operation were interviewed. Ore reserve data was examined and verified whenever possible and historical operating costs were obtained from the records. Discussions were also held with state geological/mining agencies to confirm the information on hand and to obtain additional information on potential and/or significant deposits.

Even though the operators were cooperative in providing the operations data, some of them were reluctant to share their information on cost and geological reserves. Where actual information was not obtainable, it was estimated from the available raw data using accepted engineering procedures.

It should be pointed out that during the execution of this project, our relationships with the Technical Project Officer (TPO) and other USBM officials were excellent. We were able to discuss any problem with the TPO and seek clarification by telephone. As a result, we were able to complete this project several months ahead of schedule. Furthermore, a time extension was not required when the barite grinding study was awarded.

## SCHEDULE A

### DETAILED INFORMATION CONTAINED IN PROFILE REPORTS.

The contractor shall present company/mine/deposit/district Profile reports to the Bureau of Mines according to the following format:

#### A. IDENTIFICATION

1. Property name(s) - the contractor shall specify if the name includes other known properties and the reasoning for the identification; for example, if the property is considered as a company lease area.
2. Type of operation.
3. Current status.
4. Current ownership and operator - this data shall be identified to the second stage if necessary, such as identifying ownership of a company formed for operating a mine.
5. Coordinate location - latitude, longitude to the nearest minute of arc, include location map. Location map may be sketched or copied; drafting is not required.
6. Local geographic reference - the proximity of the deposit to a known geographic point, such as a town, mountain, river.

#### B. RESOURCE DESCRIPTION

The orebody or resource must be described to the extent that the mining plan can be clearly understood. The elements that must be addressed are shown below.

The description of the orebody is not limited to these elements, however. If it is felt that other elements should be included in the resource description, then these should be included:

1. Type of orebody.
2. Shape of orebody.
3. Attitude and structural features affecting mining or ore controls.
4. Type of mineralization.
5. Economic minerals.

## SCHEDULE A (Cont'd)

6. Orebody dimension, thickness of mining horizon, veins, ore zones, depth to ore.
7. In situ reserve/resource quantity, and commodity assay, and year of estimate. Assay must include all commodities that are currently or potentially recoverable or that may affect the recovery or marketability of recoverable commodities. Reserve/resource quantity must be documented or estimated with appropriate written justification to each of the measured, indicated, and inferred levels (see U.S. Geological Survey Circular 831 for clarification of reserve/resource definition).

The reserve/resource estimate shall be current as of January 1982. The contractor shall indicate any calculations he did (such as subtracting production, etc.), to determine this reserve/resource value. The development plan, mine, mill, further processing descriptions, and cost estimates shall be based on the reserve/resource and grade of this January 1982 value at the measured plus indicated level only. Because the Bureau of Mines is studying the costs and availability, this reserve/resource must include all reserves/resources at the measured plus indicated level, and not just 'economic' reserves, or reserves based on a commodity price. Thus resource estimation by the contractor cannot be limited by company policy of economic cut-off or legal constraints, such as leasing restrictions without acceptable justification.

The contractor must demonstrate his ability to relate any obtained or calculated (published or unpublished) reserve/resource data to the deposits geological and geometric data, and identify the total remaining resources at the measured, indicated, and inferred levels.

### C. OPERATION DESCRIPTION

These data must be collected or estimated for both operating and non-operating properties. For operating properties, the contractor must identify the mining and milling technology that currently applies. Non-operating properties shall be based on similar technologies. The contractor shall estimate or describe the technology and associated costs that are applicable to the development of the January 1982 reserve/resource value.

1. Open Pit Mining
  - a. Design capacity (tonnes per 24 hours ore and waste).
  - b. Operation schedule (shifts per day, days per year).
  - c. Average annual production rate in tonnes ore and waste (note years used for average).
  - d. Excavation and loading methods and major equipment utilized, ore and waste.
  - e. Haulage methods, average haul distances, and major equipment utilized for ore and waste.
  - f. Destination/placement of ore and waste, i.e., stockpile, dump, tailings dam, etc.

## SCHEDULE A (Cont'd)

- g. Breakage requirements and major equipment utilized; powder factor.
- h. Dilution and recovery factor, ore:waste ratio, average thickness of mining horizon(s).
- i. Water drainage requirements - description of methods, rate, head.
- j. Year of initial production and annual ore production for prior fifteen (15) years or years since startup, whichever is less.
- k. Preproduction development work necessary to obtain design capacity (roads, cleaning, stripping).

### 2. Underground Mining

- a. Design capacity (tonnes per 24 hours ore and waste).
- b. Operation schedule (shifts per day, days per year).
- c. Average annual production rate (tonnes ore and waste and year(s) used for average).
- d. Year of initial production, ore production for prior fifteen (15) years or years since startup, whichever is less.
- e. Specific mining methods and percent of production from each method, mining thickness.
- f. Orebody access and haulage - describe orebody access methods and ore haulage facilities as indicated by the items shown below (may be presented in chart form).
  - 1. Underground haulage methods, major equipment (size and number) utilized, and average haul distance and elevation difference.
  - 2. Hoist(s) identification - designation, location (placement), type, use, general area served, height/depth.
  - 3. Inclines and adits - length/depth.
- g. Rock hardness/abrasiveness, powder factor, support/lining requirements.
- h. Dilution and recovery factor.
- i. Water drainage requirements - description of methods, rate, head.
- j. Level, raise, shaft and drift dimensional spacing, stope size and number (mine diagram and plant layout if available).
- k. Preproduction development work necessary to obtain design capacity (roads, shafts, drifts, raises, stope development).

### 3. Beneficiation

The contractor shall make clear in this report, the beneficiation methods, input and product quantities and grades of all contained commodities. Beneficiation shall include all processes that prepare the concentrate for market or further post mine/mill processing.

- a. Beneficiation methods.
- b. Feed grade, each method. Explain any dilution and/or blending that make this grade different from the insitu commodity grades.
- c. Design capacity, each method (tonnes feed per 24 hrs.).
- d. Average production rate (tonnes feed per year and year(s) used for average).
- e. Operation schedule (shifts per day, days per year).
- f. Commodity recoveries, for each beneficiation method and product.

## SCHEDULE A (Cont'd)

- g. Beneficiation product identification.
  1. Product(s) type.
  2. Product(s) grade.
  3. Product(s) quantity (tonnes per year).
- h. Description of size reduction methods, final grinding size, work index.
- i. Tailings disposal - description of methods, including distance and methods of transport, pumping head, impoundment methods, size, capacity, and materials required for construction.
- j. Major equipment utilization, size and number.
- k. Flowsheet (identify and quantify major tonnage splits during processing).
- l. Destination of concentrates (country, and facility when known).

## D. INFRASTRUCTURE

The purpose of the infrastructure section is to identify those areas of infrastructure which a deposit would need in order to develop the reserve/resources, as well as associated costs. If this infrastructure exists, or can be built at no cost to the deposit, this should be identified. Areas to consider include quantification of the following elements:

1. Access and haulage facilities
  - a. Roads and railroads
  - b. Pipelines
  - c. Conveyors
  - d. Tunnels
  - e. Port facilities
  - f. Other
2. Water facilities
3. Power supply
4. Personnel accommodations.
  - a. Permanent
  - b. Temporary
5. Other

## E. POST MINE/MILL PROCESSING (ANTIMONY)

The contractor shall identify, in his development plan and associated costs, where the concentrate or ore would be sent for post mine site processing. All products and byproducts shall be taken through their respective smelters. The contractor shall include in his proposal the expected market grade, and identify any possible market restrictions.

## SCHEDULE A (Cont'd)

For costing purposes, if the processing facilities will be built on-site, the contractor shall estimate the associated capital and operating costs. In the case of nonvertical integrated operations, charges for smelting, refining, etc., (actual or estimated) shall be provided, and each component of the charge (i.e., labor, energy, supplies, depreciation, profit, etc.) shall be broken out and explained.

The contractor shall provide the following information on post mine processing facilities which receive concentrate from the properties listed in Article I, Appendix A.

1. Name and location.
2. Final products.
3. Type of process used.
4. Capacity (input and output).
5. Sources of feed from producing and potential developments.
6. Grade of input and output, recoveries.
7. Explanation of penalties, etc., charged to suppliers.
8. Ownership.

The contractor shall also identify smelters where antimony is recovered as a byproduct and provide antimony production cost, capacity, and antimony sources and grade of feed to these facilities.

### F. MANPOWER REQUIREMENTS

Manpower requirements shall be provided by the contractor for mining, milling, and post mine/mill processing. These data shall be provided according to the following categories.

1. Labor
2. Technical
3. Supervisory
4. Pay schedules
5. Productivity (tonnes per manshift or analysis of manpower efficiency)

The contractor shall identify the number of personnel, with breakdown into the above 1, 2, and 3 categories for mine, mill, and post mine/mill processing. Where possible, labor (1) should be identified as to operating or maintenance personnel. The number, percent, or ratio of domestic and expatriate personnel must be provided.

## SCHEDULE A (Cont'd)

### G. ENERGY USAGE

The contractor shall provide the types, quantity, and cost of energy usage for all phases of mineral processing, that is mining development, mining, beneficiating, and post mill processing.

The energy usage shall be expressed in units per unit such as liters per metric ton, kilowatt hours per ton, quantified by type, etc.

The contractor shall also provide the cost of energy in terms of U.S. dollars (January, 1982) per unit.

### H. DEVELOPMENT PLAN

For each mine or deposit, the contractor must establish a mining plan or development plan to utilize the total measured plus indicated resource. The plan shall include necessary changes in mining methods or plans (i.e., from open pit to underground), changes in milling practices, and for operating mines any assured changes in capacities or facilities that have a high probability of occurring within five (5) years of the end of the contract period. Thus, this development plan would identify mine recovery, dilution, capacity changes, and any variations in ore quality due to high-grading, etc.

The plan must incorporate changes in facilities and associated costs that may be required throughout the exploitation of the entire resource.

### I. COSTS

The contractor shall collect actual costs, or estimate these costs, which would be applicable to the development of the January 1982 reserve/resource. The U.S. Bureau of Mines Cost Estimating Handbook shall not be used in contractor estimates; the Handbook is addressed as part of this Contract in a later section. Further explanation of costs is given in Article I, Appendix B.

1. Capital Costs. For all properties, all mine and mill capital expenditures and loan data must be provided by the contractor, either as actual or estimated for the prior fifteen (15) years. For all properties, previously expended costs must be provided in the years actually spent. Projected capital costs for bringing a property into operation, or for expansions or revitalizations, shall be in January, 1982 U.S. dollars. All past expenditures shall be given in the applicable U.S. year dollars and not as 1982 'book value' or depreciated value. Capital costs shall be split into the cost categories shown in the costing format in Article I, Appendix B.
2. Loan Data - Loan amount, debt:equity ratio, payback method and period, interest rate, and purpose of loan (i.e., for development or expansion). The basis of calculations shall be indicated where applicable.

## SCHEDULE A (Cont'd)

3. Operating Costs - For all properties, mine and mill operating costs shall be supplied by the contractor either as actual or estimated. These costs shall include complete mine and mill (separate) direct and indirect costs in terms of January 1982 U.S. dollars. The operating costs shall be broken down into the categories of (1) labor, (2) supplies, (3) energy, and (4) general and administrative categories, and shall be shown in U.S. dollars per metric ton ore. Operating costs shall not include depreciation, interest, profit, equipment replacement, amortization, or federal taxes. Equipment replacement is handled as proposed capital costs.
4. Transportation Costs - All transportation costs from the mine/mill to the areas of other processing for upgrading and/or general market areas shall be provided. These costs shall include individual costs and distances for each mode of transportation and for all byproducts. The transportation costs shall also include separate loading and handling charges, such as port handling charges. All transportation costs are to be in January 1982 U.S. dollars.
5. Economic Policy Data - The contractor shall provide country economic policy such as royalties, tariff(s), duties, taxes, leasing policy, enhancements, ownership, etc., that impact the mining, processing and marketing of the commodities.
6. Special Costs - Costs related to permitting, environmental regulations, etc., should be identified, where applicable.
7. Post Mine/Mill Processing Costs - Post mine/mill costs to be supplied by the contractor include actual or estimated charges assigned to the processing to produce marketable products. The costs shall be custom or toll values, or operating costs only if a separate capital investment is identified.
8. Costing Format - In addition to the report text, the grades, tonnages, costs and related data shall be listed in the Economic Time Diagram (ETD) format shown in Article I, Appendix B.

## J. BYPRODUCT EVALUATION

For deposits having recoverable byproducts or coproducts (see section I.B.7.), the contractor shall provide the grade, operational details, transportation, and costs for production of these commodities to a marketable product. Data shall be comparable to that outlined in Section I.C. through I.I. above, where not duplicated for the study commodity. Costs can be associated with the total concentrate until the separate commodities are split in further stages of processing. Then separate costs for smelting, refining, etc., would be necessary. The costs to bring the commodity to a marketable product, must be identified and not presented as a byproduct credit dollar amount, since the latter will not allow for variations in commodity prices, etc.

SCHEDULE A (Cont'd)

K. COST ESTIMATING BY BUREAU PERSONNEL

In addition to costs, the engineering data contained in the profile reports for the identified companies, mines, deposits, and districts shall be of such detail as to allow U.S. Bureau of Mines personnel to estimate the mines/deposits capital and operating costs using the Capital and Operating Cost Estimating System Handbook for comparison with actual or estimated costs provided in section I.I above. Thus, the contractor shall not use this Handbook as his costing method. The contractor shall review the reporting requirements (section I.A-I) in detail with respect to these data, providing an adequate base for cost estimating by the Bureau personnel.

The contractor shall indicate those areas where the Capital and Operating Cost Estimating System Handbook cannot be used for cost estimates of a unit process. The contractor shall provide sufficient data to enable the Bureau of Mines to develop a methodology of cost estimating similar to that used in the Handbook for those areas not covered in the Handbook. The Capital and Operating Cost Estimating Handbook will be provided upon request.

L. GENERAL DISCUSSION

A description is required of the major elements of the mining and milling operation. The discussion must explain the overall efficiency of the operation, and problems such as infrastructure, equipment efficiency, labor problems and efficiency, environmental constraints, and government policies affecting the operation.

For explored deposits, the elements to explain include problems that may be encountered in bringing the deposit into operation, such as access, labor, financing, water, transportation, and governmental policies.

M. REFERENCES

The references shall include all published and unpublished reports, maps, charts, tables, calculations, and other sources used in preparing the reports. Copies of all data sources must be included with the reports.

CONFIDENTIAL DATA will be handled in accordance with Bureau of Mines policy; that is, no CONFIDENTIAL DATA will be disclosed to a third party.

## COMPANIES, MINES AND DEPOSITS STUDIED

### Barite C/M/D's

Schedule B provides the names of barite properties proposed by USBM in the original contract. For comparison, properties actually profiled are shown in Schedule C.

With USBM's consent two (2) properties were substituted. They were as follows:

<u>Properties Deleted</u>	<u>Properties Substituted</u>
1. Glencarbury (Ireland)	Cobachi (Mexico)
2. Ichemoul (Algeria)	Bolan Barytes (Pakistan)

Due to exhaustion of ore reserves, Glencarbury was shut down a few years ago. With regard to Ichemoul, BARDI was unable to obtain reliable reserve information from the Algerian state agency that controls the deposit. Bolan is already a major producer. Cobachi will be in the same category when development is complete.

In addition eleven (11) more barite deposits were added to the work covered in the original award. The reason for adding the eleven (11) properties was to bring profile coverage of free world barite capacity up to the eighty-five (85) percent level specified for the MAS program. The original twenty-two (22) barite properties had an installed annual capacity of about 1.9 million tons of mud grade barite. This is only about fifty (50) percent of the 3.7 million tons of annual capacity cited in Mining Annual Review (1982). In addition, several of the properties on the original list will be closed due to exhaustion of reserves in the next few years. The eleven (11) additional properties covered an aggregate annual production capacity of 1.2 million tons. This figure includes announced production levels at new mines and planned expansions at existing operations. Thus, the added properties brought total coverage up to about eighty-four (84) percent of total annual capacity, or 3.1 million tons. Overall, a total of about 96 million tons of demonstrated barite resources were evaluated. These contain about 76 million tons of barite as BaSO<sub>4</sub>.

A study of central barite grinding mills was also added to the contract. This was done because the original contract did not include the central grinding plants. The normal drilling mud grade barite may be either lump ore or fine material coming from a jig, wash plant or flotation mill at or near the mine site. The only specification is a specific gravity of 4.2, equivalent to ninety-one (91) percent barite (BaSO<sub>4</sub>). Such products seldom meet the America Petroleum Institute (A.P.I.) standard of five (5) percent plus 325 mesh and three (3) percent plus 200 mesh. The fine grinding is generally done in mills

SCHEDULE B

LIST OF BARITE PROPERTIES INCLUDED IN THE ORIGINAL CONTRACT

Algeria	Ichemoul
Belgium	Fleurus
Brazil	Baroid Pigmina Industrial e Commercial, S.A.
Chile	Cia Minera Baritex Cia Minera Resguardo
France	Societe Barytine de Chaillac
Germany	Dreislar
Greece	Mykonos Mykobar S.A.
India	Mangampet
Ireland	Silver Mine Glencarbury
Italy	Sardina Mines
Mexico	BAROSA Barita de Sonora
Morocco	Tessaout Djebel Ihroud
Peru	Graciela - Juanita Minera Baribent
Spain	Cordoba Mines
Thailand	Australian - Thai Tin, Ltd. Siam Barite Company Dresser Minerals International, Inc.

SCHEDULE C

LIST OF BARITE PROPERTIES STUDIED

Belgium	Fleurus
Brazil	Baroid Pigmina Industrial e Commercial, S.A.
Chile	Cia Minera Baritex Cia Minera Resguardo
France	Societe Barytine de Chaillac
Germany	Dreislar
Greece	Mykonos Mykobar S.A.
India	Mangampet Tiffin Barytes, Paints & Asbestos, Ltd.
Ireland	Silver Mine
Italy	Sardina Mines
Mexico	BAROSA Barita de Sonora Cobachi (Minera de Bucarit)
Morocco	Djebel Ihroud Seksoua Tessaout Zelmu
Pakistan	Bolan Barytes
Peru	Graciela - Juanita Minera Baribent Tingo Maria
Scotland	Aberfeldy
Spain	Cordoba Mines La Carolina
Thailand	Australian - Thai Tin, Ltd. Dresser Minerals International, Inc. Loi Mining Nidhi Mining Oriental Gold Siam Barite Company STA Mining TIP Mining

that are centrally located with respect to specific markets. Although few in number, these mills nevertheless represent an essential part of the barite industry.

A summary of information on the thirty-three (33) barite deposits that were profiled is given in Schedule D. This summary is based on the profile reports which provided engineering and cost data to produce drilling mud grade barite as a final product. The profile reports included the following information: (1) Identification of each C/M/D, (2) Resource description, (3) Operation description, (4) Infrastructure, (5) Manpower requirements, (6) Energy usage, (7) Development plan, (8) Costs, (9) Byproduct evaluation, (10) General discussion, and (11) References.

Antimony C/M/D's

Schedule E provides the names of antimony properties proposed by USBM in the original contract. For comparison, properties actually profiled are shown in Schedule F.

With USBM's consent six (6) properties were substituted. They were as follows:

<u>Properties Deleted</u>	<u>Properties Substituted</u>
1. Caborca (Mexico)	Timerhdoudine (Morocco)
2. El Catorce (Mexico)	Candelaria (Bolivia)
3. Higino (Thailand)	Bothong (Thailand)
4. Mina El Perro (Mexico)	Tourtit (Morocco)
5. Nakacha (Thailand)	Doi Ngoem (Thailand)
6. Phadad (Thailand)	Mae Ta (Thailand)

These substitutions were required for a variety of reasons. In Mexico both Caborca and Mina El Perro were deleted as field work showed that these had been shut down due to exhaustion of known minable reserves. El Catorce was deleted because it was found to be a silver, rather than an antimony mine. In Thailand, Nakacha and Higino were deleted because both had been permanently closed due to exhaustion of reserves. Phadad was dropped when no antimony company, mine or deposit could be found with this name. The three Thai replacements represent about ninety (90) percent of the antimony output in this country. The two Moroccan substitutes are the principal producers in the country and have at least fifteen (15) years of reserves. The other substitute, Candelaria, is a major Bolivian producer.

In addition to the six (6) substitutions, three additional Bolivian properties were added to the list to be profiled. These were Churquini, Salvadora and S. Rosa Del Oro. The justification for the additions is that the four Bolivia properties in the original contract accounted for 8,160 metric tons per year of antimony or about sixty-five (65) percent of the country's output. As the world's largest producer of antimony, coverage of eighty-five (85) percent of Bolivia's production seemed desirable for the MAS program. The three additio

SCHEDULE D

SUMMARY OF BARITE PROPERTY DATA

Barite Companies, Mines and/or Deposits	Reserves @ 75% Probability, mt	In-Situ Grade, % BaSO <sub>4</sub>	Annual Production, mt/yr Ore	Mining Method	Milling Method	No. of Employees	Operating Cost 1982 US\$/mt Ore
Belgium: Fleurus	C	A	C	OP	G	C	D
Brazil: Baroid Pigmina Indus- trial e Commercial, S.A.	C	C	C	OP	G	A	D
Chile: Cia Minera Baritex	A	B	C	OP	N	D	C
Cia Minera Resguardo	A	B	A	OP	N	A	C
France: Societe Barytine De Chaillac	D	E	G	OP	F	B	C
Germany: Dreislar	C	A	C	UG	G/F	B	E
Greece: Mykonos Mykobar S.A.	C	D	C	UG	G/F	B	E
India: Mangampet	E	A	F	OP	N	D	B
Tiffin Barytes, Paints & Asbestos, Ltd.	C	A	A	OP	N	B	B
Ireland: Silver Mine	D	A	F	OP	N	B	B
Italy: Sardina Mines: Barega <sup>(1)</sup>	D	E	E	OP	N	B	C
Montega	D	E	D	UG	F	B	E

SCHEDULE D

SUMMARY OF BARITE PROPERTY DATA

Barite Companies, Mines and/or Deposits	Reserves @ 75% Probability, mt	In-Situ Grade, % BaSO <sub>4</sub>	Annual Production, mt/yr Ore	Mining Method	Milling Method	No. of Employees	Operating Cost 1982 US\$/mt Ore
Mexico:							
BAROSA	D	B	C	UG	F	B	C
Barita de Sonora	C	A	D	OP	N/F	B	B
Cobachi (Minera de Bucarit)	E	C	G	OP	F	C	B
Morocco:							
Djebel Ihroud	D	E	C	UG	G	C	B
Seksaoua	D	A	C	UG	N	D	C
Tessaout	A	A	A	UG	N	B	C
Zelmu	E	A	F	OP	N	B	A
Pakistan:							
Bolan Barytes	D	B	B	OP	N	B	B
Peru:							
Graciela - Juanita <sup>(2)</sup>	D	B	F	OP/UG	F	C	E
Minera-Baribent	A	A	A	UG	N	N/A	C
Tingo Maria (Chagla) <sup>(3)</sup>	D	A	D	OP	N	B	B
Scotland:							
Aberfeldy	D	A	D	UG	N	B	C
Spain:							
Cordoba Mines: <sup>(4)</sup>							
Guillermin	B	E	C	UG	F	B	D
San Fernando <sup>(5)</sup>	A	B	A	UG	G	A	E
La Carolina	E	E	F	OP	G	A	B

SCHEDULE D

SUMMARY OF BARITE PROPERTY DATA

Barite Companies, Mines and/or Deposits	Reserves @ 75% Probability, mt	In-Situ Grade, % BaSO <sub>4</sub>	Annual Production, mt/yr Ore	Mining Method	Milling Method	No. of Employees	Operating Cost 1982 US\$/mt Ore
Thailand:							
Australian-Thai Tin, Ltd:							
Atbar	A	A	B	OP	W	B	E
Thung Wa	B	A	B	OP	W	B	E
Dresser Minerals Inter- national, Inc. (Khao Ma Thai)							
Loi Mining	B	A	C	OP	W	D	C
Nidhi Mining	D	A	B	OP	W	B	B
Oriental Gold	D	E	C	OP	N	C	A
Siam Barite Co.	D	D	B	OP	N	A	B
STA Mining	A	A	A	OP	W	B	D
TIP Mining	D	D	B	OP	N	A	A
	D	E	D	OP	W	C	A

REMARKS:

- (1) Flotation plant is planned for 1985.
- (2) Pb, Zn by-product
- (3) Under development
- (4) Pb, Zn by-product
- (5) A flotation section may be added in 1985 to improve recovery.

SCHEDULE D  
SUMMARY OF BARITE PROPERTY DATA

LEGEND

A. RESERVES

<u>Code</u>	<u>Range (tonnes)</u>
A	Under - 250,000
B	250,001 - 500,000
C	500,001 - 1,000,000
D	1,000,001 - 5,000,000
E	Over - 5,000,000

B. IN-SITU GRADE

<u>Code</u>	<u>% BaSO<sub>4</sub></u>
A	Over 90.0
B	80.0 - 89.9
C	70.0 - 79.9
D	60.0 - 69.9
E	Less than 60.0

C. PRODUCTION

<u>Code</u>	<u>Range (tonnes/year)</u>
A	Under - 25,000
B	25,001 - 50,000
C	50,001 - 100,000
D	100,001 - 150,000
E	150,001 - 200,000
F	200,001 - 300,000
G	Over - 300,000

D. MINING & MILLING METHODS

<u>Code</u>	<u>Method</u>
OP	Open Pit
UG	Underground
G	Gravity
F	Flotation
N	Sorting
W	Washing

E. EMPLOYMENT

<u>Code</u>	<u>No. of Employees</u>
A	Less than 25
B	26 - 100
C	101 - 200
D	Over - 200

F. COSTS

<u>Code</u>	<u>Range (\$/mt)</u>
A	0 - 5
B	5 - 10
C	10 - 15
D	15 - 20
E	Over - 20
N/A	Not Applicable

SCHEDULE E

LIST OF ANTIMONY PROPERTIES INCLUDED IN THE ORIGINAL CONTRACT

Australia	Hilgrove Wild Cattle Creek
Bolivia	Caracota Chilcobija Espirito
Canada	Lake George
Italy	Manciano-Tafone
Mexico	Mina El Perro Wadley Mine Caborca El Catorce
South Africa	Gravellote
Thailand	Nakacha Phadad Higino
Turkey	Turhal-Tokat

SCHEDULE F

LIST OF ANTIMONY PROPERTIES STUDIED

Australia Hilgrove  
Wild Cattle Creek

Bolivia Candalaria  
Caracota  
Chilcobija  
Churquini  
Espirito  
Salvadora  
Rosa De Oro

Canada Lake George

Italy Manciano-Tafone

Mexico Wadley Mine

Morocco Timerhdoudine  
Tourtit

South Africa Gravelote

Thailand Bothong  
Doi Ngoem  
Mae Ta

Turkey Turhal-Tokat

properties, with a combined output of 2,300 metric tons of contained antimony, increased coverage of Bolivia's production to about eighty-three (83) percent.

A summary of information on the nineteen (19) antimony deposits that were profiled is given in Schedule G. This summary is based on profile reports which provided engineering and cost data to produce antimony metal or trioxide. The profile reports included the same information as did the barite reports (see preceding section), plus data on post mine/mill processing.

A total of 13,698,000 tons of demonstrated resource is contained in mines evaluated. This resource contains about 478,000 tons of antimony, for weighted average grade of 3.5 percent antimony. Total annual capacity for the mines evaluated amounts to about 36,300 tons of contained antimony as metal.

SCHEDULE G

SUMMARY OF ANTIMONY PROPERTY DATA

Antimony Companies, Mines and/or Deposits	Reserves @ 75% Probability, mt	In-Situ Grade, % Sb	Annual Production, mt/yr Ore	Mining Method	Milling Method	No. of Employees	Operating Cost 1982 US\$/mt Ore
Australia:							
Hilgrove	A	B	C	UG	F	B	D
Wild Cattle Creek	C	B	D	UG	F	B	C
Bolivia:							
Candalaria	D	C	D	UG	G/F	D	B
Caracota	C	D	D	UG	G/F	D	A
Chilcobija	C	C	D	UG	F	D	A
Churquini	B	C	B	UG	G/F	B	A
Espirito	B	E	C	UG	F	C	A
Rosa De Oro	D	D	B	UG	S/F	A	A
Salvadora	B	D	B	UG	F	B	B
Canada:							
Lake George	D	B	D	UG	F	B	B
Italy:							
Manciano-Tafone	D	E	C	OP	F	B	A
Mexico:							
Wadley	C	A	A	UG	S	A	B
Morocco:							
Timerhdoudine	C	D	C	UG	G/F	C	A
Tourtit	D	D	D	UG	F	C	A
South Africa:							
Consolidated Murchison <sup>(1)</sup> (Gravellote)	D	E	D	UG	F	D	B

SCHEDULE G

SUMMARY OF ANTIMONY PROPERTY DATA

Antimony Companies, Mines and/or Deposits	Reserves @ 75% Probability, mt	In-Situ Grade, % Sb	Annual Production, mt/yr Ore	Mining Method	Milling Method	No. of Employees	Operating Cost 1982 US\$/mt Ore
Thailand:							
Bothong	B	A	A	OP	None	C	A
Doi Ngoem	A	B	A	OP	None	C	A
Mae Ta	A	A	A	OP	None	A	B
Turkey:							
Turhal-Tokat	D	D	C	UG	S,G,F	D	C

LEGEND

A. RESERVES

Code	Range (mt)
A	Less than 50,000
B	50,001 - 200,000
C	200,001 - 500,000
D	Over - 500,000

B. IN-SITU GRADE

Code	Range, % Sb
A	Over 10.0
B	5.0 - 10.0
C	4.0 - 4.9
D	3.0 - 3.9
E	Less than 3.0

C. PRODUCTION

Code	Range (mt/yr)
A	Less than 5,000
B	5,001 - 20,000
C	20,001 - 50,000
D	Over - 50,000

D. MINING & MILLING METHODS

Code	Method
UG	Underground
OP	Open Pit
F	Flotation
G	Gravity
S	Hand Sorting

E. EMPLOYMENT

Code	No. of Employees
A	Less than 50
B	51 - 100
C	101 - 200
D	Over - 200

F. COSTS

Code	Range (\$/mt Ore)
A	10 - 30
B	30 - 50
C	50 - 70
D	Over - 70

- A. The chemistry of concentrate reduction in smelting or hydro-metallurgy.
- B. The influence of impurities on concentrate processing and end uses.
- C. Process alternatives for various antimony feeds.
- D. Principal antimony product grades and specifications.
- E. A summary of operating and cost information on current processing plants in the free world.

CERTIFICATION

Brown & Root Development, Inc., of Houston, Texas, as contractor, and Mineral Systems Inc. of Stamford, Connecticut, as subcontractor, hereby certify that there are no subject inventions developed in whole or in part from work done under U.S. Department of the Interior, Bureau of Mines Contract J0225017.