Barite: World Production, Reserves, and Future Prospects

GEOLOGICAL SURVEY BULLETIN 1321

Barite: World Production, Reserves, and Future Prospects

By DONALD A. BROBST

GEOLOGICAL SURVEY BULLETIN 1321

Trends in use and production of barite. A geological summary of deposits. Outlook is favorable for discovery of new deposits to meet rising demand

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1970

UNITED STATES DEPARTMENT OF THE INTERIOR

WALTER J. HICKEL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. 72-607768

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington D. C. 20403 — Price 30 cents (paper cover)

CONTENTS

CONTENTS

ILLUSTRATION

TABLES

BARITE: WORLD PRODUCTION, RESERVES, AND FUTURE PROSPECTS

By DONALD A. BROBST

ABSTRACT

The world reserves of barite in 1969 are estimated at about 200 million tons. This apparently large supply will last only 20 years, if production grows no faster during the next 20 years than it did in the past 20. In 1945, world barite production was about 1 million tons annually; by 1966, it was 4 million tons. It is startling to realize that of the estimated total world barite production of 83 million tons, nearly 60 million tons was produced during 1945–67.

At least 80 percent of the world's barite is consumed in drilling mud for oil and gas wells; the remainder is used largely in the chemical, glass, paint, and rubber industries. In the intensifying search for oil and gas and the expanding industrialization of the world to supply the needs of an increasing population, barite consumption likely will continue to rise.

Barite deposits are of three major types—vein and cavity filling, bedded, and residual. Since World War II, nearly 50 nations have reported barite production, chiefly from vein and bedded deposits. In the United States, the world's chief producer and consumer of barite, production is mostly from bedded and residual deposits. Other major barite production comes from the bedded and vein desposits of Canada, Mexico, and the nations of Europe.

Geologic factors suggest that world barite production and reserves can be increased in the coming years. Possibilities for the discovery of new barite deposits similar to the large, high-grade, bedded deposits of Nevada and Arkansas are good.

INTRODUCTION

This report is a summary of world trends in the uses and production of barite and presents a tabulation of the world's reported reserves, as well as a discussion of the geologic features of barite deposits that will bear upon the supplies of barite available to fill projected future demands in world markets. With increasing demands for oil, gas, and mineral raw materials arising from the industrialization of many nations and the expanding economies of others, the world's annual rate of barite production has quadrupled, from an estimated 1 million tons in 1945 to 4 million tons in 1966, according to information from the U.S. Bureau of Mines (1945–66, minerals yearbooks). This report will examine briefly some major aspects, trends, and prospects in the world's barite industry.

The data concerning barite deposits outside the United States were compiled from many published sources and commonly had to be translated from pertinent foreign publications into English. The references from the foreign literature were selected to provide a wider knowledge of barite deposits for readers seeking information about them for scientific and commercial purposes.

USES

Barite ($BaSO_4$) has long been mined for use directly as the natural sulfate or as a source for various barium compounds and barium metal needed in many industrial processes and products. Many of the specialized uses of barite and barium products are hidden among the complexities of modern industry. A survey of the uses of barium chemicals by the Food Machinery & Chemical Corp. (1961) listed more than two thousand specific industrial applications in 17 major classifications. Most uses of barite require only a small, although steadily increasing, part of the world's supply.

Most of the world's barite production since 1926 has been used as an ingredient of the muds circulated in rotary drilling of oil and gas wells. These muds lubricate the drill and the stem, seal off the walls of the hole, remove cuttings, and help to confine the high oil and gas pressures met at depth. Barite is particularly well suited to this purpose because it is soft (about 3 on Moh's scale of hardness), heavy (max sp gr 4.5), and rather inert. In 1967, about 80 percent of the barite consumed in the United States went into drilling mud, as probably did at least that much of the world's supply, although statistics on world uses are not available.

Much of the remainder of the world's annual supply of barite goes into the manufacture of glass, as a flux and to add brilliance and clarity to the product; into the wares of the paint and rubber industry, principally as filler and pigment; and to the chemical industry for the preparation of barium compounds.

Barite is a common industrial filler, extender, and weighting agent, and it is added to bristolboard, playing cards, heavy printing papers, rope finishes, brake linings, clutch facings, plastics, and linoleum. As a pigment, barite is used in several ways: as the natural (or acid-bleached) white sulfate; as blanc fixe, a white pigment of chemically pure reprecipitated barium sulfate, perhaps best known as an indicator in medical X-ray photography; and in lithopone, a white pigment of 70 percent barium sulfate and 30 percent zinc sulfide. The use of lithopone as a prime white pigment has declined rapidly since titanium pigments were introduced after World War II.

Various barium compounds, but especially the chloride, carbonate, and hydroxide, are used widely as reagents and catalysts, as in sugar refining; the manufacture of synthetic zeolites for water softeners; sizing, waterproofing, and fireproofing for textiles; drugs, for the manufacture of vitamins, hormones, and blood coagulants; various pyrotechnics, notably green flares; stabilizers for glue and starch; coagulation of synthetic rubber; plastics; insecticides, herbicides, and germicides; case hardening of steel; phosphors for fluorescent lamps; bonding phosphors to glass for black and white TV tubes; reagents for the beneficiation of ores and paper manufacture; welding fluxes; melting and refining of magnesium; the recovery of indium; and the recovery of zinc from dross.

Barium titanate ceramics are used in the electronics industry, and barium ferrate ceramics are used for permanent magnets.

Barium metal is used in many alloys and as a getter in the degasification of TV and other vacuum tubes.

In the construction industry, some barite is used in concrete aggregate to weight down pipelines buried in marshy areas and to shield stationary nuclear reactors. Because barite absorbs gamma radiation well, its use reduces the amount of expensive lead shielding otherwise necessary. About 10 percent barite is used with rubber and asphalt in a paving mixture suitably durable for parking lots, roads, and airport runways. Barium carbonate solutions are used to descum bricks. Recently the tires of heavy road construction equipment have been partly filled with a barite mixture to add weight as an aid in packing areas of fill.

TRENDS

The trends in the uses of crushed and ground barite in the United States since 1958 are posted in the statistics compiled in table 1, which updates the data in table 2 in the report by Brobst (1958, p. 70). The figures indicate that a prosperous barite industry is dependent on continued high rates of well drilling. With oil and gas requirements rising in the United States, there is every reason to believe that the demand for drilling mud will continue at high levels, and even increase. The statistics also show that the United States consumption of barite in the glass, paint, and other industries has increased significantly, to about four times that of 10 years ago. Many of these uses involve "soft" consumer goods, for which demand will surely increase.

Continued increases in the use of barium chemicals also may be expected. According to data from the U.S. Bureau of Mines minerals yearbooks, the average annual production of barium chemicals in the United States during 1957–61 was 92,000 tons, and from 1962 to 1967 it rose to 116,000 tons, a nearly 30-percent increase from the first to the second half of the decade.

Outside the United States, long the world's largest consumer of barite, the demand for barite for all uses will increase rather sharply. Especially large increases in the use of drilling mud in the worldwide search for oil and gas can be expected. Not only will there be more wells drilled, but many targets will require deeper holes into high-pressure areas of deeply buried reservoir rocks. Such deep holes, with a greater potential for blowouts and leakage losses, will require large amounts of drilling mud. Other industrial uses of barite are sure to consume barite at accelerated rates as new nations industrialize, and as economies expand in the older industrial nations.

TABLE 1.—*Barite consumption by major industries in the United States*

[Data from U.S. Bureau of Mines (1957–67, minerals yearbooks)]

Industry	1957–61		1966		1967		10-year trend
	Average annual consumption (short tons)	Percent of total	Consumption (short tons)	Percent of total	Consumption (short tons)	Percent of total	
Well drilling	1,077,006	94	1,022,106	85	949,982	81	About the same.
Glass	19,075	2	73,660	6	91,220	8	Up four times.
Paint	16,453	1	69,895	6	59,698	5	Do.
Rubber	20,213	2	38,249	3	31,039	3	Up one-half times.
Other	10,553	1	4,605	<1	39,166	3	Up four times.
Total	1,143,300	------	1,208,515	------	1,171,105	------	--------

PRODUCTION

Barite mining became commercially important when Europe and the United States were industrialized during the middle of the 19th century. Records of world barite production prior to 1914 are incomplete, but Germany and Great Britain supplied most of the barite that reached world markets prior to World War I. In the

United States, the earliest recorded production was 160,000 tons of barite mined from the Cheshire district, Connecticut, between 1838 and 1878 (Fritts, 1962, p. 29). From 1882 to 1914, the United States annually produced about 20,000 to 50,000 tons of barite (Santmyers, 1930), but not until the curtailment of international trade during World War I did a stable barite industry become established in the United States. Since World War I, the world barite industry has grown, and the United States has become the world's leading barite producer, as well as consumer. The barite production and import statistics shown in table 2, compiled chiefly from the annual volumes of mineral statistics published by the U.S. Geological Survey (1882–1923) and the U.S. Bureau of Mines (1924–31, mineral resources; 1932–67, minerals yearbooks), reveal the fact that the total recorded world barite production is about 83 million tons, of which nearly 29 million tons was produced in the United States and another 10 million tons was imported by the United States. Nearly 75 percent of the world's barite production has been mined in the last 22 years. The United States has produced 35 percent of the world's barite and consumed nearly 50 percent.

TABLE 2.—*Barite: world production and U.S. production and imports, in millions of short tons, through 1967*

	World production	U.S. production	U.S. imports
Through 1914	[1]6.5	1.2	0.2
1915–18	[1]1.2	.7	[2].0
1919–44	16.7	7.1	.9
1945–67	58.8	19.8	9.1
Total	83.2	28.8	10.2

[1] Author's estimate; few foreign production data available.
[2] 2,500 short tons imported during period.

Production of barite by States in the United States is listed in table 3. The apparent discrepancy between totals in tables 2 and 3 arises from the fact that the total in table 2 is based on annual production figures for the entire United States whereas the total in table 3 is based on available annual production data for each State. Of the five major barite-producing States, Missouri, Georgia, and Tennessee have recorded production annually since late in the 19th century. Nevada has been a barite-producing State since about 1907. Most of the barite from Arkansas has been mined since 1940.

TABLE 3.—*United States barite production, in short tons, by State, 1882–1967*

Rank	State	Short tons	Rank	State	Short tons
1	Missouri	10,236,000	13	Idaho	100,000
2	Arkansas	7,754,500	14	Montana	100,000
3	Georgia	3,994,400	15	New Mexico	37,500
4	Nevada	1,984,500	16	Alabama	29,200
5	Tennessee	1,644,000	17	Washington	15,800
6	California	770,000	18	Utah	5,400
7	South Carolina	500,000	19	Colorado	5,000
8	Arizona	317,000		Alaska, Maryland, Pennsylvania, Texas, Wisconsin	+
9	North Carolina	301,000			
10	Virginia	200,000			
11	Connecticut[1]	160,000			
12	Kentucky	117,600		Total	28,271,900+

[1] Recorded production between 1838 and 1878.

The spectacular growth of world barite mining began in 1945 as world economy started its great expansion following World War II. The graphs in figure 1 show that in the 25 years from 1919 to 1944, the world rate of barite production doubled, from about half a million to about 1 million tons annually, and in the 22 years from 1945 to 1967, it increased fourfold, from about 1 million to 4 million tons annually. During 1945–58 there is a close positive correlation between United States and world production, but after 1958, this correlation is much less obvious, as other nations of the world increased their production at rates greater than did the United States.

Table 4 lists the barite mining countries of the world and their production from 1945 through 1967. The countries are grouped by geographic areas and rank in production. This grouping also provides an order for the subsequent discussion of the countries in the text. The data were compiled from many sources, but chiefly from the minerals yearbooks of the U.S. Bureau of Mines (1945–67). Nations of North America and Europe constitute the top 10 world barite producers since 1945, but the disparity is great between the United States, in first place with nearly 20 million tons, and Great Britain, in tenth place with 1.6 million tons. Production records of some of the lower ranked countries are deceptive, because some countries began or ceased mining during this period. Appropriate notice of this is given in the text.

BARITE IN WORLD TRADE

Nations that produce large amounts of barite for export are Mexico, Canada, Peru, Brazil, Morocco, Algeria, Ireland, Greece, Yugoslavia, Bulgaria, Romania, and North Korea. The world's major importers are the United States and the Soviet Union. The United States since the mid-1950's has imported a total of about half a million tons annually, chiefly from Mexico, Canada, Peru, Ireland,

TABLE 4.—*Barite: world production, 1945–67, and world reserves*

[*, no reserve figures available, but some reserves are probable; ---, no production data available]

	Production (thousands of tons)	Reserves (millions of tons)
North America	27,717	92
United States	19,814	*83
Canada	4,039	5
Mexico	3,864	4
West Indies and Central America	39	1
Cuba	39	1
Jamaica	------	*
British Honduras	------	*
South America	2,735	8
Peru	1,430	1
Brazil	713	3
Argentina	396	*
Colombia	155	1
Chile	41	3
Bolivia	------	*
Europe	23,326	46.7
German Federal Republic (West Germany)	8,288	7
U.S.S.R.	2,830	*3
Italy	2,273	5
France	1,793	3.5
Yugoslavia	1,783	3
Greece	1,677	3.5
Great Britain	1,664	2.2
Romania	1,066	2
Spain	579	1
Poland	413	2
Ireland	366	3
German Democratic Republic (East Germany)	335	3
Bulgaria	149	*5
Austria	90	.3
Portugal	20	.6
Czechoslovakia	------	2
Belgium	------	.6
Africa	1,900.3	19.7
Morocco	1,001 }	12
Algeria	767 }	
Republic of South Africa	56	3.2
United Arab Republic (Egypt)	55	*
Rhodesia	10	1
Swaziland	9	1
Tunisia	2	*
Kenya	.3	*
Liberia	------	2
Malagasy Republic	------	.5
Zambia	------	*
Tanzania	------	*
Uganda	------	*
Somalia	------	*
Near East	929	9.7
India	565	1
Iran	202	3
Turkey	90	4
Pakistan	51	1.6
Burma	17	*
Afghanistan	4	*
Saudi Arabia	------	.1
Far East	2,080.2	21.8
China (mainland)	850	10
Japan	533	3.3
Democratic People's Republic of Korea (North Korea)	656	3
Philippines	29	*
Republic of Korea (South Korea)	12	3
Thailand	.2	2.5
Oceania	195	5
Australia	195	5
Fiji	------	*
Grand total	58,921.5	203.9

Greece, Yugoslavia, and Morocco. The Soviet Union in recent years has augmented its own annual production of about 200,000+ tons with another 100,000+ tons of imported barite, coming chiefly from Yugoslavia, North Korea, Romania, and Bulgaria.

In western Europe, Germany, France, Great Britain, and Italy are, or can be, net exporters. The Benelux nations import from their neighbors and North Africa, and the Scandinavian countries supply their needs from West Germany.

Middle East markets are supplied from barite deposits in the Mediterranean region, but domestic industries are springing up in some of the oil-rich countries, notably Iran, and even in the United Arab Republic.

South American oil fields are supplied mostly by locally mined barite, although Brazil does supply some exports, notably to Venezuela, which has no known commercial deposits.

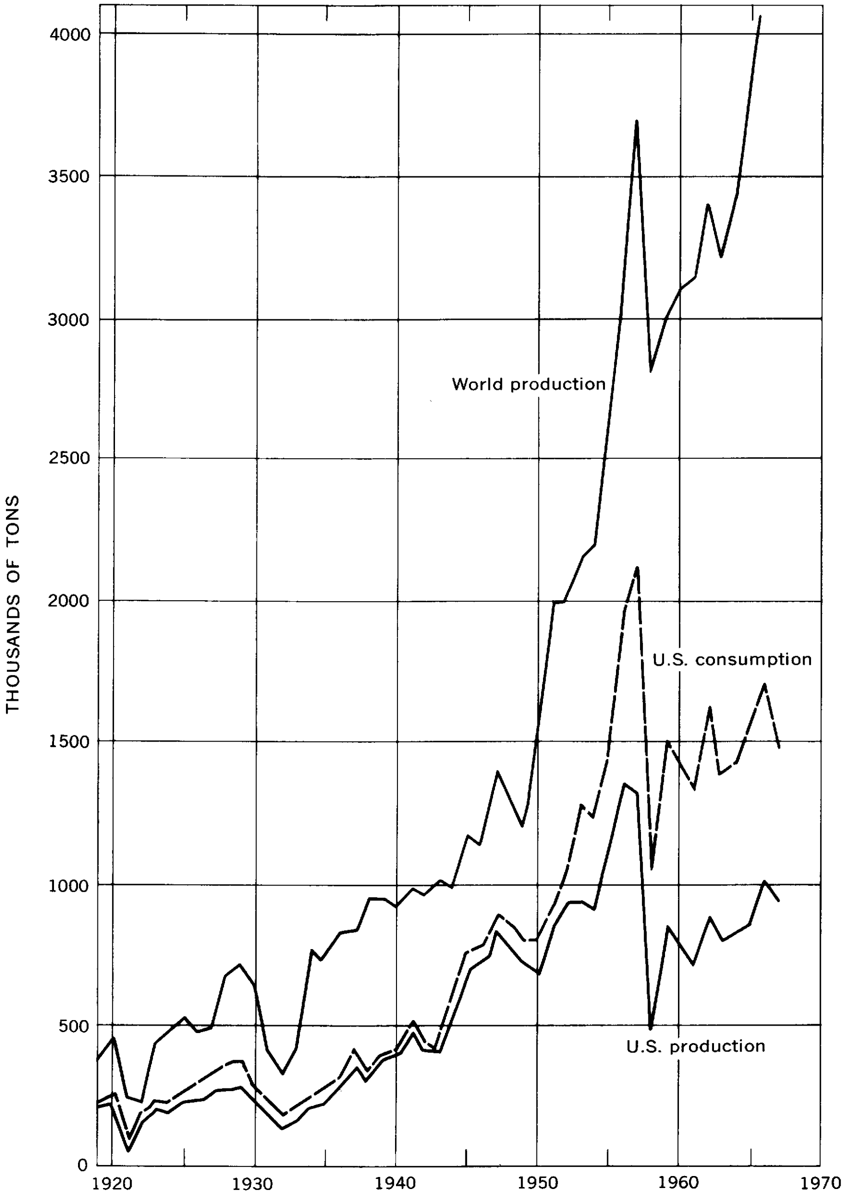

FIGURE 1.—Barite: world production and U.S. production and consumption, in short tons, 1919–67.

Eastern Asian markets are developing rapidly, and trading done there is mostly on a regional basis. Japan supplements its needs by imports from mainland China and India. Taiwan is supplied chiefly from South Korea. Australia's domestic industry is expanding rapidly, and its small imports of recent years have come from mainland China and even the United States.

World trade in barite is not large, because most regional demands can be satisfied from relatively local sources, as attested by the long list of widely scattered barite-producing nations (table 4), and because transporting large volumes of such a heavy commodity of low unit value for long distances is very expensive.

Although there will be spotty increases in international trade of barite as isolated temporary high demands are met by today's producers, the exploration for and development of new deposits will increase markedly all over the world. The success of these search-and-development programs will be the greatest single factor affecting the long-range future of international trade in barite.

OUTLOOK

The current upward trend of world barite production likely will continue. The rate of increase will depend mostly on drilling in the world oil and gas industry. A detailed discussion of the many factors affecting the future production of barite is beyond the scope of this paper, but the amount of barite required for the next 20 years to supply increasing demands can be summarized in general terms. If production in the next 20 years is to continue at the present annual rate of 4 million tons, 80 million tons of barite must be mined. If the rate increases evenly through 20 years to double the current rate, about 120 million tons will be required; if the rate trebles, about 160 million tons will be required; and if the current rate quadruples, as it has in the past 20 years, then about 200 million tons will be required.

The projected barite requirements for the next 20 years at the levels just suggested come sharply into focus when these values are compared with the world's estimated total production to date—83.2 million tons. Even if there should be no increase in the rate of world barite consumption in the next 20 years, the mining industry will be asked to supply an amount at least equal to the entire tonnage mined in little more than the past 100 years. If the fourfold rate of increased production of the past 20 years continues in the next 20-year period, the nearly 200 million tons required is about equal to the entire sum of the world's reported barite reserves, as compiled in this report (table 4). If the future needs of barite are to be met, now is the time to examine and interpret the geologic aspects and the reported reserves of world barite deposits.

GEOLOGY AND RESERVES

The present status of knowledge of world barite deposits and their reserves as reported in the literature is summarized in this section. Reported world barite reserves are listed in table 4. A broad use of the term "reserves" is necessary here because of the many shades of meaning it expresses when used by authors the world over. The term "reserves" is used here to include bodies of barite-rich rock of sufficient size and grade to be mined now or to warrant serious consideration for mining under slightly more favorable economic conditions. In this report, resources refer to concentrations of barite which cannot be mined until there is a change in conditions in world markets.

The barite deposits of the United States were classified and geologically characterized (Brobst, 1958, 1960) in three major categories—(1) vein and cavity-filling deposits, (2) residual deposits, and (3) bedded deposits. The same broad classification may be applied to deposits elsewhere in the world.

Vein and cavity-filling deposits are those in which barite and associated minerals (commonly quartz, calcite, fluorite, and sulfides of base metals) occur along faults, gashes, joints, and bedding planes, and in breccia zones, solution channels, and sink structures. The latter two are especially common in limestones. Barite mined from these deposits may be either the principal product or a coproduct. Vein deposits currently are a major source of barite in many nations, except the United States, West Germany, Yugoslavia, and Brazil. In the United States, deposits in this category have yielded only an estimated 2 million of the 28 million tons of barite produced. Many of the vein deposits in the United States mined principally for barite have been rather small and expensive underground operations. Barite buyers in the United States have paid little attention to supplies available as a coproduct; the supply is too variable because of fluctuations in the demand for the principal product.

Residual deposits are those concentrations of barite, generally in clay, that have been derived from preexisting rocks. These deposits, commonly in residuum from Cambrian and Ordovician carbonate rocks, are of great commercial importance in the United States because of their large size (in spite of low grade), ease of mining and beneficiation, and proximity to markets. Residual deposits in Missouri, Georgia, and Tennessee have yielded nearly 16 million of the 28 million tons of barite mined in the United States. Almost no information is available about residual deposits in the rest of the world.

Bedded deposits are those in which barite of either epigenetic or syngenetic origin is restricted to certain beds or sequences of beds in sedimentary rocks. Some of the most valuable commercial deposits known, especially in the United States (Arkansas and Nevada), West Germany, Yugoslavia, and Brazil, are bedded deposits that contain millions of tons of ore having a grade of 50 percent to more than 90 percent $BaSO_4$. With the exception of the long-mined deposits in Germany, some of the large bedded deposits were found and (or) came into production during World War II. In the last 25 years, a relatively small number of these deposits have yielded about one-third of the world's supply of barite. Bedded deposits in Arkansas and Nevada have supplied about 10 million of the 28 million tons of barite mined in the United States. Since 1939, more than 7 million tons has been mined from the Magnet Cove deposit, Arkansas.

Bedded deposits of the type in Arkansas and Nevada have geological characteristics that may cause the barite to be easily overlooked during fieldwork. The barite is massive to laminated, dark gray to black, and very fine grained, and commonly gives off the odor of hydrogen sulfide. The chief impurity is silica, and a few percent of organic matter is common. Except for its heaviness, much of this ore could be mistaken for impure limestone.

New deposits of bedded barite were recently found in Nevada, and geological study by Shawe, Poole, and Brobst (1967, 1969) suggests that the barite was deposited along with other sediments in a eugeosynclinal environment during early Paleozoic time. The recognition of the possibility that barite may form a eugeosynclinal sedimentary facies opens new possibilities for world exploration for barite.

NORTH AMERICA

UNITED STATES OF AMERICA

The barite reserves of all grades of ore in the United States were reevaluated for this report. The reserves now are estimated to be 83 million tons of barite, nearly half of the reported world reserves of 204 million tons (table 4). About 14 million tons are in the vein deposits of the Rocky Mountain and Pacific Coast regions; 19

million tons are in the residual deposits, chiefly in Missouri, Georgia and Tennessee; and about 50 million tons occur in the great bedded deposits, chiefly in Nevada and Arkansas. Many references to the geology and reserves of barite in the United States are listed by Dean and Brobst (1955) and Brobst (1958, 1965). More recent papers describe barite in New Mexico (Williams and others, 1964), Arkansas (Brobst and Ward, 1965), California (Weber, 1966), Nevada (Shawe and others, 1967, 1969), and the Appalachian region (Brobst and Hobbs, 1968).

CANADA

The mining history, production, economics, geology, and reserves of barite in Canada were summarized by Ross (1960). Canada's total recorded barite production is about 4.3 million tons, of which about 90 percent came from the large epigenetic deposits associated with faulted and folded sedimentary rocks of Mississippian and Triassic age in the vicinity of Walton, Nova Scotia. These deposits and the associated base-metal sulfide and silver ore discovered in 1956 have been described in detail by Boyle (1963), who also estimated that the barite reserve to a depth of 1,000 feet was 2.5 million tons of ore containing 90 percent $BaSO_4$. Another 2 million tons of ore occurs in other large deposits, especially in British Columbia (Ross, 1960, p. 46). Ross has stated that barite resources are building up significantly as barite associated with metallic ores is washed into Canadian tailings ponds at the current rate of 225,000 tons annually. Barite reserves of Canada are about 5 million tons (table 4), and resources are undoubtedly large.

MEXICO

Among the mineral deposits of Mexico are barite deposits listed in about 20 States, but the major mines are in the Muzquiz district, Coahuila, and in Nuevo León (Reyna, 1956). The barite deposits of the Galeana district, Nuevo León, are lenticular veins along northeast-trending tension fractures that dip steeply to the northwest in red beds of the Huizachal Formation of Jurassic age. According to Tavera Amezcua, Lopez, and Avila (1960, p. 49), about 60 deposits have reserves of 100,000 tons and resources of another 100,000 tons. Few reports are available about Mexican barite deposits, but the 3.8 million tons of barite that had been mined since 1952 make Mexico one of the world's great producers. Reserves and resources probably are relatively large. The reserve figure of 4 million tons in table 4 is from Chermette (1962, p. 36).

WEST INDIES AND CENTRAL AMERICA

CUBA

Cuba has barite deposits in northern and western Pinar del Rio Province that were explored and briefly mined in 1957 and 1958, when about 30,000 tons was exported to the United States. Total reserves were then estimated to be in excess of half a million tons, and one group of mines had measured reserves of 250,000 tons of barite (U.S. Bureau of Mines, 1960, Mineral trade notes, v. 51, no. 4, p. 13).

JAMAICA

The most important barite deposits form veins in water-laid tuffs of Early Cretaceous age in the Benbow Inlier south of Guys' Hill. The largest of four mineralized zones has a lenticular vein as much as 32 inches wide and 750 feet long. From 2,500 to 3,500 tons of barite is estimated to occur within 20 feet of the surface. There is sufficient ore for local use, but probably not enough for export (Zans, 1951).

BRITISH HONDURAS

A zone of quartz-barite veins 60 feet wide, dipping 70°, is exposed along Vaqueros Creek in the vicinity of Mountain Pine Ridge, British Honduras. Barite of hydrothermal origin is associated with Cretaceous limestone, according to reports in Colonial Geology and Mineral Resources (1954, p. 287). Reserves have not been calculated.

SOUTH AMERICA

PERU

Peru is a newcomer among the leading barite producers of the world. From 1903 to 1957, Peru had produced about 200,000 tons of barite; beginning in 1958, production has exceeded 100,000 tons annually, for a total production in the last decade of 1.3 million tons. Most of this barite has been mined from large hydrothermal deposits associated with andesitic volcanic rocks and dioritic to granodioritic intrusive rocks of Tertiary age in the Rimac valley, near Lima. Cabrera La Rosa (1962) has described the barite potential of Peru as great, with much area still to be explored. Reserve data are not available, but it seems reasonable to assume that Peruvian reserves of barite are at least 1 million tons.

BRAZIL

Brazilian barite deposits are listed in the States of Rio Grande do Norte, Paraíba, Bahia, Rio de Janeiro, São Paulo, Paraná, and

Minas Gerais (Abreu, 1960, p. 303–311). The largest known deposits are on Ilha Grande and Ilha Pequena on Camamu Bay, Bahia, where barite has replaced sedimentary rocks of Cretaceous age. Reserves are estimated at 1 million tons of high-quality ore and another 2 million tons of inferior-quality ore. The deposits on Camamu Bay were described in considerable detail by Bodenlos (1948). Deposits in Paraná are anticipated to have appreciable reserves. Great parts of Brazil remain to be explored geologically.

ARGENTINA

Barite is produced chiefly from vein deposits in the Provinces of Neuquén, Jujuy, La Roija, and Mendoza, although Cordoba and Salta have recorded some production. Beder (1921, p. 21) published a short summary of the locations of barite deposits. Almost no information has been published recently on the barite deposits and reserves of Argentina. Small amounts of barite, only 15,000 to 20,000 tons, are produced annually, and the entire production since World War II is only about 396,000 tons.

COLOMBIA

Wokittel (1956) reported nearly 1 million tons of barite available in Santander (300,000 tons) and Norte de Santander (600,000 tons). Other barite reserves, which are unmeasured, occur in the Departments of Cundinamarca, Huila, Magdalena, and Tolima. Barite production in Colombia has been about 10,000 tons annually since 1960, so that the major part of these reserves is still available.

CHILE

Barite deposits are relatively common in Chile, in crosscutting veins and in metallic ore deposits (Vila, 1953, p. 108–112). The Caracoles deposit, about 120 miles (200 km) east of the port of Antofagasta, contains veins of white barite, average grade 80 percent, with reserves of 3 million tons. Many other vein deposits, relatively unexplored, are listed in the Provinces of Antofagasta, Atacama, Aconcagua, Coquimbo, Santiago, and Valparaiso.

BOLIVIA

No reserves of barite are known, although resources may exist, according to Ahlfeld and Schneider-Scherbina (1964, p. 320–321). Barite gangue is reported in lead-bearing veins in the central Cordillera in the Cochabamba, Torotoro, and Sucre areas. Some veins of pure white barite occur in Devonian sandstones. Veins, termed of major importance, are localized in Ordovician rocks in the vicinity of Angaldo.

EUROPE

GERMAN FEDERAL REPUBLIC (WEST GERMANY)

Germany has produced more than 10 million tons of barite since 1900 and is second only to the United States in total barite production. In one of the world's largest barite deposits, at Meggen, Westphalia, barite and various sulfides of iron, copper, and zinc were deposited syngenetically during the late Middle Devonian in a double syncline, part of the Rhenish geosynclinorium (Ehrenberg and others, 1954). The metal ions were delivered to the sea water by hydrothermal solutions that entered through fractures on the sea floor. Barite reserves still available are estimated at about 5 million tons.

Recent studies of the barite at Grube Eisen, southwestern Hunsrück, Saarland, suggest that this ore had syngenetic exhalative sedimentary origin in Early Devonian time (Hofmann, 1966). These deposits are similar in many respects to those at Meggen. Barite lenses 140 meters long and about 10 m thick are reported. Reserve estimates have not been published.

Another major source of barite is the famous banded ore of Rammelsberg, near Goslar, in the western Harz Mountains. These deposits, mined for a thousand years, have yielded barite, lead, zinc, copper, and small amounts of gold and silver from fine-grained beds in the Wissenbacher Schiefer of Middle Devonian age. The metals derived from volcanic exhalations were deposited contemporaneously with the enclosing sediments. Later, the deposits were slightly metamorphosed during Variscan (Carboniferous) folding. The reserves, calculated in 1954, are considered final and suggest a mining expectancy of 30 years at the 1954 rates of production (Kraume and others, 1955, p. 332–333). These data suggest that 1 million tons of barite is available.

The U.S. Bureau of Mines (1960, Mineral trade notes v. 51, no. 4, p. 15) reported that barite veins in the Bad Lauterberg area, western Harz, had reserves of 1 million tons. These vein deposits are associated with granites of Variscan age, but not much is known about their geochemistry or genesis (Bolduan and others, 1961, p. 13).

Near Pforzheim in the northern Schwarzwald, some 40 veins containing fluorspar and barite are known, and some of the larger ones were described by Henglein (1934). Hoffmann, Hulsemann, Isert, Landschutz, and Schlicht (1930, p. 302–303) gave a brief catalog of barite deposits in Germany.

The total barite reserves of the German Federal Republic are about 7 million tons.

UNION OF SOVIET SOCIALIST REPUBLICS

Most of the barite produced in the Soviet Union comes from deposits in the Transcaucasus region of Georgia, Armenia, and Azerbaijan: the Kutaisi district, about 50 km north of Kutaisi; the Chordski district, about 70 km northeast of Kutaisi; the Kirovabad district, about 160 km southeast of Tiflis; and the Madneuli district, about 50 km southwest of Tiflis (Liubimov, 1966, p. 134, 144). In the valleys of the Rion and Kvirila Rivers northeast of Kutaisi, more than 100 veins of 96- to 98-percent barite as thick as 1 m have been traced for several kilometers (Shimkin, 1953, p. 285). The veins, of hydrothermal origin, were deposited in tectonic fractures in a tuff-porphyry unit of Middle Jurassic age. The Madneuli deposits are among the nation's largest and have yielded much chemical- and glass-grade barite. These deposits occur in volcanic rocks of Late Cretaceous age and may be genetically related to dacitic extrusive rocks of Tertiary age (Nazarov, 1959).

In Salair, near the Kuznetsk Basin in western Siberia, barite comprises 35 to 40 percent of the tailings from zinc and gold mining. Up to 1946, more than half a million tons of barite had been produced, and no threat of exhaustion was noted (Shimkin, 1953, p. 285). Reserves of 2 million tons of barite were listed for this area by Schenderei (1932, p. 34). Other deposits in western Siberia include those in the Altai area, where the deposit at Zmienogorsk was reported to have reserves of nearly 800,000 tons in 1935 but was considered exhausted by 1946 (Shimkin, 1953, p. 285). Small deposits were reported in the Askiz and Achinsk areas (Schenderei, 1932, p. 34–37).

In Turkmen, barite occurs in the Kara Kala district in the Kopet Mountains, along the Iranian border (Ahlfeld, 1934). The mountains are formed almost exclusively of marine rocks of Cretaceous age and consist of a sequence of calcareous and clayey sandstones and clay shales. No rocks of Tertiary age are reported, and eruptive rocks are absent. The largest deposits at remote Arpaklen have reserves of several million tons of barite and witherite. These deposits might be of sedimentary origin (Shimkin, 1953, p. 286).

In eastern Kazakhstan, lenses of barite at Kara-gaili may contain substantial resources, as great as 10 million tons. Shimkin (1953, p. 286) also termed these deposits as of possible sedimentary origin.

Deposits of barite have been mined in the Ural Mountains. At the Medvedevka site, barite has been mined from a vein with a maximum thickness of 8.5 m, a depth of 100 to 140 m, and a strike length of 2.25 km. The barite content was 37.6 percent, along with about 20 percent magnetite and some quartz. Mechanical concentration of the barite proved difficult during the 1930's (Shimkin, 1953, p. 286). No recent production is reported from the Ural Mountains.

The development of deposits and new reserves of barite and other nonmetallic commodities apparently has been difficult. Resources of barite seem to be large, but supplies of minable ore close to markets seem to be constantly in short supply. During World War II a production decline in the Baku oil fields resulted from a shortage of barite, and even in 1946 the barite supply was still termed exceptionally tight (Shimkin, 1953, p. 284). The Soviet Union today is estimated to be about two-thirds self-sufficient in barite as both production and imports continue to rise. Domestic production has risen from 80,000 tons in 1962 to 260,000 tons in 1967. In the same period imports have climbed from 80,000 to 150,000 tons. In recent years, imports have come chiefly from Yugoslavia, Bulgaria, Romania, and North Korea.

Reserve data on barite in the Soviet Union are few, elusive, and difficult to interpret. Shimkin (1953, p. 284) reported that Soviet barite reserves in 1935 were 18 to 23 million tons, but that by 1948 reserve estimates had been reduced to 5 to 9 million tons, most of which occur in the Transcaucasus region. From 1948 to 1967, about 3 million tons of barite was produced, leaving an unsupplemented reserve of 2 to 6 million tons. Chermette (1962, p. 36) listed reserves of 3 million tons. Orr (1961) estimated reserves to be more than 3 million tons. In view of the increasing demands for barite in the U.S.S.R., these reported reserves are not large.

ITALY

Few data are available on the barite deposits of Italy, even though barite has been produced there for many years. Production has nearly doubled, increasing from 103,000 tons in 1956 to 171,000 tons in 1967. Recent production came from 20 mines, but the center of production has shifted successively from Lombardy to Trento, in northern Italy, and now to southern Sardinia, which produced 60 percent of the nation's barite early in the 1960's (Chermette, 1962, p. 35). The barite deposits of continental Italy occur in veins of good grade. The barite in Sardinia forms veins and bodies in limestone in the lead-zinc district. Barite occurs with quartz, fluorite, and sulfides in a complex combination requiring separation by flotation. Some of the deposits are favorably situated close to the sea. The Santona district, Sardinia, had reserves of as much as 1 million tons of barite, according to Orr (1960). Chermette (1962, p. 36) estimated the barite reserves of Italy at 5 million tons.

FRANCE

The barite resources of France have been described in considerable detail by Chermette (1962). Barite occurs in hydrothermal veins in metamorphic rock and more rarely in basement granites. Fluorite and quartz normally accompany the barite, along with minor amounts of metal sulfides. Typical vein deposits are in the Central Massif and in southern France. Stratiform or bedded deposits that attain a thickness of several meters are well developed in Paleozoic rocks in eastern Montagne Noire (Herault), where barite is especially common in dolomite of Devonian age. In the Corbiere (Aude) region, other stratiform deposits in Devonian dolomite have important reserves, but silica and sulfides of copper and lead commonly contaminate the ore. One type of stratiform deposit at Pessens, in Aveyron, is interlayered with marl near the base of the lower Lias. These deposits have thin overburden and can be worked by open-pit methods. Another important type of stratiform deposit occurs at Chaillac (Indre) on the northwest border of the Central Massif, where barite occurs with nonphosphatic hematite.

The deposits of the Central Massif—chiefly the Aveyron, Correze, Allier-Puy-de-Dome, Rhone, and Indre districts—have yielded 35 percent of French barite production. Barite veins occur in the contact aureole around the granite batholith of Mont Lozere in the Lozere and Gard Departments. The deposits of the Montagne Noire, west of Montpellier, have supplied 200,000 tons of barite from marly beds of Silurian to Permian or Triassic age, but the best host rock in this area is calcareous dolomite of Devonian age. The barite from these deposits is quite pure; silica and sulfides are practically absent. Hoffmann (1969) considered these deposits to be of possible diagenetic origin and of limited economic value. The barite deposits of the Corbiere (Aude) area, southeast of Carcassonne, are in the Mouthoumet massif, a horst of Paleozoic rocks formed during the Hercynian orogeny. The commercial deposits are concentrated in a calcareous dolomite of Devonian age. Many barite veins with sulfides and fluorite of late Hercynian age are scattered across the crystalline massif of Maures-Esterel (Var). Among many barite veins in the Vosges Mountains of northeastern France, the large barite deposit at Val d'Ajol occurs in a mylonitized granite in the contact zone between the granite and Permian rocks. Other barite deposits of some economic potential are known in the Alps and the Pyrenees. The Armorican Massif of Brittany is poor in barite, perhaps because it is deeply covered. The only vein of any reported importance in Brittany is in Ordovician sandstone 2 km southeast of Paimpol.

The report by Chermette (1962) concludes with a discussion of economics of the world barite industry, a résumé of world barite reserves (estimated at 120 million tons), and a résumé of French barite reserves by district. The national total reserve is estimated to be 3.5 million tons.

YUGOSLAVIA

Barite in Yugoslavia is exploited in Bosnia, Serbia, and Croatia (Nienaber, 1962). The largest deposits in Bosnia are near Kresovo, in the Krivaja Basin, about 40 km west of Sarajevo, and near Sanski Most and Sinjakovo. Barite deposits in Bosnia-Hercegovina are described by Ramovic (1963). Bedded deposits of marine origin are the richest and most productive ones in the Sarajevo region and northern Montenegro (Chermette, 1962, p. 35). Deposits in Croatia are at Topusko, near Petrova Gora, and in the vicinity of Mrgle Vodice, in the Gorski Kotar, about 70 km east of Rijelka. In Serbia, deposits are near Negotin, in the area where the Danube River flows into Romania and Bulgaria, and near Misljenovac. The U.S. Bureau of Mines (1961, Mineral trade notes, v. 53, no. 6) reported the discovery of deposits with reserves of 1.2 million tons at Brezak and Donje Livade, near Cacak, about 120 km south of Belgrade.

Barite reserves in 1958 were reported by the U.S. Bureau of Mines (1960, Mineral trade notes, v. 51, no. 4, p. 17) at about 3 million tons. Production of 1 million tons since 1958, coupled with the new 1-million-ton reserve near Cacak, suggests that about 3 million tons of reserves are yet available. Much of the barite produced is exported to the United States and the Soviet Union. Resources of barite are large and include much barite associated with sideritic iron deposits.

GREECE

Greece has been a major barite producer since World War II, from the argentiferous lead deposits on the Aegean Islands of Milos, Mikolos, Mykonos, Polyvos, and Kimlos. The barite deposits of Greece were described briefly by Siotis (1936), and the deposits of Milos were described by Wollack (1951). The stratiform deposits of Milos are mined from open pits, and veins in granite are mined on Mykonos (Chermette, 1962, p. 35). The U.S. Bureau of Mines (1960, Mineral trade notes, v. 51, no. 4, p. 15) estimated the reserves of Milos and Mikolos at 1.1 million tons of ore composed of about 95 percent barite and 5 million tons of ore containing 50 percent barite. Chermette (1962, p. 36) estimated reserves of barite in Greece at 3.5 million tons.

GREAT BRITAIN

Barite deposits are widely distributed in Great Britain, especially in Ayrshire and Renfrewshire, Scotland, and in Westmoreland, Yorkshire, Derbyshire, and Devonshire, England.

The Muirshiel mine in Renfrewshire, Scotland, is one of the two mines in Britain currently worked only for barite. The veins are in Devonian and Carboniferous sedimentary rocks. The theory that the veins of this area do not persist at depth is not subscribed to by Hobson (1959), who said that the veins do go to great depths and have considerable lateral persistence, subject to local pinching and swelling.

The other property currently being worked for barite is the Closehouse mine near Middleton in Teesdale, in the North Riding of Yorkshire. A program is underway to prepare substantial reserves at depth in anticipation of doubling production (Orr, 1968, p. 100).

One of the largest barite mines, the Gasswater mine, near Muirkirk, Ayrshire, Scotland, closed down in 1962 or 1963 after having yielded more than half a million tons of barite from veins in Devonian and Carboniferous sedimentary rocks. More than 80 occurrences of barite are known within 7 miles of Muirkirk; most of these are small, but the veins of Nutberry Hill are as much as 6 feet wide and appear to have major potential (Scott, 1967, p. 40).

Much barite occurs in vein and replacement deposits of lead, zinc, witherite, and fluorite in Carboniferous limestones and sandstones in the northern Pennine district (Dunham, 1959, p. 115–147). Most of the deposits are associated with east- to northeast- and west- to northwest-trending fractures of small displacement which were probably formed during gentle doming in Early Permian time. Lateral zoning of the ore deposits is evident: fluorite is a common gangue mineral in the inner zone, and barite in the outer zone. The maximum amounts of galena and sphalerite occur in the outer part of the fluorite zone and the inner part of the barite zone. The origin of these ores has recently been discussed by Sawkins (1966) and Solomon (1966).

In Derbyshire, barite is recovered currently as a coproduct in the mining of fluorspar and lead.

Cores from north of Darlington show that the Magnesian Limestone of Permian age is mineralized with galena and sphalerite throughout its entire thickness. Fluorite and barite of probable Tertiary age are most abundant in the lower part of the formation (Fowler, 1957).

The 1950 reserves of barite in Great Britain were listed by the U.S. Bureau of Mines (1960, Mineral trade notes, v. 51, no. 4, p. 16) at about 3.5 million tons. Since that time production has been about 1.3 million tons, suggesting that about 2.2 million tons of those reserves remain. Resources of barite probably are still large.

The British barite industry has been shrinking in recent years, largely because of rising costs, depletion of reserves in developed mines, and the availability of low-cost supplies from abroad (Orr, 1968, p. 100). Barite prices in the United Kingdom are £8 to £10 delivered for chemical-grade crude and £13 for mud-grade on the Continent. These prices are simply too low to allow exploration and development of new mines. In 1967, imports of crude white barite for special uses were down 35 percent, to 51,000 tons, but imports of mud-grade barite for use in North Sea drilling were up 112 percent.

ROMANIA

A comprehensive summary of the ore deposits of Romania indicates that the mineral wealth is large (Superceanu, 1967). Three major metallogenic provinces are outlined, and each contains barite. The metallogenic province of Dobrogea lies along the Black Sea coast within the cratonic rocks on the southeast border of the Carpathian Mountains. In the northeastern part of this province, at Somova-Cisla and other places, are the old Kimmerian geosynclinal deposits with their fissure veins of barite, lead, zinc, and copper in limestones of Late Triassic age. New barite deposits at Somova were first reported in the mid-1960's. A polycyclic metallogenic province lies in the eastern Carpathian Mountains, where many reconstituted barite and metal sulfide deposits occur, such as those with important reserves reported in veins that cut beds of Middle Triassic age at Ostra. The third metallogenic province, the so-called "alpinide-young volcanic-inner Carpathian province," is well known and important for its gold and silver deposits of Tertiary age, but has few barite deposits.

Barite production is rising in Romania, from an estimated annual production of 45,000 tons during 1945–65 to an estimated 170,000 tons annually by 1970. Most of the barite is exported to the Soviet Union, Czechoslovakia, and Hungary. No reserve data have been published, but reserves are estimated to be at least 2 million tons of barite.

SPAIN

Most of the barite mines in Spain are small, and the average recorded annual production from 1948 to 1958 was about 15,000 tons from 18 mines in 11 provinces. By 1966 national production had increased to 65,000 tons. Little geological information about these deposits is available. The U.S. Bureau of Mines (1960, Mineral trade notes, v. 51, no. 4, p. 16) reported that the most extensive reserves are in the Provinces of Cordoba, Guadalajara, Navarra, Oviedo, Tarragona, Teruel, and Zaragoza.

POLAND

The barite deposits of Poland are in the Swietykrzyz Mountains, which yielded only 3 percent of the national production in 1958, and in Lower Silesia, the nation's chief producing area (Kulesza, 1961).

In the Swietykrzyz Mountains, three districts have produced barite. At Stravszinik, near Promniki, veins of 14 to 72 percent barite in Devonian limestone have been traced for 1 km. At Hucisk, also near Promniki, vertical veins of barite with sulfides of lead, zinc, and iron occur in dolomitic host rocks of Devonian age. At Wisniowce, veins have been mined out, but possibilities are good for additional discoveries.

In Lower Silesia, three major deposits yield most of the barite from tectonic zones in the Sudeten Mountains and foothills. Veins in these zones contain barite, quartz, calcite, fluorspar, and various sulfides of lead, zinc, iron, and copper. The largest confirmed reserves are here (Kulesza, 1961, p. 588), but no figures are available. Vertical veins at Boguszow, the largest deposits in Poland, contain 85 percent $BaSO_4$. Three irregular veins are as thick as 1.3 m. At Jedlinka, barite occurs in veins with braunite and chalcopyrite. Steeply inclined fissure fillings generally 1 m thick occur in sericitic quartzose phyllites of early Paleozoic age at Stanislawow, in the Kaczawski Mountains. In 1961, the area to the south of these known deposits had not yet been explored.

Barite might be produced as a coproduct with fluorspar from the veins in the Sowich Mountains. These veins are similar to those in Thueringen, Germany.

Poland is well endowed with barite in hydrothermal veins, and the potential for the discovery of new deposits is considered excellent (Kulesza, 1961, p. 590). Barite production is increasing, according to the minerals yearbooks of the U.S. Bureau of Mines: 11,000 tons was mined in 1961, and 60,000 tons was mined in 1967.

IRELAND

Major barite deposits occur in the Ballynoe-Silvermines area, County Tipperary, where high-grade barite occurs adjacent to rich lead-zinc-silver deposits (Engineering and Mining Journal, 1968, p. 70–72; Mining and Minerals Engineering, 1968, p. 40–44). The barite of Silvermines Hill is mined in an open pit and occurs in a sequence of Carboniferous chert, limestone, and dolomite, all of which is locally brecciated. The barite beds dip about 18° NW, and their thickness varies from 10 to 60 feet. No beneficiation is required for a marketable barite product. Since December 1953, more than 400,000 tons of barite has been shipped (Mining and Minerals Engineering, 1968, p. 40). The mineralogy, structure, and economic geology of the Silvermines district have been described by Rhoden (1959a, b), who postulated a hydrothermal origin for the bodies, but a syngenetic origin from colloidal precipitation, possibly of a biogenic nature, has also been suggested (Mining and Minerals Engineering, 1968, p. 44).

Coproduct barite also is produced from the lead-zinc-silver-copper mines in Carboniferous limestone at Tynagh, County Galway. This barite is sold in British markets, and potential annual production is thought to be 100,000 tons (Orr, 1968, p. 100).

The U.S. Bureau of Mines (1960, Mineral trade notes, v. 51, no. 4, p. 15) reported reserves of about 900,000 tons of good-quality barite in the Benbulben Range, County Sligo, and reserves of 1.5 million tons of barite in the Silvermines district. Other occurrences are in Counties Wicklow and Monaghan.

GERMAN DEMOCRATIC REPUBLIC (EAST GERMANY)

Barite deposits in East Germany are concentrated in the Erzgebirge, Harz, Vogtland, and the Thüringer Wald. Klaus and Schröder (1967) briefly described many deposits and summarized much information in a paper on geophysical prospecting for barite and fluorspar. (They concluded that no specific geophysical technique was ideal for finding covered or otherwise hidden deposits of barite and fluorspar.) Bolduan, Richter, and Tischendorf (1961) reported a shortage of chemical- and pigment-grade barite and described the geology of some newly explored deposits at Schneckenstein, 10 km southeast of Falkenstein, Vogtland, that are believed to have substantial reserves of barite. The deposits are in metamorphic rocks in the outer contact zone of the Eibenstocker Granite of Variscan age. Selective mining is necessary, but a product suitable for chemical- and pigment-grade barite is obtainable. At Huhn Trusetal, on the southwestern border of the Thüringer Wald, veins containing barite and fluorspar in the ratio of 3:1 occur in old Paleozoic mica schists and gneisses and associated Variscan granites (Pratzka, 1959). Metasomatic veins of barite in the Riffkalk of the Middle Zechstein (Permian age) occur at Leutnitz, 4 km west of Bad Blankenburg in the Rinnetal, Thüringen, where the reserves were conservatively estimated at 1 million tons (Bender, 1934).

Barite reserves in East Germany probably are 3 million tons, and current rates of production are 25,000 to 30,000 tons annually.

BULGARIA

Barite is common in Bulgaria, according to summaries of the geology and ore deposits of that nation compiled by Jovčev (1965) and by Reh (1966). Barite deposits occur in two of the three major tectonic divisions of the country—in the Rhodope massif to the south, and in the centrally located Balkanide belt.

Barite is abundant in widely distributed deposits of lead and zinc associated with sedimentary and igneous rocks of Tertiary age and various metamorphic rocks of presumed Precambrian age in the Rhodope massif. Barite is especially abundant and has been produced from deposits near Momchilgrad in the Madan district (Bogdanov, 1963, pl. 1) and in the eastern reaches of the massif (Kostov, 1963, pl. 1).

The Balkanide belt is a complex anticlinorium composed of two large elements, the Balkan Mountains on the north and the Sredna Gora on the south. The major ore deposits of the Balkanide belt occur in the west and are of Caledonian (early Paleozoic), Variscan (Carboniferous), and Alpine (Tertiary) age. The fissure veins of the Ciporovci district contain complex ores of lead, zinc, siderite, and barite. The Vraca-Iske district has lead-zinc and copper deposits with some pyrite and barite. The metallogenic province of the Sredna Gora extends eastward across Bulgaria to northeastern Asia Minor. The province is best known for its copper deposits, with subordinate ores of manganese, iron, molybdenum, and barite in commercial amounts. The Sofia-Panagyurishte region is a major center of mineral deposits in which large bodies of iron ore and barite, discovered about 10 years ago, have been developed and are now in production at Kremikovtsy, 16 km northeast of Sofia.

The deposits at Kremikovtsy are hydrothermal metasomatic replacement bodies in dolomitic limestones of Middle Triassic age covered by 14 to 195 m of Pliocene sediments (Tonev, 1961). The ore minerals include hematite, limonite, siderite, manganese oxides, and barite, as well as small amounts of silver associated with the siderite (10 g per ton) and the barite (26 g per ton). The barite forms as much as 43 percent of lenses and pockets 3 to 55 m thick, and 15 to 20 percent of some of the hematitic, sideritic, and limonitic ores. Barite is a coproduct, but beneficiation is required. By 1964, the open pits were supplying a great part of the Bulgarian barite production (Tonev, 1964, p. 102). Bulgarian barite production rose from 21,000 tons in 1962 to an estimated 45,000 tons in 1967, presumably a reflection of mining at Kremikovtsy, where reported reserves of all ores total 248 million tons.

The barite reserves of Bulgaria probably exceed 5 million tons, and the resources are large.

AUSTRIA

As of 1960, the U.S. Bureau of Mines (1960, Mineral trade notes, v. 51, no. 4, p. 14) reported that Austria supplied about 40 percent of its needs from its own annual production of less than 10,000 tons. Domestic sources were Grosskogl, Tyrol, where barite was produced from deposits formerly worked for chalcopyrite; Trattenbach, Lower Austria, where barite was mined from sideritic ore; and Oberstiering, Styria, where barite occurs with lead and zinc.

Beds several tenths of a meter thick in the Wetterstein Limestone in the Gailtal Alps contain barite and associated fluorite, calcite, quartz, sphalerite, galena, pyrite, marcasite, and clay minerals (Schulz, 1967). The deposits are believed to be syngenetic, and the source of the barium is attributed to submarine hydrothermal emanations. No estimate of the reserves for these deposits was given.

PORTUGAL

Total barite production in Portugal is very small, being only about 20,000 tons in the past 20 years (table 4). Barite occurs in high-grade deposits at Castro Verde and Mertola in the Beja district; as a gangue mineral with galena at Segura, Castelo Branco district; and as a banded filling in the iron-manganese deposits of Cercal do Alentejo, Setubal district. Reserves of barite in 1953 were reported by the U.S. Bureau of Mines (1960, Mineral trade notes, v. 51, no. 4, p. 16) as 370,000 tons at Segura and "several hundred thousand tons" at Cercal. Most of this reserve is presumably still available.

CZECHOSLOVAKIA

Vein deposits of barite are shown on recent mineral deposit maps of Czechoslovakia (Svoboda and others, 1966). Small deposits of barite are shown near Pernarec, northwest of Plzen (Pilsen). Other deposits are reported to contain barite with fluorspar and quartz in the crystalline rocks of the Krusne and Smirciny Mountains in northwestern Bohemia. The amount of barite in these deposits decreases with depth (Svoboda and others, 1966, p. 148). Barite gangue fills faults in ore deposits in the Slavkovsky-Les Mountains and some barite is known in the Brno Massif. In northern Moravia, barite occurs with lead-zinc ores in the Nizky Jesnik Mountains.

The largest concentrations of barite in Czechoslovakia are associated with the well-known siderite-sulfide veins of the Rudnany region in the western Carpathian Mountains of eastern Slovakia. The mineralogy and geochemistry are described in detail by Bernard (1961). The deposits, composed chiefly of siderite, barite, and some sulfides, are part of the "Zips-Gomorer Erzgebirge" in the old Alpine-West Carpathian ore province associated with intensive magmatic activity of the Gemeride Granite of Middle Cretaceous age (Bernard, 1961, p. 192). The veins occur in zones many meters wide that continue in length for as much as 30 km. The veins in one area extend to a depth of 200 m and are zoned both laterally and vertically. The host rocks are metamorphosed sedimentary rocks of Paleozoic age. Barite and siderite are the major components of the Drozdiak and Hruba veins. In the Hruba vein, barite is concentrated in the upper part and is believed to occur in the western part of the vein, which has not yet been mined. The first of two generations of barite is of greater commercial importance because this early barite filled voids or formed great metasomatic complexes in the siderite veins. The reserves of these deposits are estimated to be at least 2 million tons, and the resources are undoubtedly large.

BELGIUM

Barite has not been produced in Belgium since 1913, when the Fleurus mine near Charleroi, Hainaut Province, was flooded. From 1890 to 1913 the Fleurus mine yielded 670,000 tons of excellent-quality white crystalline massive barite from a replacement body in Viseen limestone (Chermette, 1962, p. 36). The Fleurus area has been drilled recently, and reserves of 600,000 tons of barite have been located (Industrial Minerals, 1968). Exploration for barite also is underway in the Vierves area, in southeastern Namur Province (Orr, 1968, p. 100).

AFRICA

De Kun (1965, p. 405–409) reviewed the distribution and geology of barite deposits in Africa. Current major sources of barite are the veins of the Atlas Mountains in Morocco and Algeria, where reserves of 12 million tons were estimated by Chermette (1962, p. 36). In addition to the deposits described in the following sections on individual nations, barite occurrences, mostly in veins, are reported by De Kun in Ghana, Nigeria, Congo, Gabon, and Burundi. Exploration and need for barite in Africa are just beginning. Major barite resources are associated with the carbonatites of East Africa.

MOROCCO

The barite deposits of Morocco were described by Huvelin (1962). Large amounts of barite have come from the Jebel Irhoud mine at the west end of the Paleozoic Jebilet massif. The barite occurs in veins and replacement bodies in Paleozoic carbonate rocks near the margins of fault blocks. The deposits are described as telethermal and post-Triassic in age. Reserves of "possible ore" were estimated in 1960 at about 800,000 tons. A mineralized district in the High Atlas has veins enclosed in purplish-red sandstone, conglomerate, and shale of probable Permian age. Veins at Zelmou in eastern Morocco have reserves of more than 2 million tons that should be exploitable in spite of their remote location. Barite veins with reserves of 100,000 tons were already being mined in 1962 at Glib-en-Nam, 32 km south of Oujda. At Bou Ousel, in Central Morocco, a large body of siliceous siderite and barite must await better means of beneficiation before about 4.5 million tons of barite can be recovered.

ALGERIA

The principal barite deposits of Algeria are concentrated in Grand Kabylia, east of Algiers, and in the vicinity of Algiers (De Kun, 1965, p. 405). About 60 percent of the 1-million-ton Algerian reserves of barite is in an area of about 3 square miles near Keddara, where barite veins cut sedimentary rocks of Jurassic and Tertiary age.

REPUBLIC OF SOUTH AFRICA

One of the largest barite deposits known in Africa, at Gams, Namaqualand, also contains manganiferous iron ore and hematite (Coetzee, 1958). Good-quality barite, mostly gray, in these deposits dips 30°–50° and has been traced 8,300 feet along strike. The barite is believed to be more continuous than the adjacent and parallel veins of iron ore. The ore deposits are at or near the contact of recrystallized quartzite and biotite schist on the Gamsberg, a doubly plunging anticline. The origin of deposits is attributed to metasomatic replacement of the country rock from an igneous source. Coetzee estimated that 3 million tons of ore is available in the deposit's known depth of at least 100 feet.

Other barite deposits are listed by De Kun (1965, p. 409) and are reported in a mineral resources volume compiled by the South Africa Geological Survey (1959).

Among the mineral resources of Bechuanaland is barite in the sedimentary rocks of the Waterberg System north of Molepolole in Bakwena tribal territory, and in quartzitic and calcareous metasedimentary rocks in the basement complex of the Matsitamma area (Boocock, 1965, p. 399). No further information is available.

UNITED ARAB REPUBLIC (EGYPT)

The discovery of oil in the Sinai-Gulf of Suez area in Egypt has created a small domestic barite industry. Said (1962, p. 264) made brief mention of rare veins of barite of shallow mesothermal to epithermal origin scattered through the Eastern Desert. Barite occurs in pink granite east of Aswan; in quartz veins with galena at Siwigat el-Soda; and in quartz veins with a little stibnite, at an unspecified location. In a résumé of ore deposits in the United Arab Republic, Reh (1965, p. 611) cited a barite deposit at Wadi Dib in a geologically complex area on the west coast of the Gulf of Suez. No reserve data are available.

RHODESIA

Reserves of 1 million tons of barite are reported by the U.S. Bureau of Mines (1964, Mineral trade notes, v. 58, no. 4) for the Shamva district, Rhodesia. At the Dodge mine, the chief producer of the district, barite occurs in lenticular veins along the contact between limestone and banded ironstone.

SWAZILAND

Barite is mined from vein deposits at the Londosi mine northeast of Oshoek, near the Transvaal border. In 1961, four veins ranging in thickness from 1 to 4 feet were reported to have reserves of 1 million tons (U.S. Bureau of Mines, 1961, Mineral trade notes, no. 11). These deposits supply South African glass and paint industries. De Kun (1965, p. 409) reported barite veins in the Londosi Valley 5 to 6 feet thick that contain as much as 4 percent zinc. The Overseas Geological Surveys (London) Annual Report for 1963 (Davies, 1964, p. 92) reported the discovery of two new barite deposits in the remote Piggs Peak district. The veins are 700 feet long and as much as 7 feet wide. Total barite reserves of Swaziland are not shown.

TUNISIA

Barite in Tunisia is associated chiefly with fluorite and base-metal veins. Reserve data are lacking (De Kun, 1965, p. 407).

KENYA

Three hundred tons of barite was mined in Kenya during 1965–67, according to the U.S. Bureau of Mines (1967, Minerals yearbook).

LIBERIA

Six barite veins have recently been described in Precambrian granitic gneisses in an area of about 20 square miles in the Gibi area, eastern Montserrado County, Liberia (Pomerene and Stewart, 1967). Reserves of barite may be as much as 2 million tons (Pomerene and Stewart, 1967, p. 19), and 70 percent of the reserves are probably in the largest deposit.

MALAGASY REPUBLIC

According to Murdock (1963, p. 109), comparatively large reserves of barite are known in the Andavakoera quartz-barite veins in the Ambilobe region (lat 13°12′ S., long 49°06′ E.) of the Malagasy Republic. Veins exposed in the Ankitokazo-Andafia area and the Bereziky sector are more amenable to exploitation now than those of the Andavakoera system. Other deposits are known in the Ambakirano-Bobasatrana region southeast of Ambilobe. Total reserves in all these deposits are estimated at 500,000 tons. Reserves of 2,000 tons are available in a vein 2 m wide at Ampandrana, 20 km northwest of Ambositra.

ZAMBIA

Five occurrences of barite in the former territory of Northern Rhodesia are of interest, especially one about 17 miles south of Mporokoso, in the valley of the Luangwa River (Reeve, 1963, p. 148). A 6-inch-thick barite bed overlies a 3-foot-thick bed of laminated chert in a 200-foot section of red and blue shales of the "Plateau Series." The shales are rarely exposed, but at four places within 27 miles the chert and barite beds are exposed. The barite is light and dark gray and assayed 94.79 percent $BaSO_4$. The association of bedded barite with siliceous rocks appears similar to that known in Arkansas and Nevada and suggests that the "Plateau Series" would be worth exploring for large deposits of bedded barite.

Deposits of barite occur near the contact of granite and schist south of the Kafue River, about 14 miles east of Kafue Township. Residual boulders of coarse-grained white to brown iron-stained barite occur in three areas along a strike of half a mile (Guernsey, 1952).

Three other occurrences mentioned by Reeve (1963) were considered minor.

TANZANIA

No minable deposits of barite are known in Tanzania (Harris, 1961, p. 33), but barite occurs as a gangue mineral with quartz and carbonates in a number of gold and base-metal veins in the Western Rift zone, especially in the Mpanda mineral field and the Lupa goldfield, and is reported in the Musoma goldfield. Barite also occurs in sedimentary rocks, in veinlets in dolomitic limestones in the Kigoma and Handeni areas, as nodules in the Karroo sandstones in the coal fields of the southwest, and in veinlets cutting sandstones of Cretaceous age at a depth of 229 feet in a drill hole at Wingayongo, near Kibiti, north Rufiji District. Barite is reported in carbonatites and occurs in concentrates from kimberlite pipes.

UGANDA

A considerable tonnage of barite possibly may be recovered from hematite lenses in granitoid gneiss at Mugabuzi Hill, northwest Ankole, Uganda (Barnes, 1961, p. 61). The deposit lies only 3 miles from the Kampala-Kasese railway. Barite also occurs in the phosphate-bearing soils associated with the Sukulu carbonatite and is a potential coproduct should the other minerals be mined.

SOMALIA

Pallister (1958, p. 158–159) listed three areas of barite occurrences in Somalia. From two of these, barite is likely to be only a coproduct with fluorite or base metals. In the third area, south of Berbera, in the Bihendula Range, barite fills fractures as much as 2 feet wide in gneiss. One vein containing 90 percent barite is exposed for 300 yards. Three other occurrences in the same region are listed at Dananjiehh, Gol Ebed, and Law. Reserves are probably small.

NEAR EAST

INDIA

The total recorded barite production in India from 1918 to 1966 is about 700,000 tons, of which 92 percent came from Andhra Pradesh, 7 percent from Rajasthan, and the remainder from Madhya Pradesh, Kashmir, Vindhya Pradesh, and Manbhum, in Bihar (Brown and Dey, 1955, p. 448–452). Systematic geological investigations were carried on by Coulson (1933), who found that most of the occurrences either were replacements or were fissure veins in the Vempalle (Viampalli) Limestones or in the associated intrusive dolerite and basalt sills. The Vempalle limestones and slates are rocks of Precambrian age that form the upper part of the Papaghni Series of the Cuddapah System. Large quantities of barite are believed to be available in a vein at Kottapalle (lat 14°22′ N., long 78°21′30″ E.). Many localities are described by latitude and longitude in a report by Krishnan (1944).

In Anantapur, the major deposits are in veins in limestone. Near Nerijamipalle one vein is 3 to 11 feet thick and extends for half a mile, and near Mutssukota the best vein is 100 yards long and as much as 30 feet wide.

There are many deposits in the Kurnool district, the most important of which are in Dhone Taluk, in the vicinity of Balaplapalle (lat 15°27′30″ N., long 78°6′30″ E.).

Barite also occurs near Naravada (lat 14°54′ N., long 79°57′ E.) and in other places in the Nellore district of Andhra. Near Alangayam (lat 12°37′30″ N., long 78°45′ E.), veins with quartz and 30 percent barite in porphyritic gneiss are several feet thick and have been traced for 7 miles.

The major deposits of Alwar, Rajasthan, at Bhakera (lat 27°32′ N., long 76°36′ E.), Sampuri, Bhagat Ka Bas, and Rampur, occur in fissure veins in members of the Alwar Quartzites (Precambrian age) of the Delhi System.

Barite occurs in veins with copper minerals at Sleemanabad, Madhya Pradesh, in central India. In Bihar, barite occurs with ores of lead at Silwai and Bogebera in the Ranchi district and with rare-earth silicate minerals near Malthole in the Manbhum district.

In the Tikamgarh district of Vindhya Pradesh, gray barite forms 30–45 percent of veins as much as 2.5 ft thick that cut the Bundelkhand Gneiss.

In the Kashmir, thin barite veins occur in the Great Limestone Formation of the Riasi district, especially near the Jangalgali Pass and Kheri Kot.

The catalog of deposits and occurrences offered in the references cited above is lengthy. Although detailed estimates of the barite reserves of India are incomplete, several million tons of barite probably is available there. Mineral Resources Development Series Report 27 (United Nations, 1967, p. 73) listed the inferred reserves of barite in India at about 800,000 tons.

IRAN

The barite industry of Iran began about 1959, when the closing of the Suez Canal cut off barite imports (Hooper, 1963). About 25 barite deposits were known in Iran prior to 1959, but none supplied any of the 40,000 tons of barite needed anually for drilling mud. The mud requirements for each hole drilled in Iran are higher than in most other parts of the world. Reservoir pressures are so great that it is common to drill with mud weighing about 168 pounds per cubic foot.

Most of the barite is white, although some is red from iron stains; it commonly occurs in relatively thin, structurally controlled veins. The most common host rocks are the volcanic tuffs of the Oligocene and Miocene green beds (Hooper, 1963, p. 437).

Barite deposits have been explored chiefly near Tehran, Ghazoin, Saveh, and Ghom, where ore reserves of 400,000 tons containing

90 percent barite were listed by the United Nations Economic Commission for Asia and the Far East (United Nations, 1963, p. 39). The geological setting of the region suggests that this estimate is conservative.

TURKEY

Nine areas of barite deposits are scattered across Turkey, but the most important commercial deposits are in Mus Province, eastern Turkey (Kaaden, 1963). Most Turkish barite is hard crystalline material that occurs in veins along shear zones or in metasomatic replacement bodies in limestone. Most deposits seem to be small, except those near Mus.

In the areas of Bilirkoy, Kizilkilise, and Kasorkoy, Mus Province, barite veins as much as 40 m wide occur in schists, of early Paleozoic age, that generally strike west and dip north. The strike of most veins coincides with that of the schists, but the dip of the veins commonly cuts the schistosity at an oblique angle. Some veins follow mineralized shear planes along the approximate boundary between rigid quartzites and more friable schists. Brecciated barite recemented by iron oxide and quartz indicates some postmineralization movement. Except for hematite, quartz, and secondary iron and manganese oxides, the veins are filled with barite. The ore has an average content of 94 percent $BaSO_4$ and less than 0.5 percent ferric oxide. Reserves of about 3 million tons are available there, only a few kilometers from a railroad.

PAKISTAN

The barite deposits of Pakistan are in the western part of the country, principally in the Hazara, Khuzdar, and Las Bela districts (Klinger and Abbas, 1963). Vein deposits are most common; they are pod shaped, rarely more than 100 feet long, and are controlled by shear zones, faults, and tension fractures in the Hazara and Las Bela districts. Bedded replacement deposits in the Khuzdar and Las Bela districts follow sedimentary structures and have rather precise stratigraphic controls. These deposits are reported to be generally larger and more regular than the vein deposits. The bedded deposits at Gurga, Khuzdar district, consist of four principal lenses, each 270 to 1,200 feet long and 10 to 80 feet thick containing 80 to 90 percent $BaSO_4$. Adjacent beds have been altered extensively, especially by silicification, suggesting that the ore bodies originated by hydrothermal replacement of the host rocks (Klinger and Abbas, 1963, p. 422). Reserves in these deposits alone are estimated at 1.4 million tons of barite.

In most deposits, quartz and (or) calcite are the chief gangue minerals, but some galena, sulfides of iron and copper, and iron oxides are common. Periods of barite deposition range from Jurassic to Pleistocene, and the host rocks are Precambrian to Pleistocene in age.

Geologic descriptions, as well as economic and reserves assessments, of nine deposits are supplied by Klinger and Abbas (1963). Reserves amount to about 1.6 million tons of barite. The total recorded barite production of Pakistan is only about 51,000 tons, most of which has been mined in the Hazara and Las Bela districts since 1957.

BURMA

The Northern Shan States and the Amherst, Mandalay, and Kyankse districts have minable barite deposits (Krishnan, 1944). The Azintuang Hill, about 15 miles south of Mitan (lat 16°0′ N., long 98°24′ E.) in the Amherst district, has many barite veins in limestone, and other deposits are known in this area along the Thailand border. At Bawdwin, in the Mandalay region, four parallel veins 1 to 3 feet thick were estimated to contain 20,000 tons of barite. In the Southern Shan States near Mawston (lat 20°57′ N., long 98°50′ E.), barite veins with quartz are common. Few details are known about the barite deposits of Burma.

SAUDI ARABIA

About 20 km N. 50° E. of Rabigh on the Red Sea coast 150 km north of Jiddah, Saudi Arabia, barite veins from a few centimeters to 3 m wide fill fractures in the Red Sea Rift System of Tertiary age (Brobst, 1966). The geology of the area is complex. The barite veins dip steeply, generally 60° or more, and pinch and swell along strike. The crystalline barite is white to pink and contains scattered crystals of galena and chalcopyrite and pods of dark-golden-brown jasperoid with black oxides of manganese. Most of the barite veins are clustered in an area of a few square kilometers, but the area of mineralization may be much more extensive. Reserves of 100,000 tons of barite in the Rabigh area were listed by the U.S. Bureau of Mines (1960, Mineral trade notes v. 51, no. 4, p. 19).

The deposits near Rabigh are not far inland from the deeps of the Red Sea, where hot mineralizing brines are now issuing from fractures (Delevaux and others, 1967). The Red Sea Rift System in Saudi Arabia and Africa seems to be an attractive target for further mineral exploration.

OTHER AREAS

Barite is being mined in Afghanistan for use in the local oil fields, but no information is available about the geology of the deposits. Production amounted to 3,900 tons in 1960, according to a report by the United Nations Economic Commission for Asia and the Far East (United Nations, 1962, p. 19). The U.S. Bureau of Mines (1964, Mineral trade notes, v. 58, no. 4, p. 5) reported a discovery of barite veins in Jordan, near Jerusalem, and (1957, Mineral trade notes, v. 51, no. 4, p. 19) near Aqaba. The veins near Aqaba were not regarded as of commercial interest.

FAR EAST

CHINA (MAINLAND)

Few new data on the barite deposits of China have become available since the U.S. Bureau of Mines' 1948 report on the mineral resources of China. Prior to World War II, the principal mines were in quartz-barite-galena veins cutting red sandstones of Cretaceous age in Shantung Province. Some of the deposits were reported (U.S. Bureau of Mines, 1948, Mineral resources of China, p. 122) to be "large," and ore from the veins at Hwa-shan was said to be 98 percent barite. Estimated reserves of 7 million metric tons of barite were reported at Hsui-jen in the Hsiang district of Kwangsi Province. A deposit of high-grade barite with reserves of 1.2 million tons to a depth of 80 m occurs at T'ang-shan, Hopeh Province. About 1 million tons of barite, 90 percent $BaSO_4$, occur in the deposits of Tung-shan, Lin-ch'uan district, Kiangsi Province.

Barite production recorded from 1932 to 1942 was about 107,000 tons, and from 1959 to 1967 it was estimated at about 850,000 tons. A substantial part of the reserves reported 20 years ago is probably still available.

JAPAN

Pollard (1951, p. 56–58) summarized the geology and economics of barite deposits in Japan. The few barite mines in Japan are on Hokkaido and Honshu. By the end of 1950 the Otaru Matsukura mine in Hokkaido had yielded 80 percent of the nation's total production from high-grade ore replacements in volcanic rocks of Tertiary age. The hydrothermal mineralization is late Miocene or early Pliocene (Sugimoto, 1962). Vein deposits of moderately high grade ore have been mined from pre-Cretaceous calcareous rocks at Mogari, Hokkaido, and from Paleozoic slate at Kasatori, Honshu. The gangue minerals in these veins consist of quartz, sphalerite, galena, and limonite. The third type of deposit occurring in Japan is the kuromono or kuroko ore, a black complex metal ore in which small amounts of barite are associated with sphalerite, chalcopyrite, pyrite, quartz, gypsum, and their oxidation products. Coproduct barite has been produced from these ores at the Hanaoka copper mine in northern Honshu, where reserves were listed by Pollard (1951, p. 58) at 600,000 tons of barite, but resources of barite in these ores are considered to be vast. Mining operations in kuroko ore were recently described in Mining Engineering (1969).

The barite reserves available in rock 45 percent or more $BaSO_4$ from major deposits were posted by the Japan Geological Survey (1960, p. 215) to be 3.3 million tons. Mineral Resources Development Series Report 27 (United Nations, 1967, p. 89) states that as of April 1, 1963, reserves of ore (31 percent $BaSO_4$) in the ground contain 898,000 tons of barite, but that minable ore (25 percent $BaSO_4$) contains 661,000 tons.

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA (NORTH KOREA)

The barite deposits of the Korean peninsula were described by Gallagher (1963, p. 61–68). Most of the deposits are hydrothermal veins emplaced in siliceous host rocks. The veins contain barite, fluorite, and, in small amounts, iron, lead, zinc, and copper sulfides with or without quartz. The amounts of barite are believed to decrease with depth, but the amounts of fluorite apparently increase with depth. Some ore bodies formed by the replacement of limestone host rocks; these bodies tend to be larger and less contaminated by sulfides than the veins. Most of the large known deposits are in North Korea, where total recorded production reached the half-million-ton mark after 1961. Production during 1967 exceeded 100,000 tons. Most of this has been exported to the Soviet Union.

The largest known barite deposit in North Korea, the Changdo mine near Hakpang-ni (lat 38°29′ N., long 127°43′ E.), has barite and small quantities of sulfides in about 20 replacement bodies in magnesian limestone of the Great Limestone Series. The bodies are 97 percent $BaSO_4$ and have a maximum width of 16 m and a length of 50 m. Proved ore reserves of about 1 million tons were reported (Gallagher, 1963, p. 65).

In the Chaeryong-gang district, many barite deposits are known in the limestone, shale, and clay slate of the Masan-ni (Masanri) beds of the Middle Cambrian Choson system, and in the unconformably overlying succession of three units of porphyrite, breccia, conglomerate, sandstone, quartzite, tuffaceous shale, shale, and limestone in the Upper Taedong (Daido) Formation of Late Cretaceous age. All these rocks were later intruded by dikes of porphyrite and quartz porphyry. The deposits in the Masanri beds are commonly lenticular or pocketlike, and those in porphyritic tuff beds are comparatively thick and have substantial reserves. Thin veins, only about 50 cm thick, seem to have considerable continuity along both strike and dip.

Gallagher listed 11 other barite deposits in North Korea.

PHILIPPINES

Little is known about barite deposits in the Philippines. The U.S. Bureau of Mines (1960, Mineral trade notes, v. 51, no. 4, p. 20) reported that small quantities of barite were mined from a single deposit at Lobo, Batangas Province, Luzon (lat 13°39′ N., long 121°15′ E.). The ore at Lobo contains copper and barite, and conservative estimates made in 1957 indicated 26,000 tons of recoverable barite and 60,000 tons of recoverable copper ore (4 percent Cu).

REPUBLIC OF KOREA (SOUTH KOREA)

Gallagher (1963, p. 68) stated that only two barite deposits were known in the Republic of Korea, but that barite occurred at many places. The Songhung mine in the Yongtap-ni area (lat 36°55.4′ N., long 126°26.5′ E.) was reported to be a fairly large body that replaced dolomite associated with quartzite and mica schist. The upper part of the body was 94 to 97 percent $BaSO_4$, but the grade diminished near the bottom. Nothing is known about the Samhwa (Sanwa) barite mine in Imdong-myon of Andong-gun, Kyongsang-pukto. The source of the few tons of barite produced in South Korea in 1945–67 (table 4) is unknown. Mineral Resources Development Series Report 27 (United Nations, 1967, p. 94) estimated the barite reserves of South Korea at 3 million tons, but no geologic data or grades were given.

THAILAND

Two barite occurrences in northern Thailand, at Ban Hin Khao and Ban Tin Pha, are of geologic and economic interest. The deposit at Ban Hin Khao has an estimated reserve of 2.5 million tons of barite (Jacobson and others, 1969, p. 66–68). It lies on a northwest-trending ridge 7 km southeast of Ban That and has been geologically mapped and sampled. The barite forms a bedded replacement deposit in a sequence of limestone, dolomite, shale, and tuff of

Devonian and Early Carboniferous age. The barite beds, massive and with varying amounts of dolomite, strike north to northwest and dip steeply east. The main deposit has a strike length of 1,200 m, and two smaller deposits were noted to the west. Trenches expose massive barite beds 1–9 m wide, but the average width is 5.2 m. The massive barite exposed in the trenches generally is flanked by soil containing barite boulders, so that the true width of the barite is difficult to determine. Barite has been observed at an elevation of 350 m at the south end of the ridge and at an elevation of 550 m on the hilltop.

The geology of Ban Tin Pha prospect, about 1 km west of the village of the same name, is believed to be similar to that of the Ban Hin Khao deposit. The prospect is in an area of poorly exposed sandstone and shale of Devonian and Carboniferous age. Barite fragments are exposed in an area 0.5 km square; one exposure of bedrock 5 m wide and 30 m long is massive barite, 99.4 percent $BaSO_4$. Further prospecting is needed in this area.

OCEANIA

AUSTRALIA

The barite deposits of Australia are listed and described by Gourlay (1965, p. 61–72). Total recorded barite production from vein and replacement deposits through 1967 is 280,718 tons. Most of the barite has come from the Oraparinna and Noarlunga mines in South Australia, where about 50 deposits occur in the Flinders and Mount Lofty Ranges, but deposits and prospects are widely distributed throughout the country.

The Oraparinna deposits (Nixon, 1962) consist of 73 lodes, 53 of which are considered to be workable, in steeply dipping tension fractures in sedimentary rocks of Cambrian and Precambrian (Marinoan and Sturtian) age. The veins of lode 1 are persistent for a vertical distance of 400 feet. The veins vary in width; the maximum width is 30 feet, but the average is 8 feet. Reserves in the main vein are estimated at 340 tons per vertical foot (Nixon, 1962, p. 15).

Massive outcrops of barite occur at Bunbinyunna, described by Gourlay (1965, p. 67) as located in sec. 16, hundred of Moralana, which is between Elder's Range and the Wilpena Pound Range and about 20 miles north of Hawker, South Australia. Large tonnages of barite and associated hematite could be mined from opencuts, but no further information about the deposit was available in 1965. Several large low-grade deposits are known in the Olary district, South Australia. These deposits are all bedded replacements at the same stratigraphic level. Silica and iron oxides are the principal contaminants. Beneficiation by flotation methods is needed to yield a satisfactory commercial product.

In Western Australia, economic and potentially economic barite deposits occur in Precambrian rocks. A large tonnage of high-grade barite is reportedly available from veins near Cardup, 20 miles south-southeast of Perth. Large reserves of barite are reported at Breen's Camp, about 24 miles west-northwest of Marble Bar in an area just northeast of the Hamersley Range, where development of iron deposits is in progress.

Condon (1968, p. 64) described syngenetic barite in bentonitic siltstone and shale of the Gearle Siltstone of Early Cretaceous age in the Carnarvon Basin along the coast of Western Australia. A bed 1 foot thick containing loose crystals of barite 1 millimeter in diameter is exposed at two places 15 miles apart. No further geologic work on the extent and geochemistry of the bed was reported, but the geologic and economic implications are of considerable significance in the search for new resources of barite.

Other deposits are known in the Northern Territory, Tasmania, Queensland, Victoria, and New South Wales. In New South Wales, the Kempfield area, about 30 miles south-southwest of Bathurst, has yielded about 10 percent of Australia's total barite production from lenticular masses in schistose rocks about 1 mile from a granite mass.

No barite reserve figures have been published for Australia, but geological data available in the literature suggest that reserves of 5 million tons could certainly be termed a conservative estimate.

NEW ZEALAND

Veins of barite and fluorite in the Mount Arthur Marble of Ordovician age at Thomson Hill, Wangapeka Valley, Nelson, New Zealand, were studied by Braithwaite and Watters (1962). The vein and residual materials were likened to those of the deposits in the Sweetwater district, Tennessee, but the authors concluded that the deposits at Thomson Hill did not have enough barite to warrant commercial exploitation.

FIJI

Barite occurs with metallic minerals in eastern and western Viti Levu and Vanua Levu (Houtz and Phillips, 1963). The largest deposit adjoins the Koroisa magnetite deposit. The several thousand tons of barite in fragments as much as 4 inches in diameter in the soil were derived from covered veins. Barite is reported in the Mount Kasi gold mine and is associated with copper and zinc minerals in the Wainaviti deposit of eastern Viti Levu, where mineralized limestone contains about 3 percent barite. Hydrothermal minerals in limestones in Fiji are of Miocene, Pliocene, and post-Pliocene age. The presence of commercial-grade barite is a possibility, according to Houtz and Phillips (1963, p. 19).

CONCLUSIONS

The 200 million tons of barite in the currently reported world reserves are only a 20-year supply, if the annual production rate continues to climb in the next 20 years as it did in the past 20. All the trends in use suggest that demands will continue to increase as industry strives to provide for the needs of an increasing world population that will be 6 billion by the year 2000. Requirements for drilling oil and gas wells alone insure a constantly increasing demand for barite. New deposits must, therefore, be sought and developed and resources converted to reserves, a process which can only take place slowly.

Geologic factors suggest that world barite production can be increased in the coming years, and the possibilities for discovering new barite deposits throughout the world are favorable. Among the most worthy targets for search the world over are deposits of bedded barite similar to those in Arkansas and Nevada. Such deposits probably have not yet been seriously sought or recognized in many areas. These deposits tend to be large and are amenable to large-scale low-cost mining operations. The estimated barite reserves of 50 million tons in the bedded deposits of Arkansas and Nevada alone constitute about 25 percent of the world's known reserves.

Vein deposits mined chiefly for barite are yielding major amounts of ore in many countries of the world, and substantial amounts will continue to be obtained from vein deposits of all sizes. Smaller deposits, however, will lose their economic significance in the more advanced stages of industrialization, as has already happened in the United States. The search will have to be pressed for larger deposits with great volumes of ore.

An increasingly important source of barite may well be as a coproduct from the mining of iron, base-metal, fluorspar, and rare-earth ores already known in many parts of the world. Larger volumes of barite may also be recovered from mine dumps and tailings ponds, where barite is already partly ground and concentrated.

Too few data are available to evaluate the possibilities of increasing the world's reserves of barite in residual deposits. Prospecting and assessing residual barite deposits are difficult. Despite the problems, much barite has been mined from residual deposits in the United States, where the deposits have been large, although of relatively low grade, and easy to mine by opencut methods. Ores from residual deposits generally can be beneficiated easily and inexpensively.

REFERENCES CITED

Abreu, S. F., 1960, Recursos minerais do Brasil, v. 1, Materiais não metálicos: Brazil, Inst. Nac. Technologia, 471 p.

Ahlfeld, Federico, and Schneider-Scherbina, Alejandro, 1964, Los yacimientos minerales y de hidrocarburos de Bolivia: Bolivia Dept. Nac. Geologia Bol. 5 (espec.), 388 p.

Ahlfeld, Friedrich, 1934, Neue Baryt- und Witheritvorkommen in Turkmenien: Zeitschr. Prakt. Geologie, v. 42, no. 9, p. 129–133.

Barnes, J. W., ed., 1961, The mineral resources of Uganda: Uganda Geol. Survey Bull. 4, 89 p.

Beder, Roberto, 1921, Breve Recopilación de los yacimientos de materias explotables de la República Argentina: Dirección General de Minas Geología e Hidrología Bol. 26, ser. B (Geología), 32 p.

Bender, H., 1934, Die Umlagerung des Schwerspates bei Leutnitz in Thüringen: Zeitschr. Prakt. Geologie, v. 42, no. 8, p. 116–120.

Bernard, J. H., 1961, Mineralogie und Geochemie der Siderit-Schwerspatgänge mit Sulfiden im Gebiet von Rudnãny (Tschechoslowakei): Geol. Práce, v. 58, 222 p.

Bodenlos, A. J., 1948, Barite deposits of Camamú Bay, State of Bahia, Brazil: U.S. Geol. Survey Bull. 960–A, p. 1–33 [1949].

Bogdanov, B. D., 1963, Tipove xipogenna zonalnost b Madanskiya ryden raion [Types of hypogene zoning in the Madan ore district] [English summ.]: Bulgaria Akad. Nauk Geol. Inst. "Strashimir Dimitrov," Ser. Geokhimiya, Minrealogiya i Petrografiye, v. 4, p. 59–71.

Bolduan, Helmut, Richter, Peter, and Tischendorf, Gerhard, 1961, Ergebnisse von Untersuchungsarbeiten auf Baryt im Gebiet vom Schneckenstein (Vogtland): Zeitschr. Angew. Geologie, v. 7, no. 1, p. 11–19.

Boocock, C., 1965, Mineral resources of the Bechuanaland Protectorate: London, Overseas Geology and Mineral Resources Quart. Bull., v. 9, no. 4, p. 369–417.

Boyle, R. W., 1963, Geology of the barite, gypsum, manganese, and lead-zinc-copper-silver deposits of the Walton-Cheverie area, Nova Scotia: Canada Geol. Survey Paper 62–25, 36 p.

Braithwaite, J. C., and Watters, W. A., 1962, Barite-fluorite mineralization at Thomson Hill, Wangapeka Valley, Nelson: New Zealand Jour. Geology and Geophysics, v. 5, no. 4, p. 567–578.

Brobst, D. A., 1958, Barite resources of the United States: U.S. Geol. Survey Bull. 1072–B, p. 67–130.

———1960, Barium minerals *in* Industrial minerals and rocks [3d ed.]: Am. Inst. Mining, Metall., and Petroleum Engineers, p. 55–64.

———1965, Barite in the United States, exclusive of Alaska and Hawaii: U.S. Geol. Survey Mineral Resources Map MR–43.

———1966, Anomalous metal concentrations in jasperoid from hypogene barite veins near Rabigh, Kingdom of Saudi Arabia, *in* Geological Survey research 1966: U.S. Geol. Survey Prof. Paper 550–C, p. C187–C189.

Brobst, D. A., and Hobbs, R. G., 1968, Barite *in* Mineral resources of the Appalachian region: U.S. Geol. Survey Prof. Paper 580, p. 270–277.

Brobst, D. A., and Ward, F. N., 1965, A turbidimetric test for barium and its geologic application in Arkansas: Econ. Geology, v. 60, no. 5, p. 1020–1040.

Brown, J. C., and Dey, A. K., 1955, Barytes *in* India's mineral wealth, a guide to the occurrences and economics of the useful minerals of India [3d ed.]: Oxford Univ. Press, p. 448–452.

Cabrera La Rosa, Augusto, 1962, La baritina en el Perú: Peru, Inst. Nac. Inv. y Fomento Minerios, Ser. Mem. 6, 62 p.

Chermette, Alexis, 1962, Les ressources de la France en barytine: Bur. recherches géol. et minières Bull. 2, p. 1–43.

Coetzee, C. B., 1958, Manganiferous iron ore, hematite, barite, and sillimanite on Gams (portion 1), Namaqualand: South Africa Geol. Survey Bull. 28, 25 p.

Colonial Geology and Mineral Resources, 1954, British Honduras: London, Her Majesty's Stationery Office, v. 4, no. 3, p. 286–287.

Condon, M. A., 1968, The geology of the Carnarvon Basin, Western Australia, Pt. 3, Post-Permian stratigraphy, structure, and economic geology: Australia Bur. Mining Resources Geology and Geophysics Bull. 77, pt. 3, 68 p.

Coulson, A. L., 1933, Barytes in the ceded districts of the Madras Presidency; with notes on its occurrence in other parts of India: India Geol. Survey Mem., v. 64, pt. 1, p. 1–142.

Davies, D. N., 1964, Swaziland *in* Overseas Geological Surveys Annual Report for 1963: London, Her Majesty's Stationery Office, p. 91–94.

Dean, B. G., and Brobst, D. A., 1955, Annotated bibliography and index map of barite deposits in the United States: U.S. Geol. Survey Bull. 1019–C, p. 145–186.

De Kun, Nicolas, 1965, The mineral resources of Africa: New York, Elsevier Publishing Co., 740 p.

Delevaux, M. H., Doe, B. R., and Brown, G. F., 1967, Preliminary lead isotope investigations of brine from the Red Sea, galena from the Kingdom of Saudi Arabia, and galena from the United Arab Republic (Egypt): Earth and Planetary Sci. Letters, v. 3, no. 2, p. 139–144.

Dunham, K. C., 1959, Non-ferrous mining potentialities of the northern Pennines *in* Future of non-ferrous mining in Great Britain and Ireland: Inst. Mining and Metallurgy, p. 115–147; discussion, p. 204–232.

Ehrenberg, Hans, Pilger, Andreas, and Schröder, Fritz, 1954, Das Schwefelkies-Zinkblende-Schwerspatlager von Meggen (Westfalen) (Monographien der deutschen Blei-Zink-Erzlagerstatten 7): Geol. Jahrb. Beihefte, no. 12. 352 p.

Engineering and Mining Journal, 1968, Ireland's "new era" mines continue going on stream: Eng. and Mining Jour., v. 169, no. 8, p. 67–72.

Food Machinery & Chemical Corporation, 1961, Barium bibliography: New York, Food Machinery & Chem. Corp., Mineral Products Div., 433 p.

Fowler, A., 1957, Minerals in the Permian and Triassic of north-east England: Geologist's Assoc. Proc., v. 67 (1956), pt. 3–4, p. 251–265.

Fritts, C. E., 1962, The barite mines of Cheshire: Cheshire, Conn., Cheshire Hist. Soc., 36 p.

Gallagher, David, 1963, Mineral resources of Korea, V. 6A, Non-metallics and miscellaneous metals: Korea Mining Br., Industry and Mining Div., in coop. with Korea Geol. Survey, 121 p.

Gourlay, A. J. C., 1965, Barite *in* McLeod, I. R., ed., Australian mineral industry; the mineral deposits: Australia Bur. Mineral Resources Geology and Geophysics Bull. 72, p. 61–72.

Guernsey, T. D., 1952, A prospector's guide to mineral occurrences in Northern Rhodesia [2d ed.]: Salisbury, British South Africa Co., 91 p.

Harris, J. F. 1961, Summary of the geology of Tanganyika, Pt. 4, Economic geology: Tanganyika Geol. Survey Mem. 1, 143 p.

Henglein, M., 1934, Die Flussspat- und Schwerspatgänge bei Pforzheim: Zeitschr. Prakt. Geologie, v. 42, no. 8, p. 113–116.

Hobson, G. V., 1959, Barytes in Scotland, with special reference to Gasswater and Muirshiel mines [with discussion] *in* Future of non-ferrous mining in Great Britain and Ireland: Inst. Mining and Metallurgy, p. 85–100.

Hoffmann, Adolf, Hülsemann, Paul, Isert, F., Landschütz, H., and Schlicht, G., 1930, Die Bergwerke Deutschlands auf bergwirtschaftlicher und lagerstättenkundlicher Grundlage: Stuttgart, Ferdinand Enke, 412 p.

Hoffmann, Thomas, 1969, Barite deposits of the "Montagne Noire," southern France: Mineralium Deposita (Berlin), v. 4, no. 3, p. 260–274.

Hofmann, Richard, 1966, Lagerstättenkundliche Untersuchungen im Bereich der Schwerspat-Grube Eisen (südwestlicher Hunsrück): Neues Jahrb. Geologie u. Paläontologie Monatsh., no. 1, p. 22–35.

Hooper, C. J., 1963, The barite industry of Iran *in* Symposium on industrial rocks and minerals, Lahore, Pakistan, December 1962: Central Treaty Organization (CENTO), p. 434–439.

Houtz, R. E., and Phillips, K. A., 1963, Interim report on the economic geology of Fiji: Fiji Geol. Survey Dept. Econ. Rept. 1, 36 p.

Huvelin, Paul, 1962, La barytine au Maroc: Rabat, Éd. Direction Mines et Géologie, v. 5, no. 18, p. 37–43.

Industrial Minerals, 1968, Belgium—Barite mine to be re-opened: London, Metal Bull., Ltd., no. 14, p. 30.

Jacobson H. S., Pierson, C. T., Danusawad, Thawisak, Japakasetr, Thawat, Inthuputi, Boonmai, Siriratanamongkol, Charlie, Prapassornkul, Saner, and Pholphan, Narin, 1969, Mineral investigations in northeastern Thailand: U.S. Geol. Survey Prof. Paper 618, 96 p.

Japan Geological Survey, 1960, Geology annd mineral resources of Japan [2d ed.]: Kawasaki, 314 p.

Jovčev, J. S., 1965, The geology and mineral deposits of Bulgaria *in* Carpathobalkan Geol. Assoc. Guidebook 7th Cong., Sept. 1–16, 1965 [in Russian, with French and English summ.]: Carpathobalkan Geol. Assoc., 109 p.

Kaaden, G. van der, 1963, Barite deposits in Turkey *in* Symposium on industrial rocks and minerals, Lahore, Pakistan, December 1962: Central Treaty Organization (CENTO), p. 429–433.

Klaus, Dieter, and Schröder, Norbert, 1967, Erfahrungen beim Einsatz geophysikalischer Messverfahren in der Flussspat- und Schwerspaterkundung: Zeitschr. Angew. Geologie, v. 13, no. 11/12, p. 610–618.

Klinger, F. L., and Abbas, S. H., 1963, Barite deposits of Pakistan *in* Symposium on industrial rocks and minerals, Lahore, Pakistan, December 1962: Central Treaty Organization (CENTO), p. 418–428.

Kostov, Ivan, 1963, Mineralogichesko raionirane na Rodopite [Mineralogical subdivisions of the Rhodopes] [English summ.]: Bulgaria Akad. Nauk Geol. Inst. "Strashimir Dimitrov," Ser. Geokhimiya, Mineralogiya i Petrografiya, v. 4, p. 7–26.

Kraume, Emil, and others, 1955, Die Erzlager des Rammelsberges bei Goslar (Monographien der deutschen Blei-Zink-Erzlagerstätten 4): Geol. Jahrb. Beihefte, no. 18, 393 p.

Krishnan, M. S., 1944, Barium minerals: Jour. Sci. and Indus. Research, v. 3, no. 5, p. 222–226.

Kulesza, Krystyna, 1961, Baryty krajowe: Przeglad Geol., v. 9, no. 11, p. 588–590.

Liubimov, I. M., 1966, Polezn'e Iskopaem'e C.C.C.P. [Useful minerals of the U.S.S.R.]: Izdatel'stvo Prosveshchenie, 257 p.

Mining and Minerals Engineering, 1968, Mogul at Silvermines: Mining and Minerals Eng., v. 4, no. 11, p. 40–47.

Mining Engineering, 1969, The black ore district of Hokuroku: Mining Eng. (AIME), v. 21, no. 5, p. 60–65.

Murdock, T. G., 1963, Mineral resources of the Malagasy Republic: U.S. Bur. Mines Inf. Circ. IC 8196, 147 p.

Nazarov, Y. I., 1959, Osobennosti otlozheniya barita i sulfidov isvetnykh metallov v mestorozhdenii Madneuli: Geol. Rudnykh Mestorozhdenii, no. 6, p. 90–101; English summ., Features of the deposition of barite and sulfides of nonferrous metals in Madneuli deposits: Econ. Geology, v. 56, no. 6, p. 1160, 1961.

Nienaber, J. H., 1962, Mineral resources of Yugoslavia *in* Conant, L. C., ed., Excursion to Yugoslavia, May 12–16, 1962: Libya Petroleum Explor. Soc., 83 p.

Nixon, L. G. B., 1962, Oraparinna barite mine: South Australia Dept. Mines Mining Rev., no. 113, p. 10–15.

Orr, A. R. D., 1960, Barytes: Mining Jour., Ann. Rev. issue, May, p. 65.

______1961, Barytes: Mining Jour., Ann. Rev. issue, May, p. 66.

______1968, Barytes: Mining Jour., Ann. Rev. issue, May, p. 100–101.

Pallister, J. W., 1958, Mineral resources of Somaliland Protectorate: Overseas Geology and Mineral Resources, v. 7, no. 2, p. 154–165.

Pollard, Melvin, 1951, Japanese mineral resources: Tokyo, Allied Powers GHQ Nat. Resources Sec. Rept. 141, 107 p.

Pomerene, J. B., and Stewart, W. E., 1967, Barite veins in the Gibi area of Liberia: Liberia Geol. Survey Bur. Nat. Resources and Surveys Bull. 1, 23 p.

Pratzka, Günter, 1959, Zur Paragenese der Flussspat-Schwerspat-Lagerstätte Hühn/Trusetal am SW-Rand des Thüringer Waldes: Zeitschr. Angew. Geologie, v. 5, no. 1, p. 27–34.

Ramovic, Mehmed, 1963. Barite deposits in Bosnia-Hercegovina: U.S. Dept. Commerce Tech. Translation Office Tech. Services, 20 p.

Reeve, W. H., 1963, The geology and mineral resources of Northern Rhodesia: Northern Rhodesia Geol. Survey Bull. 3, v. 1, 213 p.

Reh, Herbert, 1965, Geologie Lagerstätten und Berkwirtschaft der Vereinigten Arabischen Republik: Zeitschr. Angew. Geologie, v. 11, no. 11, p. 608–613.

______1966, Grundzüge der Geologie und Minerallagerstatten der Volksrepublik Bulgarien: Zeitschr. Angew. Geologie, v. 12, no. 2 ,p. 100–101.

Reyna, J. G., 1956, Riqueza minera y yacimientos minerales de Mexico: Internat. Geol. Cong., 20th sess., Mexico City, p. 379–380.

Rhoden, H. N., 1959a, Structure and economic mineralization of the Silvermines district, county Tipperary, Eire: Inst. Mining and Metallurgy Bull. 625 (Trans., v. 68, pt. 3), p. 67–94.

______1959b, Mineralogy of the Silvermines district, county Tipperary, Eire: Mineralog. Mag., v. 32, no. 245, p. 128–138.

Ross, J. S., 1960, The barium minerals industry in Canada: Canada Dept. Mines and Tech. Surveys Mines Br. Inf. Circ. IC 126, 60 p.

Said, Rushdi, 1962, The geology of Egypt: New York, Elsevier Publishing Co., 377 p.

Santmyers, R. M., 1930, Barite and barium products, Pt. 1, General information: U.S. Bur. Mines Inf. Circ. IC 6221, 55 p.

Sawkins, F. J., 1966, Ore genesis in the North Pennine orefield, in the light of fluid inclusion studies: Econ. Geology, v. 61, no. 2, p. 385–401.

Schenderei, G. F., 1932, Baritov'e mestorojdeniya zapadno-Sibirskoga kraya [Barite deposits in western Siberia]: Vestnik Zapadno-Sibir. Geologo-Razved. Tresta, Izdanie Z.S.G.R.T. Tomsk, pt. 3–4, p. 31–37.

Schulz, Oskar, 1967, Sedimentäre Barytgefüge im Wettersteinkalk der Gailtaler Alpen: Tschermaks Mineralog. u. Petrog. Mitt., 3d ser., v. 12, no. 1, p. 1–16.

Scott, Barry, 1967, Barytes mineralization at Gasswater mine, Ayrshire, Scotland: Inst. Mining and Metallurgy Trans., v. 76, Sec. B, Bull. 723, p. 40–51.

Shawe, D. R., Poole, F. G., and Brobst, D. A., 1967, Bedded barite in East Northumberland Canyon, Nye County, Nevada: U.S. Geol. Survey Circ. 555, 8 p.

______1969, Newly discovered bedded barite deposits in East Northumberland Canyon, Nye County, Nevada: Econ. Geology, v. 64, no. 3, p. 245–254.

Shimkin, D. B., 1953, Minerals—a key to Soviet power: Cambridge, Mass., Harvard Univ. Press, 452 p.

Siotis, G. J., 1936, The barytes deposits of Greece: Sands, Clays and Minerals, v. 3, no. 1, p. 43–46.

Solomon, Michael, 1966, Origin of barite in the North Pennine ore field: Inst. Mining and Metallurgy Trans., v. 75, Sec. B, Bull. 717, p. 230–231.

South Africa Geological Survey, 1959, The mineral resources of Union of South Africa [4th ed.]: Union South Africa Geol. Survey, Dept. Mines, 622 p.

Sugimoto, Ryoya, 1962, Barite ore-deposits of Hokkaido, Japan [Japanese and English summ.]: Hokkaido Geol. Survey Rept. 26, p. 1–66.

Superceanu, C., 1967, Metallogenetische Provinzen Rumäniens: Zeitschr. Angew. Geologie, v. 13, no. 2, p. 57–65.

Svoboda, Josef, Beneš, Karel, Chaloupský, Josef, and others, 1966, Regional geology of Czechoslovakia, Pt. 1, The Bohemian massif: Czechoslovakia Geol. Survey, 668 p.

Tavera Amezcua, Eugenio, Lopez, L. S. J., and Avila, J. L., 1960, Yacimientos de barita en el distrito de Galeana, Nuevo León: Mexico Consejo Recursos Nat. no Renovables Bol. 55, 70 p.

Tonev, Stanko, 1961, Gidrotermal'no-metasomaticheskoe mestorojdenie Kremikovtsy, Bulgarii [Hydrothermal-metosomatic ore deposits at Kremikovtsy, Bulgaria]: Razved. i Okhrana Nedr, no. 11, p. 56–61.

——— 1964, Die mineralischen Rohstoffe der VR Bulgarien: Zeitschr. Angew. Geologie, v. 10, no. 2, p. 99–102.

United Nations, 1962, Mining developments in Asia and the Far East, 1960: United Nations Econ. Comm. Asia and Far East, Mineral Resources Devel. Ser. Rept. 16, 85 p.

——— 1963, Mineral distribution map of Asia and the Far East: United Nations Econ. Comm. Asia and Far East, 4 sheets; expl. brochure, 53 p.

——— 1967, Mining developments in Asia and the Far East, 1945–1965: United Nations Econ. Comm. Asia and Far East, Mineral Resources Devel. Ser. Rept. 27, 136 p.

U.S. Bureau of Mines, 1924–31, Mineral resources of the United States: Washington, U.S. Govt. Printing Office (ann. volumes for the years indicated).

——— 1932–67, Minerals yearbook: Washington, U.S. Govt. Printing Office (ann. volumes for the years indicated).

——— 1948, Mineral resources of China: U.S. Bur. Mines Economics and Statistics Div. Foreign Minerals Survey, v. 2, no. 7, 226 p.

——— 1957, 1960–61, 1964, Mineral trade notes: Washington, U.S. Bur. Mines Metals and Nonmetals Div. (monthly serial pubs. for the years indicated).

U.S. Geological Survey, 1882–1923, Mineral resources of the United States: Washington, U.S. Govt. Printing Office (ann. volumes for the years indicated).

Vila, Tomás, 1953, Recursos minerales no-metálicos de Chile [3d ed.]: Santiago, Chile, Editorial Univ., 449 p.

Weber, F. H., Jr., 1966, Barite *in* Mineral and water resources of California, Pt. 1, Mineral resources report: California Div. Mines and Geology Bull. 191, p. 94–98.

Williams, F. E., Fillo, P. V., and Bloom, P. A., 1964, Barite deposits of New Mexico: New Mexico Bur. Mines and Mineral Resources Circ. 76, 46 p.

Wokittel, Roberto, 1956, Situacion de barita en Colombia: Colombia Ministerio Minas y Petroleos Bol. Minas 3, no. 32, p. 7–15.

Wollack, Otto, 1951, Die Schwerspatlagerstätte von Kavos-Pilonisi auf der Insel Milos, Griechenland: Wien, Berg- u. Huttenm. Monatsh., v. 96, p. 94–100.

Zans, V. A., 1951, Economic geology and mineral resources of Jamaica: Jamaica Geol. Survey Dept. Bull. 1, Pub. 4, 61 p.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1970 O—384-686