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THE FLUORSPAR INDUSTRY IN THE SOVIET BLOC

CIA/RR 4

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CENTRAL INTELLIGENCE AGENCY

OFFICE OF RESEARCH AND REPORTS

SECRET

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S-E-C-R-E-T

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CIA/RR 4

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Office of Research and Reports

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SECURITY INFORMATION

THE FLUORSPAR INDUSTRY IN THE SOVIET BLOC

Summary

The nonmetallic mineral fluorspar is essential to the steel and aluminum industries. The steel industry uses metallurgical-grade fluorspar directly as marketed. The use of acid-grade, required for the aluminum industry, is more involved.

Acid-grade fluorspar is a raw material source of hydrofluoric acid (HF), from which synthetic cryolite (for the aluminum industry) and other fluorine products are derived. Recently, relatively new uses for HF, in the preparation of chemical warfare materials and in the atomic energy programs, have assumed great importance.

The total production of fluorspar in the Soviet Bloc is broadly estimated at 200,000 metric tons annually as of 1951, which is approximately one-quarter of the total world production. The principal fluorspar producing centers are located in the USSR and East Germany. Chinese and North Korean mines, important producers under the Japanese occupation, may have been reactivated to some extent by the Soviets, but North Korean mines have probably been inoperative during the period of military action in that country. Proved ore reserves of fluorspar in the Soviet Bloc are estimated at nearly 5 million metric tons, with the major portion in the USSR.

Consumption of fluorspar by the steel and aluminum industries of the Soviet Bloc in 1951 is estimated at 110,500 metric tons of metallurgical-grade and 23,600 metric tons of acid-grade. This leaves a balance of about 66,000 metric tons for distribution to other consuming industries. It is assumed that part of the Soviet supply of acid-grade fluorspar is being diverted to new military as well as to industrial uses, but these additional needs are not estimated.

The fluorspar industry of the Soviet Bloc apparently is capable of supplying the demands of the USSR, but the position of the Satellites may be critical. The Satellites have depended mainly on Western countries for their supply. If East-West trade restrictions are effective, the USSR will be required to relinquish some of its supply or increase the total Bloc production. A similar situation exists with regard to the Satellite supply of cryolite.

Any limitations to the fluorspar industry within the Soviet Bloc would probably be in fluorspar processing capacity for the production of acid-grade and in the capabilities of HF plants for the manufacture of fluorine products.

I. Introduction.

1. General Description.

Fluorspar, or fluorite, is a nonmetallic mineral distinguished by its crystalline form, octahedral cleavage, and specific gravity. Its specific gravity is 3.18, and its hardness in the Mohs scale is 4.

Fluorspar occurs as a vein mineral associated with galena, sphalerite, calcite, and barite; in tin-stone veins associated with cassiterite, apatite, topaz, and lepidolite; and in limestones. The chemical composition is calcium fluoride, CaF_2 (F equaling 48.9 percent). Fluorspar is, notably, the only common fluoride occurring in nature. The impurities usually found with it are calcite, dolomite, barite, or quartz.

Little change has taken place in methods of fluorspar mining during the last decade except for more mechanization involving the use of mucking machines, slushers, mechanical haulage, and other equipment. Progress in prospecting techniques during the past 10 years has been largely in the development of better core-drilling equipment and in the fuller study and application of geology. 1/

The regional distribution of fluorspar is world-wide. Fluorspar deposits have been developed on every continent, more importantly in North America, Europe, and Asia. The US has maintained the leading position in fluorspar production. Other major producers of fluorspar are Canada, Mexico, Great Britain, France, Germany, Italy, Spain, and the USSR. Currently the USSR may rank second to the US, although before World War II, Germany held that position.

2. Uses and Specifications.

Fluorspar is used extensively* in metallurgy, in ceramics, and, more recently, in chemistry, where important new uses of hydrofluoric

* A small quantity of optical-grade fluorspar is used to correct the color and spherical aberration errors in lenses of microscopes and small telescopes.

acid (HF) have been developed. Fluorspar is marketed in three principal grades of concentrates: metallurgical, ceramic, and acid (chemical).

In the preparation of fluorspar concentrates the methods of separation are the standard ore-dressing techniques, which include hand-sorting, gravity separation, and flotation. The milling of fluorspar for the ceramic or acid trade is relatively more difficult and requires more careful control than the processing of the metallurgical grade. No new techniques have been developed during the past 10 years, but there have been improvements in the old techniques such as the use of improved flotation reagents and heated flotation circuits.

The metallurgical and ceramic grades are shipped direct to the steel and ceramic industries, respectively. The acid grade is more complex in its distribution and use. Prices are higher for the ceramic and acid grades than for the metallurgical grade.

a. Metallurgical Grade.

Metallurgical-grade fluorspar is used essentially as a fluxing agent in the manufacture of high-grade steel, ferroalloys, nickel, brass, and basic refractories and to refine nonferrous metals. This grade should contain not less than 85 percent fluorite and not more than 5 percent silica and 0.03 percent sulphur. These specifications may be considerably relaxed without damage to the steel produced. Physically, metallurgical-grade gravel must pass through a 1-inch screen and must contain less than 15 percent fines. Lump metallurgical fluorspar, from 2 to 6 inches in diameter, is used as a flux in foundries for making high-grade iron castings.

b. Ceramic Grade.

Ceramic-grade fluorspar is used in the manufacture of opalescent, opaque, and colored glass; enamels; brick facings; and Portland cement. It serves not only as a flux but also as a component of glass and enamel mixes. It is also used as a bonding agent for the constituents of emery wheels; in the manufacture of carbon electrodes; and in the preparation of electric-arc welding electrodes, where the fluorspar serves as a flux. The ceramic grade is chemically an intermediate one. A minimum of 95 percent fluorite usually is required, and 2.5 percent silica is the standard maximum. It must be colorless and therefore can contain not more than 0.12 percent ferric oxide and only traces of other iron compounds or lead or zinc sulphide. These specifications may be considerably modified for some uses.

c. Acid Grade.

Acid-grade fluorspar is complex in its use because it involves initially the preparation of hydrofluoric acid (HF), from which the fluorine products are derived. Any study of acid-grade fluorspar, therefore, is necessarily a partial study of HF. HF is made by the reaction of acid-grade fluorspar with sulphuric acid in the ratio 1:1.3. The specifications for acid-grade fluorspar may be relaxed slightly, but this grade should contain not less than 98 percent fluorite or more than 1 percent silica. Barite, lead, zinc, lime, and iron also are unwanted impurities because they interfere with the making of HF. The fluorspar must be finely ground and must be absolutely dry.

Two grades of HF are produced. Hydrous, or technical, HF is prepared in aqueous solutions up to 60 percent HF maximum and is used in the manufacture of inorganic fluorides. The two important fluorides are synthetic cryolite (see III 2, below) and aluminum fluoride, which are required in aluminum reduction. The supply of these materials to the aluminum industry has been the principal function of the HF industry.

Anhydrous HF, at 99 percent HF minimum, is used in the manufacture of the element fluorine and organic fluorine compounds including fluorcarbons and their polymers. Most of the organic compounds and related processes have been developed during and after World War II. In the US, capacity for the production of anhydrous HF has increased to more than half the total HF capacity. 2/

New developments in the use of anhydrous HF include the manufacture of freon used as a refrigerant, and also as a carrier in aerosol bombs for dispersing insecticides, paints, and other materials; the alkylation process in which HF serves as a catalyst in the manufacture of high octane gasoline; and the manufacture of fluorcarbons including the strategic plastic "Teflon."

Recently, new military uses of HF in chemical warfare and in atomic energy programs have assumed great importance. In atomic energy programs, HF is used in the manufacture of uranium metal; in the manufacture of uranium hexafluoride, which is the only suitable gas compound for use in isotope separation plants; and in the manufacture of highly stable fluorcarbons for heat exchange fluids and gasket material.

II. Production and Reserves.*

The fluorspar-producing countries of the Soviet Bloc are East Germany, the USSR, China, and North Korea.** The Soviet Bloc lags behind the US and other Western countries in production of fluorspar but under present world conditions may have stepped up production to about 200,000 metric tons. This would amount to one-quarter of the total world production, which in 1951 should have reached a minimum of 800,000 metric tons.

Tables 1 and 2, which follow, give the estimated production figures and the estimated ore reserves of fluorspar in the Soviet Bloc.

* Production figures refer to fluorspar in one of the three grades of concentration. Reserve figures refer to ore containing fluorspar.
** For the principal fluorspar producing and consuming centers in the Soviet Bloc, see the map following p. 22.

Table 1

Production of Fluorspar in the Soviet Bloc
Average Annual Rate, 1936-51

Thousand Metric Tons

	1936-40	1941-45	1946-50	1951
East Germany	41.4 3/	63.5 a/	37.5 b/	50.0
USSR c/	75.0 d/	50.0 e/	100.0 f/	150.0
China	10.0 4/	61.9 5/	g/	g/
North Korea	10.0 6/	20.0 7/	3.3 h/	i/

a. 1941-44. 8/
b. 1948-50, exclusive of production by certain small mines. 9/
c. Rough estimates derived mainly from Soviet plans for processing facilities in relation to production figures for 1929-36.
d. Based on an established figure of 65 in 1936 and an assumed annual rate of increase of 5. During the first 4 years of the Second Five Year Plan (1933-36) the annual increase in production varied from 8 to 22. In some mining areas, however, the hand-sorted material was soon exhausted, and, without adequate processing facilities, this rate probably could not be maintained. Thus the lower increase rate of 5 for the period 1936-40 is considered reasonable. Non-Soviet estimates for 1940 production range from 70 to 90. The increase rate of 5 would give a production figure of 85 for 1940.
e. Based on assumed decreased rate during the war period.
f. Based on assumed figures of 50 in 1946 and annual rate of increase of 25. By the end of the period 1946-50, according to the Soviet press, prewar plans for installation of processing plants were effected. Thus total plant capacity in 1950 would approximate 120, with an estimated minimum 30 available by hand-sorting. If the figure of 50 in 1946 is accepted, then an annual increase rate of 25 up to 1950 would be justified in order to achieve gradually the possible production of 150 with plant facilities in operation.
g. Possibly a few thousand tons.
h. Delivered to the North Korean government for the USSR in 1949. 10/
i. Mines probably inoperative during 1951.

Table 2

Estimated Ore Reserves of Fluorspar in the Soviet Bloc
(Latest Available Date)

Thousand Metric Tons

Country and Region	Deposit	Ore Reserves (40 Percent CaF_2 Average)	Date
East Germany			
Saxony-Anhalt (South Harz Areas)	Fluss-Schacht (near Rottleberode)	176	1941 11/
	Herzog-Schacht (near Siptenfelde)	340	1941 12/
Other Regions		a/	
Total		1,000 b/	1945 13/
USSR			
Northern European USSR	Amderma	1,320	
Kazakh SSR	Aurakhmat	252	
Central Asia	Takob	415	
East Siberia	Kalanguy	307	
	Abagatuy	50	
	Soloneshnyy	309	
	Other	29	
Other Siberian and Far East		9	
Total		2,691 c/	1938 14/
China			
Liaoning	Kai-p'ing	600	1947 15/
Jehol	K'o-la-ch'in-wang-fu	50	1947 16/
	Lung-hua	100	1947 17/
Chekiang	All Deposits	400	1946 18/
Total		1,150	
North Korea		100 d/	1948 19/
Grand Total		4,941	

a. Insufficient data.
b. Based on an estimate of Germany's total reserves and taking into consideration East Germany's production capacity. 20/
c. Two million tons of this reserve require concentration.
d. Based on a figure of 50,000 tons for one mine in a group of five.

1. East Germany.

East Germany, with its established mines and flotation plants and an estimated annual output of 50,000 metric tons, is the only important source of fluorspar among the European Satellites. The fluorspar deposits of East Germany, occurring in veins commonly associated with barite, are found in Saxony-Anhalt, Thuringia, and Saxony. The oldest and most important producing field is in the Harz mountains, with the two largest single mines of Saxony-Anhalt being the Fluss-Schacht mine near Rottleberode and the Herzog-Schacht mine near Siptenfelde. The area of fluorspar deposits lies mainly between these two centers but also extends northeast and northwest of Rottleberode.

In Thuringia and Saxony, smaller mines were developed during World War II, some of which are now probably exhausted. Current appraisal of fluorspar resources at these mines varies, but the planned production for 1949 is considered to be a reliable basis for evaluation. This plan verifies the current significance of the Gottesgabe mine at Steinbach in Thuringia and of mine groups near Ilmenau in Thuringia and near Oelsnitz in Saxony. The Ilmenau producing area extends in a southeast direction from Ilmenau through Langewiesen to Gehren. In Saxony the producing area extends from Oelsnitz southwest to Wiedersberg.

According to the 1949 Plan, more than half of the East German fluorspar production is of acid grade, which is allotted to reparations for the USSR. Flotation plants near Rottleberode, Siptenfelde, and Steinbach supply this grade, most of which is shipped to the fluorine works at Dohna in Saxony. Other East German plants supply metallurgical-grade fluorspar for East German requirements and for export. Details of the 1949 Plan are given in Table 3.*

* Table 3 follows on p. 9.

Table 3

Fluorspar Processing Plants in East Germany 21/
1949

Region	Plant Location	Planned Production (Metric Tons)	Planned Production (Percent CaF_2)	Allocation of Products
Saxony-Anhalt	Siptenfelde	9,000	96 to 97	To reparations
	Rottleberode	8,000	96 to 97	To reparations
		5,000	80	a/
Thuringia	Steinbach	5,600	96 to 97	To reparations
	Ilmenau b/	680	96 to 97	a/
		2,060	93 to 95	a/
		5,860	70 to 90	a/
Saxony	Oelsnitz c/	2,800	70 to 80	a/
		1,060	d/	

a. For East German requirements and export.
b. Includes plants at Langewiesen and Gehren.
c. Includes plants at Wiedersberg.
d. Insufficient data.

2. USSR.

Production of fluorspar in the USSR in 1951, based primarily on Soviet data and allowing for increased demand, is estimated at 150,000 metric tons. The Soviet fluorspar industry established in 1922 maintained an annual output of a few thousand tons, with a net increase rate during 1929-34 of 4,300 tons. Total production increased from 27,000 tons in 1934 to 65,000 tons in 1936. The increase rate for 1936-40 is estimated at 5,000 tons annually, with an estimated annual output of 85,000 tons by 1940. With the decline of the Soviet steel industry during wartime, fluorspar production was probably curtailed to an annual average rate of 50,000 metric tons. Published figures for fluorspar for the Fourth Five Year

Plan (1946-50) are not available. During this period, on the basis of additional processing plants, the increase rate is estimated at 25,000 metric tons annually, which would give a figure of 150,000 metric tons for 1950.

Planned expansion of plant facilities for production of acid-grade fluorspar has probably been completed during the postwar and Fourth Five Year Plan periods, but the fact that the USSR is forcing East Germany to increase its acid-grade production leaves some doubt as to whether the installations within the USSR are adequate.

The important producing and reserve areas of fluorspar in the USSR are found in four remote economic regions: Northern European USSR, Kazakh SSR, Central Asia, and East Siberia. None of these areas is readily accessible by rail to the big industrial centers. East Siberia has been the main source of fluorspar pending installation of processing plants in the other areas. Some of the production from East Siberia and Northern European USSR is hand-sorted material, but in Kazakh SSR and Central Asia the ore must be concentrated. If processing plants are now operating as planned, East Siberia should be producing at the rate of 60,000 metric tons a year, and the other three regions at 30,000 tons each.

Small fluorspar deposits occurring in the Ukraine, Urals, West Siberia, and the Far East may be more fully exploited for local industry. The largest known fluorspar reserve outside the main producing areas is found on the Chukotski peninsula in the Far East. This reserve had not been explored in 1939, and, with Soviet emphasis on the established fluorspar areas, it is unlikely that this extremely remote area would be included in Soviet planning for the near future.

From a geological point of view, the fluorspar deposits of the USSR may be divided into two groups. The deposits of Eastern Siberia and the Far East are associated with granitic intrusions into sandstones and clayey shales of the Jurassic period. The ores of this group are uncontaminated with sulphides but often contain high silica. The deposits of Northern European USSR, Kazakh SSR, and Central Asia apparently derive their origin from granitic intrusions of the Paleozoic era. The ores of this group have been subjected to hydrothermal redeposition in fractures and faults and occur either in lenses or are disseminated through breccia. Barite and sphalerite are common accessory minerals. Consequently, great variations in the purity of fluorspar found in the second group of deposits are present.

a. Northern European USSR.

The Amderma deposit of Northern European USSR is the largest known reserve of fluorspar in the USSR. When railroad connections are completed, this field will be more accessible to consuming centers. Present shipping is by sea routes to Archangel or Murmansk. Prewar plans for fluorspar production were based upon establishing Amderma as one of the principal sources of acid-grade fluorspar in the USSR. These mines came into production in 1934 with 3,600 metric tons and increased to 8,759 tons in 1935. Production for 1951 is roughly estimated at 30,000 metric tons of fluorspar concentrates.

The Amderma fluorspar occurs with sulphides in which fluorite is dominant and as breccia and fluoritized limestones. Some of the sulphide ore is of very high grade as reported by prewar German sources, but according to a Soviet source 22/ the fluoritized limestone type of ore is the principal raw material at Amderma, and this ore is analyzed at 40 percent CaF_2 or less.

According to prewar plans the output of the Amderma deposit was to be of acid grade, and a concentration plant was to be built to supplement the hand-sorting process. Planned concentrating capacity in 1937 was 5,000 to 7,000 metric tons requiring 14,000 to 18,000 tons of ore. 23/ In 1940, planned concentrating capacity was reported as requiring 36,000 to 37,000 metric tons of ore. 24/

During the period of the Fourth Five Year Plan the Amderma mines were variously reported as "being equipped with all modern technical improvements," with a "concentrating plant," with "stepping up production ahead of schedule," and with "overfulfillment of production quotas."*

b. Kazakh SSR.

The fluorspar deposits of Kazakh SSR are characterized by low-grade complex ores, all of which now require mechanical processing. The two known deposits are the Aurakhmat and the Badam.

The Aurakhmat mine, 90 kilometers northeast of Tashkent, was opened in 1933. Production of fluorspar by hand-sorting at Aurakhmat averaged 3,000 metric tons a year from 1933-35. High-grade ore was soon exhausted, and a new concentrating plant was required. Prewar planned capacity was up to 30,000 metric tons of concentrates. The average grade of the ore in 1939 was 38 percent CaF_2. This mine at the present time should produce at the rate of 30,000 metric tons of fluorspar concentrates annually.

* These quotations are taken from both Soviet and non-Soviet publications.

The Badam deposit, approximately 50 kilometers north-northeast of Tashkent, is a potential source of fluorspar. The ore is complex, containing barite, fluorspar, and copper. It is possible, however, that the Badam deposit has not yet been fully investigated.

c. Central Asia.

This region, with an important reserve of fluorspar ore, has only recently been developed. The production of fluorspar for 1951 is estimated at 30,000 metric tons. The mines are found in Tadzhik and in Uzbek within an area extending south and east of Tashkent and in Kirgiz. The fluorspar deposits are similar to those of Kazakh SSR.

In Tadzhik, two fluorspar deposits are known, the widely publicized Takob deposit and the lesser-known Kulikalon deposit.

The Takob mine is 48 kilometers north of Stalinabad. Exploitation of this deposit was delayed for years pending construction of the concentrating plant. Planned concentrating capacity is 30,000 tons of fluorspar, 97 percent CaF_2. 25/ Completion of the fluorspar installations at Takob was to have been achieved during the period of the Fourth Five Year Plan, the Soviet press claiming that production began in 1948.

The complex Takob ore contains fluorspar in association with lead, zinc, and silver. The CaF_2 content of the ore varies but carries an average of 50 percent CaF_2, 26/ which, together with its large reserve, "ranking second only to Amderma," and the possible recovery of nonferrous metals, marks this mine as one of the most important fluorspar mines in the USSR. Undoubtedly, more will be heard of Takob in the immediate future.

The Kulikalon deposit, discovered in 1933, and located at some distance northwest of Takob, may be an important potential source of optical fluorspar. Apparently some production of fluorspar at this deposit was initiated during the late 1930's by hand methods. In 1948 the local press reported that the mine was reexamined in 1943 and that "because of the purity and size of the crystals, this deposit is a unique thing in the world." This statement is verified by prewar German sources. Apparently this deposit has not yet been explored thoroughly.

In Uzbek, two small fluorspar deposits are known: the Chibargatinskoy and Agatinskoy vein deposits, lying about 50 kilometers east and southeast of Tashkent. The Chibargatinskoy mine was opened during the war and operated by hand methods whereas the Agatinskoy ore requires concentration. 27/

In Kirgiz the Khaidarkhan mine, 80 kilometers southeast of Fergana, is a potential source of fluorspar. The basic ore of this deposit is mercury and antimony containing an average of 19 percent CaF_2. This deposit was the principal wartime source of mercury, and the prewar Soviet plan was to include by-production of fluorspar. This operation, however, has not been verified.

d. East Siberia.

The fluorspar mines of East Siberia are found in east Transbaikal, the first known fluorspar region of the USSR. Mines, first operated here in the early 1930's, have since maintained a major position in supplying Soviet industry. Production for 1951, based on the operation of one concentrating plant and hand operations, is estimated at 60,000 metric tons.

The fluorspar deposits extend over a large area which lies between Chita and the Chinese border. The fluorspar occurs in quartz veins and is uncontaminated with sulphides. The quantity of high-grade ore is limited, but a substantial portion of the ore can be hand-sorted.

The important mines producing fluorspar are Kalanguy and Abagatuy, and the Soloneshnyy mine is considered a strong potential.

The Kalanguy mine is the principal producing mine of Transbaikal and during the prewar period was the largest single producer of the USSR, supplying 50 percent of the total fluorspar output. This mine may still hold first position. Kalanguy is situated 57 kilometers northeast of the Karymskoe-Otpor railroad and is connected by highway. Smaller mines such as the Taminga mine are in the immediate vicinity. Prewar mining capacity at Kalanguy was rated at 80,000 metric tons annually of ore. The ore containing more than 60 percent CaF_2 can be treated by hand methods, but the lower-grade ore requires mechanical processing. The 1936 Plan called for completion of a processing plant at Kalanguy, with a planned capacity of 30,000 metric tons of concentrates. Recent Soviet press reports point to "overfulfillment of production plans" at this mine. The estimated annual production rate is 50,000 metric tons.

The Abagatuy mine is the oldest fluorspar mine in the USSR. It is situated near the Chinese border 37 kilometers from the Karymskoe-Otpor railroad. Abagatuy is noted for its high-grade ore, having been the only Soviet source of acid-grade fluorspar until the Amderma mine was opened. The first recorded production was 8,000 metric tons in 1930. The planned production for 1936 was 12,000 metric tons. During 1948-49 the Soviet press claimed that the Abagatuy mine was ahead of its monthly production schedules. It is reasonable to assume an annual production rate of 10,000 metric tons of fluorspar concentrates by hand-sorting. The proved fluorspar reserve at the Abagatuy mine is substantial but not comparable with the Kalanguy reserve.

The Soloneshnyy mine was opened in 1933, with small production reported, but because of its remote location, it has probably been neglected. This mine has an ore reserve comparable to the Kalanguy deposit, and when transport facilities can be provided, the Soloneshnyy mine is certain to be exploited more fully.

3. China.

The fluorspar industry of China was for the most part developed in order to supply Japanese industry during the Japanese occupation. After World War II the Japanese and later the Soviets engaged in widespread dismantling of equipment, but some reactivation of fluorspar mines as well as planning for the future is indicated by an occasional report and by recent offers of Chinese fluorspar on the market. During the period 1936-40 the fluorspar production of China averaged 10,000 metric tons a year, increasing to an average of 61,900 tons during 1941-45, with possibly a few thousand tons produced during recent years. Chinese fluorspar was mainly hand-sorted and shipped to Japan for processing. At least one concentrating plant, however, was operated in China by the Japanese. The Chinese fluorspar industry is only in its beginning stages, and the full potential of its fluorspar resources is as yet unknown. However, more than a million tons of ore reserves are reliably reported, with the possibility of a greater reserve to be developed.

Fluorspar is widely distributed in China, but the more important producing areas during the Japanese occupation were Liaoning, Jehol, and Chekiang provinces.

In Liaoning province the outstanding fluorspar mine is the Kai-p'ing mine, southeast of Kai-p'ing station, where in 1944 a flotation plant was installed. During 1940-44 the total production at this mine was 15,719 metric tons of fluorspar concentrates, of which 8,740 tons were 94 percent CaF_2. Kai-p'ing has a reserve of 600,000 metric tons of ore containing an average of 40 percent CaF_2. The deposit occurs as a vein, in granite gneiss, 1,500 meters long with an average width of 3 meters. 28/

The Soviets removed all the equipment at Kai-p'ing, but it is possible, inasmuch as some used equipment is being supplied in this province in exchange for agricultural products, that this mine has been reopened in order to supply the local steel industry.

In Jehol province, 29/ during the period 1940-44, two areas were brought into production: the K'o-la-ch'in-wang-fu mine, 85 kilometers southwest of Chihfeng, and the Lung-hua mines, directly northwest of the town of Jehol. Production of fluorspar at K'o-la-ch'in-wang-fu during this period totalled 11,911 metric tons of concentrates containing 85 percent CaF_2. Reserves are reported as 50,000 tons with an average grade of 70 percent CaF_2. This deposit is a discontinuous vein in granite, 2,000 meters long and 1 meter wide. The Lung-hua mines during the period 1941-44 produced a total of 20,426 metric tons of fluorspar concentrates, principally 85 percent CaF_2. Fluorspar reserves at Lung-hua are given as 100,000 metric tons. Apparently, the Jehol product was all hand-sorted.

In Chekiang province, fluorspar deposits were initially developed during World War I and more extensively by the Japanese during the occupation. At least 16 deposits have been worked in the north, central, and coastal regions of this province. The fluorite forms irregular veins in rhyolite ranging in width from a few centimeters to more than 6 meters. A thickness of 2 or 3 meters is common, and the length is generally 100 meters. Some of the veins consist entirely of fluorite masses, whereas others are composed of frameworks of silica filled by fluorite crystals. The fluorite is generally suitable for the metallurgical-grade uses of fluorspar. Fluorspar reserves in Chekiang province amount to 400,000 metric tons. Fluorspar production during 1932-34 totalled 13,000 tons. The best material shipped appears to have averaged 90 to 95 percent CaF_2, and the lower grade material over 80 percent. 30/

Four producing centers are indicated in Chekiang province: Wu-hsing and Lin-an in the north, Hsiang-shan near the coast, and Chin-hua in the central part of the province. Chin-hua on the Chekiang-Kiangse railroad line appears to be the major center. The mining area extends northeast, east, and southeast of the town of Chin-hua and includes the important Wu-i mines lying east of Chin-hua.

Chinese press comment indicates plans for increased activity at Hsiang-shan and Chin-hua. In 1948 it was stated that "Plans are being made to extend the Hang-chou--Ning-po light railroad from Ning-po to Hsiang-shan, in order to develop these mines." 31/ In 1949 the Chinese planned to rebuild the light railroad from Wu-i mines to Chin-hua, which the Japanese had built in 1942 and torn down in 1945. 32/

4. North Korea.

In North Korea, fluorspar deposits are scattered across the peninsula, occurring in sedimentary rocks and at the contact zone of sedimentary and igneous rocks. The five principal mines are the Hasong and Ch'ongsok mines in Hwanghae-do (southwest province), the Chojon mine in P'yongan-namdo (west central province), the Changdong mine in Hamgyong-namdo (east coastal province), and the Mundung mine in Kangwon-do (southeast province). 33/

These mines, first opened in 1930 by the Japanese, reached a total average annual production of 20,000 metric tons during 1941-45. Based on reports for all Korea, the Korean fluorspar produced averaged from 50 to 60 percent CaF_2, and about one-third of total production during the period was at least 93 percent CaF_2. In 1949, 3,300 metric tons were delivered to the USSR, but during the recent period of military action these mines have probably been inoperative. Many of the small mines were apparently exhausted during the Japanese occupation.

The total ore reserve figure is not available, but on the basis of an estimate of 47,000 metric tons for the Mundung mine, 100,000 metric tons of total reserve would be reasonable. North Korea, however, is not generally considered to have any substantial reserve of fluorspar.

III. Consumption.

Consuming industries of the Soviet Bloc require much less total tonnage of fluorspar than the US because of the comparatively smaller production of steel and aluminum. Ceramic industries are important in certain Bloc countries. None of the new consuming industries has thus far used by US standards any great quantity of fluorspar singly, but total new consumption has increased the demand for acid-grade. A similar increased demand in the USSR is indicated by the reparations quotas of acid-grade fluorspar from East Germany.

It should be noted that above and beyond the metallurgical and ceramic industries, the primary consumer of fluorspar is necessarily the hydrofluoric acid industry.

1. Steel and Aluminum Industries.

The steel industries take metallurgical-grade fluorspar direct from mines or initial processing plants. The aluminum industries, on the other hand, use fluorspar in the form of synthetic cryolite derived from acid-grade fluorspar (see I 2c, above). The consumption of fluorspar by the steel and aluminum industries of the Soviet Bloc in 1950-51, calculated on the basis of ORR estimates of Bloc production and US consumption figures, is denoted in Table 4.*

* Table 4 follows on p. 17.

Table 4

Estimated Consumption of Fluorspar by Steel and Aluminum Industries in the Soviet Bloc a/
1950-51

Thousand Metric Tons

	1950		1951	
	Steel b/ Industry	Aluminum c/ Industry	Steel b/ Industry	Aluminum c/ Industry
USSR	77.2	17.0	86.6	20.0
Czechoslovakia	7.9		8.2	
East Germany	2.7	0.1	3.7	1.8
Hungary	2.3	1.3	2.4	1.8
Poland	6.8		7.0	
Rumania	0.8		0.8	
Total European Satellites	20.5	1.4	22.1	3.6
China	1.5		1.8	
Grand Total	99.2	18.4	110.5	23.6

a. Based on steel and aluminum production estimates by ORR.
b. Calculated on the basis of 3,039.1 metric tons of fluorspar per 1 million metric tons of steel, derived from the US average of 6 pounds per short ton (equivalent to 6.7 pounds per metric ton).
c. Calculated on the basis of 0.1 metric ton of fluorspar (the fluorspar content in cryolite and aluminum fluoride) per metric ton of aluminum metal, derived from US and USSR data.

Table 5, which follows, gives the main consuming centers in the Soviet Bloc of fluorspar in the steel and aluminum industries.

Table 5

Principal Fluorspar Consuming Centers of the Soviet Bloc

Country and Region	Steel	Aluminum
East Germany	Riesa, Unterwellenborn, Hennigsdorf	Bitterfeld, Lauta, Dohna a/
Czechoslovakia	Chomutov, Moravska-Ostrava	
Poland	Czestochowa, Katowice Sosnowiec	
Hungary	Salgotarjan, Diosgyor, Budapest	Felsogalla, Ajka
Rumania	Recita, Hunedoara, Bucharest	
USSR		
Northwest	Leningrad	Kandalaksha, Volkhov
Ukraine	Krivoy Rog, Dneprodzerzhinsk, Dnepropetrovsk, Makeyevka, Voroshilovsk, Voroshilovgrad, Stalino Zaporozh'ye	Zaporozh'ye
Lower Don-North Caucasus	Taganrog, Rostov	
Transcaucasus	Rustavi	Yerevan
Volga	Stalingrad	
Central European	Moscow	
Urals	Magnitogorsk, Chelyabinsk, Sverdlovsk, Nizhniy-Tagil, Serov, Orsk, Chusovoy, Zlatoust, Alapayevsk, Asha, Beloretsk, Kushva	Kamensk-Ural'skiy Krasnotur'insk (Bogoslov), Polevskoy a/
West Siberia	Stalinsk, Kemerovo	Stalinsk
Kazakh SSR	Karaganda	
Central Asia	Begovat	
East Siberia	Petrovsk-Zabaykal'skiy	
Far East	Komsomol'sk-na-Amure	
China (Liaoning Province)	Anshan b/	Fu-shun b/
North Korea	Kyomip'o, Ch'ongjin b/	Hungnam b/

a. This is not an aluminum center, but the cryolite produced here is consumed by the aluminum industry.
b. During the Japanese occupation.

2. Cryolite Plants.

In reference to the terms natural cryolite and synthetic cryolite, it is necessary to keep them in separate categories. Greenland is the only country in the world producing natural cryolite, which is marketed either direct or through Denmark, and as the US is the only other country importing direct from Greenland, the marketing of natural cryolite can be traced through Denmark's trade data. All other production of cryolite, East or West, is synthetic cryolite. The evaluation of cryolite plants operating in the USSR is derived mainly from prisoner-of-war reports.

Prewar synthetic cryolite installations in the present European Satellites, East Germany, Czechoslovakia, and Poland, as well as in the USSR, suffered either by dismantling of plants or by actual war damage. Postwar activity was directed mainly to the reconstruction and some new construction of synthetic cryolite plants. It is not certain that Czechoslovakia's or Poland's prewar plants are currently producing cryolite, but one plant in East Germany is definitely producing this material. Three important cryolite plants are operating in the USSR, with the possibility of smaller plants being under construction at various aluminum centers. The Japanese did not establish a synthetic cryolite industry in Far East Satellite areas during the war period.

In East Germany the fluorine works at Dohna is currently producing synthetic cryolite and other fluorides, with plans for eventual production of organic fluorine compounds. Plant capacity is from 48 to 60 tons of cryolite a day and from 48 to 60 tons of fluorine salts (fluorides) a day, which on an annual basis would amount to from 14,000 to 18,000 metric tons for each category. 34/

The Usti plant in Czechoslovakia produced synthetic cryolite before the war, but all recent data point to the production of other fluorides but not of cryolite.

In the USSR, synthetic cryolite plants are operated in the economic regions of Northwest USSR, Ukraine, and Urals at or near the aluminum centers. The Volkhov (Kirov) aluminum plant in Northwest USSR was rebuilt after the war, with a new installation for the manufacture of synthetic cryolite. 35/ Plant capacity should be adequate to supply the aluminum industry in this region. In the Ukraine the cryolite plant operated at Zaporozh'ye before the war was to be reconstructed by 1952. Prewar capacity at Zaporozh'ye was 7,500 metric tons annually. In the Urals the Polevskoy cryolite plant, also reconstructed after the war, supplies Urals industry and possibly other regions of the USSR. Plant capacity at Polevskoy should amount to at least 10,000 metric tons annually. In the Transcaucasus a cryolite plant may have recently been constructed to supply new local industry, but this has not been verified. No other cryolite installations at aluminum plants have been verified.

IV. Trade.

The trade position of Bloc fluorspar is reflected in the export trade of East Germany and China and in the import trade of Czechoslovakia, Hungary, Poland, and Rumania. The USSR, except for an occasional offer,* apparently has not entered the world market on its own account and has not offered any of its production to its European Satellite consumers. The USSR at the same time demands East Germany's acid-grade product.

East Germany has exported some metallurgical-grade fluorspar to the other European Satellites, which also depend on West Germany, the Benelux countries, France, and Italy for fluorspar and fluorides and on Denmark for natural cryolite. Trade with the West was to be definitely cut off at the end of 1951, leaving the Satellites entirely dependent on the Bloc supply of fluorspar. If the European Satellites are to be entirely supplied from East Germany, the USSR must decrease its reparations quotas of acid-grade fluorspar.

Trade items related to the fluorspar industry are the raw materials — fluorspar, fluorite, fluorite dust, and natural cryolite — and the manufactured materials -- synthetic cryolite, hydrofluoric acid, aluminum fluoride, sodium fluoride, ammonium fluoride, fluorine salts (fluorides), metallic fluorides, and fluorine compounds.**

1. Exports.

The exporting countries of the Soviet Bloc are mainly East Germany and China. Czechoslovakia exports a small quantity of hydrofluoric acid and fluorides to Hungary and Poland. Both China and North Korea exported fluorspar to Japan during World War II.

East Germany's acid-grade material and manufactures have been delivered mainly to the USSR as reparations. The reparations quota for 1948 was itemized as 16,000 metric tons of fluorspar powder, as well as synthetic cryolite and fluorides at the rate of 375 tons each per quarter. 37/ The quota for 1951 is stated in terms of 4,300 metric tons of "fluorine compounds," with 100 tons of this amount allotted to Poland and 10 tons to Czechoslovakia 38/ and the stipulation added "that fluorine compounds are not to be offered for sale to West Germany." 39/

* In June 1951 a boat-load of synthetic cryolite of Soviet manufacture was offered to a US broker operating in Mexico City. 36/

** The term fluorine compounds may refer either to the inorganic fluorides or to organic compounds.

After the reparations quota is met, the exportable surplus of acid-grade material is shipped to the Satellites or is offered on the Western market. Complete trade data are not available. During 1950, East German cryolite appeared in export trade to Hungary and Czechoslovakia. In April 1951, 280 metric tons of East German cryolite were shipped to China. 40/ In May 1951, three Hungarian freight cars were loaded with cryolite for shipment to Hungary, 41/ and later shipments during 1951 averaged about 100 metric tons a month. In May 1951, 200 metric tons of fluorides were shipped to Switzerland, and the same amount of fluorides was shipped to Austria. US companies report that Norwegian companies offered 3,000 metric tons of acid-grade fluorspar in 1950 and 6,000 metric tons in 1951. This fluorspar was of East German origin. Also in 1950 an East German company offered 100 tons of synthetic cryolite of East German origin.

East Germany's metallurgical-grade fluorspar is not required for reparations. The exportable surplus of this material has been shipped to European Satellites in amounts varying from a few hundred tons to Rumania to 6,000 metric tons to Poland. Planned export to Poland in 1951 was 9,000 metric tons. In reference to fluorspar, Poland has been favored in trade agreements over Czechoslovakia.

Chinese fluorspar was offered to Japan in 1950, 42/ and in 1951, exports of fluorspar were reclassified by the Soviets as "specially permitted exports of Barter Export Schedule B." 43/ China, during the period 1941-44, exported an average of 26,300 metric tons of fluorspar annually to Japan and an average of 18,950 tons to North Korea. This material was graded at approximately 93 percent CaF_2.

2. Imports.

The only known import of fluorspar by the USSR is that of East Germany's acid-grade mentioned previously. China has recently appeared in the import trade picture with spot shipments of cryolite. Czechoslovakia imports fluorspar for its steel and ceramic industries and for the manufacture of hydrofluoric acid and fluorides. Czechoslovakia has imported about 3,000 metric tons annually of metallurgical-grade fluorspar from East Germany. Additional requirements were probably met by imports from Western European countries. In 1948 the USSR promised to arrange for the delivery to Czechoslovakia of 2,000 metric tons of fluorspar, which apparently was to be supplied from West Germany and Italy. 44/ Czechoslovakia, by agreement with Denmark (1949-50), was to have imported 200 metric tons of sodium fluoride and in 1951 was allotted 10 tons of "fluorine compounds" from East Germany. In August 1951, Czechoslovakia imported 40 metric tons of synthetic cryolite from East Germany, but regulár import from this source has not yet been established. Czechoslovakia has imported natural cryolite from Denmark at an annual average rate of more than 400 metric tons.

Poland's situation is similar to that of Czechoslovakia in that it imports fluorspar for the steel industry and, to a lesser extent, for the ceramics industry. Under present trade conditions, Poland is more likely to benefit from Soviet distribution of fluorspar than the other Satellites.

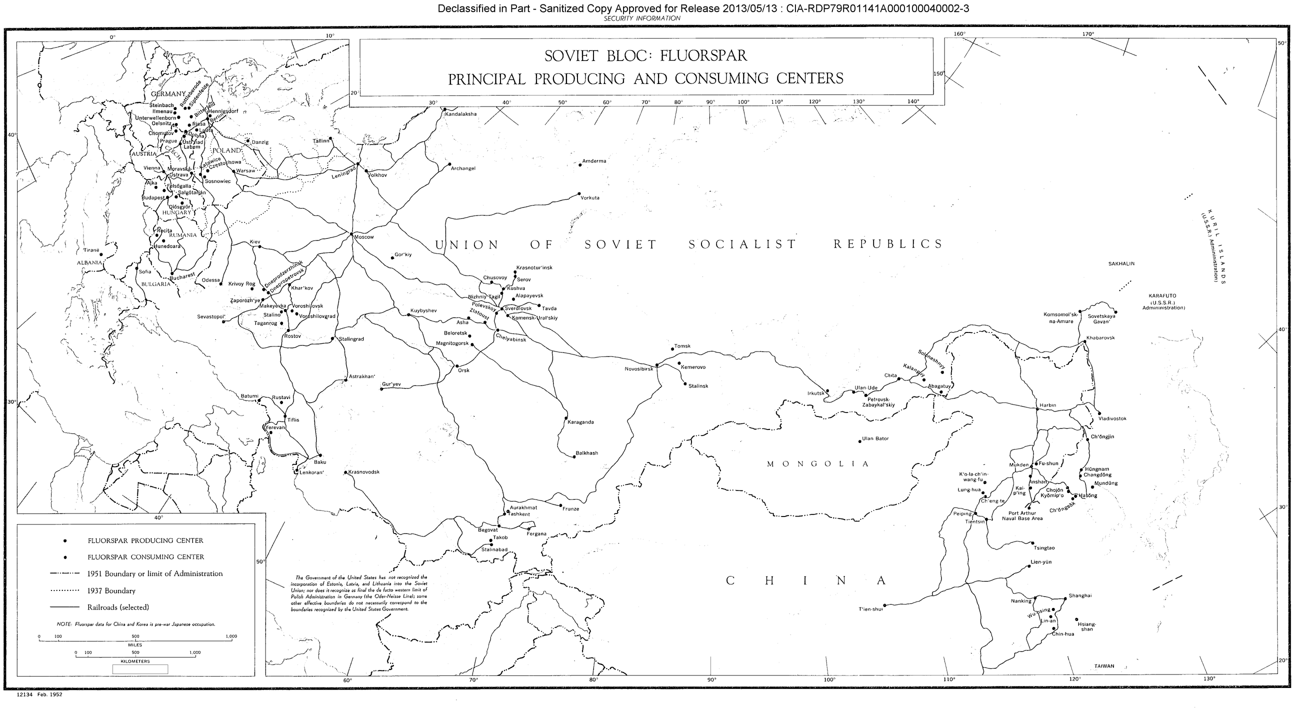
Hungary imports metallurgical-grade fluorspar for its steel industry and cryolite for its aluminum industry. Under the trade agreement with West Germany for 1948-49, Hungary was to import 1,000 metric tons of fluorspar, probably of metallurgical grade. Imports of natural cryolite from Denmark amounted to 1,055 metric tons in 1948 and 2,399 tons in 1949. Danish shipments probably continued through 1951. In 1950, some imports of synthetic cryolite from East Germany also appeared in trade data. In May 1951, Hungary received three carloads of cryolite from East Germany, and later shipments during 1951 averaged about 100 metric tons a month.

Rumania imports a few hundred tons of metallurgical-grade fluorspar annually for its steel industry. The import allotment from East Germany in 1949 was 500 metric tons.

China, in 1949, imported 528 metric tons of natural cryolite from Denmark, and in April 1951 imported 280 tons of synthetic cryolite from East Germany.

V. Strategic Position.

The Soviet Bloc supply of fluorspar is adequate for present Soviet requirements, but it is not certain whether Satellite needs can be met from Bloc sources. It is believed that the USSR has developed an increased demand for acid-grade fluorspar used in preparation of hydrofluoric acid, which is the key material to military as well as to new industrial uses of fluorspar. Any limitations to the industry, therefore, would probably be in fluorspar processing capacity and in the capabilities of hydrofluoric acid plants.



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APPENDIX B

METHODOLOGY

In appraising the country situations of the Soviet Bloc it was necessary to give the widest margin of estimates to the USSR. Soviet data, except for occasional press items, have not been published since the prewar period, whereas later data have been reported for the Satellite countries. In particular, estimates of fluorspar production in the USSR for later periods are controversial. The following methodology was employed for estimating production rates for fluorspar in the USSR.

Beginning with an established figure of 65,000 metric tons in 1936, the annual rate of increase for the period 1936-40 is assumed to be 5,000 tons. Although the rate of increase for 1933-36 was higher, varying from 8,000 to 22,000 tons, this rate probably could not be maintained. In some mining areas the hand-sorted material was soon exhausted, and adequate processing facilities were not yet in operation. Therefore, the increase rate of 5,000 tons is considered more reasonable for this period. An additional check was made with non-Soviet estimates for 1940 production, which range from 70,000 to 90,000 tons. Note that by using the 5,000-ton figure, the production in 1940 would amount to 85,000 metric tons.

The average annual rate of production was lowered to 50,000 metric tons during the war period (1941-45) because it is believed that since the Soviet steel industry was greatly damaged and its aluminum industry not yet strongly established, 50,000 tons would be a liberal estimate for this period.

For the Fourth Five Year Plan period (1946-50), if the figure of 50,000 metric tons is accepted for 1946 and if prewar Soviet plans for processing facilities were carried out as claimed by the Soviet press, the total maximum plant capacity should have approximated 120,000 metric tons by 1950, and, allowing a minimum production of 30,000 tons by hand-sorting, the total production should have amounted to 150,000 metric tons by 1950. This would be equivalent to an average increase rate of 25,000 metric tons during the period.

Regional distribution of the important fluorspar mines is considered as fairly well established by prewar data together with the trend of recent reports. Distribution of consuming centers, primarily steel and aluminum, was supplied by mineral specialists of ORR. Consumption estimates of fluorspar by the steel and aluminum industries, calculated the same for all Bloc countries, are primarily based on the average US figures.

Inter-Bloc and East-West trade data are sufficiently comprehensive to reach certain conclusions in regard to the Soviet supply of fluorspar. The important conclusion reached, that the USSR's demand for acid-grade fluorspar is increasing, is shown in Soviet reparations requirements from East Germany for stepped-up production of acid-grade material.

Detailed methodology for many of the production and consumption figures will be found in the footnotes to the tables in the text.

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