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INTELLIGENCE RELATING TO THE USE OF BORON SUBSTANCES AS FUELS

I. Summary

The potentialities for high-energy yield render boron substances extremely useful in the development of fuels for aircraft, missiles, and other specialized weapons. US armed forces currently use boron powder in slurry fuels for aircraft. In addition, research and development of boron hydride fuels for aircraft has progressed to the pilot-plant stage; application is dependent, in large part, on completion of engine development. Boron propellants are also used in rockets and in other special weapons. Within the next five to six years the annual military requirements for boron raw materials in scheduled aircraft and missile programs are expected to exceed the current US output of 800,000 tons, with a content of about 250,000 tons of boric oxide.

25X6A [redacted] the USSR also are believed to be conducting boron fuel research programs. Technical know-how regarding the manufacture and application of boron substances in fuels may be as far advanced in the USSR as in the US or any other free world country. But whether or not the Soviet Bloc is using boron fuels in actual jet aircraft or missile operations is not known. Nor can the adequacy of bloc supplies for such a program be determined at this time.

II. Technical Background Related to Fuel Use of Boron Substances

The importance of boron and boron compounds in the development of fuels lies primarily in their value as high-energy substances. The added energy provided by use of boron powder in slurry fuels, and the even greater energy produced by liquid boron fuels, are translated directly into greater thrust and increased range. For example, boron hydride, upon oxidation, releases 50% more energy than a similar weight of hydrocarbon fuel. To obtain this 50% additional energy, military engineers estimate a cost of 150 times that of conventional fuels would be justified.

Other advantages of various boron substances as compared with alternative materials include properties such as:

(a) The wide range of temperatures at which they remain liquid;

(b) Their ability to render hydrocarbons spontaneously inflammable in air and to increase flame speed, both of which lessen the possibility of failure of a propellant resulting from flame blow-out;

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(c) Their reaction to water which makes possible an increase in speed of water-borne vehicles, such as torpedoes; and

(d) Their performance as gas-generating reagents to pressurize fuel tanks.

Some difficulties encountered in the development of certain boron substances include problems such as the newness and complexity of this special field of chemistry, a high level of toxicity, and undesirable deposits on turbine blades. However, through revisions of engine design, changes in the chemical formulas of the boron compounds, and in other ways, the directors of US research and development programs believe that none of these problems will long remain insurmountable.

III. Plans and Programs for Use of Boron Substances in Fuels

A. Developments in the United States

The US Defense Department is continuing a comprehensive program to enlarge the scope of practical uses for boron substances as fuel. At the present time, the largest US consumption of boron raw materials for fuel is in making boron powder for slurry fuels for jet aircraft. In addition, research and development of boron hydride fuels for jet aircraft has progressed to the pilot-plant stage though actual use will have to await development of jet engines that can efficiently employ the fuels.

Some boron compounds are now used in rocket propellants. Recent research has shown that at least two boron compounds in low concentrations will provide satisfactory properties and at the same time will maintain and even exceed the hydrazine rocket performance.

Many other uses of boron and boron compounds in missiles and other special weapons are being considered or developed at this time in the United States. Experiments have utilized boron substances as a ramjet fuel additive, water reactive fuel for torpedoes, and gas-generating reagents to pressurize fuel tanks. For example, one ramjet test model using a slurry fuel reached the extremely high speed of more than 2,500 miles per hour.

Within the next five or six years the annual consumption of borax and other boron raw materials in scheduled US aircraft and missile programs is expected to exceed the current output of 800,00 metric tons, having approximately 250,000 metric tons of boric oxide content. It is believed that the United States can double its 1954 borax output so that supplies will be available for general industrial consumption as well as for military requirements.

B. Other Free World Activity

The countries which are most likely to engage in boron research are those capable of conducting lengthy and complex chemical investigations. [redacted] Very little information is available on boron research in other free world countries. 25X6A

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C. Soviet Developments

Technical know-how regarding manufacture and application of boron substances in fuels may be as far advanced in the USSR as in the US or any other free world country. Russian chemists and engineers are believed now to be engaged in boron fuel research and development. This conclusion is based not only on reports of returning German scientists but also on recent technical literature published in the USSR. Intelligence is not available to indicate that the Soviets have started to use boron fuels in actual aircraft or missile operations, nor is there any assurance that they are not doing so. 1/

IV. Soviet Bloc Boron Position

A. Deposits and Production in the Sino-Soviet Bloc

Borax is the chief source of boron known to be currently exploited in the Sino-Soviet Bloc. Principal borax deposits are located in the USSR, although there are known to be some in Communist China.

1/ It is known that the USSR has used magnesium powder in a slurry fuel for jet aircraft during the Korean War. This involves a technology comparable in advancement to that used in the development of boron slurry fuels. Magnesium cannot be substituted for boron in liquid fuels, however, US chemists believe.

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Reserves of unmined borax available in the USSR in 1938 are shown in the attached table (See Annex). They show a total ore availability in geologically explored reserves of about 2,000,000 metric tons, having a boric oxide (B_2O_3) content of approximately 150,000 tons. If inferred or geologically investigated reserves are also included, the total becomes about 7,500,000 metric tons, having a boric oxide content of about 630,000 tons.

About 22,000 tons of borax, containing about 8,000 tons of boric oxide, is reported to have been mined in 1938. 2/ If, since that time, it is assumed that output in terms of boric oxide content has varied approximately with Gross National Product, the total depletion of the 1938 reserves would have been about 170,000 metric tons of boric oxide. This presumes a current annual output of perhaps 35,000 to 40,000 tons of borax minerals, containing 10,000 to 15,000 tons of boric oxide. However, since there is no recent information on the quantities of borax mined in the USSR, actual recovery of boric oxide may have been greatly different from the possibility here presented.

The major deposits of the USSR are in the vicinity of Inder Lake at Inderborskiy (48°31' N - 51°47' E) and at many points along the north shore of the Caspian Sea. Good highway and railway transportation is available from these deposits. Other deposits are located in the Mineralnovod-Cheskiy Rayon in the North Caucasus and the Azov-Black Sea area. Although of lower grade, these deposits are being worked, and are also favorably situated for transportation facilities.

As in the United States, the mining of borax in the USSR consists of open pit or surface operations. Recovery of the borax from its ore is a simple matter of dissolving in water and recrystallizing refined borax. Equipment for mining and processing is simple and inexpensive. A very large expansion of capacity could be accomplished easily and quickly without any bottlenecks or limitations due to technological difficulties or shortage of special equipment.

Definite information on usable Chinese reserves of borax are not available. Very high-grade deposits in Tibet are believed to be too inaccessible for practical exploitation. Several recent reports

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2/ Demitri B. Shimkin, Minerals - A Key to Soviet Power (Cambridge, Mass., 1953), p. 253.

indicate some recovery of borax from long-established salt brine wells[3] and the beginning of construction on a borax plant at Tsu-Kung, Szechwan Province.[4] Transportation facilities linking these latter areas with other parts of China appear to be adequate.

B. Imports from the Free World

Preliminary estimates indicate that Sino-Soviet Bloc imports of borax and related products from the free world totalled at least 15,000 metric tons in 1954. Virtually all of these shipments have gone to the European satellites and Communist China. Imports appear to have been greater in 1954 than in any other recent year.[5] Current intelligence includes many references to possible diversion of US-origin borax. Also, Turkey is exporting significant portions of its boracite production to the Satellites. It is possible that 1955 shipments to the Bloc of products containing boron may be considerably larger than those made in 1954.

C. Adequacy of Supplies

Little is known of the general industrial or military requirements for boron substances in the Soviet Bloc. It is therefore difficult to make any observation as to the adequacy of supplies of boron raw materials in the Sino-Soviet Bloc. Intelligence information does indicate that in 1954 East German imports were 1,000 tons less than the volume that was reportedly required and planned. At the end of November 1,000 tons were released from "State Reserves." As of 11 January 1955, only 30 tons of this had been returned to the Reserves. Subsequent reports indicate that borax continues to be a chief bottleneck in supplies for the East German chemical industry.

FOIAb3b1 [redacted]

5/ "Implementation of PD 810 with Respect to Borax, US MESL Item 3715, Code Q(P)-4A," JOC Document No. 118 (23 May 1955), p. 1 and attachment, p. 3, Secret, and "Recommendation for the Transfer to List I of Borates, I/L 3715," JOC Document No. 137, (5 August 1955,) pp. 7-8, Confidential.

ANNEX I

USSR RESERVES OF UNMINED BORAX ORE

(1938 estimate) a/

NATURE OF RESERVES	ORE TONNAGE (In thousands of metric tons)	
Explored Ores		
Thoroughly Explored b/		
Good grade (25-35% B_2O_3)	264	
Low grade (3-9% B_2O_3)	1,417	
Total		1,681
Geologically Explored c/		
Good grade (25-35% B_2O_3)	342	
Low grade (3-9% B_2O_3)	112	
Total		454
Total Explored Ores		2,135
Geologically Investigated Ores d/		
Good grade (25-35% B_2O_3)	138	
Low grade (3-9% B_2O_3)	5,245	
Total		5,383
Total Explored and Investigated Ores		7,518

a/ Source: Geologicheskaya Isuchennost i Mineralno-Syrevaya Baza SSSR k XVIII ... Seyezdy VKP (b) /Geological Study of Mineral Raw Material Sources of the USSR for the XVIII Congress of the VPK (b)/ Moscow-Leningrad 1939.
b/ Reserves explored ready for mining.
c/ Reserves geologically explored and defined by tests, with preliminary examinations computed.
d/ Reserves established on the basis of naturally or artifically induced appearance of the material on the surface.