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The Soviet Titanium Industry and Its Role in the Military Buildup

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A Research Paper

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Analysis. Comments and queries are welcome and
may be directed to Chief, Soviet Economy Division,
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Summary

Information available as of 1 March 1985 was used in this report.

Moscow has created the world's largest titanium metal industry, primarily to support defense industries that produce advanced aircraft, missiles, and submarines. We estimate that the USSR produced approximately 71,000 tons of titanium metal in 1984, roughly 70 percent of global output and more than five times as much as the United States. Titanium production grew rapidly during the industry's early years, averaging growth of more than 20 percent per year during 1960-70 and about 7 percent per year in 1971-75. Production growth slowed markedly during 1976-80 to an average of about 3½ percent per year and during 1981-84 to an estimated 1 percent annually.

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The USSR is the only country to use titanium extensively in the construction of submarines. We believe the Soviets have built at least nine, and possibly 10, such ships to date, and several more are under construction. A submarine with a titanium hull has several potential military advantages, including the ability to dive to greater depths and a low magnetic signature. Titanium alloys are also used in airframes and engines of aircraft and missiles in which their high strength-to-weight ratio and ability to resist heat and corrosion are important design factors.

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The key role of the titanium industry in supplying the defense industries is demonstrated by the unusually high degree of control these industries apparently have over titanium consumption. Nonmilitary use of rolled titanium products is approved by an arm of the Ministry of the Aviation Industry. Even Gosplan, the State Planning Committee, cannot overrule the allocation decisions. The Ministry of the Aviation Industry is in a good position to monitor titanium use because it probably controls most Soviet titanium rolling mills.

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A rise in military consumption may have led to strains in titanium supplies in the middle and late 1970s. Since 1975 the USSR has sharply reduced titanium sponge metal exports. The reduction was particularly sharp in 1979, reportedly because of increased demand by Soviet shipyards. Although production grew little during 1981-84, a further reduction in exports and increased recycling of titanium scrap probably made more titanium available for domestic consumption. More of the metal may also have been made available from government stockpiles.

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We believe the USSR has sufficient accessible reserves of titanium-bearing ore to enable the titanium industry to be self-sufficient for many years. From the beginning of the industry, the Soviets placed a high priority on raw material self-sufficiency, choosing to develop and use abundant domestic deposits of low-grade ilmenite ore rather than depend on foreign sources of higher grade rutile ore. During 1979-84, however, the USSR imported large amounts of titanium ore from Australia. There is evidence that some of the ore was used to make up for domestic shortages caused by delays in opening a new ore deposit. The magnitude of the imports, however, suggests that Moscow could be increasing its stockpile—which in turn could signal plans to boost titanium metal production.

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We project little or no growth in titanium production until at least the late 1980s. new construction and a large open area at Ust'-Kamenogorsk that indicate this plant's capacity could eventually be doubled. This analysis and the large imports of ore suggest that by 1990 Soviet titanium metal production could increase to as much as 95,000 tons, about one-third more than its current level. An increase of this magnitude would suggest growing military demand for titanium.

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During the 1990s, increasing scrap recycling and advances in manufacturing technology could increase the supply of titanium without additional new production capacity. By the end of the century, advances in titanium substitutes such as composite materials could begin to hold down growth in titanium use.

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Meanwhile, increasing domestic requirements for ilmenite will likely continue to outstrip domestic ore production, causing the USSR to maintain imports of Western ore. The titanium metal industry probably will receive adequate supplies of ore because of the high priority accorded military applications. Sudden increases in demand could easily be met by reallocating ore from civilian uses or by drawing down government stockpiles.

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Introduction

Spurred primarily by increasing military demand, the USSR has become the world's largest producer of titanium. In both 1983 and 1984, we estimate the Soviets produced approximately 71,000 tons of titanium sponge metal, roughly 70 percent of the global output and more than five times as much as the United States (table 1). A lightweight metal with desirable physical properties, titanium is vital to the production of many types of Soviet weapon systems and has important applications in civilian industry.[1] This paper presents an overview of the USSR's titanium industry. It reviews production trends over the past 30 years and the industry's role as a supplier to the defense industries. Civilian use, trade, raw material supply, and the outlook for the industry are also discussed.

Table 1
Major Producers of Titanium Sponge Metal [a]

Thousand metric tons

	1960	1965	1970	1975	1980	1983
USSR	6	23	40	57	68	71
United States	5	8	14	14	20	13 [b]
Japan	2	5	9	8	19	11 [b]
United Kingdom [c]	0	0	1	1	1	2
China [c]	0	0	0	0	1	1

[a] Titanium sponge metal is pure, porous titanium metal produced from vacuum distillation.
[b] US and Japanese production declined between 1980 and 1983 because of the dropoff in demand from the aerospace industry.
[c] Estimated.

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The Early Industry

During the mid-1950s Moscow foresaw the military importance of titanium and made plans for its extensive use in aircraft, missiles, and submarines. Production capacity and technology were still in their infancy, however. In 1956, production was only 1,000 tons—less than one-third the amount eventually required for the first titanium-hulled submarine. Moreover, Soviet production methods could not yet meet the high metallurgical standards necessary for critical military applications. The USSR also lacked the design and fabrication technology necessary to build weapons with titanium. This would become especially critical in submarine construction because of the extreme difficulty in welding thick titanium plates into pressure hulls.

During the late 1950s and 1960s, the USSR strove to build the production capacity and develop the technology necessary for military applications. Three combination titanium-magnesium plants began production: at Zaporozh'ye in 1956, at Berezniki in 1964, and at Ust'-Kamenogorsk in 1965 (figure 1). By the early 1960s titanium had been used in several models of military aircraft, and in 1968 the Soviets launched the world's first titanium-hulled combatant submarine.

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Recent Production Trends

We estimate the annual output of titanium in the USSR grew from approximately 40,000 tons in 1970 to about 71,000 tons in 1984. Annual production growth averaged about 7 percent during 1971-75, but slowed markedly during 1976-80 to an average of

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[1] Titanium (chemical symbol Ti) is the ninth most abundant chemical element in the Earth's crust. The principal titanium minerals are rutile (TiO_2), ilmenite ($FeTiO_3$), and sphene or titanite ($CaTiSiO_5$). Pure titanium is a lustrous white metal that burns in air. It is noted for its high strength relative to its weight and its ability to resist corrosion and extreme temperatures. Titanium is as strong as steel but 45 percent lighter. Although 60 percent heavier than aluminum, it is twice as strong

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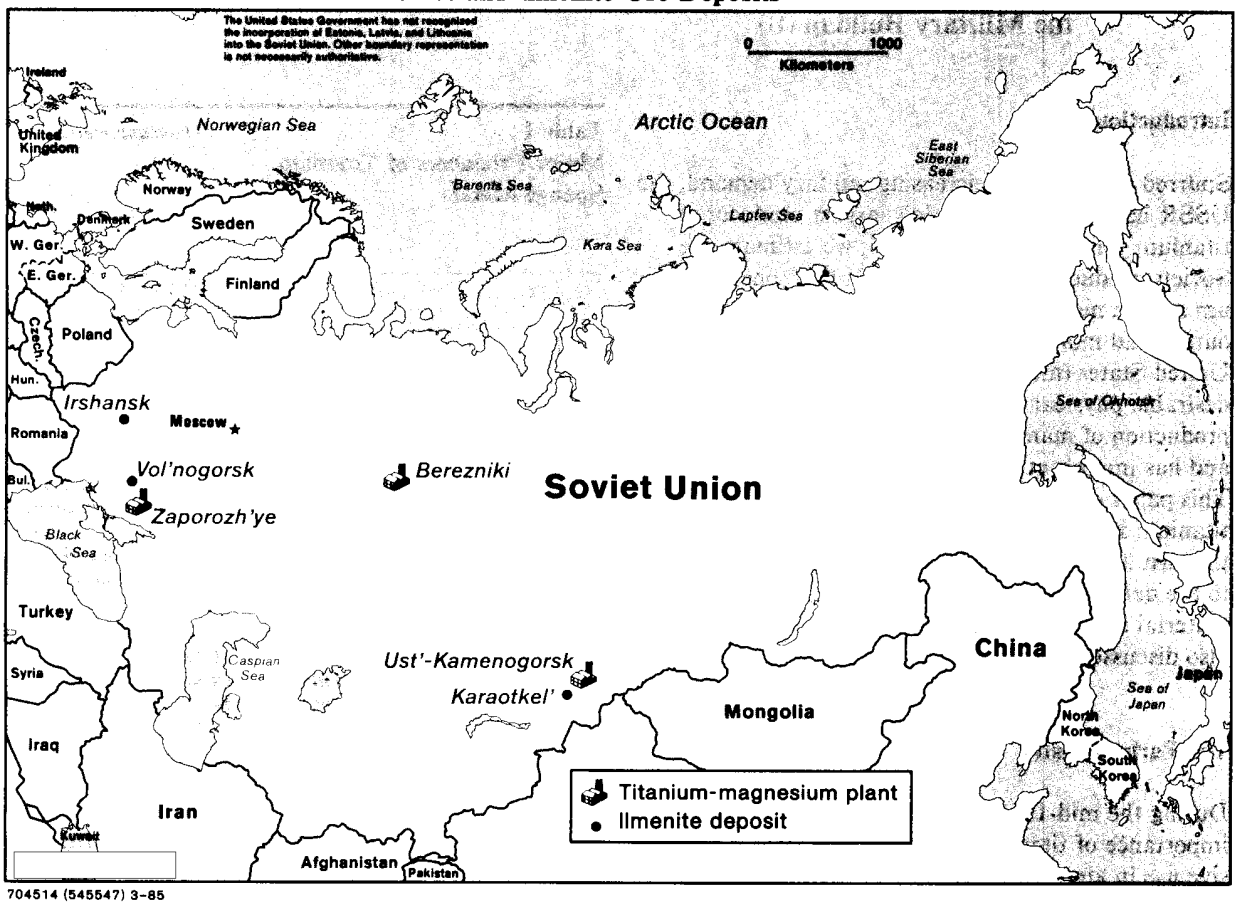
Figure 1
Titanium Metal Production Combines and Ilmenite Ore Deposits



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about 3½ percent and during 1981-84 to about 1 percent.[2] Although growth in output has slowed, the Soviets appear to be self-sufficient. The press has not reported any serious domestic shortages of titanium metal, and the USSR exports a small amount to the West.

The slow production growth in recent years may have been planned. The USSR did not announce a planned percentage increase for titanium production for the 11th Five-Year Plan (1981-85), the first time this has occurred in any plan period since the early 1960s.

This suggests that the targeted growth was relatively small.[3] It is also possible that, because of the renewed military importance of titanium, the USSR stopped announcing planned increases in output.

Although no national titanium production increase was published, a Soviet journal stated that output at the Ust'-Kamenogorsk plant was slated for a 27.1-percent increase between 1981 and 1985.

[3] Since 1965, the USSR has announced planned increases in the production of a nonferrous metal only when the percentage increase is relatively high. For the 1981-85 period, the USSR announced production increases for aluminum (15 to 20 percent), copper (20 to 25 percent), and nickel and cobalt (not less than 30 percent).

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Soviet open literature suggest the Berezniki and Zaporozh'ye plants were slated for little or no increase. Because the Ust'-Kamenogorsk plant accounts for roughly one-third of total capacity, we believe the Soviets plan for total titanium production to grow approximately 10 percent, to about 75,000 tons, in 1985.

Military Use of Titanium

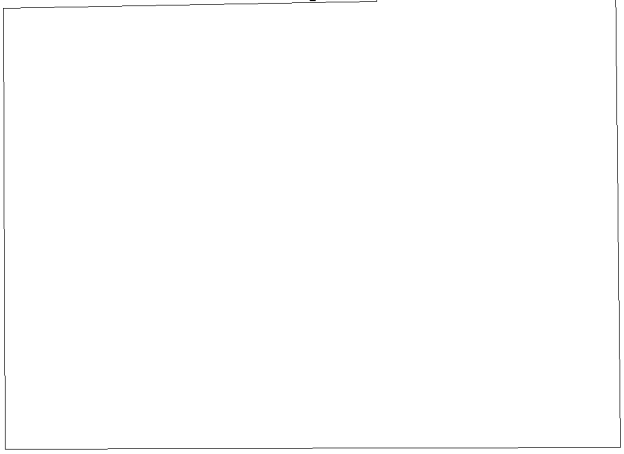
The defense industries are the largest single consumer of titanium metal in the USSR. Primary uses are in aircraft, submarines, and missiles, with secondary uses in spacecraft, surface ships, armored vehicles, and body armor. Titanium alloys are used in airframes and engines in which their high strength-to-weight ratio and ability to resist heat and corrosion are critical design factors. To ensure an uninterrupted supply to key defense industries, the USSR probably maintains a large strategic stockpile of titanium metal.[4]

The USSR is the only country to use titanium extensively in submarine construction. We believe the Soviets have built at least nine, and possibly 10, such ships to date, and several more are under construction. A submarine with a titanium pressure hull can dive to greater depths than one with a steel pressure hull of the same weight. If carefully designed and equipped to minimize the effects of ferromagnetic material within the hull, such a vessel would also have a very low magnetic signature, offering a measure of protection from magnetically actuated antisubmarine warfare systems. Despite the military advantages of using titanium in submarines, the expense has limited its use in US submarines. Titanium is about 30 times costlier than steel, but the bulk of the higher cost of titanium submarines is embodied in the metalworking and assembly of titanium parts; the cost of unworked titanium metal is only a small part of the total.

[4] There is evidence of a stockpile, but we do not know its size. Because of the military importance of titanium, we believe the stockpile is large and that additions to it could account for a large share of annual output. The USSR has apparently been increasing its stocks of numerous strategic materials recently. In 1980, the Soviet press reported that the State Planning Committee (Gosplan) and the State Committee for Material and Technical Supply (Gossnab) issued an unpublished decree ordering enterprises to sharply increase transfers of several types of materials—including nonferrous metals—to reserve stockpiles during the 1981-85 plan period.

Besides their use in aircraft and submarines, titanium alloys are used extensively in the production of some types of missiles. For example, the airframe of the SA-10, a high-speed, surface-to-air missile first produced in the late 1970s, is made extensively of titanium.

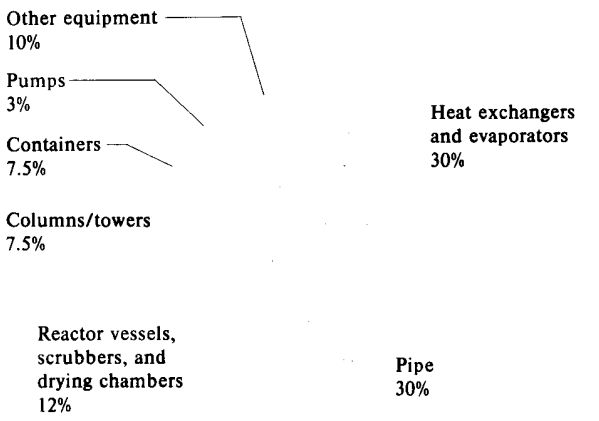
An indication of the key role of the titanium industry in supplying the defense industries is the unusually high degree of control these industries apparently have over titanium consumption.



Civilian Applications

The Soviets claim that titanium metal products are used in nearly every sector of civilian industry. We believe that civilian consumption, however, is considerably less than military consumption and is heavily concentrated in the aircraft and chemical industries. The use of titanium alloys in the airframes and engines of civilian aircraft probably began during the 1960s. In the chemical industry, the widespread use of titanium products began during the early 1970s (see figure 2).

Figure 2
USSR: Titanium Metal Products Used in the Chemical Industry



Source: Kornilov, I. I., *Titan dlya narodnogo khozyaystvo*, Moscow, Nauka, 1976, p. 24.

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Soviet open sources assert that, although the price of intermediate and finished titanium products used in the chemical industry is higher than that of products made from other metals (particularly stainless steel), the use of titanium results in a net economic gain because it lasts much longer and requires less maintenance. Its use in the chemical industry has grown rapidly—reportedly increasing eightfold between 1969 and 1973. Open literature, nonetheless, indicates that corrosion-resistant equipment is still in short supply in the industry. The use of titanium products in this and other civilian industries was undoubtedly boosted by the development of similar types of products for the military sector. For example, technology to produce titanium pumps, tubes, and pipes was probably developed during the 1960s for the titanium submarine program and passed to the civilian sector.

Declining Exports

Until the mid-1970s, Soviet production of titanium sponge exceeded domestic requirements, leaving a large exportable surplus.[6] The United States and West Germany were the USSR's leading customers (table 2). Exports of titanium sponge and scrap rose from several hundred tons per year in the mid-1960s to a peak of 7,700 tons in 1974—about 15 percent of estimated sponge production. The Soviets offered large amounts of high-quality titanium, generally at prices below prevailing market prices.

From 1975 through the first half of 1984, domestic requirements appear to have risen faster than production, forcing a sharp cutback in exports the Western press indicate the decline in sales was particularly severe in 1979

the main reason for the cutback in exports was heavy demand by Soviet shipyards for titanium mill products.

[7] Since 1982, reduced world titanium demand also may have contributed to lower Soviet exports.

Table 2
USSR: Titanium Metal Exports, 1970-83 [a]

Thousand metric tons

	1970	1975	1980	1981	1982	1983
Total	**4.3**	**5.2**	**3.5**	**1.5**	**1.2**	**1.0**
United States	0.9	1.5	1.5	0.5	0.3	0.2
Sponge	NA	1.2	0.2	0.1	0.1	0.2
Scrap and waste	NA	0.3	1.3	0.4	0.2	0
West Germany	1.4	2.6	0.8	0.7	0.8	0.7
Other	2.0	1.1	1.2	0.3	0.1	0.1

[a] Totals shown are probably understated because some countries do not report titanium imports by country of origin. Separate trade categories for sponge and for scrap and waste are only available for the United States for 1975-83; other countries aggregate these categories in their trade statistics. Soviet wrought (worked) titanium exports are negligible.

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Civilian consumption also rose during the 1970s and may have contributed to the reduction in exports. In early 1979 the USSR would not be able to export titanium during the remainder of 1979 and 1980 because of unspecified domestic demands. Also, in late 1979 Soviet demand for titanium was greater than capacity and that some segments of Soviet industry would face shortages.

Further reductions in exports and increased scrap recycling made more titanium available for domestic consumption in 1981-83. (It is also possible that more titanium was made available from the Soviet stockpile.) In 1983 only about 1,000 tons were exported.

Titanium exports have been a small and declining source of hard currency revenue for Moscow. We estimate that titanium sales in 1983 earned the Soviets only about $5 million, a negligible share of total hard currency earnings.

Raw Material Supply

Soviet writings indicate the USSR has sufficient accessible reserves of titanium-bearing ore to enable the titanium industry to remain self-sufficient for many years. We agree with this assessment. The US Bureau of Mines estimates there are about 70 million tons of titanium-bearing ore reserves in the USSR. These reserves are believed to contain more than 5 million tons of recoverable titanium—roughly a 75-year supply at the 1984 production level. From the beginning of the industry, Soviet planners have placed a high priority on raw material self-sufficiency, choosing to develop and use abundant domestic reserves of ilmenite rather than depend on foreign sources of higher grade rutile ore.

Ilmenite is mined and concentrated at two locations in the Ukraine—north of Irshansk in the Zhitomirskaya Oblast' and near Vol'nogorsk in the Dnepropetrovskaya Oblast' (see figure 1). Dredges, probably equipped with facilities for concentrating the ore, are used to recover ilmenite from alluvial sands at Irshansk, where the ilmenite concentrate reportedly contains 48.7 percent titanium dioxide. At Vol'nogorsk, ilmenite as well as zircon are excavated from an open pit at another large alluvial sand deposit. The ilmenite is processed at a nearby ore concentration plant. The Soviets claim that a third ilmenite deposit, at Karaotkel' in eastern Kazakhstan, will be able to supply the Ust'-Kamenogorsk titanium plant at an expanded rate of production for a century.

During 1979-82, despite apparent self-sufficiency in raw material, the USSR imported sizable quantities of ilmenite and rutile from Australia, the world's largest producer of titanium-bearing ore (see table 3). These imports contained enough titanium to have supplied the Soviet titanium industry with roughly 30 percent of its requirements in 1979, 100 percent in 1980, 40 percent in 1981, and 35 percent in 1982. large imports continued in 1983 and 1984. the Soviet press indicate that part of the imports was used by the titanium dioxide pigment industry—probably the largest single consumer of titanium ore.[8] the USSR claimed in 1983 that the imported ore was needed for the paint industry. The Soviet press reported a shortage of titanium pigment in the same year.

Although there is a lack of evidence as to why the Soviets turned to foreign sources for a large share of their domestic needs, one of two reasons seems to explain the large purchases during this period. A tight supply of ore for the titanium metal industry may

[8] Titanium dioxide pigment is used in the manufacture of paints, plastics, paper coatings, and other products.

Table 3 *Thousand metric tons*
USSR: Titanium Ore Imports From Australia, 1979-82 [a]

	Ilmenite Concentrate	Rutile Concentrate	Estimated Recoverable Titanium Metal
1979	67.3	NA	20.4
1980	186.4	26.1 [b]	69.8
1981	84.5	5.0 [c]	28.2
1982	79.6 [d]	0	24.1

[a] Australian trade statistics show no titanium ore exports to the USSR during 1974-78. Most other titanium ore-producing countries do not report exports, but we believe such exports are very small. Official Australian trade statistics are not yet available for 1983-84.

[b] July 1979 to June 1980.
[c] July 1980 to June 1981.
[d] Preliminary.

have triggered these imports. During the early 1980s, the Soviet press cited serious problems in obtaining raw material for the Ust'-Kamenogorsk plant. Imported ore—probably from Australia—was reportedly used to help make up the shortfall, which was apparently caused by delays in developing the nearby Karaotkel' ilmenite deposit. The Soviet press attributed these delays to coordination problems among the ministries involved. If there was an ore shortage, the titanium metal industry almost certainly would have had a much higher priority in obtaining available supplies than the pigment industry, suggesting that supplies earmarked for pigment production may have been diverted to metal production.

Another possible explanation for recent ore imports is increased stockpiling. The large volume of imports could signal plans for large increases in titanium metal production. Alternatively, the USSR may be stockpiling ore to guard against future supply disruptions or to build up strategic reserves.[9]

[9] Although each may maintain a small covered stockpile. Because of the strategic importance of titanium, however, we believe a larger national stockpile probably exists.

Outlook

The expansion of the Soviet titanium industry is proceeding even more slowly during the 1981-85 period than in the previous five-year period. We estimate that production in 1985 will remain at about 71,000 tons, an increase of only 5 percent over the 1980 level. This compares with a 19-percent rise in 1976-80. Soviet literature suggests that most of the increased production in that period resulted from equipment modernization. We project little or no further growth in titanium production until at least the late 1980s. 25X1

The USSR may be planning a major expansion in capacity for the late 1980s and early 1990s. 25X1 25X1 25X1

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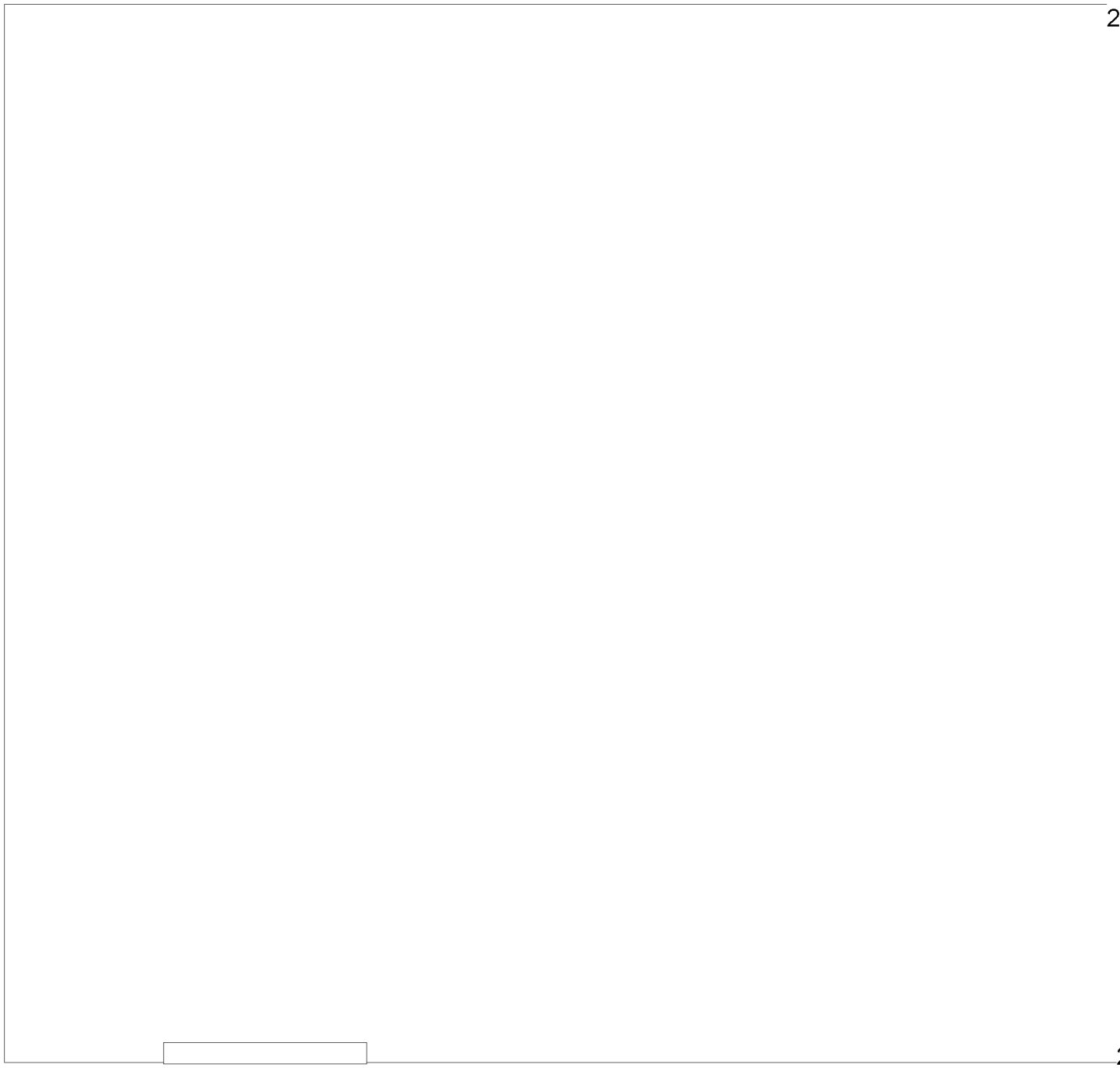
an expansion in output. This analysis and the large volume of recent ore imports suggest that by 1990 Soviet production could increase to as much as 95,000 tons, about one-third more than its 1985 level. 25X1

An increase in capacity of this magnitude would suggest rising military demand for titanium, which may leave little room for growth in civilian use. The relatively high price of intermediate titanium products, compared with similar products made from other metals, will probably continue to limit growth to applications in which resistance to corrosion and heat and a high strength-to-weight ratio are important considerations. Potential growth areas for titanium metal products in civilian industry—similar to those projected for the West—include saltwater-desalinization, oil-refining, and pollution-control equipment. 25X1 25X1 25X1 25X1 25X1 25X1



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During the 1990s, increases in scrap recycling and advances in manufacturing technology could increase the supply of titanium without additional new production capacity. According to Soviet literature only 30 to 35 percent of titanium metal output is actually used in finished products. the USSR is increasing the amount of titanium scrap it recycles.[10] In addition, the USSR is in the early stages of developing new

[10] A large part of titanium scrap is probably used in ferrotitanium (generally 30 percent iron and 70 percent titanium), which is mainly used to make specialty steels. Some titanium scrap is exported to the West for hard currency, but only a small part is recycled into titanium ingots.

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manufacturing technologies—such as precision casting and powder metallurgy—that eventually could sharply reduce the amount of scrap produced in titanium metalworking. 25X1

By the end of the century, advances in titanium substitutes could begin to hold down growth in Soviet titanium use. US aircraft experts predict that the substitution of advanced alloys and composite materials could cause titanium use in new Soviet aircraft to level off or even decline. 25X1

Meanwhile, increasing domestic requirements for ilmenite for production of titanium metal and titanium dioxide pigment and for possible stockpiling probably will continue to outstrip domestic ore production, causing the USSR to continue to import Western ore. The titanium metal industry probably will receive adequate supplies of ore because of the high priority accorded military applications. The USSR could easily meet sudden increases in demand from this industry by reallocating ore from the production of pigment or by drawing down government stockpiles. 25X1

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