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MAIN WAR USES OF THE FIFTEEN MOST IMPORTANT STRATEGIC METALS

The well-nigh incredible increase in consumption of metals used in the war effort was beginning to make itself apparent in the statistical summaries of the U.S. Bureau of Mines as early as 1939 and 1940, as is shown by the figures in the following abstract of war uses of minerals. Undoubtedly these rising curves of consumption of metal steepened even more during 1941 and 1942, but the data to draw them is unavailable. Magnesium and aluminum production in particular, probably has doubled and redoubled in the last two years to amounts undreamed of even five years ago.

The following list gives the most important of the war uses, in probable order of their importance to the war effort:

Aluminum:

1. For transportation (planes, trains, automotive uses, ships). (40% of total consumption).
2. For foundry and metal working of small machine parts.
3. For electrical uses.

Sixty percent of the weight of most airplanes is aluminum. Other new uses include aluminum foil, bearings, coating for steel, die castings, and wrought aluminum.

Aluminum consumption rose 87% in 1939 and 35% in 1940 to a total of 454 million pounds in the latter year, and has probably continued to rise just as rapidly since.

Antimony:

1. For Babbitt metal and bearings. (Consumption up 30% in 1940).
2. For storage batteries (antimonial lead). (Up 15% in 1940).
3. For electrical cable-covering (antimonial lead).
4. For chemical uses, enamel ware, pigments. (Up 75% in 1940).

Consumption for 1939 was 11,000 pounds and for 1940, 18,000 pounds.

Chromium:

1. For stainless steel and other ferro-alloys. (About half of total consumption).
2. For refractory brick for furnace linings. (Less than half of total).
3. For chemical uses.

New uses include stainless and armor-plate welding rods, and for structural parts of airplanes where construction can in many cases be as strong per unit of weight as the lighter metals.

Consumption of chromite ore rose from one-third to two-thirds of a million tons in 1940.

Copper:

1. For shell cases and ammunition. (Consumption rose 79% in 1940).
2. For electrical material, rods, wire, etc.
3. For automotive industry, now includes military cars and tanks.
4. For shipbuilding.
5. For power lines.
6. For telephones.

Consumption of copper rose from 600,000 tons in 1939 to a million tons in 1940 and has doubtless increased another 30 to 50 percent since then.

Iron:

1. For transportation (shipbuilding, military vehicles, tanks, railroads, planes). (Probably nearly 40% of total consumption).
2. For construction.
3. For export to Allied Nations. (Was 17% of total in 1940).

New uses include graphitic steel for moving parts of rifles, machine-guns and machinery bearings; porous oil-soaked iron bearings; low-alloy steels to replace aluminum in trainer planes; steel shell cases instead of brass; stainless-clad instead of stainless steels.

Pig iron production was up 30% in 1939 and 25% in 1940.

Lead:

1. For batteries. (30% of consumption in 1940).
2. For ammunition.
3. For cable-covers.

Also of extreme importance is lead for solder, bearing-metals, for tetra-ethyl gasoline. New high-lead solders and lead plate are saving tin, and lead water pipe is saving copper.

Lead consumption increased 17 percent in 1940 to 782,000 tons.

Manganese:

1. For chemical oxidizing and desulfurizing agent in the production of steel.
2. For constituent of steels to replace stainless steel and in armor-plate.
3. For other non-ferrous alloys.
4. For dry batteries.

Other uses are in the chemical, ceramic, and pigment industries.

Magnesium:

1. For aircraft. (Used 70% of total in 1940).
2. For automotive trade (now mostly military vehicles).
3. For lightweight portable machinery.

Magnesium is used for structural alloys (castings, forgings, and sheets) 64%; for aluminum, zinc, and other alloys 32%; for other uses (magnesium wire, ribbon, shavings) 2%.

A spectacular increase in magnesium production has taken place, rising from six and a half million pounds in 1939 to eleven and a half million pounds in 1940, and probably has doubled again since that time.

Mercury:

1. For mercuric fulminate for explosive detonators.
2. For anti-fouling pigment for ship bottoms.
3. For medical preparations.

Other important uses include storage batteries, barometers, mercury boilers, mercury-vapor lamps, and in the manufacture of felt.

In 1939 about 21,000 flasks were used; in 1940, 27,000 flasks (of seventy-six pounds each).

Molybdenum:

1. For molybdenum-steels, replacing nickel and chromium and tungsten steels for high-speed tool steel.
2. For alloy steels for planes, railroads, and automobile parts.  
The United States produces over 95% of the world's supply (34 million pounds in 1940), and due to the fact that it can be used as a substitute in alloys for less abundant metals, very little is now being exported.

Nickel:

1. For an essential component for stainless steel, as used in planes, ships, military vehicles, etc., etc. Over one-half is used in the transportation industry.
2. For electro-plating and chemical industries.  
A 1939 consumption of 52,000 tons rose 136% over 1938, and rose another 63% to 83,000 tons in 1940.

Silver:

1. For photographic film in military reconnaissance.
2. For bus-bars in hydroelectric plants.
3. For replacing tin in solder.
4. For chemical and medical supplies.  
Sixty-five million ounces were produced in 1939, and 72 million in 1940.

Tungsten:

1. For metal-cutting alloy tool steels (by far the most important use).
2. For lining big guns; for armor plate; in gun breeches; for cores in armor-piercing bullets.  
Other important uses include the use of the metal itself in electric light and radio filaments. A "heavy metal" composed of compressed tungsten and nickel powder is used in X-ray and radio-active screens, and for circuit-breaker electrical contacts.  
Consumption of tungsten rose from four to five million pounds in 1940.

Vanadium:

1. For ferrous alloy steels in machinery and tools.
2. For non-ferrous alloys.
3. For catalyst in the production of sulfuric acid, which is the basis for a large part of the chemical industry.  
Vanadium production in 1939-40 remained stable at around two million pounds a year.

Zinc:

1. For brass shellcases and ammunition. (Up 33% in 1940).
2. For die castings of small machine parts and structural elements. (Up 38% in 1940).
3. For galvanizing of sheet metal.
4. For rolled zinc.  
Brass (copper-zinc) is replacing bronze (copper-tin), and brass embossed dies are replacing steel dies.  
In 1939, 607,000 tons of zinc were consumed, and in 1940, 719,000 tons were consumed.

John Eliot Allen

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## KUIN RADIO TALKS ON THE MINERAL INDUSTRY

Mineral industry problems and developments are discussed over KUIN (1340 kc), Grants Pass, each Tuesday at 7:15 p.m. by Ray C. Treasher and Robert Bassett of the Department staff, stationed at Grants Pass.

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## TITANIUM

Titanium, long one of the neglected elements, has only recently come into its own, and is now being used in a multitude of ways. Discovered in 1791 by W. Gregor in the magnetic sands of Cornwall and first isolated by Berzelius in 1825, as late as 1910 no important commercial application of the metal had been discovered. It was still considered a rare element, was practically unknown to the general public, and textbooks on chemistry scarcely mentioned it.

Now it is known to be one of the most abundant of elements, only eight others--oxygen, silicon, aluminum, iron, calcium, sodium, potassium, and manganese--being more common. It is very widespread; but generally it does not occur in large-sized deposits, which is possibly the reason it was so long overlooked. Of 800 igneous rocks analyzed by the United States Geological Survey, 748 contain some titanium. It occurs in almost all magnetic iron ores, in clays, soils, and many mineral waters, in the sun's atmosphere, in plants, and in the bones and flesh of animals.

Minerals: Titanium does not occur native, in the free state. The most important commercial ore is the mineral ilmenite, the ferrous titanite ( $\text{FeTiO}_3$ ). It crystallizes in the hexagonal system, and is usually massive and compact, but also occurs in thin plates and in grains. Its hardness is 5.5 to 6 and the specific gravity is 4.7. It has a metallic to sub-metallic luster, iron-black color, black to brownish-red streak and is sometimes slightly magnetic without heating.

Three mineral oxides of titanium ( $\text{TiO}_2$ ) are known, of which rutile is by far the most common. It is tetragonal, frequently twinned in many repeated elbows, is generally crystalline, but does occur massive. The hardness varies from 6 to 6.5 and the specific gravity is 4.2. It has adamantine to sub-metallic luster, a red, reddish-brown to black streak, is usually nearly opaque, but may be transparent.

Octahedrite (anatase) also crystallizes in the tetragonal system, but is usually pyramidal and the crystal axes have a different arrangement from those in rutile. It is somewhat softer, and is not so heavy. Its hardness is 6 to 6.5; specific gravity 3.8 to 3.95.

Brookite is orthorhombic and has a varied habit. It occurs only in crystals, has a hardness of 6, a specific gravity of 4 to 4.07 and an adamantine to sub-metallic luster. The color is hair-brown to black and it is translucent to opaque.

Rarer minerals which contain titanium are titanite (sphene)  $\text{CaTiSiO}_5$ , Perovskite  $(\text{CaFe})\text{TiO}_4$ , Schorlomite  $\text{Ca}(\text{TiFe})\text{SiO}_5$ , and Kiolhaite  $\text{CaY}(\text{TiAlFe})\text{SiO}_5$ .

It is sometimes difficult to identify ilmenite, or to determine whether a mineral, such as magnetite, is titaniferous. In such cases, quick chemical tests, such as are given below, may be of value.

Tests for Titanium:

1. A small amount ( $\frac{1}{2}$  gram) of the finely powdered material to be tested is fused with 1 gram of sodium hypophosphite in a small crucible. If the melt is blue, titanium may be present. When water is added drop by drop to the cool melt the water becomes a pale pink color if the melt contains titanium. The addition of hydrogen peroxide gives an orange-red color in the presence of titanium. Ammonia causes the pink color to change to blue.

2. The powdered material is fused with potassium pyrosulfate until effervescence ceases. When the fused mixture is cooled it is dissolved in 10% sulfuric acid. When hydrogen peroxide is added the solution becomes a yellowish-orange color. Hydrofluoric acid or a fluoride destroys the color. A similar yellowish orange color is given by vanadium but this color is not destroyed by addition of fluoride ion.

3. Zinc when added <sup>to a</sup> hydrochloric acid solution of titanium produces a violet color. Tin interferes with this test.

4. The powdered mineral to be tested, mixed with microcosmic salt, is heated on charcoal or on a platinum wire in a reducing flame and if titanium is present, it produces a violet colored bead.

5. A small amount of the powdered mineral is fused with 3-4 times that amount of potassium bisulfate on a platinum lid. The melt is transferred to watch glass, mixed with a little water, and placed on a filter paper impregnated with chromotropic acid. If titanium is present a red to brown color appears. Sensitivity increases when a drop of HCL solution of stannous chloride is added to the melt on the watch glass and a few drops of chromotropic acid are added. In the presence of titanium not only the dissolved, but also the undissolved particles are tinted red.

Occurrence: Ilmenite is usually associated with magnetite; sometimes with hematite. In the ilmenite-magnetite ores, the ratio of titanium to iron is quite variable. There seems to be no sharp distinction between magnetite and titaniferous magnetite, or between titaniferous magnetite and ilmenite. The largest known titaniferous iron deposits are in Norway, Madagascar, Canada, and the United States.

Pure ilmenite, in place, as a minable body, is found only in nelsonite--a peculiar rock in which ilmenite (or rutile) and apatite are the essential minerals.

Ilmenite also occurs in the black-sands of beach deposits, associated with magnetite, monazite, zircon, quartz, and rutile. Important commercial deposits of these sands have been found in Florida, Brazil, India, and Africa. They also are known to occur at several places on the Oregon and Washington coast.

For many years most of the world's supply of ilmenite (and hence titanium) came from the beach sands of Travancore, India. One deposit, at Manavalakurichi (called "M.K.") has been worked since 1911, but until 1924 monazite was the only mineral desired; the ilmenite had no value. With the discovery of commercial uses for titanium and the increased demand for its ore, these stores of hitherto discarded ilmenite became important and valuable. Exploration uncovered a second deposit eighty miles farther north, richer than the first.

Concentration of these sands was accomplished first by wet tables to remove the bulk of the quartz. After drying in the sun, further concentration was carried out by dry tables and magnetic separators, to eliminate the zircon, monazite, rutile, and other minerals. The zircon and monazite were themselves separated and concentrated for commercial markets. The production of ilmenite from these two localities rose from 641 long tons in 1924 to 129,000 long tons in 1935. By the end of 1936 the total production was in excess of 700,000 long tons.

With the depletion of these deposits and the advent of war with its manifold problems of shipping, the United States has sought and found commercial deposits closer to home. The National Lead Company has recently begun large-scale mining of ilmenite in the Adirondacks. The deposit along Piney River, in Amherst and Nelson Counties, Virginia, has been known for many years. It is in the form of a dike of nelsonite which outcrops for 350 feet along the river in a bluff 70 to 80 feet high. It increases in width to 400 feet at the surface a short distance from the river and extends for 1300 feet without materially diminishing this width. In the next 600 feet it tapers down to about 100 feet. A wedge varying from 60 to 100 feet in width extends for another 1000 feet. The nelsonite is enclosed in a biotite-schist and dips 45° with the schist. It has been drilled to a depth of 400 feet and apparently continues below that point. The upper 75 feet of the nelsonite is weathered, rusty, and easily crushed in the hand. Below this it becomes fresh and hard. The ilmenite is black, the apatite comparatively clear, and enough chlorite is present to give the rock a greenish tint. Some pyrite occurs along cracks. Only the decomposed rock has been quarried (as of 1937). It contains 18.5%  $TiO_2$  and if the analyses submitted are typical it should yield about 42.5% of concentrates. The remainder is mostly apatite. The hard rock below is said to be as easily treated as the weathered portion. If the depth of 400 feet is considered as obtaining along the length of the dike, and the specific gravity of the nelsonite be placed at 3.89, more than 4,400,000 tons of  $TiO_2$  is indicated.



Other deposits in the United States are known to occur in Wyoming, Colorado, California, Minnesota, Rhode Island, North Carolina, and elsewhere.

Uses: The time honored use for  $TiO_2$  is for pigment as it makes the whitest of all white paints. Because of its whitening and obliterating power it is unexcelled and is widely used, not only in paint, but also in rubber, linoleum, leather, plastics, soap, printing inks, paper, textiles, and ceramics.

For many years it has been used to a very small extent in alloying steel. Of late years its utilization for this purpose has increased markedly. Like aluminum, and to a greater extent than silicon, it has a strong affinity for oxygen. As a deoxidizer in steels it is often more satisfactory than aluminum, because its oxide is more easily eliminated and because at high temperatures it has an affinity for nitrogen as well as for oxygen. The presence of titanium in steel materially improves ductility and impact resistance, without unduly lowering the strength.

Perhaps the greatest increase in the use of titanium has occurred in the welding-rod industry. The oxide is applied as a coating and serves to stabilize the arc, thus permitting the deposition of a more homogeneous and a purer weld metal.

Titanium has also been used for filaments in electric lights. In the form of the tetrachloride it is used for making smoke screens to cover war movements and in sky-writing.

Market: Ilmenite, per gross ton and containing 60 percent  $TiO_2$ , brings \$28.00 to \$30.00, f.o.b. at the Atlantic seaboard depending on grade and impurities. Rutile, having a guaranteed minimum of 94 percent concentrate, sells at 8 to 10 cents per pound; 88 to 90 percent brings \$95.00 per ton, c.i.f. New York. (Quotation as of November 20, 1941.)

The following are possible buyers:

American Zirconium Corp., St. Helena Ave., Baltimore, Maryland.

Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N.Y.

The Chemical & Pigment Co., Div. Glidden Co., 6401 St. Helena Ave., Baltimore, Maryland.

DuPont de Nemours, E.I., & Co., Inc., (Krebs Pigments Department), Wilmington, Delaware.

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Commercial Minerals of California: George L. Gary, 1942.

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