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THE TITANIUM STORY

Introduction

News stories about titanium, naming it the "wonder metal," the "miracle metal," the "Cinderella metal," etc., have appeared frequently of late. The theme of these stories is that the metal has amazing characteristics of corrosion resistance and strength at high temperatures highly desirable in jet plane construction, that we have been backward in making the metal available to plane manufacturers, that it is necessary to step up production if we are to have a superior air force; and the impression has been also given that the lack of our supplies of metal is due in part to a shortage of the domestic titanium mineral supply. The statements about the superior characteristics of the metal are true and those concerning the need for increased production of the metal are true, but the reports that there is a shortage of domestic titanium minerals are inaccurate unless the shortage is confined to rutile. The shortage of titanium metal is the result of metallurgical obstacles, not scarcity of titanium minerals.

The list of companies owning titanium ore reserves, producing titanium slag or oxide or metal, and carrying on research to produce the metal more cheaply contains many prominent names in American industry as: E.I. du Pont de Nemours, Inc., National Lead Company, Allegheny Ludlum Steel Corporation, Crucible Steel Company, Kennecott Copper Corporation, New Jersey Zinc Company, American Cyanamid Company, Glidden Paint Company, Bohn Aluminum and Brass Corporation, Crane Company, Foote Mineral Company, and Republic Steel Corporation. In addition, there are several smaller companies in the pigment business and a few are mining ore.

Titanium minerals

Titanium ranks as the ninth most plentiful element in the earth's crust. Among structural metals titanium ranks fourth in nature and is exceeded only by magnesium, aluminum, and iron. It may be said that, like the other structural metals mentioned, titanium is all-pervasive in the rocks of the earth's crust. Like aluminum and iron, almost all rocks contain titanium but also, like aluminum, the occurrences of rocks containing economic amounts of titanium are restricted. Contrasted with aluminum, whose silicates are much more abundant than oxides, titanium oxide is more widespread than titanium silicate.

The most important titanium minerals are ilmenite, titanium-iron oxide ($FeO \cdot TiO_2$), and rutile, titanium dioxide (TiO_2). Domestic ilmenite deposits are much more important commercially than rutile deposits.

In places ilmenite occurs in large masses as ilmenite-magnetite or titaniferous magnetite or as ilmenite-hematite. Outstanding examples of these are in the Adirondacks of New York and Allard Lake deposits of Quebec. According to some authorities, some of the so-called ilmenite in sands may be arizonite, which is $Fe_2O_3 \cdot TiO_2$ but this is of academic rather than economic interest. Leucoxene is an altered titanium mineral and may be present in the ilmenite of commerce. Ilmenite occurs in the sands of the Oregon coast and in many Oregon rocks.

Rutile is widespread in occurrence, usually in sparsely disseminated grains so that the deposits have no economic value. However important concentrations of rutile (or anatase or brookite which are different crystal forms of titanium dioxide) occur in Florida, Arkansas, and Virginia, but Florida appears to have had the only commercial production of rutile in 1952. Rutile usually contains some iron as an impurity.

Other titanium minerals in this country of possible future economic importance are titanite, calcium titanium silicate, and perovskite, calcium titanate. A large body of perovskite is known in Colorado.

Large titanium mineral deposits occur in many foreign lands. Travancore, India, has the greatest beach sand concentrations. Australia, from which most United States imports of rutile have come, has very extensive beaches containing ilmenite, rutile, and zircon. Brazil likewise has large beach sand deposits. Norway reportedly has substantial ilmenite masses, and Russia is reported to have large deposits also.

Uses of titanium

By far the largest use for titanium is as the oxide in pigment. Its whiteness, spreading quality, chemical stability, and cheapness make it the most popular white pigment. Titanium, mainly from rutile, is used in welding rod coatings. It is also used in alloys and as carbide and a minor amount in ceramics. Artificial titanium dioxide gems came on the market in 1950. They have exceptional brilliance but have about seven-tenths the hardness of the diamond. Titanium metal is of first importance as a structural material and its application is restricted only by its supply and cost.

Production statistics

The U.S. Bureau of Mines reports the following titanium statistics for 1952:

Production and Shipments of Ilmenite

Production (short tons)	Shipments		
	Gross weight (short tons)	TiO_2 content (short tons)	Value
(1) 528,588	(1) 522,515	(1) 265,596	$8,022,752

(1) Contains altered ilmenite, leucoxene, and rutile.

Consumption

Ilmenite		Rutile	
Gross Weight (short tons)	Est. TiO_2 content (short tons)	Gross Weight (short tons)	Est. TiO_2 content (short tons)
682,850	351,553	18,317	17,353

Pigments consumed 670,829 short tons of ilmenite.

Welding rod coatings consumed 11,418 short tons of rutile.

Imports of titanium concentrates in 1952 were 184,013 short tons classed as ilmenite and 19,394 short tons of rutile. Of the ilmenite concentrates 145,562 short tons came from India and 38,451 short tons from Canada. Ninety-nine percent of the Canadian imports were titanium slag, a product obtained by smelting ilmenite ore from the huge deposit at Allard Lake, Quebec. Electric smelting results in a high-titanium slag and a low-carbon iron. All of the rutile came from Australia. Because of its simple composition, rutile is preferred for producing titanium metal.

Titanium metal production in the form of sponge amounted to 1,075 short tons in 1952 according to the U.S. Bureau of Mines. This was double the amount produced in 1951.

E&MJ Metal and Mineral Markets reports that facilities under construction for making the metal plus those now in operation can produce 20 tons a day. It is also reported that the Crane Company will go into production in 1955 at a rate of about 6000 tons a year. Defense Minerals Production Administration has a goal of 25,000 tons a year for 1956.

Metallurgy

Titanium is reduced to metal with great difficulty because of its tenacity to hold to and combine with oxygen. Thus it is necessary to reduce in a vacuum or in the atmosphere of an inert gas.

Two processes have been used to make titanium metal, the Van Arkel-De Boer iodide decomposition method, and the Kroll process. Other processes and modifications of the processes mentioned are constantly being investigated in the search for a lower cost of production.

The iodide process produces a purer metal but is more expensive. It employs a reaction of iodine with impure titanium in an evacuated vessel. Volatile iodides are formed and are decomposed on a white hot titanium wire to form pure crystalline titanium, releasing the iodine which again acts to carry atoms from the impure metal to form the pure metal on the wire.

In the Kroll process, which is most widely used, chlorine is passed through a mixture of titanium oxide and carbon, forming titanium tetrachloride. This chloride is dripped through helium gas onto molten magnesium, forming titanium sponge and magnesium chloride which is distilled to get rid of and collect the magnesium. The sponge is removed, cleaned, melted in an induction or arc furnace, alloyed, forged, and rolled.

Dr. W. J. Kroll, a consulting metallurgist and a resident of Corvallis, Oregon, introduced his process primarily for the production of zirconium (the twin of titanium) at the U.S. Bureau of Mines Northwest Electrodevelopment Laboratory, Albany, Oregon, following the end of World War II, to supply the Atomic Energy Commission with metallic zirconium. Dr. Kroll has recently been awarded the James Douglas Gold Medal for 1954 by the American Institute of Mining and Metallurgical Engineers "for outstanding contributions to nonferrous metallurgy, particularly in the art of lead refining and the production of metallic titanium." One wonders why zirconium is not mentioned in the citation.

Titanium has a density of 4.5 compared to 2.7 for hard-drawn aluminum and 7.8 for low-carbon steel. Pure titanium metal, like other pure structural metals, has no notable structural strength. However, small quantities of other elements even the small amounts of impurities in commercially pure metal change the picture. Titanium base alloys now available have outstanding strength and ductility characteristics if measured by their densities - that is, there are titanium base alloys which are as strong as structural alloy steels but which weigh considerably less, giving a strength-to-weight ratio far better than other structural metals. In addition, titanium base alloys hold their strength at elevated temperatures such as in the range of 300° to 750° F. where other structural metals lose strength rapidly. It is reported also that titanium alloys have superior fatigue properties and excellent noncorrosive characteristics especially its immunity to attack by salt water. Reportedly a 40-percent weight saving can be obtained in a gage-for-gage replacement of stainless steel by titanium in aircraft. Hence the concern expressed publicly a short time ago by the Secretary of the Air Force over our small titanium production and the need for greater effort to speed up production both for military aircraft and for industry.

Costs

Because titanium is necessarily made in relatively small quantities and because of the nature of the reduction technique, unit cost of the metal is high. According to

E&MJ Metal and Mineral Markets, the price for titanium sponge is about $5 a pound and $6 to $7 a pound for ingot. Mill products may cost from $15 to $30 a pound.

Many researchers are working on the problem of reducing the cost of production. Perhaps the history of titanium will parallel that of aluminum. In the early days of aluminum, production costs were high in dollars per pound, but as the demand for the metal increased, production techniques were gradually improved so that costs were reduced and at present the unit cost is 21½ cents a pound. As costs were reduced, the market expanded to proportions which would have seemed fantastic fifty years ago. Titanium may take a similar course.

F.W.L.

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GALICE QUADRANGLE GEOLOGIC MAP PUBLISHED

Publication of a geologic map of the Galice quadrangle in Josephine County of southwestern Oregon has just been announced by the State Department of Geology and Mineral Industries. The U.S. Geological Survey, which cooperated with the Geology Department, printed the map in five colors on a sheet measuring 50 by 30 inches. The map has a scale of one inch to the mile and is the first Oregon quadrangle to be printed in the recently adopted format. Authors are F. G. Wells and G. W. Walker, geologists with the Federal Survey.

The map embraces a gold mining area, and the locations of 95 gold lode and placer mines are shown. The oldest rocks of the area are of Jurassic age and are estimated to be at least 150 million years old. A brief description of the geologic formations and mineral resources appears on the sheet together with cross sections detailing the structure.

Copies of the geologic map of the Galice quadrangle may be obtained from the office of the Department of Geology and Mineral Industries in the State Office Building, Portland, or from the field offices in Baker and Grants Pass. Price is $1.00 postpaid.

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SOUTHERN OREGON MINING NEWS

M. J. and Phil McShane, Grants Pass, Oregon, have discontinued work at the Midnight claim (chromite) located at the water level of the Illinois River in sec. 21, T. 37 S., R. 9 W., and have moved to higher ground for the winter. They are now working the nearby Black Beauty claim. An incline is being sunk to intersect the lowest of two caved tunnels that were dug in the past by Pete Neubert. This new incline has intersected and by-passed the face of the upper tunnel. A narrow stringer of high-grade chromite is reported to have been exposed in the old tunnels. This stringer may be an extension of the chromite layer being mined by Everett McTimmonds on the Lucky Star claim adjoining the Black Beauty on the west. The ore and serpentine are badly crushed due to landsliding.

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The U.S. Bureau of Mines began a diamond drilling program in December 1953 at the Queen of Bronze Copper mine 1½ miles east of Takilma, Oregon. Richard N. Appling is supervising the drilling. The exploration program was planned as a result of soil sampling and other work done on this property a few years ago by R. H. Hundhausen and associates of the Bureau. Several drill holes are planned, but the exact number will depend on results of the drilling as it progresses.

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BULLETIN 16

Many inquiries have been received by the Department regarding when the revised (fifth) edition of Bulletin 16, "Field Identification of Minerals," will be available. There have been unavoidable delays caused mainly by the increased amount of material in the book. Probably it cannot be ready before early in April. Price will be $1.00.

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