



2010 Minerals Yearbook

THORIUM

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Thorium consumption worldwide is relatively small compared with that of most other mineral commodities. There was no domestic production of thorium reported in 2010. All thorium alloys, compounds, and metal used by the domestic industry were derived from company stocks, imports, or material previously acquired from the U.S. Government stockpile. Domestic imports for consumption of refined thorium products increased by 35% in 2010, according to data collected by the U.S. Census Bureau (tables 1, 2). The value of thorium compounds used by the domestic industry in 2010 was \$208,000, a decrease of 24% from \$275,000 in 2009. Only minor amounts, less than 10 metric tons (t) of thorium, are typically used annually. However, large fluctuations in consumption are caused by intermittent use, especially for catalytic applications that do not require annual replenishment. In 2010, India (87%) and France (13%) were the leading sources of thorium compound imports.

Thorium has been found to some extent in every continent of the world, but is concentrated in a few geologic deposit types. There are three principal sources of thorium that are of commercial interest—monazite in heavy-mineral sand placer and vein deposits, thorite ores in vein deposits, and thorium recovered as a byproduct of uranium mining. Thorium and its compounds were produced primarily from the mineral monazite, which was recovered as a byproduct of processing heavy-mineral sands for zircon and the titanium minerals, ilmenite and rutile, or the tin mineral cassiterite. Monazite was recovered primarily for its rare-earth content, and only a small fraction of the byproduct thorium produced was consumed. Monazite-producing countries were, in decreasing order of production, India, Brazil, and Malaysia (table 3).

Problems associated with thorium's natural radioactivity represented a significant cost to those companies involved in its mining, processing, manufacture, transport, and use. The costs to comply with environmental regulations and potential legal liabilities and the high costs to purchase storage and waste disposal space were the principal deterrents to its commercial use.

Limited demand for thorium, compared with demand for rare earths produced from thorium-containing minerals, continued to create a worldwide oversupply of thorium compounds and residues. Most major rare-earth processors have switched feed materials to thorium-free intermediate compounds, such as rare-earth chlorides, hydroxides, or nitrates. Excess thorium not designated for commercial use was either disposed of as a low-level radioactive waste or stored for potential use as a nuclear fuel or in other applications. Principal nonenergy uses have shifted from refractory applications to chemical catalysts, lighting, welding electrodes, and heat resistant ceramics, in descending order of use.

Production

Domestic mine production data for thorium-bearing minerals were developed by the U.S. Geological Survey from a voluntary canvass of U.S. thorium operations. The one mine to which a canvass form was sent responded. Thorium was not produced in the United States in 2010, and the mine that had previously produced thorium-bearing monazite at Green Cove Springs, FL, (Iluka Resources Inc., a wholly owned subsidiary of Iluka Resources Ltd.) ceased production of zircon from tailings during 2009. The monazite production capacity has been on care-and-maintenance status for several years. Monazite was last produced in the United States in 1994.

Consumption

Statistics on domestic thorium consumption were developed by evaluating import and export data, and surveying various processors and manufacturers. Domestic thorium producers and processors that were surveyed reported no consumption of thorium oxide equivalent in 2010 and were temporarily shut down owing to the lack of thorium demand. Additional information on domestic consumption was not available. Essentially all thorium alloys and compounds used by the domestic industry were derived from imports, company stocks, or materials previously sold from the National Defense Stockpile. Domestic companies processed or fabricated various forms of thorium for nonenergy uses, such as ceramics, chemical catalysts, lighting, and welding electrodes. Lightbridge Corp. (McLean, VA) continued work on the design of a light water reactor using thorium (Lightbridge Corp., 2010).

Prices

Thorium oxide prices in 2010, as quoted by Rhodia Inc. (Cranbury, NJ) [a subsidiary of Rhodia S.A. (La Rochelle, Poitou-Charentes, France)] were estimated to be the same as those of the previous year (table 1). At yearend, the estimated price for thorium oxide delivered, duty paid, was \$300 per kilogram for 99.9% purity, the same as that at yearend 2009. In 2007, the 99.99%-pure thorium oxide product was discontinued. Thorium nitrate prices from Rhodia were estimated to be unchanged at \$27 per kilogram for mantle-grade material. Thorium nitrate was used in the manufacture of mantles for incandescent "camping" lanterns, including natural gas lamps and oil lamps. Thorium mantles provide an intense white light that is adjusted toward the yellow region by a small addition of cerium. Thoriated mantles were not produced domestically owing to the development of a suitable thorium-free substitute.

Foreign Trade

Exports of thorium compounds from the United States were 1,500 kilograms (kg) valued at \$605,000, a decrease from 4,730 kg in 2009 (table 2). Principal destinations were, in order of quantity, Singapore, Canada, the United Kingdom, and Saudi Arabia.

Imports of thorium compounds in 2010 totaled 3,030 kg valued at \$208,000, an increase from 2,250 kg valued at \$275,000 in 2009. India and France were, in order of quantity, the leading suppliers of thorium imports in 2010 (table 2). Rhodia's rare-earth separation plant in La Rochelle remained the principal source of thorium compounds imported into the United States. Most of the thorium was supplied from older stocks that were produced when the plant was processing monazite. In 2010, the La Rochelle plant processed intermediate rare-earth concentrates that had the thorium removed. No thorium ores or concentrates were imported in 2010; imports of thorium ores and concentrates including monazite were 26,000 kg in 2009.

World Review

Thorium demand worldwide remained depressed because of concerns about its naturally occurring radioactivity. Industrial consumers expressed concerns about the potential liabilities, the cost of environmental monitoring to comply with regulations, and the cost of disposal at approved waste burial sites. Interest in thorium increased worldwide, however, as various countries exhibited an interest in thorium-fueled nuclear power as an alternative to uranium. In 2010, exploration for rare-earth elements associated with thorium continued in Canada, India, and the United States.

France.—Areva Inc. (Paris, France) announced construction of a facility in Bessines to extract lead 212 for use in experimental cancer treatments. Lead 212 is a daughter product of thorium 232, and Areva planned to extract the lead from thorium using proprietary technology. The facility would be completed in 2013 (Areva Inc., 2010).

India.—The Indian Department of Atomic Energy designed a 300-megawatt (MW) advanced heavy water reactor fueled by thorium. The reactor would be built at Kalpakkam, where an experimental thorium reactor was already located. The reactor was scheduled for completion by 2019 (Outlook India, 2010; Sabha, 2010).

Indian Rare Earths Ltd. planned to construct a monazite processing plant at its Orissa Sands Complex in the Ganjam district. The plant would have a capacity of 10,000 metric tons per year and be operational in 2013 (Hindu, The, 2010).

Japan.—International Thorium Energy Molten-Salt Technology Inc. announced plans to develop a thorium molten salt reactor. Thorium fluoride fuel would be dissolved in molten beryllium and lithium fluoride salts. The reactor would operate at normal pressure, a design that is perceived to be safer than the

solid-fuel reactors that operate in high-pressure containers. A 10 MW pilot plant would be built, and then, a 200 MW powerplant is proposed if the pilot plant is successful. A schedule was not available (International Thorium Energy Organization, 2010).

Outlook

Thorium use in the United States has decreased substantially since the early 1990s. Domestic consumption is expected to remain at recent low levels unless thorium's use as a nonproliferative nuclear fuel becomes widely commercialized or a low-cost technology is developed to dispose of thorium residues created as a byproduct during mineral processing, specifically monazite. In the long term, high disposal costs, increasingly stringent regulations, and public concerns related to thorium's natural radioactivity are expected to continue to discourage its use in global nonenergy applications. Interest in thorium-powered nuclear reactors was expected to increase, especially after the accidents at nuclear reactors in Japan, which were damaged by tsunamis triggered by an earthquake on March 11, 2011.

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TABLE 1
SALIENT U.S. REFINED THORIUM STATISTICS¹

(Kilograms and dollars per kilogram)

	2006	2007	2008	2009	2010
Exports, gross weight:					
Thorium ore, including monazite	--	-- ²	-- ²	18,000	(3)
Compounds	1,090	1,630	12,600	4,730	1,500
Imports for consumption, gross weight:					
Thorium ore, including monazite	10,000	--	--	26,000	--
Compounds	48,600	6,370	692	2,250	3,030
Prices, yearend:					
Nitrate, gross weight ^{4,5}	27.00	27.00	27.00	27.00	27.00 ^e
Oxide, 99.9% purity ⁵	175.00	200.00	300.00	300.00	300.00 ^e

^eEstimated. -- Zero.

¹Data are rounded to no more than three significant digits, except prices.

²Data estimated by the U.S. Geological Survey.

³Less than ½ unit.

⁴Source: Rhodia Canada Inc., free on board port of entry, duty paid, thorium oxide basis.

⁵Source: Rhodia Inc.

TABLE 2
U.S. FOREIGN TRADE IN THORIUM AND THORIUM-BEARING MATERIALS¹

	2009		2010		Principal destinations/sources and quantities, 2010
	Quantity (kilograms)	Value	Quantity (kilograms)	Value	
Exports:					
Thorium ore, monazite concentrate	18,000	\$269,000 ²	(3)	\$15,200	Algeria.
Compounds	4,730	379,000	1,500	605,000	Singapore 600; Canada 250; United Kingdom 250; Saudi Arabia 210.
Imports for consumption:					
Thorium ore, monazite concentrate	26,000	19,500	--	--	XX
Compounds	2,250	275,000	3,030	208,000	India 2,620; France 400.

XX Not applicable. -- Zero.

¹Data are rounded to no more than three significant digits.

²Data estimated by the U.S. Geological Survey.

³Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
MONAZITE CONCENTRATE: ESTIMATED WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons, gross weight)

Country ³	2006	2007	2008	2009	2010
Brazil	958 ⁴	1,173 ⁴	1,200	1,200	1,200
India	5,000	5,000	5,000	5,000	5,000
Malaysia	894 ⁴	682 ⁴	233 ^r	25 ^r	30
Total	6,850	6,860	6,430 ^r	6,230 ^r	6,230

^rRevised.

¹World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Table includes data available through May 9, 2011.

³In addition to the countries listed, China, Indonesia, Nigeria, North Korea, the Republic of Korea, and countries of the Commonwealth of Independent States may produce monazite, available information is inadequate for formulation of reliable estimates of output levels.

⁴Reported figure.