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2011 Minerals Yearbook

THORIUM

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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 2011. 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 thorium compounds increased by 88% in 2011, according to data collected by the U.S. Census Bureau (tables 1, 2). The value of thorium compounds used by the domestic industry in 2011 was $398,000, an increase of 91% from $208,000 in 2010. Only minor amounts, less than 10 metric tons (t) of thorium, are typically used annually. However, large fluctuations in apparent consumption are caused by intermittent use, especially for catalytic applications that do not require annual replenishment. In 2011, India (89%) and France (11%) were the sources of thorium compound imports. China continued to dominate the supply of thorium, accounting for 81% of global mine production.

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 element (REE) content, and only a small fraction of the byproduct thorium produced was consumed. Monazite-producing countries were, in decreasing order of production, India, Malaysia, Vietnam, and Brazil (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 REEs 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 2011, 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 2011 and were idle 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. In 2011, Idaho National Laboratory was in the process of completing an analysis of the company's thorium-based technology (Lightbridge Corp., 2011, p. 26).

Prices

Published prices for thorium oxide and nitrate were not available. The average unit value of imported thorium compounds was $68.6 per kilogram, nearly unchanged compared with $69.7 per kilogram in 2010.

Foreign Trade

Exports of thorium ores and concentrates are minor relative to world production. In 2011, there were no exports of thorium ores and concentrates, and imports were about 1 t valued at $762,000 in 2010. Exports of thorium compounds from the United States were 4.28 t valued at $762,000, an increase from 1.5 t in 2010 (table 2). Principal destinations were, in order of quantity, Brazil, China, Republic of Korea, and Singapore.

Owing to limited demand, thorium ores and concentrates, and thorium compounds, are imported sporadically. In 2011, 30 t of thorium ores or concentrates was imported from inventory located in the United Kingdom (table 2). Imports of thorium compounds in 2011 totaled 5.71 t valued at $398,000, an increase from 3.03 t valued at $208,000 in 2010. India and France were, in order of quantity, the leading suppliers of thorium compound imports in 2011.

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 2011, the exploration and development of rare-earth projects associated with thorium was underway in Australia, Canada, Greenland, India, South Africa, the United States, and Vietnam.

China.—The Chinese Academy of Sciences began a new research initiative to develop thorium molten-salt reactor (TMSR) technologies. The effort was being led by the TMSR Center at the Shanghai Institute of Applied Physics. By 2017, two 2-megawatt (MW) research reactors based on two molten salt technologies were expected to be constructed, and by 2035, construction of a 1,000-MW reactor was expected to help demonstrate the commercial feasibility of the technology (Chen, 2012).

France.—Areva Inc. (Paris) began 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. In 2011, Areva received approval from the U.S. Food and Drug Administration to begin clinical trials of a new treatment using lead-212 and the facility was expected to be completed in 2013 (Areva Inc., 2011).

India.—The Indian Department of Atomic Energy continued development of a 300-MW advanced heavy water reactor fueled by thorium. At yearend 2011, site selection for the new reactor was ongoing, but was expected to be adjacent to an existing nuclear powerplant in India. Once regulatory and environmental approvals are obtained, construction of the rector was expected to require 6 years to complete (Rahman, 2011).

At yearend, Indian Rare Earths Ltd. continued work on the construction of a 10,000-metric-ton-per-year monazite processing plant at its Orissa Sands Complex in the Ganjam District. The Orissa plant was expected to support domestic and international rare-earth production, and was expected to be operational in 2013 (Kaul, 2012).

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 continue.

References Cited

Areva Inc., 2011, Treatment against cancer—AREVA launches construction of the Maurice Tubiana laboratory to produce lead-212: Paris, France, Areva Inc. press release, May 31. (Accessed September 18, 2012, at http://www.areva.com/EN/news-8921/treatment-against-cancer-areva-launches-construction-of-the-maurice-tubiana-laboratory-to-produce-lead212nbsp.html.)

Chen, Kun, 2012, China thorium fueled molten salt reactor research in Shanghai Institute of Applied Physics: Berkeley, CA, University of California Berkeley Colloquium, August 6. (Accessed September 18, 2012, at http://www.youtube.com/watch?v=5UT2yYs5YJs.)

Kaul, Aditya, 2012, India revs up rare earth production to join big league: New Delhi, India, DNA, September 8. (Accessed September 21, 2012, at http://www.dnaindia.com/india/report_india-revs-up-rare-earth-production-to-join-big-league_1738207.)

Lightbridge Corp., 2011, Form 10–Q: U.S. Securities and Exchange Commission, November 9, 51 p.

Rahman, Maseeh, 2011, India plans 'safer' nuclear plant powered by thorium: The Guardian, November 1. (Accessed September 19, 2012, at http://www.guardian.co.uk/environment/2011/nov/01/india-thorium-nuclear-plant.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Nuclear Fuels. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Thorium. Ch. in Mineral Commodity Summaries, annual.

Other

Thorium. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
Uranium Industry Annual. U.S. Department of Energy, 2002.

TABLE 1
SALIENT U.S. THORIUM STATISTICS[1]

		2007	2008	2009	2010	2011
Exports, gross weight:						
Thorium ore, including monazite	metric tons	--	61	18	1 r	--
Compounds	do.	1.63	12.62	4.73	1.50	4.28
Imports for consumption, gross weight:						
Thorium ore, including monazite	do.	--	--	26	--	30
Compounds	do.	6.37	0.69	2.25	3.03	5.71
Prices, yearend:						
Nitrate, gross weight[2]	dollars per kilogram	27	NA	NA	NA	NA
Oxide, 99.9% purity[2]	do.	200	252 r	252 r	252 r	NA

rRevised. do. Ditto. NA Not available. -- Zero.
[1]Data are rounded to no more than three significant digits.
[2]Source: Rhodia, Inc., free on board port of entry, duty paid, thorium oxide basis.

TABLE 2
U.S. FOREIGN TRADE IN THORIUM AND THORIUM-BEARING MATERIALS[1]

	2010		2011		
	Quantity (metric tons)	Value	Quantity (metric tons)	Value	Principal destinations/sources and quantities, 2011
Exports:					
Thorium ore, monazite concentrate	1 r	$15,200	--	--	XX
Compounds	1.50	605,000	4.28	$762,000	Brazil, 1.30; China, 1.12; Republic of Korea, 0.50; Singapore, 0.50.
Imports for consumption:					
Thorium ore, monazite concentrate	--	--	30	49,800	United Kingdom, 30.
Compounds	3.03	208,000	5.71	398,000	India, 5.11; France, 0.60.

rRevised. XX Not applicable. -- Zero.
[1]Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 3
MONAZITE CONCENTRATE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2007	2008	2009	2010	2011
Brazil	1,173 r, 4	834 r, 4	303 r, 4	249 4	250
India	5,000	5,000	5,000	5,200	5,200
Malaysia[4]	682	233	25	732 r	779 r
Vietnam	1,400	1,400	1,200	310	360
Total	8,260 r	7,470 r	6,530 r	6,490 r	6,590 r

rRevised.
[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]Table includes data available through May 9, 2012.
[3]In addition to the countries listed, other countries may produce monazite, but available information is inadequate for the formulation of reliable estimates of ouput levels.
[4]Reported figure.