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STRONTIUM [ADVANCE RELEASE]

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STRONTIUM

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Domestic strontium consumption continued to decrease for the eighth consecutive year because its major end use, color television faceplate glass production, had declined dramatically in the United States owing to the shift of production to Asia and increased popularity of new flat panel television displays that do not use strontium carbonate in their glass. The last television glass plant in the United States closed in 2006. Therefore, no strontium was consumed in what had been the leading end use since the early 1970s. Worldwide, strontium ore production increased slightly as a result of expanded production in China.

Strontium occurs commonly in nature; it averages 0.04% of the Earth's crust and ranks 15th among elements in abundance (MacMillan and others, 1994). Only two minerals, celestite (strontium sulfate) and strontianite (strontium carbonate), however, contain strontium in sufficient quantities to make its recovery practical. Of the two, celestite occurs much more frequently in sedimentary deposits of sufficient size to make development of mining facilities attractive. Neither mineral is mined in the United States, although deposits have been identified and were mined in the past.

Production

Chemical Products Corp. (CPC) discontinued production of strontium compounds at its Cartersville, GA, plant in 2006, although the company continued to produce strontium carbonate and strontium nitrate at its operation in Reynosa, Mexico. A few companies produce downstream strontium chemicals elsewhere in the United States, but in small quantities.

Consumption

It has become difficult to estimate the end uses for strontium without basic information that had formerly been provided by CPC. Data in table 2 are very broad estimates based on trade data and previous reports from CPC. The most significant development is that no television faceplate plants operated in the United States in 2007, eliminating what was once a dominant end use, and reconfiguring the entire strontium consumption scenario. At its peak, more than 70% of all strontium consumption in the United States was used in faceplate glass for color television cathode-ray tubes (CRTs) to block x-ray emissions from the devices. Modern television technology has replaced CRTs with flat-panel display systems.

Major production of faceplate glass for CRT televisions and computer monitors has shifted to the Far East, especially China, where production of these devices continued. Globally, flat panel display technology that requires little or no strontium continues to gain market share, as the consumer prices decrease. Market economics have shifted the production of faceplate glass and smaller televisions with CRTs to Asia and Mexico, where they now are being built, even for those sold in the United States. These changes have resulted in the cessation of domestic production of strontium carbonate with little likelihood of recovery in the foreseeable future. Television glass production also has declined in Europe and Japan. Strontium demand for CRTs continues to be strong in Asia and Mexico, but newer television technology is likely to eventually replace CRTs in those markets as well.

Even without strontium carbonate consumption in television glass, estimated strontium consumption in ceramics and glass manufacture remained one of the top end-use industries through its use in ceramic ferrite magnets and other ceramic and glass applications. These applications gained market share, but the new consumption patterns were based on a much smaller total market. Although strontium compounds were used in some flat panel displays, consumption was much lower than what was used in CRT screens, and these devices were not produced domestically. The use of strontium nitrate in pyrotechnics was estimated to equal the use of strontium carbonate in ferrite magnets.

Permanent ceramic ferrite magnets are used extensively in small direct current motors for automobile windshield wipers, loudspeakers, magnetically attached decorative items, toys, and other electronic equipment. Strontium ferrite magnets have high coercive force and high thermal and electrical resistivities and are chemically inert. They retain their magnetism well, are not adversely affected by electrical currents or high temperatures, do not react with most chemical solvents, and have a low density (Haberberger, 1971).

One of the most consistent and continuing applications for strontium has been in pyrotechnic devices. Strontium burns with a brilliant red flame, and no other material is known to perform better in this application. The compound used most frequently in these devices is strontium nitrate, although strontium carbonate, strontium chlorate, strontium oxalate, and strontium sulfate may also be used. Pyrotechnic devices are used in military and nonmilitary applications. Military pyrotechnic applications include marine distress signals, military flares, and tracer ammunition. Nonmilitary applications include fireworks and warning devices (Conkling, 1981).

Strontium can be used to remove lead impurities during the electrolytic production of zinc. The addition of strontium carbonate dissolved in sulfuric acid reduces the lead content of the electrolyte and of the zinc deposited on the cathode (Solvay S.A., 2007).

Strontium chromate is used as an additive in corrosion-resistant paint to effectively coat aluminum, most notably on aircraft fuselages and ships. These paints are also used on aluminum packaging to prevent corrosion (Roskill Information Services Ltd., 1992, p. 76).

Strontium metal has become a more important part of total strontium consumption. Small amounts of strontium added to molten aluminum make it more suitable for casting such items as engine blocks and wheels. The addition of strontium to the melt also improves the machinability of the casting. The use of cast aluminum parts instead of steel has become common in the automotive industry because of the reduced weight, resulting in improved gas mileage (Lidman, 1984).

Other end uses consumed only small amounts of strontium and strontium compounds. Strontium improves the quality of certain ceramic glazes and eliminates the toxicity that may be present in glazes that contain barium or lead. Strontium titanate is sometimes used as a substrate material for semiconductors and in some optical and piezoelectric applications. Strontium chloride is used in toothpaste for temperature-sensitive teeth. For this application, impurities must be strictly controlled; some limits are in the parts-per-million range. Strontium also appears to be one of the most effective substances yet found for the prevention and treatment of osteoporosis and other bone-related conditions. Strontium phosphate is used in the manufacture of fluorescent lights, and the entire range of strontium chemicals is used in analytical chemistry laboratories.

Prices

Based on data published by the U.S. Census Bureau, the average customs unit value for celestite imported from Mexico was about $67 per metric ton (t), which was about 5% higher than that of 2006, although the quantity imported was 19% lower. The average unit customs value of imported strontium carbonate was $0.57 per kilogram, which was an increase of 17% from $0.49 per kilogram in 2006. In 2007, the unit value of imported strontium metal increased about 7% to $3.15 per kilogram from $2.94 per kilogram. In 2007, the corresponding value for strontium nitrate was $1.03 per kilogram, which was 19% higher than in 2006.

Foreign Trade

Exports of strontium chemicals were about the same in 2007 as they were in 2006 (tables 1, 3). The Chinese government removed the value-added export tax rebates of strontium/barium arsenite, strontium carbonates, and strontium oxide/hydroxide (Metal-Pages, Ltd., 2007).

Imports of celestite from Mexico were 1,230 t, which was 19% lower than the amount imported in 2006 (table 4). In 2007, celestite imports represented less than 3% of the 48,700 t of celestite that the United States imported in 1990, the peak year for celestite imports.

In 2007, Mexico continued to be the most important source for imported strontium compounds with almost 79% of the total, followed by Germany with 11%. Several other countries were the source for the remainder of imported material. Imports of strontium carbonate were 14% lower than those of 2006, continuing a steep decline. Imports from Mexico accounted for 79% of total strontium carbonate imports. Imports of strontium metal, declining for the second consecutive year, were 26% lower than in 2006, although still high compared with the level of imports seen before 2005. Nearly all strontium metal imports were from Japan (68%), China (21%), the Republic of Korea (6%), and Canada (4%). Imports of strontium nitrate, which was the second ranked imported strontium compound, vary significantly from year to year but prior to 2006 typically represented between 2% and 4% of total strontium chemical imports. In 2006, imports of strontium nitrate were nearly 7% of the total, and increased to nearly 21% of imported strontium chemicals in 2007. The increases were the result of the discontinuation of strontium nitrate production in Georgia in April 2006. Although production ceased, demand continued.

World Industry Structure

In most instances, celestite deposits occur in remote, undeveloped locations far from population centers and in areas where inexpensive labor is available for mining. Huge deposits of high-grade celestite have been discovered throughout the world. Strontium commonly occurs along with barium and calcium, which have chemical properties very similar to those of strontium, making separation difficult. Because removing many impurities from celestite is difficult and energy-intensive, strontium chemical producers require that raw materials contain at least 90% strontium sulfate. Most operating celestite facilities produce sufficient supplies with only minimal processing necessary to achieve acceptable specifications. Hand sorting and some washing are all that are necessary at many strontium mines; a few operations use froth flotation, gravity separation, or other methods to beneficiate ore.

The leading celestite producing countries were, in decreasing order of output, China, Spain, and Mexico, all with more than 100,000 t of production in 2006. Turkey had been another leading celestite producer, but has experienced significant declines in production in recent years. Celestite was produced in smaller quantities in Argentina, Morocco, and Pakistan (table 5). Production facilities for strontium compounds and metal were located in Canada, China, Germany, Japan, the Republic of Korea, Mexico, and the United States.

Detailed information on most world resources was not readily available because very little information on exploration results has been published. Other deposits may be well identified but are in countries from which specific minerals information was not easily obtained.

Outlook

The main strontium demand for CRT televisions continues to be in Asia and Mexico. However, newer television technology is likely to eventually replace CRTs in those markets as well.

Strontium has also been considered as a candidate for the next-generation, highly accurate atomic clock. The new technology uses a laser lattice to suspend super-cooled strontium atoms to produce the most precise ‘ticks’ ever recorded in an optical clock. Improved atomic clocks could synchronize telecommunication networks and deep-space networks as well as enable more precise navigation and positioning systems. The strontium-based approach could also serve as a storage mechanism for future quantum computers (National Institute of Standards and Technology, 2006).

Strontium use in pyrotechnics is expected to continue; however, the amounts of strontium used in pyrotechnics will most likely decline. The decline is because of improvement as well as consumer demand of eco-friendly pyrotechnic technology that uses a smaller amount of strontium to achieve the same colorful display (Environmental Science and Technology, 2007).

Ferrite magnet markets are expected to be strong, and demand for strontium is likely to continue. Growth in other markets will probably continue at current slower rates. Improved economic conditions worldwide could spur growth in demand for strontium carbonate in some of these applications, but it is unlikely that television glass will ever represent the dominant end use for strontium that it once did.

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TABLE 1
SALIENT STRONTIUM STATISTICS[1]

(Metric tons of contained strontium and dollars per metric ton unless otherwise noted)[2]

	2003	2004	2005	2006	2007
United States:					
Production, strontium minerals	--	--	--	--	--
Imports for consumption:[3]					
Strontium compounds	23,300	14,500	11,700	8,860	8,550
Strontium minerals	1,020	2,760	799	671	541
Exports, compounds[3]	693	552	255	716	720
Shipments from Government stockpile excesses	--	--	--	--	--
Apparent consumption[4]	26,600	16,700	12,200	8,820	8,370
Price, average value of mineral imports at port of exportation	57	53	56	64	67
World, production of celestite, gross weight[5]	492,000	508,000 r	551,000 r	529,000 r	539,000 e

eEstimated. rRevised. -- Zero.

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

[2]The strontium content of celestite is 43.88%, which was used to convert units to celestite.

[3]Source: U.S. Census Bureau.

[4]Production plus imports minus exports.

[5]Excludes Tajikistan, which was thought to produce significant quantities of celestite, but information was not available to make reliable estimates.

TABLE 2
U.S. ESTIMATED DISTRIBUTION OF PRIMARY
STRONTIUM COMPOUNDS, BY END USE

(Percent)

End use	2006	2007
Electrolytic production of zinc	4	10
Ferrite ceramic magnets	18	30
Master Alloys	7	10
Pigments and fillers	5	10
Pyrotechnics and signals	30	30
Television picture tubes	30	--
Other	6	10
Total	100	100

-- Zero.

TABLE 3
U.S. EXPORTS OF STRONTIUM COMPOUNDS, BY COUNTRY[1]

	2006		2007	
	Gross weight (kilograms)	Value[2]	Gross weight (kilograms)	Value[2]
Strontium carbonate, precipitated:				
Canada	7,490	$8,450	64,800	$63,100
Germany	8,890	57,700	6,450	56,800
Hong Kong	30,100	28,600	--	--
Italy	--	--	5,420	5,150
Japan	--	--	11,500	14,700
Korea, Republic of	626	13,000	10,400	9,900
Mexico	102,000	44,000	17,300	23,700
Panama	929	5,360	--	--
Total	150,000	157,000	116,000	173,000
Strontium oxide, hydroxide, peroxide:				
Argentina	--	--	25,100	13,800
Australia	16,900	9,280	--	--
Belgium	166,000	91,400	13,900	7,660
Brazil	--	--	39,000	35,100
Canada	126,000	54,200	93,300	45,400
China	4,570	2,510	--	--
Colombia	--	--	76,000	52,800
Denmark	21,000	11,600	--	--
France	113,000	177,000	222,000	217,000
Germany	9,640	5,300	99,400	55,500
Israel	19,200	10,600	55,600	30,600
Italy	--	--	43,100	177,000
Jamaica	4,590	2,520	--	--
Japan	--	--	19,000	11,200
Korea	353,000	194,000	44,200	24,300
Mexico	4,920	4,330	99,800	64,800
Sweden	12,500	6,850	7,850	4,320
Switzerland	12,900	20,200	13,500	7,430
Taiwan	--	--	40,000	51,800
United Kingdom	7,310	4,020	11,800	13,700
Total	871,000	594,000	904,000	812,000

-- Zero.

[1]Data are rounded to no more than three significant digits: may not add to totals shown.

[2]Free alongside ship value.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 4

U.S. IMPORTS FOR CONSUMPTION OF STRONTIUM COMPOUNDS, BY COUNTRY[1]

	2006		2007	
	Gross weight (kilograms)	Value[2]	Gross weight (kilograms)	Value[2]
Celestite, Mexico	1,530,000	$98,400	1,230,000	$82,900
Strontium carbonate:				
Belgium	119,000	49,400	--	--
China	86,300	196,000	636,000	968,000
Germany	1,580,000	766,000	1,730,000	878,000
Italy	11,000	51,900	6,000	28,800
Japan	2,000	2,350	--	--
Mexico	11,300,000	5,360,000	8,960,000	4,610,000
Spain	20,400	14,200	--	--
United Kingdom	9	3,430	--	--
Total	13,200,000	6,440,000	11,300,000	6,480,000
Strontium metal:				
Canada	--	--	19,800	82,100
China	131,000	548,000	94,300	369,000
Germany	--	--	13	2,140
Japan	400,000	1,020,000	309,000	843,000
Korea, Republic of	77,300	239,000	28,200	79,000
Netherlands	--	--	2,000	53,200
South Africa	8,000	10,000	--	--
Total	617,000	1,820,000	454,000	1,430,000
Strontium nitrate:				
China	339,000	293,000	256,000	220,000
Germany	78,800	73,800	20,000	19,600
India	1,850	6,220	--	--
Japan	25,000	65,500	175,000	451,000
Mexico	160,000	117,000	2,640,000	2,510,000
Spain	414,000	327,000	79,400	77,700
Total	1,020,000	883,000	3,170,000	3,280,000
Strontium oxide, hydroxide, peroxide:				
China	12,800	30,600	85,700	105,000
Germany	2,500	3,750	--	--
Japan	600	17,300	600	17,200
Total	15,900	51,600	86,300	122,000

-- Zero.

[1]Data rounded to no more than three significant digits; may not add to totals shown.

[2]Free alongside ship value.

Source: U.S. Census Bureau.

TABLE 5
CELESTITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2003	2004	2005	2006	2007[e]
Argentina	4,300	6,727	7,233	19,822 [r]	20,000
China[e]	130,000	150,000	180,000	180,000	190,000
Iran[4]	2,100	7,500	672 [r]	-- [r, e]	--
Mexico	130,329	87,609	110,833	125,000	125,000
Morocco[e]	2,700	2,700	2,700	2,700	2,700
Pakistan	402	570	1,855	1,900 [e]	2,000
Spain	152,383	192,942 [r]	188,000 [r, e]	188,000 [r, e]	190,000
Turkey[e]	70,000	60,000	60,000	12,000 [r]	9,000
Total	492,000	508,000 [r]	551,000 [r]	529,000 [r]	539,000

[e]Estimated. [r]Revised. -- Zero.

[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 20, 2008.

[3]In addition to the countries listed, Tajikistan was thought to produce celestite, but information was not available to make reliable estimates.

[4]Data are for year beginning March 21 of that stated.