LIME

By M. Michael Miller

Lime is an important chemical with hundreds of chemical, industrial, and environmental uses in the United States. Its history probably dates back at least 4,000 to 6,000 years. The ancient Egyptians utilized lime as an ingredient in mortar and plaster. The Greeks, Romans, and Chinese utilized lime for construction, agriculture, bleaching, and tanning. Its uses began expanding with the advent of the industrial revolution, but it remained primarily a construction commodity until the rapid growth of the chemical process industries at the beginning of the 20th century. At the turn of the century, over 80% of lime consumed in the United States went for construction uses, but now over 90% of lime is consumed for chemical and industrial uses.

Lime is a basic chemical that ranked fifth in total production in the United States in 1995. It was produced in 33 States and Puerto Rico, and its major uses were in steelmaking; pulp and paper manufacturing; construction; and the treatment of water, sewage, and smokestack emissions.

Total lime sold or used by domestic producers, excluding that from Puerto Rico, increased by about 1.12 million metric tons (1.24 million short tons) to 18.5 million tons (20.4 million short tons) in 1995. Production included the commercial sale or captive consumption of quicklime, hydrated lime, and dead-burned refractory dolomite. These products were valued at more than ($1.1 billion). Commercial sales increased by 864,000 tons (952,000 short tons) to a record high of 16.3 million tons (18.0 million short tons), and captive consumption increased 264,000 tons (291,000 short tons) to 2.18 million tons (2.40 million short tons). *(See table 1.)*

Production

The term "lime," as used throughout this chapter, refers primarily to six chemicals produced by the calcination of high-purity calcitic or dolomitic limestone followed by hydration where necessary. They are (1) quicklime, calcium oxide (CaO); (2) hydrated lime, calcium hydroxide [$Ca(OH)_2$]; (3) dolomitic quicklime ($CaO \cdot MgO$); two types of dolomitic hydrate, (4) type N [$Ca(OH)_2 \cdot MgO$] and (5) type S [$Ca(OH)_2 \cdot Mg(OH)_2$]; and (6) dead-burned dolomite. Nondolomitic quicklime and hydrated lime are also called high-calcium lime. Lime also can be produced from a variety of calcareous materials such as aragonite, chalk, coral, marble, and shell. Lime is also regenerated; that is, produced as a byproduct, by paper mills, carbide plants, and water treatment plants; however, regenerated lime is beyond the scope of this report.

Domestic production data for lime are developed by the U.S. Geological Survey from two separate, voluntary surveys of U.S. operations. The survey used to prepare this report is the annual "Lime" survey. Of the 108 operations to which the annual survey request was sent, 96 responded, representing 74% of the total sold or used by producers shown in table 2. Production for 11 nonrespondents was provided based on the monthly survey. Production for six nonrespondents was estimated using reported prior-year production figures.

In 1995, 61 companies produced lime. Leading producing companies, in descending order, were Dravo Lime Co., with two plants in Kentucky and one plant in Alabama; Chemical Lime Co., with two plants each in Alabama, Arizona, Nevada, and Texas and one each in California, Idaho, Missouri, and Utah; Marblehead Lime Co., with two plants in Illinois and one each in Indiana and Michigan; Mississippi Lime Co. in Missouri; Continental Lime Inc., with one plant each in Montana, Nevada, Utah, and Washington; Martin Marietta Magnesia Specialties in Ohio; APG Lime Co., with one plant each in Texas and Virginia; Bellefonte Lime Co., with two plants in Pennsylvania; Tarmac America, Inc. (formerly Wimpey Minerals PA), with two plants in Pennsylvania, and U.S. Lime & Minerals, Inc., with one plant each in Arkansas, Pennsylvania, and Texas. These 10 companies operated 35 plants and accounted for 71% of commercial sales and 64% of total lime production.

Domestic lime plant capacity is based on 365 days minus the average number of days for maintenance times the average 24-hour capacity of quicklime production, including quicklime converted to hydrated lime, and reported in short tons per year. In 1995, there were 38 commercial lime companies operating 61 lime plants; excluding combined captive and commercial producers, hydrating plants, and Puerto Rico. Capacity data were available from 32 commercial companies operating 52 plants. Based on the available data, the U.S. lime industry operated at 88% of capacity in 1995. Capacity utilization would be slightly lower if the capacity of several idle or mothballed plants were factored into the calculations.

On a regional basis, capacity utilization ranged from 82% to 97%. In the Mid-Atlantic Region (plants in eastern and central Pennsylvania, West Virginia, and northern Virginia) capacity utilization was 94%, based on data from seven companies operating eight plants. In the Southeastern Region (plants in Alabama, eastern Tennessee, and southern Virginia) capacity utilization was 92%, based on data from seven companies operating seven plants. In the Eastern Midwest Region (plants in Michigan, northern Kentucky, Ohio, and western Pennsylvania) capacity utilization was 90%, based on data from five companies operating six plants. In the Western Midwest Region (plants in Illinois, Indiana, Iowa, Missouri, and Wisconsin) capacity utilization was 82%, based on data from 9

companies operating 12 plants. In the South Central Region (plants in Arkansas, Louisiana, Oklahoma, and Texas) capacity utilization was 88%, based on data from six companies operating seven plants. In the Western Region (plants in Arizona, Colorado, Idaho, Montana, Nevada, Oregon, South Dakota, Utah, and Washington) capacity utilization was 86%, based on data from 6 companies operating 13 plants. *(See tables 2 and 3.)*

The lime industry continued the expansion of capacity begun in 1993. From 1993 to 1995, the commercial lime industry added over 1.9 million tons (2.1 million short tons) of new capacity, while losing 190,000 tons (210,000 short tons) of capacity. The lost capacity was the result of the closure of Warner Lime Co. in 1993. In 1995 alone, the industry added 1.5 million tons (1.7 million short tons) of new capacity. An additional 2.0 million tons (2.2 million short tons) of new capacity is planned for 1996 and 1997. Not included is the additional capacity planned by Martin Marietta Magnesia Specialties, a large combined captive and commercial producer of dolomitic lime in Ohio. Some of the announced new capacity will replace existing plant capacity, i.e., replacing older kilns with larger and more efficient new kilns, and may be partially offset by the closure or mothballing of some older plants.

Chemical Lime Co. started production at its new lime plant near Ste. Genevieve, MO, in December 1995. The first of two 1,100-ton-per-day (1,200-short-ton) Kennedy Van Saun (KVS) preheater rotary kilns went on-line. The second kiln was due on-line during the first quarter of 1996.[1]

Dravo Lime Co. completed the capacity expansion at its Black River Division at Carntown, KY. The expansion included the installation of two 1,000-ton-per-day (1,100-short-ton) KVS preheater rotary kilns; two lime storage silos; a barge loadout system; three coal storage silos; and a limestone processing, storage, and reclaim system. Dravo completed construction of a limestone byproducts processing plant at its Longview Division at Saginaw, AL.[2] The company announced expansion plans at its Maysville Division at Maysville, KY, including the addition of a new preheater rotary kiln and the upgrade of the underground mining operation. The new Maysville kiln will have a capacity of 1,000 tons per day (1,100 short tons per day) or about 330,000 tons per year (350,000 short tons per year).[3]

Global Stone Corp. of Canada purchased St. Clair Lime Co., a producer of quicklime, hydrate, and chemical-grade limestone located in Sequoyah County in northeastern Oklahoma. St. Clair Lime was subsequently renamed Global Stone St. Clair Inc.[4] Global Stone also purchased the assets of two Pennsylvania stone companies, Delta Carbonate Inc. and PenRoc Inc., located in York County, PA. The assets comprised three high-calcium limestone quarries producing construction aggregates and ground calcium carbonate, including high-brightness white fillers.[5]

Effective March 30, 1995, Bellefonte Lime Co. purchased the assets, real property, and mineral rights for the production of lime and limestone of its nearby competitor Centre Lime and Stone Co.[6] Acquisition of Centre Lime and Stone doubled Bellefonte's lime production capacity and strengthened its position in the Mid-Atlantic and Northeastern markets.

Greer Industries' Germany Valley Limestone Co., Riverton, WV, started up its new 450-ton-per-day (500-short-ton) KVS preheater rotary kiln in November 1995. This second kiln more than doubled the plant's production capacity.[7] In a subsequent development, Greer Industries announced the renaming of Germany Valley Limestone to Greer Lime Co. and the opening of a new sales office in Charlotte, NC.[8]

Continental Lime Inc. continued the major expansion at its Pilot Peak plant near Wendover, NV. The company began work on a third kiln for the plant due on-line during the second quarter of 1996. The newest kiln will have a capacity of 900 tons per day (1,000 short tons per day) and bring the total plant capacity to 1,900 tons per day (2,100 short tons per day).[9]

Consumption

Lime was consumed in every State, with the largest consuming States being Ohio, Pennsylvania, Indiana, Texas, and Michigan. Some States were net exporters, such as Alabama, Virginia, and Wisconsin. Some States were net importers, such as Ohio, Michigan, and Pennsylvania. *(See tables 2 and 4.)*

The breakdown of consumption by major end uses was as follows: 62% for chemical and industrial uses, 28% for environmental uses, 8% for construction uses, and 2% for refractory dolomite. Captive lime was used mainly in the production of steel in basic oxygen furnaces, in sugar refining, and in magnesia production.

In steel refining, quicklime was used as a flux to remove impurities such as phosphorus, silica, and sulfur. Dolomitic lime was often substituted for a fraction of the high-calcium lime to extend refractory life. Dead-burned dolomite, also called refractory lime, was used as a component in tar-bonded refractory brick used in basic oxygen furnaces. Despite an increase in U.S. raw steel production of more than 4% (more than 2% for basic oxygen furnace output and more than 7% for electric arc furnace output), lime consumption by the steel industry was essentially unchanged at 5.2 million tons (5.8 million short tons). The steel industry accounted for about 28% of all lime consumed in the United States.

The failure of lime consumption to increase in proportion to increases in steel production may have been the result of the use of larger amounts of scrap in basic oxygen furnaces, increased hot metal desulfurization, increased use of fluxed pellets, and improved efficiencies in steel production and energy consumption. Increased imports of quicklime from Canada were also part of the explanation. In 1995, imports of quicklime through the Detroit Customs District increased by 201% to 87,200 tons (96,200 short tons). This was undoubtably the result of the regional shortages experienced in 1995, when demand temporarily outstripped supply in the Western Midwest, Eastern Midwest, and Mid-Atlantic Regions.

In nonferrous metallurgy, lime was used in the beneficiation of copper ores to neutralize the acidic effects of pyrite and other iron sulfides and maintain the proper pH in the flotation process. It was used to process alumina and magnesia, to extract uranium

from gold slimes, and in the recovery of nickel by precipitation. It was used in gold and silver recovery operations to control the pH of the sodium cyanide solution used to leach the gold and silver from the ore. Such leaching processes are called dump leaching when large pieces of ore are involved, heap leaching when small pieces of ore are involved, and carbon-in-pulp cyanidation when the ore is leached in agitated tanks. Dump and heap leaching involve crushing the ore, mixing it with lime for pH control and agglomeration, and stacking the ore in heaps for treatment with cyanide solution. Lime is used to maintain the pH level of the cyanide solution between 10 and 11 to maximize precious-metals recovery and to prevent the generation of hydrogen cyanide gas.

The tailings that result from the recovery of precious metals may contain elevated levels of cyanides. Three of the four major treatment processes (Cyanisorb, alkaline chlorination, and SO_2/air) used to recover these cyanides used lime in the process.

In the environmental sector, lime was used in the softening and clarification of municipal potable water. Lime was used to neutralize acid mine and industrial discharges. In flue gas desulfurization (FGD) systems serving utility and industrial plants, lime was used to react with sulfur oxides in the flue gas, and was used to stabilize the resulting sludge before disposal. In 1995, the FGD market exhibited the large increase expected due to the startup of lime scrubbers at American Electric Power's Gavin powerplant in Ohio and Monongahela Power Co.'s Harrison powerplant in West Virginia. Consumption for FGD use in utility powerplants, industrial boilers, and incinerators grew an aggregate 37% to nearly 2.7 million tons (3.0 million short tons).

In sewage treatment, lime was used to control pH in the sludge digester, which removes dissolved and suspended solids that contain phosphates and nitrogen compounds. It also aided clarification and killing of bacteria. Lime also was used to stabilize sludges from sewage treatment plants.

Sewage sludge stabilization, also called biosolids stabilization, has as its goal the reduction of odors, pathogens, and putrescibility of the solids. In lime stabilization, the basic process involves mixing quicklime with the sludge to raise the temperature and pH of the sludge to minimum levels for a specified period of time. In 1995, the sewage treatment market increased by nearly 29%. This probably reflects the expected growth in the sewage sludge stabilization market, generated by the 40 CFR 257 part 503 sewage sludge regulations.

The paper industry used lime as a coagulant aid in the clarification of plant process water. It was used, generally in conjunction with soda ash, for softening plant process water. This is a precipitation process to remove bivalent soluble calcium and magnesium cations (and to a lesser extent manganese, ferrous iron, zinc, and strontium), which contribute to the hardness of water. This process also reduces carbonate alkalinity and dissolved solids content.

In the basic Kraft pulping process, wood chips and an aqueous solution (called liquor) of sodium hydroxide and sodium sulfide are heated in a digester. The cooked wood chips (pulp) are discharged under pressure along with the spent liquor. The pulp is screened, washed, and sent directly to the paper machine or for bleaching. Lime is sometimes used to produce calcium hypochlorite bleach for bleaching the paper pulp. The spent liquor is processed through a recovery furnace where dissolved organics are burned to recover waste heat and where sodium sulfide and sodium carbonate are recovered. The recovered sodium sulfide and sodium carbonate are diluted with water and then treated with slaked lime to recausticize the sodium carbonate into sodium hydroxide (caustic soda) for reuse.

Lime was used to make precipitated calcium carbonate (PCC), a specialty filler used in premium-quality coated and uncoated papers. The most common PCC production process used in the United States is the carbonation process. Carbon dioxide is bubbled through milk-of-lime, a suspension of hydrated lime in water, to form a precipitate of calcium carbonate and water. The reaction conditions determine the size and shape of the resulting PCC crystals.

The chemical industry used lime in the manufacture of alkalies. Quicklime was combined with coke to produce calcium carbide, which was used to make acetylene and calcium cyanide. Lime was used to make calcium hypochlorite, citric acid, petrochemicals, and other chemicals.

In sugar refining, milk of lime, a suspension of hydrated lime in water, was used to raise the pH of the product stream, precipitating colloidal impurities. The lime itself was then removed by reaction with carbon dioxide to precipitate calcium carbonate. Carbon dioxide was obtained as a byproduct of lime production.

Dolomitic quicklime was used as a flux in the manufacture of glass. Quicklime was used to make calcium silicate building products such as sand-lime brick; hydrated lime was used to produce silica refractory brick.

In construction, lime was used for soil stabilization to upgrade clay soils into satisfactory base and subbase materials. Common applications included the construction of roads, airfields, building foundations, earthen dams, and parking areas. Quicklime was used in autoclaved aerated concrete to produce building materials that could be cut, drilled, and nailed like wood, but with the advantages of a concrete product. Hydrated lime was used with fly ash to make a base material, in asphalt mixes to act as an antistripping agent, and in plaster, stucco, and mortar to improve durability. *(See table 5.)*

Although most lime is manufactured and sold or used as quicklime, there are some significant markets for hydrated lime. Total hydrated lime production was 2.37 million tons (2.61 million short tons), the vast majority of which was commercial sales. The construction and environmental markets were the largest consumers of hydrated lime. Sales of hydrate for construction uses (mainly asphalt, finishing lime, masonry, and soil stabilization) totaled 996,000 tons (1,098,000 short tons), which accounted for nearly 43% of total hydrate sales. Specific construction sales figures were as follows: asphalt, 206,000 tons (227,000 short tons); finishing lime, 82,000 tons (90,400 short tons); masonry, 161,000 tons (178,000 short tons); soil stabilization, 455,000 tons (502,000 short tons); and other

construction, 92,000 tons (101,000 short tons). Sales of hydrated lime for environmental uses (mainly acid neutralization, sewage treatment, and water purification) totaled 781,000 tons (861,000 short tons), which accounted for 33% of total hydrated lime sales. Specific sales figures for major environmental markets were as follows: acid neutralization, 132,000 tons (145,000 short tons); sewage treatment, 237,000 tons (261,000 short tons); and water purification, 285,000 tons (314,000 short tons).

Prices

Despite regional shortages in the lime supply and corresponding increases in spot prices, the overall average values for quicklime were essentially unchanged in 1995. Expected increases in the average values appear to have been reined in by the fierce competition between producers to aquire new powerplant FGD contracts and the moderating effect on prices of existing long-term steel and FGD contracts.

The average value of lime sold or used by producers, as reported to the U.S. Geological Survey on an f.o.b. plant basis, increased only slightly in 1995 to $59.42 per ton ($53.90 per short ton). Average values per ton were $58.63 ($53.18 per short ton) for chemical and industrial lime, $55.93 ($50.74 per short ton) for environmental lime, $71.15 ($64.54 per short ton) for construction lime, $79.48 ($72.11 per short ton) for agricultural lime, and $91.44 ($82.95 per short ton) for refractory dolomite.

The average value of quicklime sold was essentially unchanged at $56.77 per ton ($51.50 per short ton). Average values per ton sold were essentially unchanged for the following: chemical and industrial lime at $57.67 ($52.31 per short ton), environmental lime at $53.39 ($48.43 per short ton), and construction lime at $58.51 ($53.08 per short ton). The average value per ton of refractory dead-burned dolomite sold increased by 19% to $95.46 ($86.60 per short ton). Almost no quicklime was sold as aglime.

The average value of hydrated lime sold increased by 6% to $72.09 per ton ($65.40 per short ton). Average values per ton were essentially unchanged for chemical and industrial lime at $64.97 ($58.94 per short ton) and for environmental lime at $70.50 ($63.95 per short ton). The average value per ton of hydrate sold for construction increased by nearly 14% to $77.06 ($69.90 per short ton), and the average value for agricultural use increased 3% to $78.81 ($71.49 per short ton). The increase in the construction hydrate value may be partially the result of increased sales of hydrated lime slurry, which is considered a value-added product.

Foreign Trade

According to the Bureau of the Census, exports of lime were essentially unchanged at 71,900 tons (79,200 short tons). Imports of lime increased by 42% to 289,000 tons (318,000 short tons). Most U.S. trade was with Canada and Mexico, which together accounted for nearly 100% of the U.S. exports and imports of lime. Canada was the major trading partner, receiving 85% of U.S. exports and shipping 95% of U.S. imports. *(See table 1.)*

World Review

Canada.—Based on preliminary data, lime shipments totaled 2.5 million tons (2.8 million short tons) in 1995 at a value of about C$210 million. Commercial sales accounted for about 65% of the total. The industry was composed of 13 companies operating 19 plants in Alberta, British Columbia, Manitoba, New Brunswick, Ontario, and Quebec Provinces. Effective capacity utilization was approximately 70%. Apparent consumption decreased for the fourth year in a row and at 2.30 million tons (2.54 million short tons) was at the lowest level since 1987.[10]

Mexico.—Cal de Torreon S.A. de C.V., located in Coahuila State, placed an order for an oil-fired 400 ton-per-day (440-short-ton-per-day) MAERZ vertical shaft kiln. The new kiln was due on-line during the first quarter of 1996.[11]

South Africa.—Anglo Alpha's Union Lime Division was given approval to install a new kiln at its Ouplaas operation in the northern Cape. Installation of the new kiln is expected to be complete by the end of 1996, and the new kiln is expected to boost the plant's capacity by approximately 450,000 tons per year (500,000 short tons per year).[12]

The country's two largest lime producers, Union Lime and PPC Lime, ended their two-party lime cartel. The cartel agreement had the approval of the Government's Competitions Board, but the companies chose to voluntarily end the agreement. Termination of the agreement should boost competition with potential benefits to lime customers.[13]

United Kingdom.—In 1995, RMC Industrial Minerals Ltd. began work on a 5-year expansion program at its Hindlow lime plant located near Buxton, Derbyshire. The program called for the replacement of existing lime production facilities, while maintaining lime production. Phase I of the expansion program was scheduled for completion by the end of 1996, and consisted of replacement of the stone handling plant, installation of a MAERZ parallel flow regenerative vertical shaft kiln, replacement of the lime handling and lime grinding plants, and additional site work and infrastructure. Subsequent phases will include a stone washing plant, a second kiln, and replacement or upgrade of the hydration plant.[14] *(See table 6.)*

Current Research and Technology

An economic evaluation of the lime stabilization process for the treatment of sewage sludge (biosolids) was run comparing it to aerated-static pile composting and thermal drying. The study evaluated the competing Class A stabilization processes ability to handle sludge from facilities with varying capacities. Class A sludges can be distributed and marketed or land applied without the restrictions associated with Class B sludges. The economic evaluation included capital costs, annual operating and maintenance costs, and a present worth analysis. The study

concluded that lime stabilization had the lowest unit costs of the three processes evaluated.[15]

Lime manufacturing utilizing rotary kilns loses 16% to 18% of the stone charge to dust. If practical, such fines are generally sold for a few dollars per ton as aglime or for acid neutralization, or given away at no charge. Unfortunately, the majority has to be disposed of by the producer, generating a negative plant value. A possible alternative to disposal is the compaction of fines into briquets of similar size as pebble lime targeting traditional pebble lime markets. The basic equipment includes the roll-type press, screw feeder, binders or lubricants to increase the strength of the briquets, a troughed conveyor, and a vibrating screen. Builders of briquetting machinery maintain test facilities to determine compaction characteristics and are able to supply the data necessary to determine the type of roll press, feeder, additives, and briquetting conditions to deliver the best machine performance and product benefits to the lime producer.[16]

The basic concern of marketing such fines remains, whether they are sold as fines or as briquets. Lime producers do not want to impact their high-quality lime markets by offering a less expensive product to the same customers. But if capacity utilization remains high, it may be worth consideration by some producers to investigate briquetting as a means to produce additional lower-grade product.

Outlook

Lime has dozens of end uses in the chemical, industrial, and construction industries, but over 65% of consumption comes from six major markets: steel, FGD, water purification, pulp and paper, soil stabilization, and precipitated calcium carbonate.

Steelmaking is still the largest single end use for lime. The steel industry is continuing to add capacity in the form of flat roll minimills. Most of this new capacity is being built in the Southeast or Midwest. U.S. steel production should continue to increase as long as the economy stays out of a recession. Lime consumption will probably increase also, but may lag steel increases due to industry changes in raw materials and flux usage, the latter including greater use of flux pellets and hot metal desulfurization.

In 1995, the FGD market exhibited the large increase expected due to the startup of lime scrubbers at the General Gavin and Harrison powerplants in Ohio and West Virginia, respectively. Although future growth is not expected to be as dramatic, there are a number of positive factors influencing this market. There are the favorable economics of using lime in dry scrubbers used with small utility boilers (less than 25 megawatts), which will be regulated in Phase II of the Clean Air Act Amendments. Regulations covering small municipal incinerators and waste to energy incinerators favor the use of lime scrubbers. Major FGD lime producers are investing in research and development to lower the capital and operating costs associated with lime scrubbing and to produce salable byproducts. The goal of such research ultimately is to provide environmentally sound and economic technologies designed attract customers from powerplants currently utilizing limestone scrubbers and/or low sulfur coal. One negative is the evidence that the utility industry has been so successful in reducing SO_2 emissions that they have accumulated a large surplus of emissions allowances, which will allow them to delay installing scrubbers or closing older less efficient powerplants. Demand for FGD lime is expected to increase at a modest rate over the next few years.

Soil stabilization sales increased by 13% in 1995, but still fell substantially below the record year of 1993. The soil stabilization market fluctuates depending on the level of highway and related types of construction, the weather, and competition from competing products like cement. The use of lime in asphalt paving decreased by 12% in 1995, and although long-term growth is expected in this market, it is affected by the same uncertainties as soil stabilization.

Lime's traditional pulp and paper market was flat in 1995, as producers are apparently regenerating more lime from their carbonate sludge for environmental and cost reasons. The market will remain a large, mature market for lime, but growth is expected to be flat. The PCC market increased slightly in 1995 and should continue to grow as PCC attempts to expand into the groundwood paper and paper coating markets.

Overall, commercial lime sales are expected to grow at about 3% per year over the next several years. Any price increases expected because of shortages or increased demand will probably be negated by increased competition resulting from the addition of new capacity.

---

[1]McCaffrey, R. and J. D. Robinson. U.S. Lime Industry. The International Journal for Gypsum, Lime & Building Products, Apr. 1996, pp. 14-15.

[2]Dravo Corporation. News from Dravo Corporation (news release). Apr. 27, 1995, Dravo Corp., Pittsburgh, PA.

[3]_____. News from Dravo Corporation (news release). July 27, 1995, Dravo Corp., Pittsburgh, PA.

[4]Global Stone Corp. Global Stone Closes St. Clair Lime Acquisition (news release). Dec. 22, 1995, Global Stone Corp., Oakville, Ontario, Canada.

[5]_____. Global Stone Announces Unaudited Results for the Quarter to June 30, 1995 (news release). July 26, 1995, Global Stone Corp., Oakville, Ontario, Canada.

[6]Bellefonte Lime Co. Bellefonte Lime Company/Centre Lime and Stone (news release). Mar. 30, 1995, Bellefonte Lime Co., Wayne, PA.

[7]Work cited in footnote 1.

[8]National Lime Association. Germany Valley Establishes New Identity As Greer Lime. Lime-Lites, v. 62, No. 1, (1995-96), p. 6.

[9]Work cited in footnote 1.

[10]Vagt, O. Lime. Ch. in Can. Minerals Yearbook 1995, Natural Resources Canada, p. 34,1-34,7.

[11]World Cement. V. 26, No. 4, Apr. 1995, p. 13.

[12]Industrial Minerals (London). Anglo Alpha Expands Burnt Lime Capacity. No. 331, Apr. 1995, pp. 15-16.

[13]_____. Lime Cartel Dissolved. No. 334, July 1995, p. 14.

[14]World Cement. Phase I of RMC's Hindlow Plant Nears Completion. V. 26, No. 7, July 1996, pp. 2-4.

[15]Sullivan, D. G. and D. W. Oerke. Which Class A Biosolids

Stabilization Process is the Most Economical: Lime Stabilization, Composting, or Thermal Drying? Presented at the 94th Annual Convention of the National Lime Association, White Sulfur Springs, WV, May 5-9, 1996, 18 pp.

[16]Komarek, R. Roll-Press Briquetting—Squeezing Value from Lime. Industrial Minerals (London), No. 343, Apr. 1996, pp. 145-149.

OTHER SOURCES OF INFORMATION

U.S. Geological Survey Publications

Hubbard, H.A. and G.E. Erickson. Limestone and Dolomite. Ch. In United States Mineral Resources. USGS Prof. Paper 820, ed. by D.A. Brobst and W.P. Pratt, 1973, p. 357-364.

Lime. Ch. in Minerals Yearbook, annual.

Lime. Ch. in Mineral Commodity Summaries, annual.

Lime. Mineral Industry Surveys, monthly.

Other Sources

Chemical Economics Handbook, Lime.

Chemical Marketing Reporter.

Industrial Minerals (London).

Industrial Minerals and Rocks.

Industrial Specialty News.

Lime Lites (quarterly newsletter of National Lime Association).

Pit and Quarry.

Rock Products.

TABLE 1
SALIENT LIME STATISTICS 1/

(Thousand metric tons unless otherwise specified) 2/

		1991	1992	1993	1994	1995
United States: 3/						
Number of plants		112	112	112	114 r/	113
Sold or used by producers						
Quicklime		13,200	13,700	14,200	14,800	15,800
Hydrated lime		2,170	2,230	2,250	2,290	2,370
Dead-burned dolomite		308	302	315	300	308
Total		15,700	16,200	16,700 r/	17,400	18,500
Value 4/	thousands	$890,000	$950,000	$965,000	$1,020,000	$1,100,000
Average value per ton		$56.69	$58.64	$57.78 r/	$58.62	$59.46
Lime sold		13,800	14,300	14,900	15,500	16,300
Lime used		1,820	1,890	1,870	1,910 r/	2,180
Exports 5/		47	59	69	74	72
Value	thousands	$6,060	$7,540	$7,830	$7,800	$8,490
Imports for consumption 5/		158	193	201	204	289
Value	thousands	$11,100	$15,000	$13,300	$13,100	$20,200
Consumption, apparent 6/		15,800	16,300	16,900	17,500 r/	18,700
World: Production		131,000 r/	125,000 r/	122,000 r/	119,000 r/	120,000 e/

e/ Estimated. r/ Revised.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ To convert metric tons to short tons multiply metric tons by 1.10231.

3/ Excludes regenerated lime. Excludes Puerto Rico.

4/ Selling value, f.o.b. plant, excluding cost of containers.

5/ Bureau of the Census.

6/ Calculated by sold or used plus imports minus exports.

TABLE 2
LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/ 2/

	1994					1995				
State	Plants	Hydrated (thousand metric tons)	Quicklime (thousand metric tons)	Total (thousand metric tons)	Value (thousands)	Plants	Hydrated (thousand metric tons)	Quicklime (thousand metric tons)	Total (thousand metric tons)	Value (thousands)
Alabama	4	184	1,470	1,660	$88,300	4	183	1,550	1,730	$105,000
Arizona, Nevada, Utah	8	243	1,570	1,810	114,000	8	240	1,570	1,810	109,000
California	7	26	178	203	16,900	6	30	198	228	15,600
Colorado, Montana, Wyoming	10	--	335	335	20,900	10	5	340	346	21,600
Idaho, Oregon, Washington	8	25	609 r/	634 r/	45,500 r/	7	23	643	666	48,400
Illinois, Indiana, Missouri	8	464	2,910	3,380	184,000	8	451	3,000	3,450	188,000
Iowa, Nebraska, South Dakota	5	W	W	242	13,700	5	W	W	233	14,200
Kentucky, Tennessee, West Virginia	5	132	1,800	1,930	106,000	5	127	2,260	2,390	130,000
Michigan	9	26	611	637	33,000	9	38	615	653	34,600
Ohio	9	W	W	1,850	113,000	9	W	W	1,920	117,000
Pennsylvania	8	263	1,330	1,590	95,500	8	256	1,390	1,640	107,000
Texas	6	471	740	1,210	76,200	6	526	843	1,370	85,800
Virginia	5	121	621	742	40,200	5	132	598	731	41,900
Wisconsin	4	124	383	507	30,300	4	124	444	568	33,900
Other 3/	13 r/	236 r/	2,540 r/	571 r/	44,900 r/	13	255	2,700	798	50,400
Total	109	2,320 r/	15,100	17,400	1,020,000	107	2,390	16,100	18,500	1,100,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Excludes regenerated lime. Includes Puerto Rico.

2/ Data are rounded to three significant digits; may not add to totals shown.

3/ Includes Arkansas, Louisiana, Massachusetts, Minnesota, North Dakota, Oklahoma, Puerto Rico, and data indicated by the symbol W.

TABLE 3
LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, 1/ BY RANGE OF PRODUCTION 2/

	1994			1995		
Range of production	Plants	Quantity (thousand metric tons)	Percent of total	Plants	Quantity (thousand metric tons)	Percent of total
Less than 10,000 tons	9	52	(3/)	6	35	(3/)
10,000 to 25,000 tons	17 r/	258 r/	1	17	232	1
25,000 to 50,000 tons	12 r/	347 r/	2	11	326	2
50,000 to 100,000 tons	15	1,000	6	18	1,330	7
100,000 to 200,000 tons	24	3,080 r/	18	22	2,890	16
200,000 to 400,000 tons	21	5,220	31	22	5,850	32
More than 400,000 tons	11	7,450	42	11	7,870	42
Total	109	17,400	100	107	18,500	100

r/ Revised.

1/ Excludes regenerated lime. Includes Puerto Rico.

2/ Data are rounded to three significant digits; may not add to totals shown.

3/ Less than 1/2 unit.

TABLE 4
DESTINATION OF SHIPMENTS OF LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/ 2/

(Thousand metric tons) 3/

State	1994			1995		
	Quicklime	Hydrated lime	Total	Quicklime	Hydrated lime	Total
Alabama	619	53	673	545	46	591
Alaska	7	1	8	5	(4/)	6
Arizona	488	59	547	322	58	381
Arkansas	180	25	205	204	27	231
California	402	83	485	285	78	363
Colorado	73	38	111	142	35	176
Connecticut	21	6	27	19	3	23
Delaware	54	4	58	38	6	44
District of Columbia	13	13	26	17	15	32
Florida	390	24	414	400	25	426
Georgia	233	79	312	241	79	320
Hawaii	(5/)	(4/)	(4/)	(4/)	(4/)	(4/)
Idaho	210	2	213	218	3	220
Illinois	448	162	610	506	164	670
Indiana	1,550	34	1,590	1,460	32	1,490
Iowa	65	26 r/	90	64	27	91
Kansas	81	25	106	74	23	97
Kentucky	373	37	411	445	36	481
Louisiana	252	91	343	318	107	425
Maine	3	(5/)	3	4	(4/)	4
Maryland	104	17	121	160	17	177
Massachusetts	147	13	159	145	12	157
Michigan	940	30	969	914	30	944
Minnesota	271	18	289	334	20	354
Mississippi	194	22	216	219	31	250
Missouri	164	62	226	135	60	195
Montana	141	11	152	139	19	158
Nebraska	58	9	67	54	11	65
Nevada	468	46	515	494	48	542
New Hampshire	2	(5/)	2	2	(4/)	2
New Jersey	146	22	168	154	23	177
New Mexico	43	31	74	127	38	165
New York	83	31	114	87	28	116
North Carolina	197	44	241	199	56	256
North Dakota	225	3	228	282	3	285
Ohio	1,830	161	1,990	2,220	177	2,390
Oklahoma	138	13	151	131	10	141
Oregon	103 r/	27	130 r/	155	25	180
Pennsylvania	1,630	173	1,800	1,630	174	1,810
Rhode Island	2	1	3	2	1	3
South Carolina	223	45	268	255	42	298
South Dakota	20	3	22	24	3	27
Tennessee	203	52	256	211	52	262
Texas	716	468	1,180	802	511	1,310
Utah	288	26	314	303	27	331
Virginia	209	43	252	228	46	274
Washington	286 r/	17	303 r/	279	15	294
West Virginia	484	62	546	751	48	800
Wisconsin	136	40	176	144	40	184
Wyoming	97	20	117	186	18	204
Total	15,000 r/	2,270	17,300	16,100	2,350	18,400
Puerto Rico	(5/)	20 r/	20 r/	(4/)	20	20
Canada	62	17	79	55	14	68
Other 6/	28 r/	6	34 r/	25	6	32
Total	90 r/	43 r/	133 r/	80	40	120
Grand total	15,100 r/	2,310	17,400	16,100	2,390	18,500

r/ Revised.
1/ Excludes regenerated lime.
2/ Data are rounded to three significant digits; may not add to totals shown.
3/ To convert metric tons to short tons multiply metric tons by 1.10231.
4/ Less than 1/2 unit.
5/ Revised to zero.
6/ Includes other countries and U.S. possessions.

TABLE 5
LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/ 2/

(Thousand metric tons and thousand dollars) 3/

Use	1994				1995			
	Sold	Used	Total	Value	Sold	Used	Total	Value
Agriculture:	19	--	19	1,440	21	--	21	1,650
Chemical and industrial:								
Alkalies	W	W	115	5,790	W	W	72	3,050
Aluminum and bauxite	142	--	142	8,060	148	--	148	8,940
Copper ore concentration	W	W	W	25,200	W	W	W	21,300
Food products, animal or human	17	--	17	1,190	13	--	13	910
Glass	114	--	114	7,250	156	--	156	8,510
Oil well drilling	12	--	12	819	23	--	23	1,490
Oil and greese	36	--	36	4,420	13	--	13	618
Ore concentration, other	611	--	611	36,000	605	--	605	31,600
Paper and pulp	W	W	1,160	69,300	W	W	1,020	61,600
Petrochemicals	67	--	67	5,350	28	--	28	4,230
Precipitated calcium carbonate	W	W	654	35,200	W	W	677	37,000
Steel:								
Basic oxygen furnaces	W	W	4,250 r/	234,000 r/	W	W	4,100	237,000
Electric arc furnaces	1,050	--	1,050	59,800 r/	919	--	919	55,000
Argon oxygen decarburization	106	--	106	5,960	105	--	105	5,720
Ladle desulfurization, iron or steel	83	--	83	4,640	102	3	105	4,900
Other	227	--	227	12,800	342	2	343	20,200
Total steel	1,460 r/	W	5,710 r/	317,000 r/	1,470	5	5,570	323,000
Sugar refining	32	688 r/	720 r/	45,600 r/	26	802	827	52,200
Tanning	15	--	15	1,050	19	--	19	1,180
Other chemical and industrial 4/	6,950 r/	1,050 r/	1,830 r/	89,600 r/	6,970	1,200	2,300	117,000
Total	9,460 r/	1,740 r/	11,200	652,000 r/	9,470	2,000	11,500	673,000
Construction:								
Asphalt paving	238	--	238	13,000	209	--	209	13,700
Finishing lime	38	--	38	2,970	82	--	82	8,790
Mason's lime	(5/)	(5/)	168	11,100	(5/)	(5/)	194	15,700
Soil stablization	784	--	784	44,700	889	--	889	55,900
Other	188	--	188	19,100	92	--	92	10,000
Total	(5/)	(5/)	1,420	90,800	(5/)	(5/)	1,470	104,000
Environmental:								
Acid water, mine or plant	409	3	412	24,800	330	--	330	21,100
Flue gas sulfur removal	1,960	--	1,960	104,000	2,680	--	2,680	141,000
Industrial solid waste treatment	53	--	53	2,910	61	--	61	3,740
Industrial wastewater treatment	40	--	40	2,440	64	--	64	3,910
Scrubber sludge solidification	53	--	53	2,980	68	--	68	3,830
Sewage treatment	427	--	427	27,100	550	--	550	33,700
Water purification	1,160	--	1,160	67,600	1,160	--	1,160	67,800
Other	373	--	373	21,600	349	--	349	19,700
Total	4,470	3	4,480	254,000	5,260	--	5,260	294,000
Refractory lime (dead-burned dolomite)	(5/)	(5/)	300	25,000	(5/)	(5/)	308	28,100
Grand total	15,500	1,910 r/	17,400	1,020,000	16,400	2,180	18,500	1,100,000

r/Revised. W Withheld to avoid disclosing company proprietary data; included with "Other Chemical and Industrial."

1/ Excludes regenerated lime. Includes Puerto Rico.

2/ Data are rounded to three significant digits; may not add to totals shown.

3/ To convert metric tons to short tons multiply metric tons by 1.10231.

4/ Includes briquetting, brokers, calcium carbide, chrome, citric acid, commercial hydrators, desiccants, ferroalloys, fiberglass, glue, insecticides, magnesia from seawater or brine, magnesium metal, metallurgy, pelletizing, pharmaceuticals, rubber, silica brick, soap, and uses indicated by symbol W with "Chemical and industrial" lime only.

5/ Withheld to avoid disclosing company proprietary data; included in "Grand total."

TABLE 6
QUICKLIME AND HYDRATED LIME, INCLUDING DEAD-BURNED DOLOMITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1991	1992	1993	1994	1995 e/
Algeria (hydraulic) e/	61 4/	62	62	62	62
Australia e/	1,500	1,500	1,500	1,500	1,500
Austria	1,600 e/	1,716	1,811	1,850	1,800
Belgium	2,021	1,871	1,750 e/	1,750 e/	1,800
Belize e/	1	1	1	1	1
Bosnia and Herzegovina e/	XX	50	50	50	50
Botswana	(5/)	--	--	-- e/	--
Brazil e/	5,700	5,700	5,700	5,700	5,700
Bulgaria	1,034	729 r/	531 r/	500 r/ e/	500
Burundi	(5/)	(5/)	(5/) e/	(5/) r/ e/	(5/)
Canada	2,375	2,380	2,380	2,390 e/	2,567 4/
Chile (hydraulic) e/	1,200	1,300	1,300	1,250	1,000
China e/	18,500	19,000	19,500	19,500	20,000
Colombia e/	1,300	671	439	450	450
Congo e/	(5/)	(5/)	(5/)	(5/)	(5/)
Costa Rica e/	9 4/	9	10	10	10
Croatia e/	XX	144 r/	156 r/	150 r/	150
Cuba e/	180	160	180	170	180
Cyprus (hydrated)	7	6	6	6	6 4/
Czech Republic	XX	XX	1,147 r/	1,206 r/	1,186 4/
Czechoslovakia 6/	3,230	3,000 e/	XX	XX	XX
Denmark (sales)	114	128	124	125 e/	125
Egypt	749	749 e/	748 r/	750 r/ e/	750
Eritrea 7/	XX	XX	XX	6	7 4/
Ethiopia 7/	(5/)	(5/) e/	(5/) e/	3 r/	3
Finland	225 e/	241	250 e/	321 r/	300
France e/	3,000	3,000	3,000	3,015 r/ 4/	2,600
Germany	7,532	7,542	7,483	8,511 r/	8,000
Guadeloupe e/	5	5	5	5	5
Guatemala e/	72	70	70	70	72
Hungary	571	507 r/	476 r/	464 r/	480
India e/	820	850	860	860	900
Iran e/	650	650	650	650	650
Ireland	110	110	100 e/	100 e/	100
Israel e/	208 4/	208	208	210	210
Italy e/ 8/	3,800	3,600	3,600	3,500	3,500
Jamaica	95 e/	179	151 e/	170	175
Japan (quicklime only)	9,045	8,049	7,958	7,712 r/	7,871 4/
Jordan	5	7	7 e/	7 e/	7
Kenya e/	12 4/	12	12	12	12
Korea, Republic of e/	240	240	250	250	250
Kuwait e/	5 4/	5	35	40	40
Lebanon e/	10	15	15	15	15
Libya e/	260	260	260	260	260
Macedonia e/	XX	20	20	20	20
Malawi e/	4	4	3 r/	4 4/	1 4/
Martinique e/	5	5	5	5	5
Mauritius e/	7	7	7	7	7
Mexico e/	6,500	6,500	6,500	6,500	6,580 4/
Mongolia	76	68 r/	51 r/	66 r/	51 4/
New Zealand e/	90	100	100	100	100
Nicaragua	2	2	4 r/	2 e/	4
Norway e/	100	100	100	100	100
Panama e/	1 4/	2	2	2	2
Paraguay e/	100	100	100	100	100
Peru e/	14	14	14	14	14
Philippines e/	7 4/	10	10	10	10
Poland	2,413	2,526	2,584 r/	2,516 r/	2,500
Portugal e/	200	200	200	200	200
Romania	2,334 r/	1,738 r/	1,738 r/	1,621 r/	1,747 4/
Saudi Arabia e/	12	12	12	12	12
Serbia and Montenegro	XX	565	318 r/	369 r/	420
Slovakia	XX	XX	1,070	1,000 e/	1,000

See footnotes at end of table.

TABLE 6--Continued
QUICKLIME AND HYDRATED LIME, INCLUDING DEADBURNED DOLOMITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1991	1992	1993	1994	1995 e/
Slovenia e/	XX	250	250	300 r/	300
South Africa (sales)	1,765	1,738	1,599	1,597	1,688 4/
Spain e/	1,200	1,200	1,200	1,000	1,000
Sweden	506	460	500 e/	500 e/	500
Switzerland e/	40	30	40	40	40
Taiwan	614	670	650 e/	650 e/	650
Tanzania (calcined and hydrated) e/	1	2 4/	1	1	3
Tunisia e/	650	600	600	600	600
Turkey 9/	1,581	1,582	1,700 e/	1,800 e/	1,800
Uganda	2 e/	2	2	2 e/	2
U.S.S.R. e/ 10/	26,000	23,000 11/	20,000 11/	16,000 11/	16,000 11/
United Arab Emirates e/	45	45	45	45	45
United Kingdom e/	2,800	2,500	2,500	2,500	2,500
United States, including Puerto Rico (sold or used by producers)	15,700	16,200	16,800	17,400	18,500 4/
Uruguay e/	12	12	12	12	12
Yugoslavia 12/	1,600	XX	XX	XX	XX
Zaire	83	65	50 e/	40 e/	20
Zambia	184	212	227 r/	210 r/	210
Total	131,000 r/	125,000 r/	122,000 r/	119,000 r/	120,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through Aug. 1, 1996.

3/ Lime is produced in many other countries besides those listed. Argentina, Iraq, Pakistan, and Syria are among the more important countries for which official data are not available. Venezuela does not report production of lime, which is thought to be produced in very small amounts on individual farms. Previous estimates of lime production in Venezuela have lacked any basis, and will not be reported in the future.

4/ Reported figure.

5/ Less than 1/2 unit.

6/ Dissolved Dec. 31, 1992.

7/ Eritrea became independent from Ethiopia in 1993.

8/ Includes hydraulic lime.

9/ Data are lime produced for steel production and do not include the widespread artisanal production of lime for whitewash and sanitation purposes.

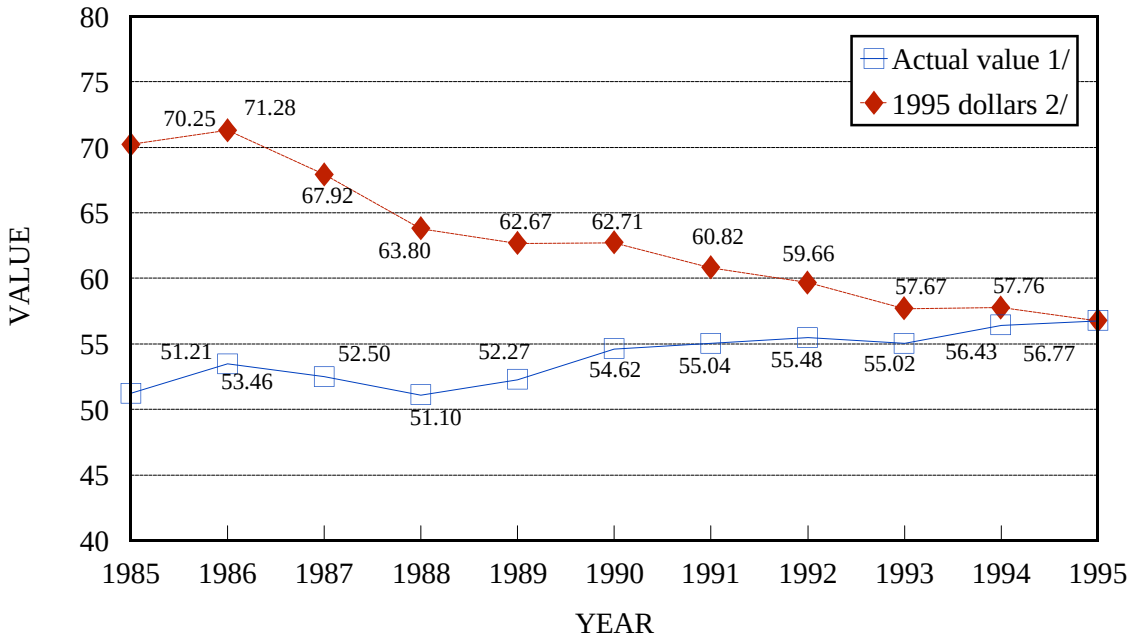
10/ Dissolved in Dec. 1991.

11/ Total production of the former U.S.S.R.. Information was inadequate to formulate reliable estimates for individual countries.

12/ Dissolved in Apr. 1992.

FIGURE 1

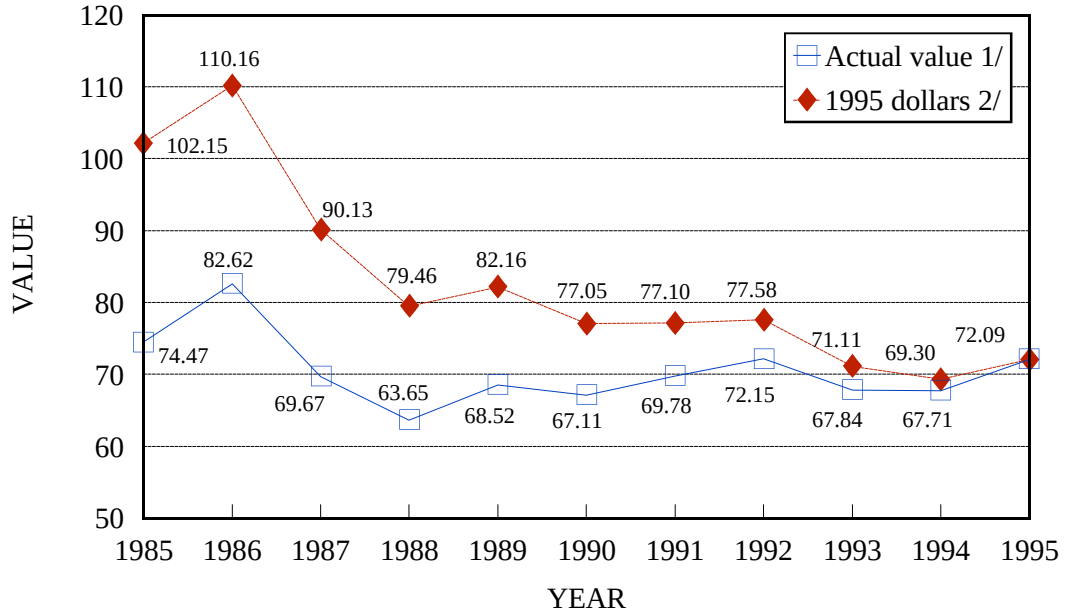
TIME-VALUE RELATIONSHIPS FOR QUICKLIME SOLD
(Dollars per metric ton)



1/ Value of lime sold as prepared for shipment, f.o.b. plant.
2/ Based on implicit price deflator for gross domestic product of nonfinancial corporate business.

FIGURE 2

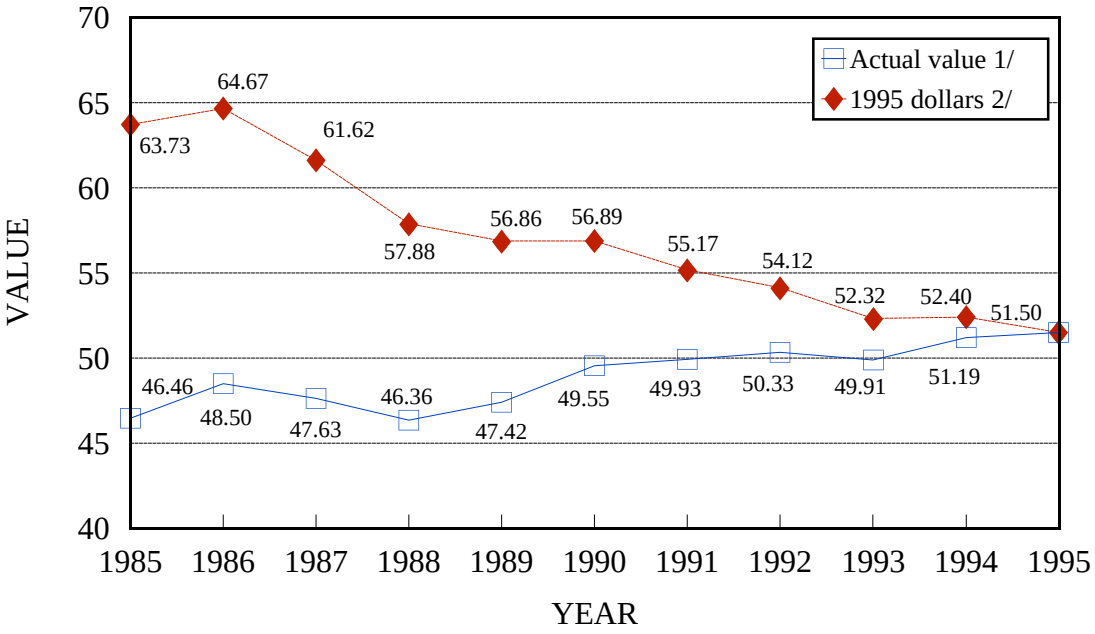
TIME-VALUE RELATIONSHIPS FOR HYDRATED LIME SOLD
(Dollars per metric ton)



1/ Value of lime sold as prepared for shipment, f.o.b. plant.
2/ Based on implicit price deflator for gross domestic product of nonfinancial corporate business.

FIGURE 3

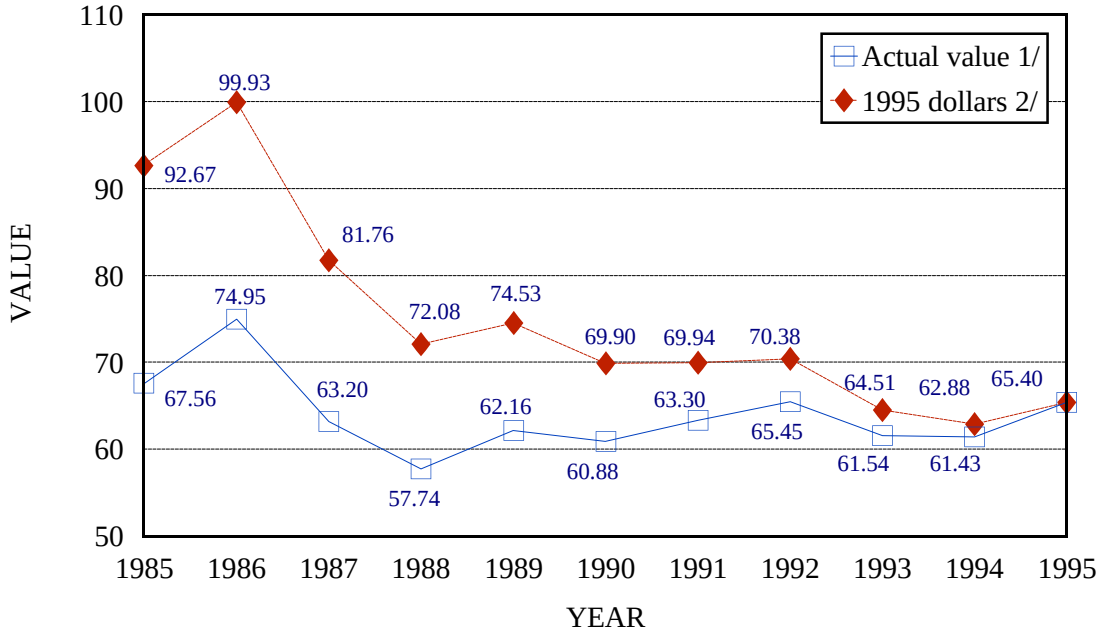
TIME-VALUE RELATIONSHIPS FOR QUICKLIME SOLD
(Dollars per short ton)



1/ Value of lime sold as prepared for shipment, f.o.b. plant.
2/ Based on implicit price deflator for gross domestic product of nonfinancial corporate business.

FIGURE 4

TIME-VALUE RELATIONSHIPS FOR HYDRATED LIME SOLD
(Dollars per short ton)



1/ Value of lime sold as prepared for shipment, f.o.b. plant.
2/ Based on implicit price deflator for gross domestic product on nonfinancial corporate business.