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KENTUCKY GEOLOGICAL SURVEY
UNIVERSITY OF KENTUCKY, LEXINGTON
Donald C. Haney, State Geologist and Director

***USE OF LIMESTONE, LIME,
AND DOLOMITE FOR SO₂
EMISSION CONTROL
IN KENTUCKY***

Garland R. Dever, Jr.

<https://doi.org/10.13023/kgs.ic31.11>

INFORMATION CIRCULAR 31
SERIES XI, 1990



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**USE OF LIMESTONE, LIME, AND DOLOMITE
FOR SO₂ EMISSION CONTROL
IN KENTUCKY**

Garland R. Dever, Jr.

COVER

Wet scrubbers for flue-gas desulfurization
retrofitted to Units 1 and 2 at the Tennessee
Valley Authority Paradise power plant in
Muhlenberg County, Kentucky

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USE OF LIMESTONE, LIME, AND DOLOMITE FOR SO₂ EMISSION CONTROL IN KENTUCKY

Garland R. Dever, Jr.

ABSTRACT

Flue-gas desulfurization and atmospheric fluidized-bed combustion systems for sulfur dioxide (SO₂) emission control have been installed at 13 coal- and gas-fired plants and one research laboratory in Kentucky. Limestone, lime, and dolomite are the principal SO₂ sorbents used in these systems.

Nine coal-fired, electricity-generating plants in the State have installed wet-scrubbing systems for flue-gas desulfurization. Lime-based scrubbers are using Thiosorbic® lime, produced from the Camp Nelson Limestone (Ordovician) of north-central Kentucky, and carbide lime, a byproduct from the manufacture of acetylene in Louisville. Limestone-based scrubbing systems at three of the plants have used stone from the Warsaw, Ste. Genevieve, and Paoli Limestones (Mississippian) of western and west-central Kentucky, southern Indiana, and southern Illinois. An experimental dry scrubber operated by the Tennessee Valley Authority uses lime produced from the Moccasin Formation (Ordovician) of eastern Tennessee.

Limestone and dolomite are employed as SO₂ sorbents in commercial, research, and demonstration atmospheric fluidized-bed combustion (AFBC) units. The New Market Limestone (Ordovician) from northern Virginia and a mixed sorbent consisting of Camp Nelson Limestone from north-central Kentucky and Peebles and Greenfield Dolomites (Silurian) from southern Ohio are used in steam-generating systems equipped with AFBC units at two commercial plants. Pilot and demonstration plants operated by the

Tennessee Valley Authority to test and demonstrate utility-scale AFBC units have used Warsaw and Ste. Genevieve Limestones from western Kentucky. Dolomite from the Oregon Formation and limestone from the Grier Limestone Member of the Lexington Limestone, both Ordovician units in central Kentucky, have been used for tests of coals and alternate fuels in an industrial-size AFBC pilot plant, operated by the University of Kentucky and Kentucky Energy Cabinet. Pilot-plant tests have shown that other Kentucky dolomites (Silurian Laurel Dolomite and Mississippian Renfro Member of the Slade Formation) and limestones (Mississippian Salem and Warsaw Formations and Ste. Genevieve Limestone) also are effective AFBC sorbents.

INTRODUCTION

Coal-fired power plants and coal mines in Kentucky, the second largest coal-producer in the United States, are an important market for industrial minerals. Carbonate rocks and lime are used in environmental-control measures to meet Federal, State, and local standards for mine safety and reclamation, air quality, and water quality.

This report outlines the utilization of limestone, lime, and dolomite by coal- and gas-fired plants in Kentucky to meet air-quality standards, specifically sulfur dioxide (SO₂) emission standards. Both flue-gas desulfurization and fluidized-bed combustion systems are operating in the State.

LEGISLATION AND REGULATIONS

Amendments to the present Federal Clean Air Act are currently (May 1990) being considered by Congress, and could result in revised SO₂ emission standards and control strategies that would increase the use of limestone, lime, and dolomite in emission control. One of the proposals submitted to Congress seeks to cut SO₂ emissions by 10 million tons a year, a reduction of almost 50 percent from current levels which would be achieved in two phases (Brown, 1989). Emissions from coal-fired power plants would be reduced to 2.5 lbs SO₂ per million Btu in the first phase and then lowered to 1.2 lbs SO₂ per million Btu during the second phase. Many coal-fired plants in Kentucky would be affected if these or similar reduced emission standards are enacted. The potential impact of revised SO₂ emission standards on Kentucky's coal resources has been calculated by Cobb and others (1982, 1989).

Federal and State legislation and regulations establishing standards for allowable SO₂ emissions from coal-fired steam generating plants follow from the Federal Clean Air Amendments of 1970 and Clean Air Act Amendments of 1977, pursuant U.S. Environmental Protection Agency (EPA) regulations, Kentucky Revised Statutes Chapters 77 (Air Pollution Control) and 224 (Environmental Protection), and pursuant regulations of the Kentucky Division for Air Quality and Jefferson County Air Pollution Control District.

For regulating SO₂ emissions, coal-fired steam generating plants are classified as either *existing* or *new* sources of emissions. Plants with a capacity of more than 250 million Btu (73 MW) per hour heat input are classified as (1) existing sources if their construction started before August 17, 1971, and (2) new sources if construction or modification started on or after August 17, 1971 (Kentucky Division for Air

Quality regulations 401 KAR 59:015 and 401 KAR 61:015; U.S. Environmental Protection Agency, 1971c). Plants with a capacity of 250 million Btu per hour heat input or less are classified as (1) existing sources if construction started before April 9, 1972, and (2) new sources if construction started on or after April 9, 1972 (Kentucky Division for Air Quality regulations 401 KAR 59:015 and 401 KAR 61:015).

Existing Sources

SO₂ emissions from existing sources are regulated to attain and maintain National and state ambient air quality standards. In 1971, national ambient air quality standards and requirements for state implementation plans to attain the standards were promulgated by the EPA (U.S. Environmental Protection Agency, 1971a, 1971b), pursuant to the Clean Air Amendments of 1970 (Federal Register Office, 1971). Kentucky's Statewide air quality standard for SO₂, adopted in 1970, was revised in 1973 and conforms with the National standard.

The strategy adopted in Kentucky for attaining and maintaining ambient air quality standards for SO₂ was to classify each county in the State. Based on air quality monitoring data, counties were classified as attainment (meeting standards) or nonattainment (not meeting standards). Allowable SO₂ emissions from existing sources are based on the classification of the county where the source is located (Kentucky Division for Air Quality regulations 401 KAR 50:025 and 401 KAR 61:015; Jefferson County Air Pollution Control District Regulation 6.07). The standards range from 1.2 to 6.0 lbs SO₂ per million Btu of heat input for coal-fired units with a capacity of 250 million Btu per hour heat input or more. For coal-fired sources of less than 250 million Btu per hour heat input, the standards generally range from 1.3 to 9.0 lbs SO₂ per million Btu of heat input.

New Sources

SO₂ emission standards for new fossil-fuel-fired steam generating units were promulgated by the EPA in 1971, pursuant to the Clean Air Amendments of 1970. The standards established a limitation of 1.2 lbs SO₂ per million Btu of heat input for coal-fired steam generating units of more than 250 million Btu per hour heat input (U.S. Environmental Protection Agency, 1971c). In Kentucky, SO₂ standards range from 1.2 lbs SO₂ per million Btu heat input for new coal-fired sources of 250 million Btu per hour heat input or more to 5.0 lbs SO₂ per million Btu heat input for new coal-fired sources of 10 million Btu per hour heat input or less (Kentucky Division for Air Quality regulation 401 KAR 59:015; Jefferson County Air Pollution Control District Regulation 7.06). In Jefferson County, the standard is 4.0 lbs SO₂ per million Btu per hour heat input for new coal-fired sources with a total heat input capacity of 10 million Btu per hour or less.

The Clean Air Act Amendments of 1977 defined a more stringent standard of performance for new fossil-fuel-fired stationary sources. As amended, standard of performance means both establishing allowable emission limits and requiring a percentage reduction in emissions which are achievable through the application of the best *technological* system of continuous emission reduction (Federal Register Office, 1980). Percentage reduction is calculated from the ratio of controlled emissions to the potential uncontrolled emissions. In contrast, the 1970 Act required only the establishment of emission standards achievable through the application of the best system of emission reduction which included the burning of compliance coal.

Pursuant to the 1977 Act, the EPA promulgated performance standards for fossil-fuel-fired electric utility steam-generating units capable of more than 250 million Btu per hour heat input on which construction or modifica-

tion was started after September 18, 1978 (U.S. Environmental Protection Agency, 1979). For coal-fired electric utility units, the SO₂ emission limit is 1.2 lbs SO₂ per million Btu heat input, and a 90-percent reduction in potential SO₂ emissions is required at all times, except when emissions are less than 0.6 lb SO₂ per million Btu heat input, a 70-percent reduction in potential emissions is required. The Kentucky Division for Air Quality regulation 401 KAR 59:016 requires the same emission limits and percent reductions, but they are applicable to coal-fired units of more than 250 million Btu per hour heat input on which construction started on or after September 19, 1978.

New-source performance standards for industrial-commercial-institutional steam generating units (other than electric utility units covered by the 1979 EPA regulations and petroleum refineries), for which construction or modification started after June 19, 1986, were promulgated by the EPA in 1987, pursuant to the Clean Air Act Amendments of 1977. Coal-fired units with a heat-input capacity greater than 100 million Btu (29 MW) per hour generally are required to achieve a 90-percent reduction in potential SO₂ emissions and to meet an emission limit of 1.2 lbs SO₂ per million Btu heat input (U.S. Environmental Protection Agency, 1987).

FLUE-GAS DESULFURIZATION

Wet-scrubbing systems employing either lime or limestone have been installed at nine coal-fired, electricity-generating plants for flue-gas desulfurization (FGD) (Fig. 1). With one to four scrubber-equipped coal-burning units at each of the nine plants, a total of 16 scrubbers have been installed in Kentucky, including one dual-alkali scrubber. Several of these plants also have coal-fired units operating without scrubbing systems. The units without scrubbers and the other coal-fired power plants in the State meet SO₂ emission

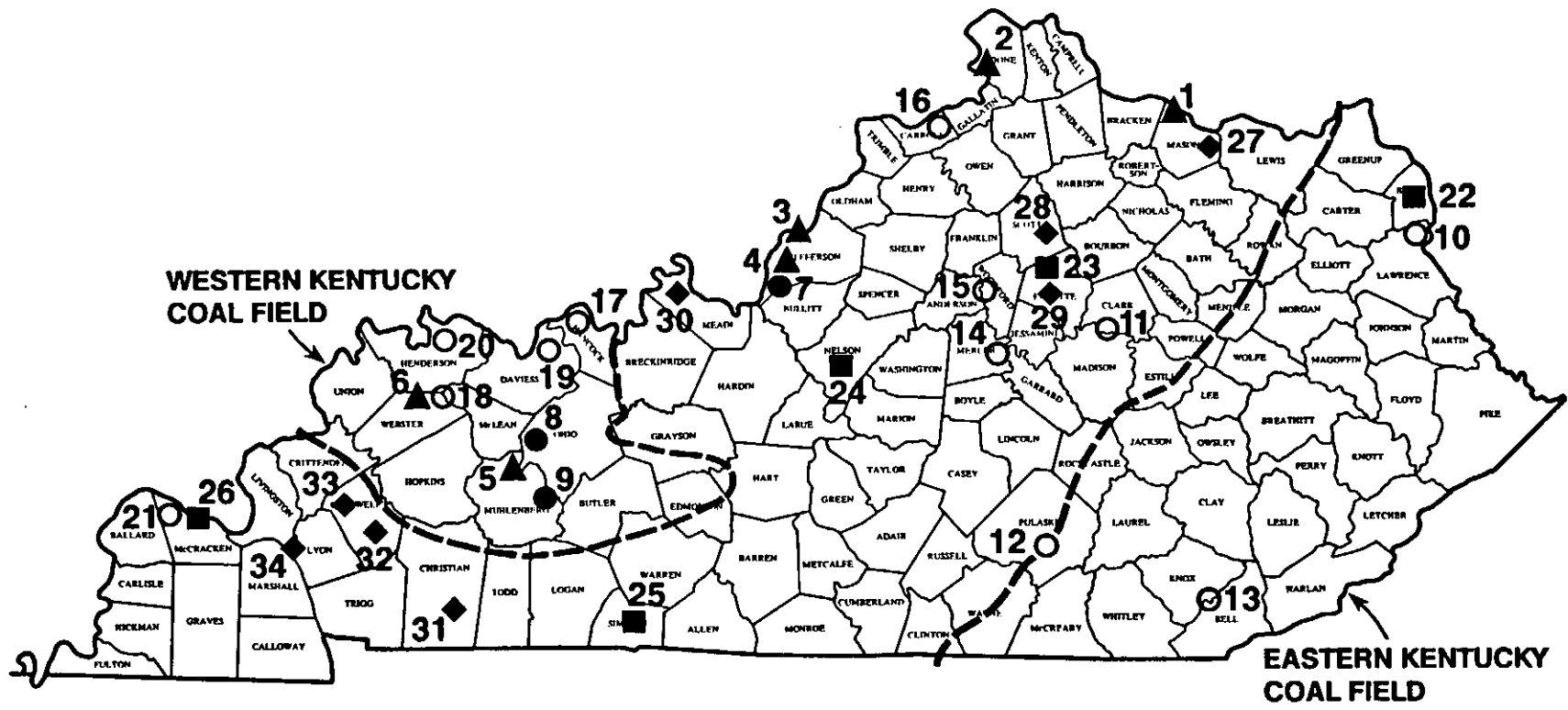


Figure 1. Map of Kentucky showing: (1) SO₂ emission control strategy of coal-fired electric utility plants [flue-gas desulfurization (FGD) or burning low- and medium-sulfur coal], (2) atmospheric fluidized-bed combustion plants, (3) sources of stone for SO₂ emission control, and (4) coal fields. Modified from Enoch (1983). Explanation for Figure 1 on following page.

EXPLANATION FOR FIGURE 1

COAL-FIRED ELECTRIC-UTILITY PLANTS

▲ FGD—Lime

1. East Kentucky Power Spurlock
2. Cincinnati Gas & Electric East Bend
3. Louisville Gas & Electric Paddys Run
4. Louisville Gas & Electric Cane Run
5. Kentucky Utilities Green River
6. Big Rivers Electric Green

● FGD—Limestone

7. Louisville Gas & Electric Mill Creek
8. Big Rivers Wilson
9. Tennessee Valley Authority Paradise

○ Low- and Medium-Sulfur Coal

10. Kentucky Power Big Sandy
11. East Kentucky Power Dale
12. East Kentucky Power Cooper
13. Kentucky Utilities Pineville
14. Kentucky Utilities Brown
15. Kentucky Utilities Tyrone
16. Kentucky Utilities Ghent
17. Big Rivers Coleman
18. Big Rivers Reid
19. Owensboro Municipal
20. Henderson Municipal
21. Tennessee Valley Authority Shawnee

■ AFBC PLANTS

22. Ashland Petroleum Co.
23. University of Kentucky
24. Bardstown Fuel Alcohol Co.
25. Kentucky Agricultural Energy Corp.
26. Tennessee Valley Authority

◆ QUARRY/MINE

27. Dravo Lime Co. mine
28. Nally & Gibson Georgetown Inc. quarry
29. Vulcan Materials Co. mine
30. Kosmos Cement Co. quarry
31. Hopkinsville Stone Co. quarry
32. Kentucky Stone Co. quarry
33. Fredonia Valley Quarries quarry
34. Reed Crushed Stone Co. quarry

standards by burning medium- to low-sulfur coal. Data for FGD systems in Kentucky, including operational, under-construction, and planned systems, were reported by Enoch (1983).

In wet scrubbers, briefly, finely ground limestone or lime is mixed with water to form a slurry which is sprayed into the SO_2 bearing flue gas. Calcium reacts with SO_2 to produce CaSO_3 and CaSO_4 , which form a precipitate that is removed from the system as sludge.

The tonnage of limestone and lime required for scrubbing is dependent mainly upon (1) the demand for electricity and (2) the sulfur content of the coal. The three plants in Kentucky using limestone require a total of about 800,000 tons of stone a year. Total consumption by currently operating lime-based scrubbers is estimated to be 400,000 to 450,000 tons per year.

Limestone

The two scrubbers at the Tennessee Valley Authority (TVA) Paradise plant in Muhlenberg County use oolitic limestone, produced from the Ste. Genevieve Limestone (Mississippian) by selective quarrying. Ledges of oolitic limestone are the principal source of chemically pure stone in the formation (Dever and McGrain, 1969). From 1983 to 1988, the stone was obtained from the Hopkinsville Stone Co. Pembroke quarry, with a small quantity coming from the Hopkinsville Aggregate Co. U.S. 41A quarry, both in Christian County. In late 1988, TVA awarded a 5-year contract to The Kentucky Stone Co. which is producing oolitic limestone from its Princeton quarry in Caldwell County. Stone is delivered to the Paradise plant by rail, but initially was transported by truck during the first contract.

The slurry of calcium sulfite (CaSO_3) and sulfate (CaSO_4) from the Paradise scrubbers is oxidized to produce gypsum prior to being

pumped into a settling pond. In November 1987, the Georgia-Pacific Corp. announced plans to build a 270-million-square-foot annual capacity gypsum-wallboard plant at Paradise which would use the synthetic gypsum produced by the power plant (Rock Products, 1988b).

Bioclastic limestone was used for scrubbing at the Big Rivers Electric Corp. Wilson plant in Ohio County from 1984 to 1989. It was selectively quarried from the Warsaw Limestone (Mississippian) at the Reed Crushed Stone Co. Lake City quarry in Livingston County. In midyear 1989, Big Rivers awarded a new contract to Rigsby & Barnard Quarry, Inc., which is supplying oolitic limestone produced from the Ste. Genevieve Limestone at its Cave-In-Rock quarry in Hardin County, Illinois. Stone is delivered to the Wilson plant by barge.

In November and December 1988, the four scrubbers at the Louisville Gas and Electric Co. (LG&E) Mill Creek station in Jefferson County were converted from carbide lime to limestone. The Kosmos Cement Co. has a 10-year contract to provide the limestone (Rock Products, 1988a). A ground-limestone slurry is produced at its Kosmosdale cement plant and transported by pipeline to holding tanks at the Mill Creek station, a short distance north of the cement plant. Limestone for the slurry is obtained mainly from the Mulzer Crushed Stone, Inc. quarry in Crawford County, Indiana, and in part from the Kosmos Cement Co. Battletown quarry in Meade County, Kentucky, both of which operate in the Ste. Genevieve and Paoli Limestones (Mississippian). The scrubber at the LG&E Trimble County power plant, currently under construction, will use limestone from a yet-to-be-determined source.

Tests of wet-scrubbing and dry-injection processes at the TVA Shawnee power plant, McCracken County, employed, among other carbonate-rock materials, high-calcium and

dolomitic stone produced from the Ste. Genevieve at the Fredonia Valley Quarries Fredonia quarry in Caldwell County (Drehmel and Harvey, 1974; Enoch, 1983; Burnett and others, 1987). In wet-scrubbing tests, the dense, dolomitic stone had a lower SO₂ sorption capacity compared to the porous, high-calcium, oolitic limestone (Drehmel and Harvey, 1974).

Based on specification data furnished by several companies, the limestones used for wet-scrubbing systems in Kentucky have a relatively high calcium carbonate (CaCO₃) content (minimum 88–90%) and a low magnesium carbonate (MgCO₃) content (maximum 4–6%). Typical specifications include maximum allowable contents for noncarbonate constituents in the limestone: 3.5–5.0% silica (SiO₂); 1.2–6.0% aluminum and iron oxides (Al₂O₃ + Fe₂O₃); 1.0% alkalis (Na₂O + K₂O); 0.3% sulfur (S); 0.03% chlorine (Cl); and 0.03% fluorine (F).

Grindability, generally expressed as a maximum Bond Work Index of 11 or 12, is specified because the limestone must be finely ground (commonly 90% minus 325 mesh) to form a slurry and because limestone reactivity is partly dependent upon available reactive surface area. The Bond Work Index relates energy requirements for grinding to the particle size of feed and product materials. The specified particle size for delivered stone generally is minus 3/4 inch, with a minimum of 50 to 60 percent retained on a 1/4-inch screen.

Lime

Four Kentucky power plants use Thiosorbic® lime for scrubbing: (1) Big Rivers Electric Corp. Green plant, Webster County; (2) Cincinnati Gas & Electric Co. East Bend plant, Boone County; (3) East Kentucky Power Coop. Spurlock plant, Mason County; and (4) Kentucky Utilities Co. Green River plant, Muhlenberg County. The Spurlock scrubber currently is inactive. The Green River plant formerly

used lime produced from the Salem Limestone (Mississippian) by the Mississippi Lime Co. in Ste. Genevieve County, Missouri, but switched to Thiosorbic® lime in 1988.

Thiosorbic® lime, containing 5 to 7 percent magnesium oxide (MgO), is produced for the scrubber market by the Dravo Lime Co. at its 1-million-ton per year Maysville plant in Mason County, the second largest lime plant in the United States (Mining Engineering, 1977; Hoffman, 1981). Stone is supplied from a 3-million-ton per year underground mine in the Camp Nelson Limestone (Ordovician) at the site. The lime is shipped by barge, with most of the production going to power plants outside Kentucky.

Carbide lime, a byproduct from the manufacture of acetylene by the Carbon and Graphite Group (formerly Airco Carbide) in Louisville, has been used by the Louisville Gas and Electric Co. for scrubbing at its Paddys Run, Cane Run, and Mill Creek stations in Jefferson County. The byproduct lime is composed mainly of calcium hydroxide, Ca(OH)₂.

At the Cane Run plant, two units use the carbide-lime slurry for scrubbing. A third unit has a dual-alkali scrubber, using a sodium-based alkali for SO₂ removal and carbide lime to regenerate the sodium solution (Enoch, 1983). Paddys Run, a peaking station, has been retired. Its No. 6 unit was retrofitted with the first commercial scrubber in Kentucky, which began operating in April 1973 (Enoch, 1983). In 1988, the four scrubbers at the Mill Creek plant were converted from carbide lime to limestone, as noted above.

A 10-MW spray dryer/electrostatic precipitator pilot plant has been installed on one of the 10 coal-fired units at the TVA Shawnee plant in McCracken County (Burnett and others, 1987). It is using lime produced from the Moccasin Formation (Ordovician) by the Tenn-Luttrell Lime Co. in Union County, Tennessee. The lime is trucked to the plant.

FLUIDIZED-BED COMBUSTION

Three industries in Kentucky have installed atmospheric fluidized-bed combustion (AFBC) units in steam-generating systems (Fig. 1) (Dixon, 1983). Research and demonstration units for evaluating utility-scale and industrial-size applications are operated by the Tennessee Valley Authority and University of Kentucky.

Briefly, atmospheric fluidized-bed combustion is a method of burning crushed coal in a bed of crushed limestone or dolomite that is suspended, or "fluidized," by an upward flow of air. The flowing air turns the coal and limestone/dolomite mixture into a turbulent mass resembling a bubbling liquid. Calcined limestone/dolomite reacts with SO_2 released by the burning coal to form calcium sulfate, a dry solid, which is removed from the bottom of the boiler. Sulfur dioxide capture is primarily dependent upon the amount of limestone/dolomite in the boiler, particle surface area, and gas and solids residence time (Tennessee Valley Authority, 1986).

Commercial Units

The Ashland Petroleum Co. Catlettsburg refinery in Boyd County operates two steam-generating systems equipped with fluidized-bed units for SO_2 removal (Dixon, 1983). Refinery off-gas, along with auxiliary fuel, is burned to produce superheated steam for use in the refinery. The fluidized-bed units use a mixed sorbent consisting of about equal amounts of dolomite and dolomitic limestone, totaling about 300 tons of stone per day. The dolomite is from the Peebles and Greenfield Dolomites (Silurian), produced at the Davon, Inc. Plum Run quarry in Adams County, Ohio. Dolomitic limestone is obtained from the Dravo Lime Co. mine, Mason County, Kentucky, operating in the Camp Nelson Limestone (Ordovician). Stone is trucked to the refinery.

The Kentucky Agricultural Energy Corp. fuel-alcohol plant at Franklin in Simpson County operates two steam-generating systems equipped with fluidized-bed units for SO_2 removal (Dixon, 1983). Coal is burned to generate saturated steam used in manufacturing ethanol. These fluidized-bed units require a low-attribution limestone, and the principal source of stone has been the New Market Limestone (Ordovician) produced by the Genstar Stone Products Co. Middletown quarry, Frederick County, Virginia. The plant has used limestones from Kentucky, including Camp Nelson Limestone (Ordovician; Dravo Lime Co. mine, Mason County), Ste. Genevieve Limestone (Mississippian; Fredonia Valley Quarries quarry, Caldwell County), and limestones from various south-central Kentucky quarries, but their attrition characteristics are not as satisfactory as the New Market for these particular fluidized-bed units. The two units require a total of about 50 tons of limestone per day. Stone has been transported to the plant by truck and, more recently, by rail. The plant has been idle since July 1988.

The Bardstown Fuel Alcohol Co. plant near Bardstown in Nelson County operated an AFBC unit in its steam-generating system used in the production of fuel alcohol (Dixon, 1983). Low-sulfur coal was burned to meet air-quality standards, and sand, rather than limestone, was used to maintain proper bed conditions. The plant has been closed for several years.

Research and Demonstration Units

In 1982, the Tennessee Valley Authority (TVA) started operating a 20-MW (electric) AFBC pilot plant on its Shawnee power plant reservation in McCracken County (Dixon, 1983). This pilot operation, jointly funded by TVA and the Electric Power Research Institute, simulates power-plant operating conditions and provided data for designing a 160-MW

(electric) utility-scale AFBC demonstration plant. The test program investigated process performance, system and equipment reliability, load-following and control-system development, and coal and limestone feeding (Castleman, 1985; Tennessee Valley Authority, 1986). The pilot plant has operated for approximately 20,150 hours and has consumed about 124,000 tons of coal and about 45,000 tons of limestone. It currently is being modified for additional tests.

Two limestones were used and evaluated in the 20-MW pilot-plant test program: (1) bioclastic limestone from the Warsaw Limestone (Mississippian; Reed Crushed Stone Co. Lake City quarry, Livingston County); and (2) oolitic limestone from the Ste. Genevieve Limestone (Mississippian; Fredonia Valley Quarries Fredonia quarry, Caldwell County). The new-source performance standard of 90 percent sulfur retention was achieved with both limestones while burning high-sulfur Springfield coal (Western Kentucky No. 9; 3-6% S). The oolitic limestone (95% CaCO₃) of the Ste. Genevieve, however, was softer, less abrasive, and better for SO₂ capture than the bioclastic limestone (88% CaCO₃) of the Warsaw (Castleman, 1985). The limestones were delivered to the plant by truck.

Startup of a 160-MW (electric) AFBC demonstration plant at the TVA Shawnee power plant, McCracken County, began in October 1988. The demonstration plant was built beside the Shawnee No. 10 unit and utilizes its turbine and generator. The operating, economic, and environmental performance of a utility-scale AFBC unit will be demonstrated during a 4-year test and demonstration program and subsequent 6-year commercial operation period (Jacobs, 1988; Tennessee Valley Authority, 1988). Project principals and participants include the TVA, Electric Power Research Institute, Duke Power Company, Com-

monwealth of Kentucky, Combustion Engineering, Inc., Atmospheric Fluidized Bed Development Corporation, and U.S. Department of Energy. The design-basis coal is the high-sulfur Springfield coal (Western Kentucky No. 9), the same coal as used in the 20-MW pilot plant, but testing of other fuels also is planned.

The demonstration plant is using oolitic limestone selectively quarried from the Ste. Genevieve Limestone (Mississippian) at The Kentucky Stone Co. Princeton quarry in Caldwell County. In late 1988, The Kentucky Stone Co. was awarded a 1-year contract, with an option to renew for two years, to supply 125,000 tons of limestone (Rock Products, 1988c). Stone is transported to the plant by rail. Limestone specifications include CaCO₃ (93% minimum; dry); SiO₂ (5% maximum); moisture (5% maximum); hardness (11 maximum; Kennedy Van Saun Work Index); and particle size (3 inch x 1 inch; maximum 5% less than 1 inch).

An industrial-size, 2.7 million Btu/hour (0.79 MW thermal), AFBC pilot plant at the University of Kentucky Center for Applied Energy Research (CAER)¹ in Fayette County has been in operation since 1982. The pilot plant was designed for research and to demonstrate the feasibility of AFBC technology for industrial and utility use (Burghardt and others, 1983; Dixon, 1983). The research program has evaluated: (1) performance of Kentucky coals, (2) behavior of Kentucky limestones and dolomites as sulfur sorbents, (3) performance of alternate fuels such as coal-preparation plant waste, and (4) effects of varying engineering parameters and construction materials, and component reliability in AFBC operations (see, for example, Institute for Mining and Minerals Research AFBC Group, 1984a, 1984b, 1984c, 1985; Adibhatla and Cunningham, 1985; Bland and others, 1986; Schaefer and others, 1986; Barron and others, 1987, 1989).

¹ Formerly Kentucky Energy Cabinet Laboratory and Kentucky Center for Energy Research Laboratory.

Three limestones and three dolomites from Kentucky were tested in the CAER pilot plant with the high-sulfur Springfield coal (Western Kentucky No. 9; average 3.5% S) to determine their sulfur-sorbent characteristics: (1) oolitic calcarenite (Ste. Genevieve Limestone, Mississippian, The Kentucky Stone Co. Irvington quarry, Breckinridge County); (2) crinoidal, bioclastic calcarenite (Salem and Warsaw Formations, Mississippian, Southern Aggregates, Inc. Scottsville quarry, Allen County); (3) fossiliferous, bioclastic calcarenite and calcisiltite (Grier Limestone Member of Lexington Limestone, Ordovician, Nally & Gibson Georgetown, Inc. Georgetown quarry, Scott County); (4) very finely to finely crystalline dolomite (Renfro Member of Slade Formation, Mississippian, Natural Bridge Stone, Inc. Bowen quarry, Powell County); (5) finely crystalline dolomite (Oregon Formation, Ordovician, Vulcan Materials Co. Central mine, Fayette County); and (6) very finely to medium crystalline dolomite (Laurel Dolomite, Silurian, Medusa Aggregates Co. Bardstown quarry, Nelson County) (Barron and others, 1987, 1989). Emission levels below the 1.2 lbs SO₂ per million Btu emission standard were achieved with all six stones. The dolomites, however, performed better than the limestones as SO₂ sorbents, based on their higher calcium utilization, higher sulfur-capture capacity, and lower SO₂ emission levels (Barron and others, 1989). The limestones had lower rates of attrition and elutriation from the bed, and slightly lower NO_x emission levels.

The Oregon dolomite and Grier limestone were used as sorbents during tests to evaluate the performance of Kentucky coals and preparation-plant waste in the CAER pilot plant. A recent project studying the corrosion of heat-exchange tubes used Ste. Genevieve oolitic limestone from the Fredonia Valley Quarries Fredonia quarry in Caldwell County as the sorbent. Stone is delivered to the pilot plant by truck.

SO₂ SORBENT RESOURCES IN KENTUCKY

Numerous and widespread limestone deposits of Mississippian and Ordovician ages in Kentucky have performed successfully as SO₂ sorbents in flue-gas desulfurization (FGD) and atmospheric fluidized-bed combustion (AFBC) systems (Table 1; Fig. 2). Additional deposits of similar stone potentially suitable for SO₂ emission control are present across the State.

Currently, oolitic limestone with a high calcium carbonate (CaCO₃) content, produced from the Ste. Genevieve Limestone (Mississippian), is being used in both FGD and AFBC systems. Deposits of high-calcium (CaCO₃ content of 95 percent or more) oolitic limestone are present in the Ste. Genevieve and younger Mississippian limestones (Paoli Limestone, Girkin Formation, Monteagle Limestone, Slade Formation, and Newman Limestone) of western, west-central, south-central, east-central, northeastern, and southeastern Kentucky (Stokley and McFarlan, 1952; Stokley and Walker, 1953; McGrain and Dever, 1967a, 1967b; Dever and McGrain, 1969; McGrain and Sutton, 1973; Dever and others, 1978, 1985). Mississippian oolitic limestones commonly are relatively soft, potentially reducing grinding costs in the preparation of FGD slurries. High-calcium, bioclastic limestone of the Warsaw Limestone (Mississippian), which has been employed successfully in FGD and AFBC systems, occurs in western Kentucky, in the region of the lower Cumberland, Tennessee, and Ohio Rivers (Dever and McGrain, 1969).

The Camp Nelson Limestone (Ordovician), presently being mined for the production of scrubber lime and used in AFBC boilers, is at a minable depth beneath a large part of central and north-central Kentucky. Widespread deposits of high-carbonate stone

Table 1. Sources Of Limestone, Dolomite, And Lime Used For SO₂ Emission Control In Kentucky.

SYS.	FORMATION	PRODUCTION LOCALITY	FGD ¹	AFBC ²
MISS.	Paoli Ls.	Kentucky, Indiana	Limestone	—
	Ste. Genevieve Ls.	Kentucky, Indiana, Illinois	Limestone	Limestone
	Salem Ls.	Missouri	Lime	—
	Warsaw Ls.	Kentucky	Limestone	Limestone
DEV.				
SIL.	Greenfield Dol.	Ohio	—	Dolomite
	Peebles Dol.	Ohio	—	Dolomite
ORDOVICIAN	Lexington Ls.	Kentucky	—	Limestone
	Moccasin Fm.	Tennessee	Lime	—
	Oregon Fm.	Kentucky	—	Dolomite
	Camp Nelson Ls.	Kentucky	Lime	Limestone
	New Market Ls.	Virginia	—	Limestone

¹ Used in flue-gas desulfurization process.

² Used in atmospheric fluidized-bed combustion process.

(CaCO₃ + MgCO₃ content of 95 percent or more), as much as 67 feet thick, occur in the Camp Nelson across the region (Dever, 1974, 1980; Dever and others, 1978).

Potential sorbent stone for AFBC systems is present in a number of formations. Limestones from the Camp Nelson and Lexington Limestones (Ordovician) and Warsaw and Ste. Genevieve Limestones (Mississippian), and dolomite from the Oregon Formation (Ordovician) have been used in pilot, demonstration, and commercial AFBC plants (Table 1). Pilot-plant tests have shown that dolomites from the Laurel Dolomite (Silurian) and Slade Formation (Mississippian), and limestone from the Salem and Warsaw Formations (Mississippian) also are effective SO₂ sorbents (Barron and others, 1987, 1989).

Limestone and dolomite are bulk commodities that have a relatively low price at the

quarry or mine; however, transportation charges are a major factor in determining their cost to utilities and industries. The widespread availability of suitable SO₂ sorbent stone within Kentucky should reduce transportation charges and, thus, lower operating costs for emission-control systems.

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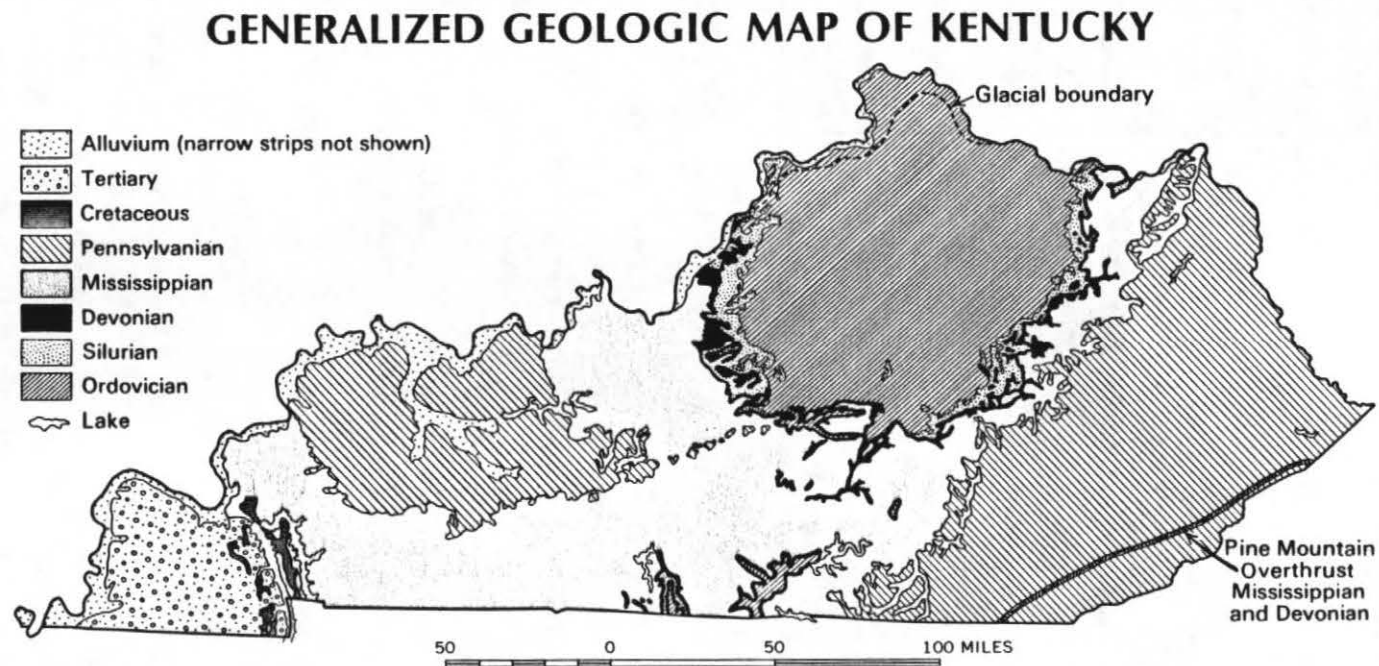


Figure 2. Geologic map of Kentucky. Principal sources of stone for SO₂ emission control are limestones and dolomites of Mississippian and Ordovician ages (Table 1). Silurian dolomite in west-central Kentucky is a potential sorbent resource.

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