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**LIMESTONE RESOURCES FOR THE COAL INDUSTRY:
AN EVALUATION OF THE NEWMAN LIMESTONE
(MISSISSIPPIAN) ON THE CUMBERLAND
OVERTHRUST BLOCK, SOUTHEASTERN KENTUCKY**

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LIMESTONE RESOURCES FOR THE COAL INDUSTRY: AN EVALUATION OF THE
NEWMAN LIMESTONE (MISSISSIPPIAN) ON THE CUMBERLAND OVERTHRUST BLOCK,
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ABSTRACT

The Eastern Kentucky Coal Field is one of the major coal-producing regions of the world. With 1,240 underground mines and 1,800 surface mines active in 1982, the region is a large market for limestone products: rock dust for explosion abatement in underground coal mines; agricultural stone for surface-mine reclamation; construction stone for haulage roads; and, to a lesser extent, high-calcium limestone for acid-drainage control.

Movement of the Cumberland Overthrust Block has brought the Newman Limestone (Mississippian) to the surface on Pine Mountain in the southeastern part of the coal field, a region otherwise generally devoid of operable limestone deposits. To evaluate the Newman as a potential source of low-silica stone (<4% SiO₂) for rock dust, 2,736 foot-by-foot samples for major-element analysis have been taken at 10 sites along the 125-mile length of Pine Mountain.

Analytical results show that thick deposits (41-64 feet) of low-silica stone are present in the lower Newman of Harlan and Letcher Counties. These deposits in the central part of the outcrop belt may be sufficiently thick to produce by selective quarrying or underground mining. Production, however, will be complicated by the steep dip of the beds and by displacement along small-scale faults within the Newman. In the northeastern and southwestern parts of Pine Mountain, low-silica zones range from 10 to 28 feet in thickness, but probably are too thin to produce economically from the dipping beds.

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INTRODUCTION

The Eastern Kentucky Coal Field in the western part of the Appalachian Basin is one of the major coal-producing regions of the world. In the 1982 calendar year, 112,055,615 tons of coal were produced from 3,040 mines (Stanley, 1983). With its 1,240 underground mines and 1,800 surface mines, the region is a large market for limestone products: rock dust for explosion abatement in underground coal mines; agricultural stone for surface-mine reclamation; construction stone for haulage roads; and, to a lesser extent, high-calcium limestone for acid-drainage control. The coal-bearing rocks (Pennsylvanian) of eastern Kentucky, however, generally are devoid of operable limestone deposits, and a major part of the coal-industry requirements is met by haulage into the region from limestone operations west of the coal field and from adjoining states.

Movement of the Cumberland Overthrust Block along the Pine Mountain Overthrust Fault has brought the Newman Limestone (Mississippian) to the surface in the southeastern part of the coal field where it crops out in a narrow belt along Pine Mountain (Figs. 1 and 2). Five quarries operating in the Newman outcrop belt furnish part of the coal-industry requirements for construction and agricultural stone (Fig. 3). However, no rock dust has

been produced from the Newman, and most, if not all, of the rock dust used by the more than 900 underground coal mines of southeastern Kentucky currently is obtained from sources outside the State. The availability of rock dust from a source within the coal field should contribute to a more economical operation for coal producers by lowering transportation charges, a major factor in determining the cost of limestone products. To evaluate the Newman as a potential source of low-silica stone (<4% SiO₂) for rock dust, 2,736 foot-by-foot samples for major-element analysis have been taken at 10 sites along the 125-mile length of Pine Mountain.

Two terms are used in this report for carbonate rocks with chemical characteristics suitable for the special requirements of coal producers and other industries. Low-silica stone designates carbonate rocks with a total (free and combined) silicon dioxide (SiO₂) content of 4 percent or less. High-calcium limestone designates carbonate rocks composed of 95 percent or more calcium carbonate (CaCO₃).

NEWMAN LIMESTONE

The Newman Limestone of southeastern Kentucky is divided into two informal units, designated as the lower member and upper member. The lower member of the Newman is composed prin-

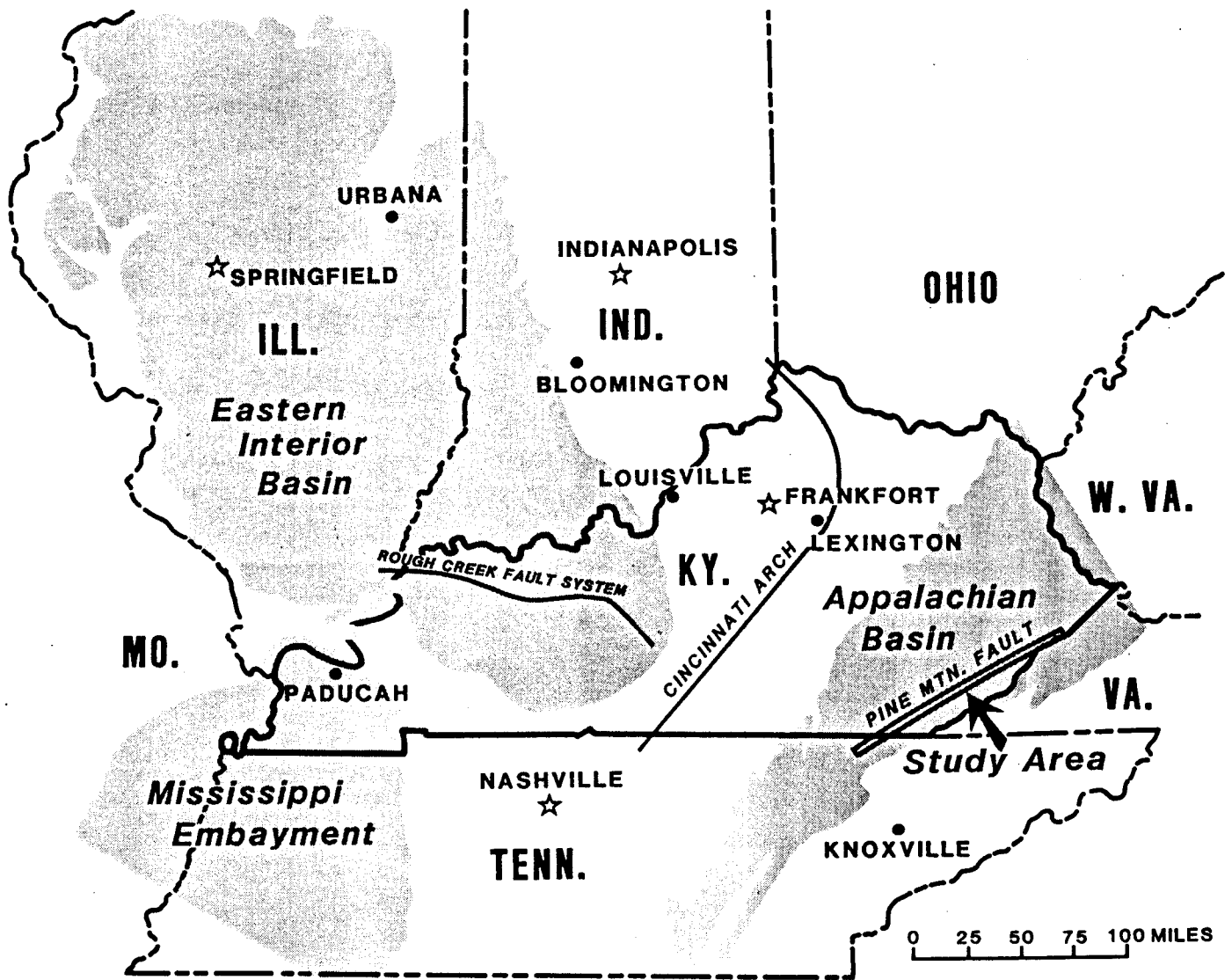


Figure 1. Regional geologic setting of Newman Limestone on Pine Mountain, southeastern Kentucky.

cipally of limestone, with lesser amounts of dolomite and shale, and minor amounts of siltstone and sandstone (Fig. 4). The upper member consists of shale with various amounts of interbedded limestone, dolomite, siltstone, and sandstone. Operable

deposits of limestone are restricted to the lower member.

The thickness of the Newman Limestone along Pine Mountain, as reported on the 18 geologic quadrangle maps covering the outcrop belt, ranges from 350 feet (Rice and Maughan, 1978) to

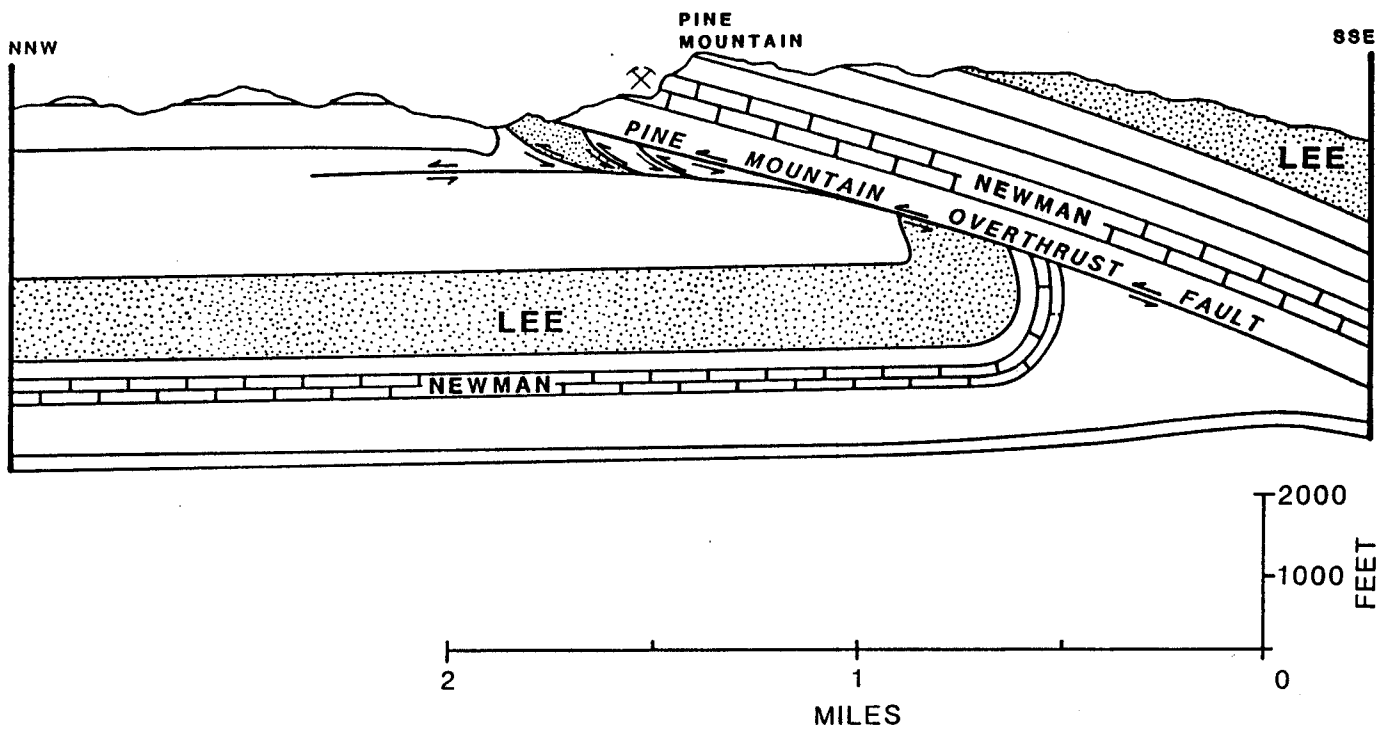


Figure 2. Generalized cross section showing structural setting of Newman Limestone on Pine Mountain. Adapted from Csejtey (1971).

800 feet (Rice and Wolcott, 1973). For the lower member, reported thicknesses range from 250 feet (Rice and Newell, 1975) to 520 feet (Rice and Wolcott, 1973).

The carbonate rocks in the lower member of the Newman can be described in general terms as consisting of four lithologic subunits. The combined thickness of the lower three subunits averages about 125 feet; the fourth (uppermost) subunit generally is more than 200 feet thick.

The basal subunit is composed of calcilutite and dolomite; chert is common. The overlying, or second, subunit, which is the best potential source of low-silica stone, consists of bioclastic and oolitic calcarenite with

varying amounts of calcilutite and dolomite. Thicknesses of these lower subunits vary along Pine Mountain (Fig. 5).

The third subunit, designated as the Taggard Red Member by Wilpolt and Marden (1959), is a useful stratigraphic marker in the central and northeastern parts of the outcrop belt. In the southwestern part of Pine Mountain, identification of the position of the Taggard presently is uncertain. The Taggard has an average thickness of about 15 feet and is composed of bioclastic calcarenite with interbedded green and red calcilutite and red and green shale in the lower and upper parts. The distinctive red and green coloration, contrasting with the domi-

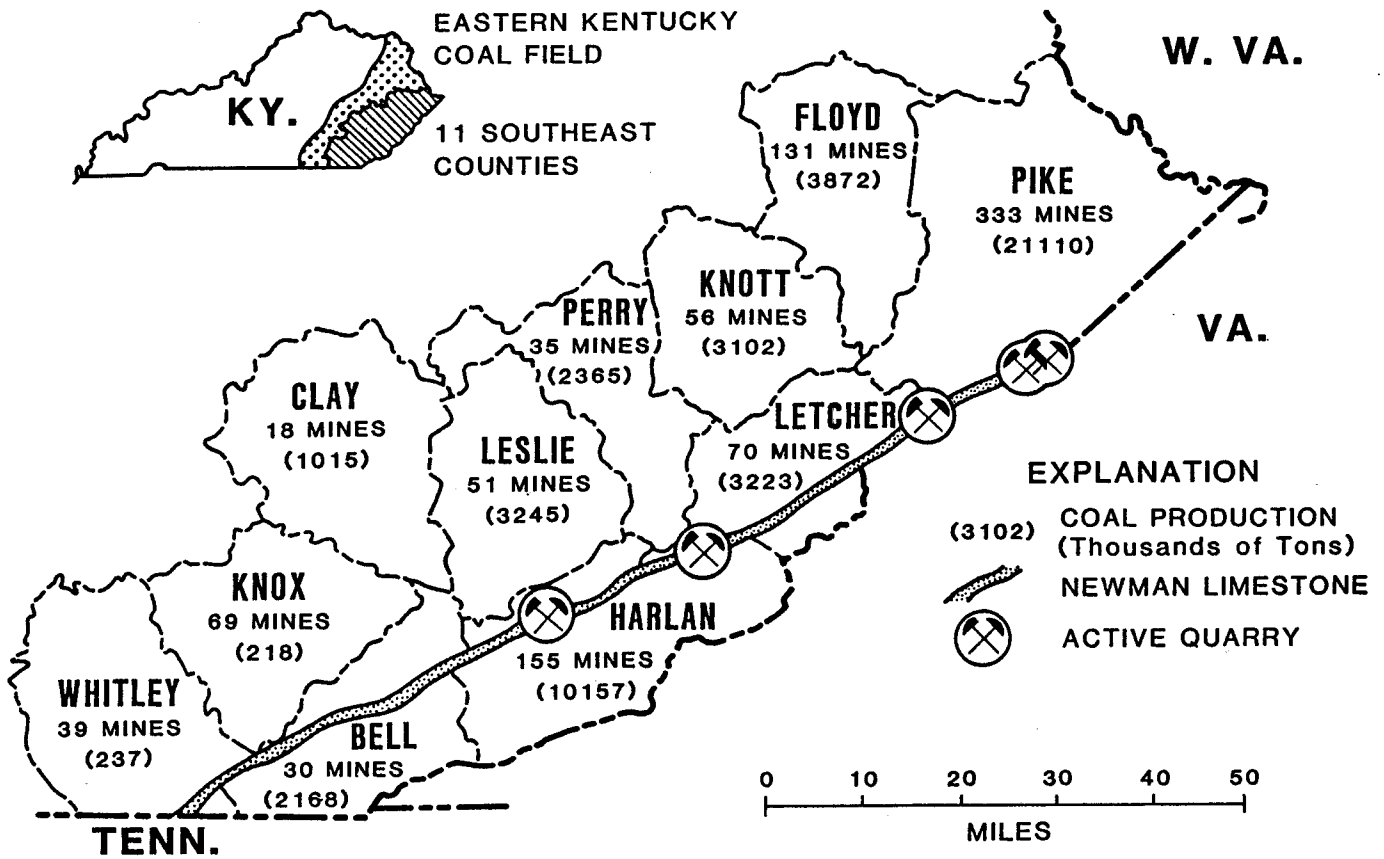


Figure 3. Map indicating potential rock-dust market in southeastern Kentucky. Shown by county are the number of active underground coal mines and their production (thousand tons) in 1982. Mine and production data from Stanley (1983).

nantly gray and greenish-gray limestones in the other subunits, facilitates its identification. However, zones of argillaceous limestone and dolomite with similar red and green coloration occur at other positions within the lower member; their occurrences are indicated as "reddish limestone" in Figures 4 and 5.

The fourth, or uppermost, subunit consists of bioclastic calcarenite (in part oolitic) alternating with greenish-gray and dark-gray, argillaceous, silty calcisiltite and calcarenite. Zones of calcilutite, dolomitic limestone, dolomite, sandy limestone,

chert, and shale occur in the subunit. Detrital quartz and clay content of the limestones generally increases upward in the unit, reflecting the gradation from the limestone-dominated lower member to the shale-dominated upper member of the Newman.

LOW-SILICA STONE FOR ROCK DUST

Pulverized limestone, dolomite, and other inert materials used as rock dust for explosion abatement in underground coal mines must meet specifications for silica (SiO₂) content. Public Law 91-173, the Federal Coal Mine Health and Safety Act of 1969, speci-

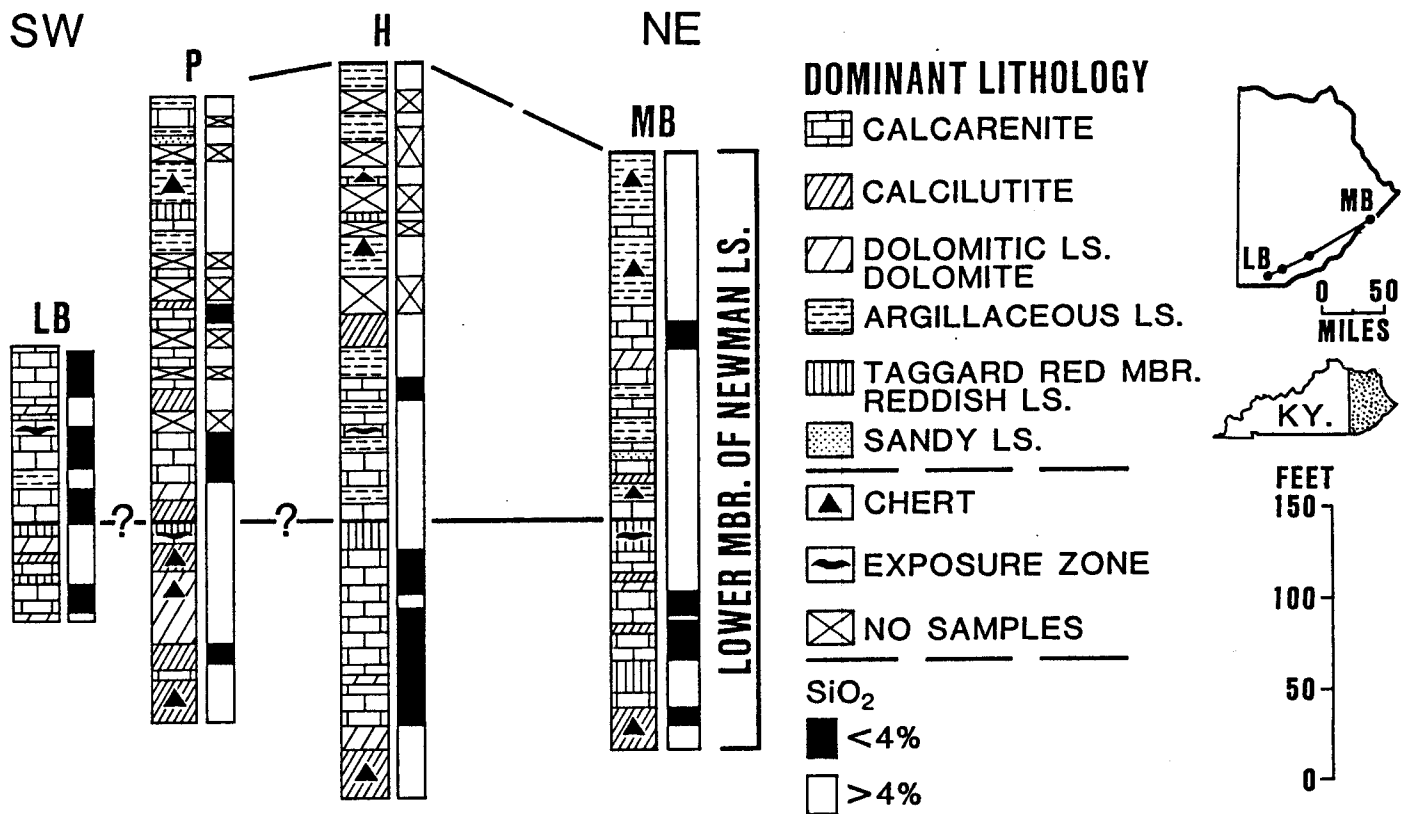


Figure 4. Paired columns showing distribution of low-silica stone and dominant lithologies in lower member of Newman Limestone at selected sites on Pine Mountain. Upper part of member at Limestone Branch quarry (LB) not accessible for sampling. Datum is top of Taggard. (See Table 1 for key to sampled sections.)

fies that these materials are not to contain more than a total of 4 percent free and combined silica (Federal Register Office, 1970).

Analysis of the foot-by-foot samples taken from the lower member of the Newman shows that potentially operable deposits of low-silica stone are present on Pine Mountain (Fig. 6; Table 2). The thickest deposits, 64 feet at the Harlan quarry (H) in Harlan County and 41 feet at the Hurricane Gap roadcut (HG) in Letcher County, are in the central part of the outcrop belt. They may be sufficiently thick to produce by selective quarrying or underground

mining. In the northeastern and southwestern parts of the outcrop belt, low-silica zones range in thickness from 10 to 28 feet, but probably are too thin to produce economically from the dipping beds. The rocks on Pine Mountain dip steeply, commonly 25° to 35° SE, into the Middlesboro Syncline (Froelich, 1973).

Production from an interval encompassing two low-silica zones and an intervening ledge partly composed of low-silica stone may be feasible locally. At the Harlan quarry (H), Harlan County, two low-silica zones are present in the lower part of the member:

Table 1.--Key to Sampled Sections Shown in Report.

B	Adams Stone Corporation Burdine quarry, Letcher County
EC	Elkhorn Stone Company Elkhorn City quarry, Pike County
H	Nally & Haydon, Inc., Harlan quarry, Harlan County
HG	Hurricane Gap roadcut, Letcher County
LB	Limestone Branch quarry (inactive), Whitley County
MB	Mountain Branch Limestone Company quarry, Pike County
P	Pineville quarry (abandoned), Bell County
W	Whitesburg quarry and mine (abandoned), Letcher County

64 feet (av. 0.82% SiO₂) and 25 feet (av. 1.01% SiO₂) (Fig. 6). The two zones are separated by a 7-foot ledge in which two of the 1-foot samples have a silica content greater than 4 percent (4.08% and 4.90% SiO₂). For the 96-foot interval encompassing the two low-silica zones and intervening 7-foot ledge, the average silica content is 0.97 percent.

Thickest deposits of low-silica stone in the Newman occur in the calcarenitic interval below the Taggard (Figs. 5 and 6). The calcarenite is bioclastic (mainly micrite-enveloped grains) and oolitic. Zones of secondary dolomite occur in the thick cal-

carenites in the central part of Pine Mountain. Northeastward along the outcrop belt, varied amounts of calcilutite (in part low-silica stone) and argillaceous "reddish limestone" are interbedded with the calcarenite below the Taggard, resulting in thinner low-silica zones. The increased amount of low-silica calcarenite in the southwestern part of Pine Mountain, as indicated by the Limestone Branch quarry (LB), Whitley County, suggests that the area warrants exploration for exploitable deposits (Fig. 4). Common sources of silica in Newman calcarenites are detrital clay and quartz, chert bodies, and selectively silicified fossil grains and fragments.

A large market for rock dust exists in the coal-producing areas northwest and southeast of Pine Mountain. In the 1982 calendar year, 50,717,754 tons of coal were produced by 987 underground mines in 11 southeastern Kentucky counties (Fig. 3; Stanley, 1983). Rock-dust requirements in the face area of underground coal mines average about 10 pounds of rock dust per ton of mined coal (Ralph Perry, Kentucky Department of Mines and Minerals, oral communication, 1983). In terms of 1982 coal-production figures, a minimum of about 250,000 tons of rock dust would be required by underground coal mines in the 11 southeastern Kentucky counties.

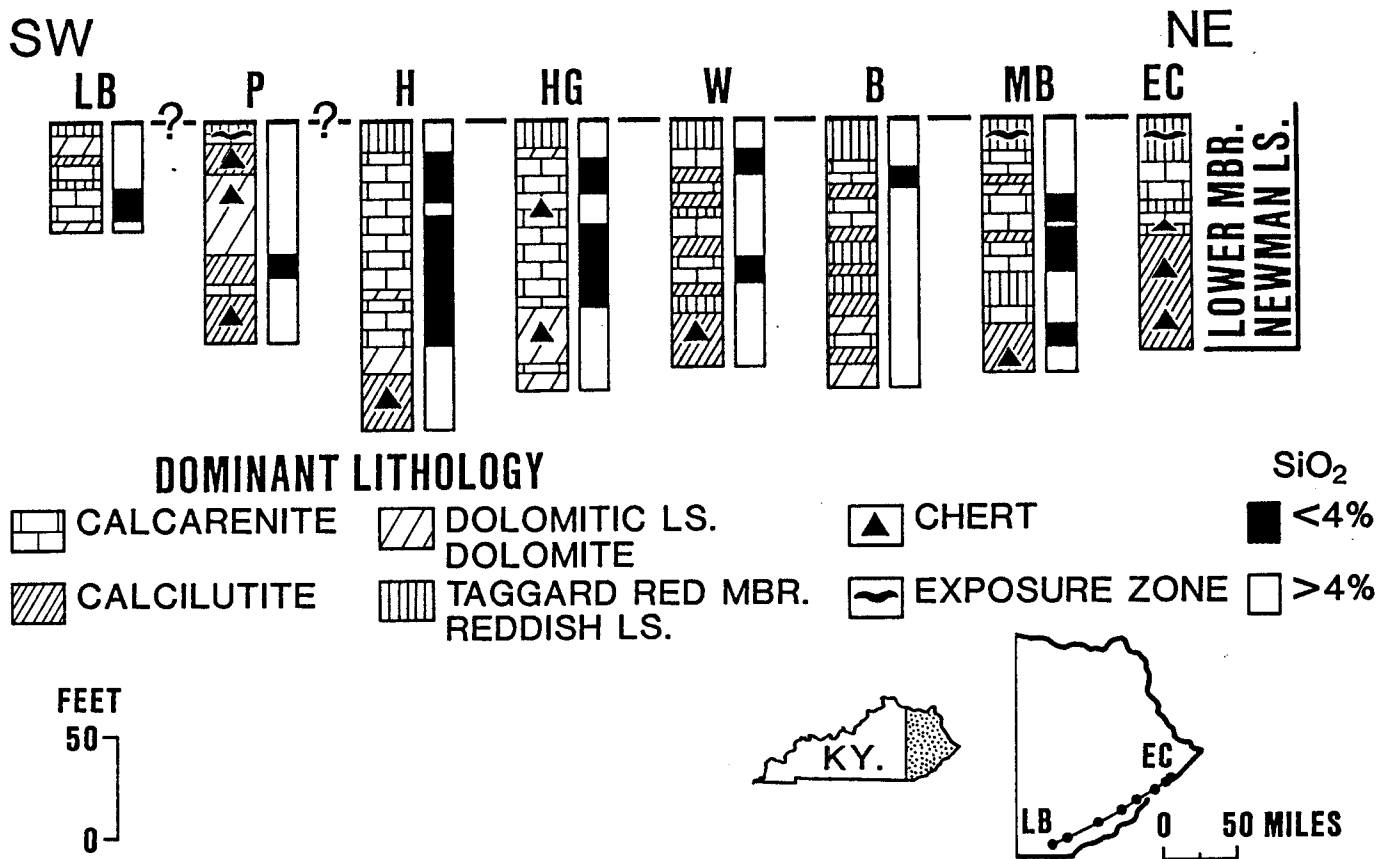


Figure 5. Paired columns showing distribution of low-silica stone and dominant lithologies in lower part of lower member of Newman Limestone on Pine Mountain. Analysis of samples from Elkhorn City quarry (EC) in progress. Datum is top of Taggard. (See Table 1 for key to sampled sections.)

Additional quantities of rock dust are needed during mining to maintain the incombustible content of the total amount of dust in the mine, particularly along conveyor-belt haulageways. The incombustible content of the combined coal dust, rock dust, and other dust is to be not less than 65 percent; in the return aircourses, the incombustible content is to be not less than 80 percent (Federal Register Office, 1970). A higher incombustible content is required where methane is present in any ventilating current.

AGRICULTURAL STONE FOR RECLAMATION

Agricultural stone is utilized by coal companies in the reclamation of surface-mined areas to adjust the pH of acidic spoils for revegetation (Barnhisel, 1975; Vogel, 1981). Chemical specifications are in terms of calcium carbonate equivalent (CCE) which is a measure of the stone's acid-neutralizing value.

Carbonate rocks used for agricultural stone must have a minimum CCE value of 80. An arbitrary CCE value of 100 is assigned to pure limestone,

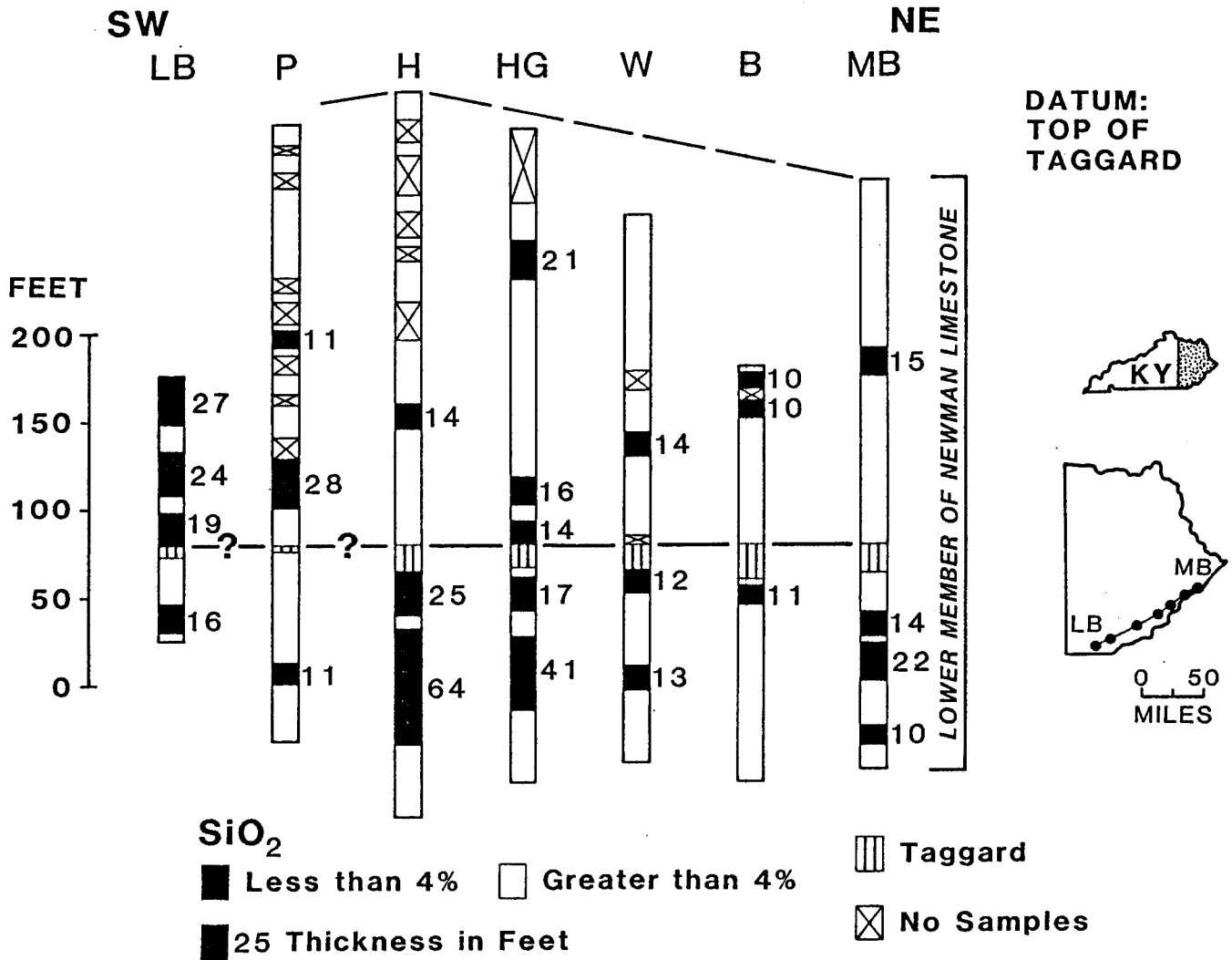


Figure 6. Distribution and thickness of low-silica deposits in lower member of Newman Limestone on Pine Mountain. Datum is top of Taggard. (See Table 1 for key to sampled sections.)

Table 2.--Average Values for Foot-by-Foot Analyses of Selected Low-Silica Deposits in Lower Member of Newman Limestone on Pine Mountain. (See Table 1 for Key to Sampled Sections.)

Section (Feet)	Thickness (%)	CaCO ₃ (%)	MgCO ₃ (%)	SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	K ₂ O (%)	Na ₂ O (%)
LB	27.5	94.76	4.18	0.90	0.18	0.10	0.03	0.04
H	64.0	91.37	6.82	0.82	0.12	0.14	0.04	0.06
HG	41.0	89.2	8.2	1.65	0.19	0.15	NA	NA
MB	22.0	95.51	1.47	1.85	0.18	0.09	0.06	0.03

NA Not Analyzed

composed of 100 percent calcium carbonate (CaCO_3); pure dolomite, $\text{CaMg}(\text{CO}_3)_2$, has a CCE value of 108.6. Pure magnesium carbonate (MgCO_3) possesses a higher CCE value than pure calcium carbonate because it has a lower molecular weight than calcium carbonate, but the same neutralizing power per molecular unit (Boynton, 1966). In calculating CCE values, the factor of MgCO_3 as CaCO_3 equivalent is 1.19 to 1.00.

A major part of the limestone, dolomitic limestone, and dolomite in the lower member of the Newman meets the chemical specifications for agricultural stone. Common exceptions are (1) cherty limestone and dolomite in the lower part of the member and (2) ledges of argillaceous, silty to sandy limestone in the upper part.

HIGH-CALCIUM LIMESTONE FOR ACID-DRAINAGE CONTROL

Limestone is used to neutralize acid drainage from coal mines and refuse piles. The most effective limestones have a high calcium carbonate content and low magnesium carbonate content (Bituminous Coal Research, 1970, 1971; Ford, 1974; Hill, 1974; Hill and Wilmoth, 1971). Dolomite and dolomitic limestone, which contain appreciable amounts of magnesium carbonate, react very slowly with acidic waters and are not effective neutraliz-

ing agents. The limestone should have a low percentage of inert constituents, such as silica (SiO_2) and alumina (Al_2O_3); their presence means less available alkalinity per ton of stone.

Nine zones of high-calcium limestone are present in the sampled sections on Pine Mountain, occurring within nine of the low-silica zones. The high-calcium deposits range from 10 to 37 feet in thickness, but mainly are less than 20 feet thick. Individual deposits probably are too thin to produce economically from the steeply dipping beds. A potentially operable thickness of high-calcium limestone, encompassing two high-calcium zones and an intervening ledge partly composed of high-calcium stone, is present at the Harlan quarry (H), Harlan County. The 69-foot section of limestone (principally calcarenite) immediately underlying the Taggard at the quarry (Figs. 5 and 6) averages 96.35 percent calcium carbonate; six of the 1-foot samples in the interval have a calcium carbonate content less than 95 percent.

EXPLOITATION

Limestone operations on Pine Mountain mainly have produced stone from steep-walled trenches or pits which have faces commonly as much as 200 feet high. The trenches essentially are oriented along the strike of the steeply dipping limestone. One open-pit

operation in Pike County currently employs a series of benches oriented along strike. Stone has been produced by underground mining at a site in Letcher County.

The production of low-silica stone or high-calcium stone from the Newman on Pine Mountain will require either selective quarrying or underground mining. Potentially exploitable deposits are overlain by a thick sequence of limestones that contain a relatively high percentage of silica and other noncarbonate constituents. Both open-pit benching, either on or within the deposit, and underground mining will permit the production of chemically pure stone without contamination from overlying limestones which do not meet specifications for silica or calcium carbonate. Underground mining also offers the potential for year-round operation and avoids costs for overburden removal and reclamation.

Production will be complicated by the steep dip of the beds, commonly 25° to 35° (Froelich, 1973), and by faulting within the Newman. Small-scale thrust faults are relatively common in the Newman and may displace a deposit of chemically pure stone. Repetition of beds by thrust faulting may result in a deposit locally having an apparent

thickness greater than its true thickness. Faults and associated fractures are avenues for the movement of water, soil, and other materials into the limestone body.

Coring will be required to determine the thickness and extent of a deposit of chemically pure stone and to establish the presence of sufficient reserves to support economic exploitation. Cores will provide samples for chemical analysis and physical testing.

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