Minerals in the Economy of Alabama, 2007

Geological Survey of Alabama
Information Series 64R

Cover photograph:

View of large-scale crushed stone (limestone/dolomite) operation in eastern Tuscaloosa County, Alabama (courtesy Vulcan Materials Company). Crushed stone accounts for about 28 percent of the total value of mineral production in Alabama.

GEOLOGICAL SURVEY OF ALABAMA

Berry H. (Nick) Tew, Jr.
State Geologist

GEOLOGIC INVESTIGATIONS PROGRAM

MINERALS IN THE ECONOMY OF ALABAMA, 2007

Information Series 64R

by

Lewis S. Dean

Tuscaloosa, Alabama
2008

GEOLOGICAL SURVEY OF ALABAMA

Berry H. (Nick) Tew, Jr.
State Geologist

420 Hackberry Lane
P.O. Box 869999
Tuscaloosa, Alabama 35486-6999
Phone (205)349-2852
Fax (205)349-2861
www.gsa.state.al.us

August 20, 2008

The Honorable Bob Riley
Governor of Alabama
Montgomery, Alabama

Dear Governor Riley:

It is with pleasure that I make available to you this report entitled *Minerals in the Economy of Alabama, 2007*, by Lewis S. Dean, which has been published as Information Series 64R by the Geological Survey of Alabama.

Mineral resources are the basis of an important part of Alabama's industrial economy. In 2007 Alabama ranked sixteenth among the states in value of nonfuel minerals produced. The estimated value of industrial mineral production in Alabama for 2007 was $1.34 billion, about 2 percent of the value of the total national mineral production. The Geological Survey of Alabama has legislative mandate to evaluate the state's mineral resources and therefore carries out a comprehensive minerals assessment program for the state. Under this program, many reports and maps are published annually, providing citizens and potential mineral industry with basic information useful for the development of these resources.

This summary report provides a brief overview of Alabama's minerals and related industry for 2007.

Respectfully,

Berry H. (Nick) Tew, Jr.
State Geologist

CONTENTS

CONTENTS—continued

ILLUSTRATIONS

TABLES

MINERALS IN THE ECONOMY OF ALABAMA, 2007

By

Lewis S. Dean

INTRODUCTION

In 2007, Alabama was ranked sixteenth among the states in value of industrial minerals produced in the United States. The principal industrial mineral resources produced were limestone, lime, dolomite, crushed stone, marble, building stone, sand and gravel, chalk, common clay, shale, kaolin, bauxite, bentonite, fuller's earth, fireclay, recovered sulfur, salt, and mica. The value of industrial mineral production in Alabama for 2007, based on preliminary data, was $1.34 billion, about 2 percent of the value of the total national mineral production. Since 1998, the state's annual mineral production value has exceeded an average of $1 billion (fig. 1). Alabama ranks second nationally in the production of lime and in common clays. The state continued to be third in bentonite and fourth in kaolin production nationally. Also, Alabama was fourth in masonry cement, fifth in portland cement, and eighth in salt production in the United States. Alabama rose to second in rank nationally in mica production with a recently developed operation at Micaville in Cleburne County (U.S. Geological Survey, 2007a, 2008a). Continued demand is expected during 2008 for industrial minerals, especially for those near urban areas where the need for construction materials is greatest.

MINERALS RELATED ACTIVITY

In 2007, there were about 200 companies or operations involved in the mining and production of industrial mineral resources in Alabama (Alabama Department of Industrial Relations, 2007). These included 53 limestone-dolomite operations for crushed stone, which were active in the state. In addition, granite, sandstone, and quartzite operations for crushed stone were active in the state. Limestone/dolomite and marble production reached a record high in 2007, exceeding 60 million short tons. Production of crushed stone has trended upward since 1994 and likely will continue to increase in 2008. Birmingham-based Vulcan Materials Co. is the largest construction aggregate producer in the country. Marble operations in the state produced micronized calcium carbonate and building stone. There were 35 clay operations and 150 sand and gravel operations active in the state. Several industrial mineral operations are related to the state's coal mining industry such as the production of fireclay, shale, and sandstone from the Pottsville Formation. Employee numbers and production figures for these and other minerals are shown in table 1.

Mineral exploration in Alabama has continued to focus on industrial resources during 2007 and into 2008 with several large expansions and new operations reported in the state, exceeding $180 million in capital investments. Commodities for which new operations or expansions were reported include brick and refractory clay, crushed stone, portland and masonry cement, iron oxide pigments, chalk, synthetic gypsum (wallboard), and nonferrous metals (Alabama Development Office, 2007, 2008). Another significant and expanding industry in Alabama is the restoration of eroding or storm-damaged beaches. Engineered beach restoration projects in Alabama began in 2001 using sand deposits located in both the Gulf of Mexico and estuarine state waters. The largest project was the "Orange Beach/Gulf State Park/Gulf Shores 2005-2006 Beach Restoration Project" that included 15.3 miles of shoreline and a

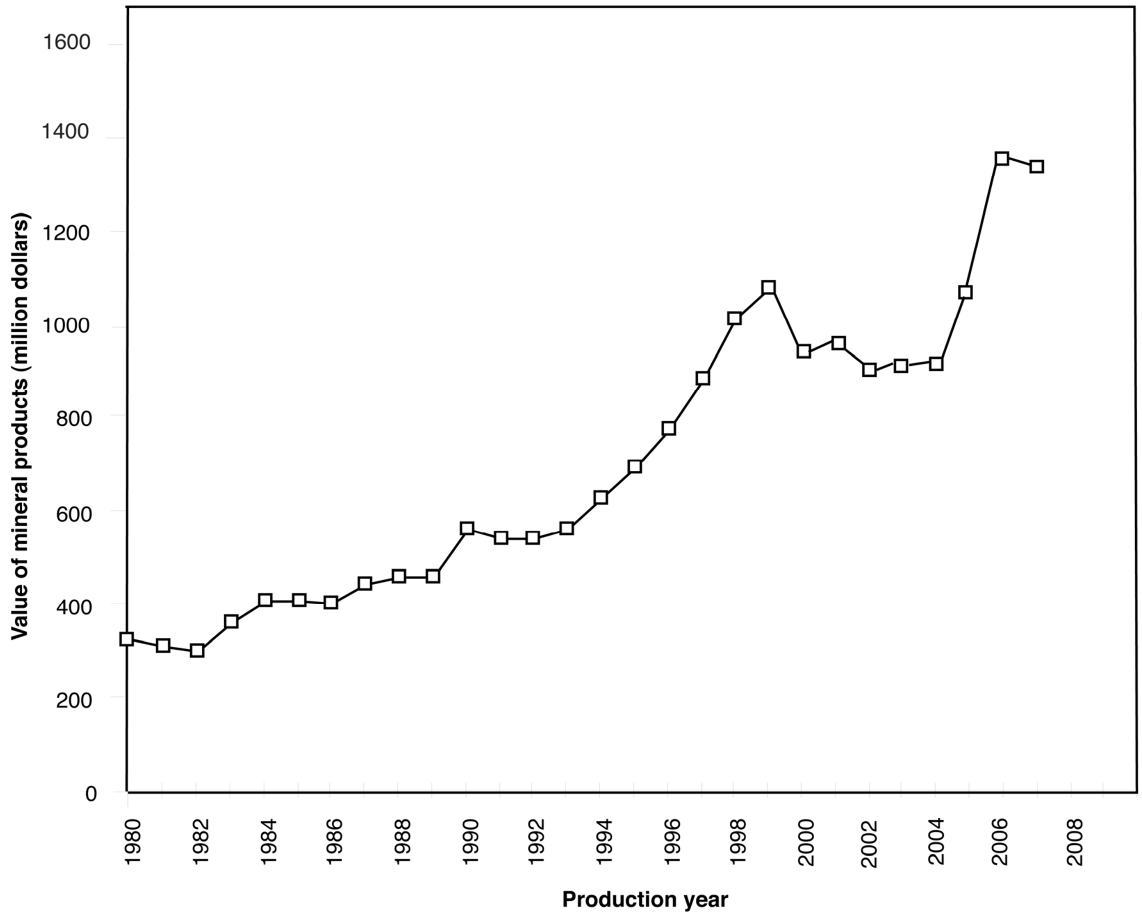

Figure 1.—Value of industrial and construction mineral production in Alabama, 1980-2007.

placement volume exceeding 7.9 million cubic yards of sand. During 2007, about 500,000 cubic yards of sand was mined from Mississippi Sound to construct the 19,500-foot Dauphin Island Emergency Berm to mitigate recent hurricane-related erosion (Stephen C. Jones, personal communication, 2008).

The Geological Survey of Alabama continued to publish 1:24,000-scale geologic maps (based on USGS 7.5-minute topographic quadrangles) in conjunction with the U.S. Geological Survey's National Cooperative Geologic Mapping Program. This new geologic mapping is concentrated in areas of rapid industrial and/or urban development, and the information is useful in the identification of supplies of industrial mineral resources (sand, gravel, clay, shale, crushed stone, and high-calcium limestone) that support construction and infrastructure development (National Cooperative Geologic Mapping Program, 2007). Recently published geologic 7.5-minute quadrangles include the Trinity, Decatur, Jones Crossroads, and Tanner quadrangles in the Limestone and Morgan County area and the Grant quadrangle in the Jackson County area of the Tennessee Valley. In addition, the Cooks Spring, Laniers, Springville, and Ragland quadrangles in the Shelby and St. Clair County area of the Valley and Ridge Province (fig. 2) were completed. Also published were the Cahaba Heights, McCalla, Greenwood, Birmingham South, Birmingham North, and Cottondale quadrangles in the Tuscaloosa-Jefferson County area. Much of this new geologic mapping is also accessible through

Table 1.--Production and number of employees in mining of coal and industrial mineral resources in Alabama for fiscal years 2005-2007[a]

Commodity	2005		2006		2007	
	Number of employees	Production in short tons	Number of employees	Production in short tons	Number of employees	Production in short tons
Coal	4,011	22,530,612	3,946	19,270,455	3,763	19,577,049[b]
Limestone/ dolomite	889	51,168,554	927	54,105,176	928	54,364,270
Sand and gravel	362	13,949,506	383	12,925,299	488	15,316,024
Sand and clay	73	2,004,738	180	9,787,375	186	6,323,670
Marble	115	3,258,107	121	7,048,833	381	4,392,030
Clay	69	2,211,004	67	2,873,540	62	3,316,804
Sand	15	263,263	75	1,205,630	86	2,533,601
Dolomite[c]	38	1,915,575	39	1,732,142	37	2,047,000
Sandstone	75	2,092,407	67	2,203,928	70	1,756,151
Granite	32	1,221,874	36	1,250,000	54	1,441,955
Shale	11	415,058	9	609,197	11	461,270
Quartzite	15	300,000	9	300,000	14	300,000
Bauxite	36	133,586	80	397,986	24	141,914
Chert	--	--	--	--	5	40,352
Hematite ocher	--	--	--	--	1	5,772
TOTAL	**5,741**	**101,464,284**	**5,939**	**113,709,561**	**6,110**	**112,017,862**

[a]Information source: Modified from Alabama Department of Industrial Relations, Office of Mine Safety and Inspection, Annual Statistical Reports, Fiscal Years 2000-2007.

[b]1,586,093 tons of coal were used for the manufacture of 1,224,320 tons of coke.

[c]Chewacla Marble, Lee County.

the Alabama Metadata Portal (Geological Survey of Alabama, 2008). New geologic mapping is critical in delineating current economic mineral deposits and identifying potential mineral resources in expanding market demand regions such as the Shelby-Jefferson County area. For example, the geologic formations mapped in the Cahaba Heights quadrangle and described in the accompanying report identify potential industrial mineral resources of high-calcium limestone, crushed stone (limestone, dolomite, sandstone), shale, sand, gravel, common clay, and chert (fig. 3).

The Alabama Department of Transportation has an annual maintenance and construction program for nearly 11,000 miles of highway. This work represents one of the largest uses of concrete, asphaltic and bituminous base, and aggregate (stone and gravel) in the state. A revised listing of approved sources of coarse and fine aggregates is updated annually by the Materials and Tests Bureau (Alabama Department of Transportation, 2008).

MINING AND PRODUCTION TRENDS

More than 20 types of mineral and rock products have been mined in Alabama. Because demand for specific products and minerals changes with technological advancement and economic circumstances, a particular mineral that has been mined in the past may be subeconomic at present. Conversely, a mineral commodity with subeconomic status at present may be valuable in the future. Improvement in availability of electrical power, water resources, or transportation could result in changes in economic status of a mineral

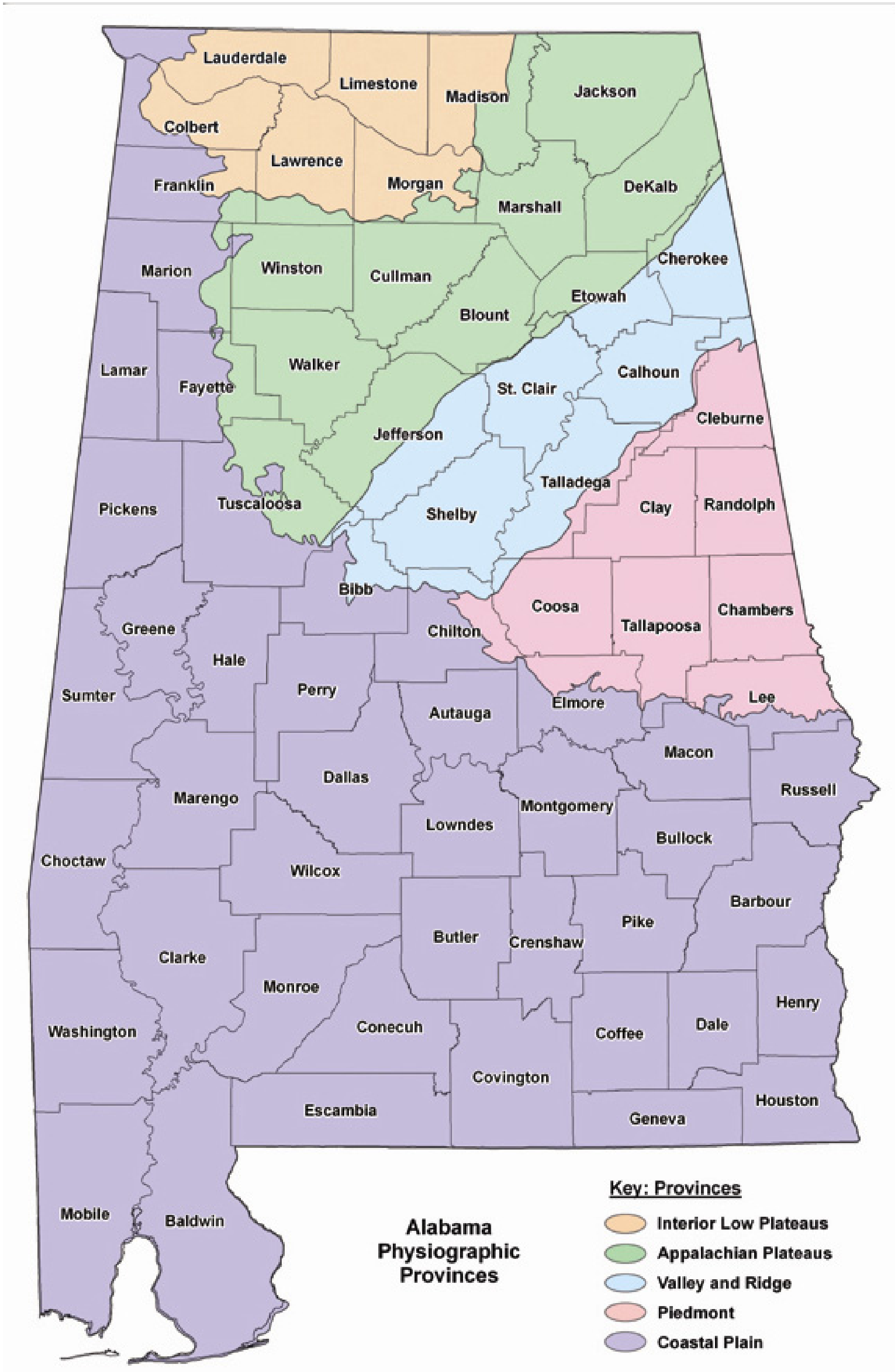

Figure 2.—Map of Alabama showing physiographic provinces and counties.

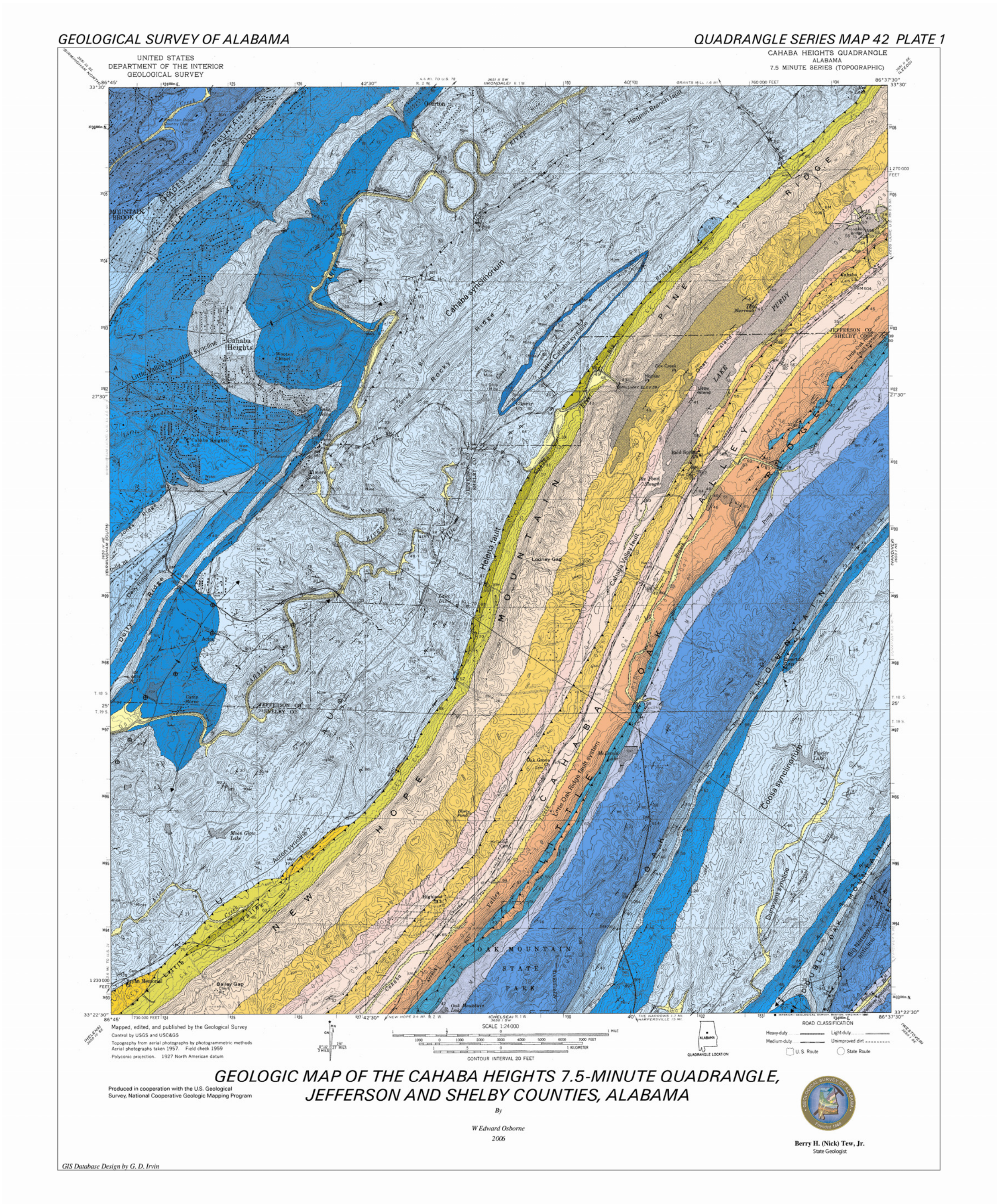

Figure 3.—Example of a quadrangle series geologic map available for selected areas from the Geological Survey of Alabama.

commodity or a mineral deposit. For example, some types of minerals and natural resources within the regional influence of the Tennessee-Tombigbee Waterway may increase in value because of availability of lower cost transportation.

Use of current and historical nonfuel mineral production data can provide insight into mineral exploration, consumption, and trade for assessing the economic and technical development of the state's mineral industries. The earliest commercial operation was in 1780 for clay used in making brick, tile, and pottery at Mobile. Other early commercial production occurred in 1809 in Washington County for salt, 1818 in Franklin County for iron ore, 1827 in Tuscaloosa County for sandstone (building stone), 1831 in Chilton County for gold, 1838 in Talladega County for marble, and 1840 for lime and limestone. Mineral production was first recorded in Alabama in 1840 for clay (brick and earthenware), stone (limestone and marble), iron, and gold. Since the 1840s, limestone and dolomite (and associated manufacture of lime), sand and gravel, iron ore (up to 1975), clay, marble, bauxite, and sandstone were the principal minerals produced in Alabama (Dean, 2000).

From 2000-2007, more limestone and dolomite were produced than any other minerals in Alabama. The major production areas are as follows: Shelby County (40 percent) and Jefferson County (15 percent) from the Cambrian Conasauga Formation and Ketona Dolomite and the Ordovician Newala Limestone; and Madison County (6 percent), Colbert County (9 percent), and Morgan County (6 percent) from the Mississippian Bangor and Tuscumbia Limestones (table 2).

Sand and gravel production from 2000-2007 has come primarily from Quaternary alluvium and terrace deposits in Montgomery County (14 percent), Mobile County (10 percent), Elmore County (8 percent), Macon County (5 percent), Tuscaloosa County (2 percent), and Russell County (5 percent), and from the Citronelle Formation in Mobile County (7 percent) (table 3). Clay production has consisted of brick and common clay (58 percent), fuller's earth (20 percent), shale (12 percent), kaolin (4 percent), bentonite (3 percent), and bauxite (3 percent).

Currently, other significant production consists of lime, cement, salt, building stone, synthetic gypsum, gemstones, iron oxide pigments, and recovered sulfur (U.S. Geological Survey, 2007a). These production trends are expected to continue in 2008. The following information provides details of the occurrence, mining history, and general economics of specific mineral resources in Alabama.

BAUXITE

Bauxite is a mixture of hydrated aluminum oxide minerals (principally gibbsite) and mineral impurities formed by the weathering of aluminum-bearing rocks. Bauxite was first mined in Alabama in 1891 from Rock Run in Cherokee County. In the 1940s, ore from Calhoun, Cherokee, St. Clair, and Colbert Counties was mined and shipped to Reynolds Metals Company at Muscle Shoals for experimental production of aluminum. Mining ceased when sufficient tonnage of metallurgical-grade bauxite became difficult to obtain.

Table 2.--Production (short tons) of limestone/dolomite by county in Alabama, 2000-2007

Data Sources: Modified from Alabama Department of Industrial Relations, Office Mine of Safety and Inspection (2000-2007).

Year	Shelby*	Jefferson*	Madison	Colbert	Morgan	Other*
2007	21,979,261	7,023,167	1,183,647	5,074,319	2,905,582	15,245,294
2006	20,486,051	6,905,091	3,992,785	5,123,983	2,229,948	17,212,906
2005	19,377,987	7,289,966	3,522,679	4,915,032	2,234,856	13,828,044
2004	19,695,015	7,658,607	3,546,982	4,787,994	2,258,550	13,698,555
2003	19,866,357	7,632,369	2,766,845	4,138,349	2,109,151	12,194,975
2002	21,378,773	7,390,626	3,020,816	3,153,257	1,888,056	10,474,247
2001	15,792,431	6,816,500	3,329,155	3,724,577	1,533,222	10,440,687
2000	14,840,589	7,136,408	2,416,303	3,148,602	2,180,702	8,390,506

*Includes dolomite.

Table 3.--Production (short tons) of sand and gravel by county in Alabama, 2000-2007

Data Sources: Alabama Department of Industrial Relations, Office of Mine Safety and Inspection (2000-2007).

Year	Montgomery	Mobile	Elmore	Macon	Tuscaloosa	Russell	Other
2007	2,801,508	3,003,018	1,635,418	1,759,317	399,532	1,032,752	13,541,750
2006	3,362,795	3,798,101	1,082,178	1,887,648	261,692	1,236,427	12,289,463
2005	2,663,316	979,200	1,087,381	339,216	209,144	930,013	10,009,237
2004	3,038,461	1,253,086	1,014,854	302,184	214,052	360,000	8,227,219
2003	2,551,345	1,266,537	1,084,240	109,351	198,371	240,000	7,870,541
2002	2,202,033	1,474,034	1,500,223	220,000	243,456	935,000	6,519,288
2001	406,530	506,000	1,261,148	400,000	261,083	1,000,000	4,453,182
2000	653,314	294,696	1,107,166	543,495	235,000	900,000	5,273,506

The major economic bauxite deposits in Alabama occur in the Barbour-Henry Counties (Eufaula) bauxite district within kaolinitic clay deposits, which are overlain by sands and clays of the Nanafalia Formation. Production began in 1927 and has been maintained on a continuous basis. Because of the irregular distribution of the bauxite deposits, considerable exploratory test drilling must be done prior to mining (Clarke, 1973). Alabama bauxite from the Eufaula district is used in making high-temperature refractory products, abrasives, and chemicals.

BUILDING STONE

Many stone materials in the state, including sandstone, limestone, granite, quartzite, and marble, have been used for building construction or ornamental stone. Annual production in Alabama for dimension stone is about 4,430 metric tons valued at about $3.63 million (U.S. Geological Survey, 2007b).

Naturally dimensioned blocks and flags of sandstone and limestone have been widely used in north Alabama. A unique tan- to buff-colored sandstone (Pottsville Formation) characterized by small-scale sedimentary structures is produced from Blount and Cherokee Counties for use as exterior building stone, walkways, and patios (Fousek, 2002). Limestone (Bangor Limestone) quarried at Rockwood in Franklin County also has been widely used. White marble quarried at Sylacauga has been used throughout the United States for monuments and for exterior and interior building stone (see Marble). A recently developed building stone operation in Lauderdale County was the first operation in Alabama to market varicolored "marble" (polished limestone) of Silurian age. In south Alabama, soft limestone of the Clayton Formation, Marianna Limestone, and Salt Mountain Limestone was saw-quarried in the 1800s and early 1900s for building stone.

CEMENT

The cement-manufacturing industry is a major consumer of raw materials in the state. This industry began in Alabama in 1895 and has since played a key role in the development of the state. Primary uses are for ready-mix concrete, concrete products, building materials, and highway construction. The principal raw materials used in making cement are limestone or chalk, clay and shale, silica, and iron oxide. Annual cement production in Alabama has increased to 5.1 million metric tons of portland cement and 475,000 metric tons of masonry cement. Annual production value of cement in Alabama is about $475.8 million (U.S. Geological Survey, 2007a).

CHERT

Chert is a siliceous stone often associated with weathered limestone or dolomite. It is a low value mineral commodity, but where a need exists for fill or base material for roads, chert deposits are of economic value. Chert quarries have been developed in most counties in north Alabama where the Fort Payne Chert and Knox Group residuum occur.

CLAY AND SHALE

Clay and shale of variable composition and character occur throughout the state (fig. 4). Bentonite, kaolin, fuller's earth, fireclay, common clays, and shale are mined in the state and used for making brick, tile, refractory and ceramic products, clay pipe, pottery, and lightweight aggregate (table 4). Brick plants are located in Bessemer, Phenix City, Montgomery, Leeds, Ragland, Huntsville, Selma, and Coosada. Tile plants are located in Fayette and Florence. The annual value of clays produced in the state is about $29 million (U.S. Geological Survey, 2007a). Potential additional growth can be anticipated in Alabama because of abundant clay and shale resources in the state.

BENTONITE

Bentonite (smectite clays), a weathering product of volcanic ash, occurs near the base of the Ripley Formation at Sandy Ridge in southeastern Lowndes County. Nonswelling calcium bentonite is mined from Sandy Ridge and processed for use in agricultural industries and as a binder in foundry sand. Since mining began in 1964, about 5.3 million short tons of bentonite has been produced. The Lowndes County bentonite has high plasticity and a very high leveling strength. Since 1980, an average of 183,000 short tons of bentonite has been produced annually, representing the only bentonite production from the Selma Group in the southeast Coastal Plain Province (Hosterman, 1984; Dean, 2000). Annual production value of bentonite is about $3.48 million (U.S. Geological Survey, 2007a). Bentonite also has been reported in Cretaceous deposits of Montgomery County and from the Tertiary in Clarke County.

Figure 4.— Varicolored clays and shales along the contact of the Coastal Plain and Appalachian Plateaus, south of Hamilton, Marion County, Alabama.

Table 4.--Production (short tons) of selected clays in Alabama, 2000-2007

Data Sources: Modified from Alabama Department of Industrial Relations, Office of Safety and Inspection (2000-2007).

Year	Brick clay	Fuller's earth	Common clay	Bauxite	Kaolin*	Bentonite
2007	1,159,832	782,952	1,095,810	141,914	167,585	110,625
2006	1,003,520	835,419	735,476	397,986	185,679	113,446
2005	746,925	851,817	302,507	133,586	185,427	124,328
2004	766,735	946,696	179,263	286,458	189,943	208,580
2003	896,801	775,157	151,082	150,442	210,673	243,461
2002	773,669	702,246	30,144	277,378	197,969	143,562
2001	850,327	883,044	24,900	273,002	195,388	254,506
2000	930,423	880,400	63,070	281,852	195,388	290,801

*St. Clair County.

FIRECLAY

Fireclay is a siliceous clay rich in hydrous aluminum silicates, useful for the manufacture of refractory ceramic products such as crucibles and firebrick. Many of the clays that occur below coal seams (underclays) of the Pottsville Formation in Alabama commonly have refractory characteristics. These underclays are distributed throughout the coal-producing areas in north-central Alabama—Blount, Fayette, Jefferson, Marion, Tuscaloosa, and Walker Counties—and can be mined in conjunction with coal. The clay that occurs below the Mary Lee coal group in the Cordova district of Walker County is used in making structural products, such as brick and tile. Since 1925, an estimated 6 million short tons of fireclay has been mined from Walker County with an average annual production since 1980 of 90,980 short tons, representing about 38 percent of the state's refractory clay production (Dean, 2000). Siliceous fireclay has also been mined in Calhoun and Shelby Counties.

KAOLIN

Kaolin, popularly known as china clay, is the best known of the pottery clays. It is composed principally of the mineral kaolinite (hydrous aluminum silicate) and has been produced from deposits in the Coastal Plain Province for more than a century. Economic deposits are associated with bauxite in the Eufaula district in Barbour and Henry Counties (Clarke, 1973). Kaolin production from the Eufaula district began in 1958. Since 1961, about 1.8 million short tons of kaolin has been mined from the Eufaula district for an average annual production since 1980 of about 55,500 short tons. Kaolin was also mined in Marion County from 1939 to 1977, with an estimated 666,000 short tons mined from 1942 to 1977 (Dean, 2000). This kaolin was used in floor and wall tiles, firebrick, and as a filler in paper and fertilizer. Kaolin is also mined in St. Clair County for use in manufacturing cement.

FULLER'S EARTH

Clay suitable for the manufacture of lightweight aggregate occurs in a zone that extends from western Wilcox County through Marengo County and across southern Sumter County (Clarke and Tyrrell, 1976). Fuller's earth in the Porters Creek Formation is mined near Livingston in Sumter County for production of lightweight aggregate. Lightweight aggregate is made from clay or shale containing carbonaceous or calcareous material. Heating it to fusion temperature produces carbon dioxide gas, which shapes vesicles. Upon cooling, the expanded product is full of cavities. This material can be used for low density, or lightweight, aggregate in making concrete blocks. It is also used to make nonskid pavement and in horticultural applications (Hosterman and Patterson, 1992).

CRUSHED STONE

Rock types in Alabama with good physical characteristics (loose unit mass, bulk specific gravity, absorption and abrasion values) for crushed stone include limestone, dolomite, marble, granite, sandstone, and quartzite. The principal uses are in construction for aggregate, agricultural uses, chemical and metallurgical uses (cement and lime manufacture, flux stone), and other special uses such as water treatment, mine dusting, and fillers and extenders. The annual production of fine to coarse construction aggregate sold or used by Alabama producers amounts to about 26.76 million metric tons with a value of $175 million (unit value of $6.54 per metric ton). The total amount of all crushed stone produced in the state in 2007 was 51.7 million metric tons valued at $375 million, accounting for about 28 percent of the total value of mineral production (U.S. Geological Survey, 2007a, 2008b).

DOLOMITE

Dolomite, a carbonate rock that consists principally of calcium magnesium carbonate, occurs extensively in northeastern Alabama (fig. 5). Dolomite is used to manufacture rock wool (used for insulation), in the chemical industry to extract metallic magnesium, in agricultural applications to condition soil, as flux, and as an alternative to limestone in the production of aggregate. The unit value of crushed dolomite is about $6.37 per metric ton (U.S. Geological Survey, 2007a). Most of the dolomite rock units in Alabama (for example, the Knox Group dolomites) have a high content of silica and other impurities, which generally preclude commercial development for most applications. The Cambrian Ketona Dolomite, however, is known for its purity and is quarried in Jefferson and Shelby Counties for a variety of applications. The Ketona Dolomite was mined from the Dolonah quarry at Bessemer from 1924 to 1981 for fluxing material and was the first large-scale industrial quarry, producing 1.1 million short tons of dolomite annually as early as 1942. The Ketona Dolomite is presently mined in the Dolcito quarry in Birmingham, which has been operating since the early 1900s. Production of dolomite from the Dolcito quarry exceeds 1 million short tons annually (Alabama Department of Industrial Relations, 2007). Beg (1984) reported on the distribution and characteristics of dolomites in Alabama.

GEMSTONES AND OTHER MINERALS

A variety of gemstones and other minerals which are of value to collectors of mineral specimens occur in Alabama. These minerals include amethyst, beryl (emerald), calcite, fluorite, gypsum, magnetite, quartz (agate), rutile, tourmaline, turquoise, and wavellite (Cook and Smith, 1982). Also, freshwater mussel shells are exported for use in the production of cultured pearls. Sections from a mussel shell are cut out, partitioned, rounded, polished, and inserted into oysters as the pearl nuclei. After a period of time, the cultured pearl is removed from the oyster and used in jewelry production. The Tennessee and Alabama River systems are currently the most important sources of commercial mussels (*Outdoor Alabama*, 2008). The yearly value of exported shell is about $370,000 (U.S. Geological Survey, 2007a).

In 1990 “star blue quartz” was designated as the official gemstone for Alabama. This gemstone is asteriated (rutilated) light-blue-gray quartz from Chambers County in the southern Piedmont. It exhibits a bluish cast when viewed in direct sunlight. Faceted material exhibits a strong, central, six-rayed star. The raw material consists of residual vein quartz found in a red clay soil profile (Rohrbach, 1989).

GRANITE

Granite is a plutonic rock composed primarily of the minerals feldspar, quartz, and mica. Rocks with granitic mineral composition occur throughout the Alabama Piedmont. These granitic rocks commonly have a

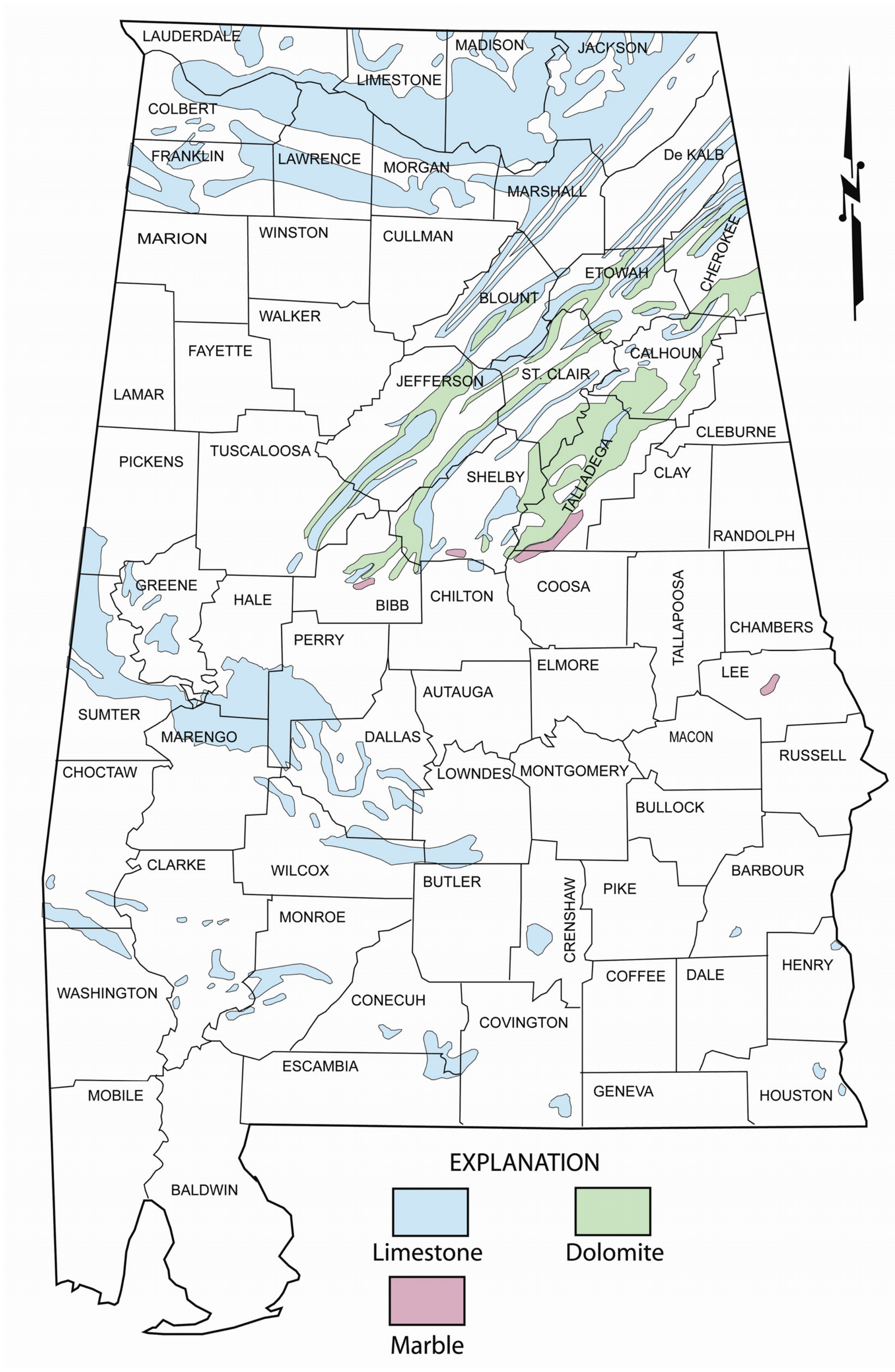

Figure 5.— Generalized distribution of limestone, dolomite, and marble resources in Alabama.

banded texture and are termed "granite gneiss." Such stone has been quarried for use as dimension stone and crushed stone. Granite has been quarried for crushed stone on an intermittent basis since 1936. Granite gneiss of the Elkahatchee Quartz Diorite Gneiss is presently quarried in Coosa County for use as crushed stone, riprap, and aggregate. Granite is also quarried in Randolph County and was used extensively in construction of the R.L. Harris hydroelectric dam on the Tallapoosa River. Other granite quarries operate in Lee and Elmore Counties. Granite production currently exceeds 1 million short tons annually (table 1). The unit value of crushed granite is about $6.88 per metric ton (U.S. Geological Survey, 2007a).

LIME

Lime is principally calcium oxide (CaO) or a mixture of CaO and magnesium oxide (MgO) produced by the calcining of limestone or dolomite. Large-scale lime production by the Shelby Lime Company began in the 1850s near Montevallo. The major uses of lime include steel making, paper manufacture, water purification, and agricultural soil conditioning. In Alabama, the Ordovician Newala Limestone is the primary source of raw material for the production of lime (Puckett and others, 1990). Annual production in Alabama is about 2.24 million metric tons of lime valued at about $181 million (U.S. Geological Survey, 2007a).

LIMESTONE

Limestone suitable for crushed stone and consisting principally of calcium carbonate is widely distributed in Alabama (fig. 5). Most limestone quarries in the state are open pits (fig. 6), but underground mining has been used in Franklin, Jefferson, Marshall, and Shelby Counties. The limestone units of Alabama have a wide variety of chemical and physical properties and are suitable for various applications (Beg, 1984). Limestone of varying grade is used for flux, aggregate, dimension stone, and soil conditioner, and in many industrial processes including the manufacture of glass, refractories, fillers, abrasives, cement, lime, and chemicals. The Mississippian Bangor and Tuscumbia Limestones are quarried throughout north Alabama. In Jefferson and Shelby Counties, the Cambrian Conasauga Formation and Ordovician Newala Limestone are extensively quarried (Rheams, 1992). Limestone is the leading crushed stone produced in Alabama with an annual value of about $269 million and a unit value of $6.56 per metric ton (U.S. Geological Survey, 2007a). Shelby County is the state's leading limestone-producing area with an average annual production since 2000 of 19.2 million short tons, representing roughly 40 percent of Alabama's entire production (table 2).

Chalk is a soft fine-textured variety of limestone that occurs in the Coastal Plain Province of west-central Alabama (figs. 2, 5). The Demopolis Chalk of the Selma Group has been mined for use in the manufacture of portland cement and agricultural soil conditioner since 1900 from the Spocari quarry near Demopolis. Approximately 29 million short tons of chalk has been mined from the Spocari quarry since 1942. Since 1980, this quarry has produced 1.2 million short tons of chalk annually. At St. Stephens in Washington County, the Tertiary Marianna Limestone was mined from 1927 to 1980 for use in cement. About 26 million short tons of limestone was mined from 1942 to 1980 (Dean, 2000).

MARBLE

In Alabama the major source of marble—the metamorphosed equivalent of limestone and dolomite—is in Talladega County (fig. 5), where it occurs in a narrow outcrop belt from the Coosa River to southeast of Talladega (Guthrie, 1989). This area is known as the Sylacauga Marble belt, named for exposures near Sylacauga, where marble has been quarried for more than 160 years. In the Sylacauga area, marble known for its high-grade crystalline texture, whiteness, and beauty has been extensively quarried with an estimated total production of 42 million short tons (Dean, 2000). In 1969, Sylacauga Marble was designated as the official rock of

Figure 6.—Quarry operation at Glenco, Etowah County, Alabama, for crushed limestone (photo courtesy of Vulcan Materials Company).

Alabama. Although marble quarried in early operations was used primarily for monuments and for decorative purposes, today's operations produce predominantly crushed marble. Crushed marble is used in a number of diversified applications including industrial fillers, fertilizer, aggregate, and micronized marble, which is shipped as a slurry for use in paper pigment and coating. In 2007 marble production was 4.4 million short tons (table 1). Marble production has a unit value of $6.62 per metric ton (U.S. Geological Survey, 2007a).

In addition to the Sylacauga Marble, the dolomitic Chewacla Marble crops out in a number of large isolated areas in Lee County and has been quarried for aggregate near Auburn (Fousek, 2007). Dolomitic marble was quarried as early as 1849 south of Auburn and used in lime production. Nearly 35 million short tons of Chewacla Marble has been quarried since 1958, when large-scale mining for crushed stone began (Dean, 2000).

MICA

Muscovite mica (hydrous potassium aluminum silicate) is found as sheets or "books" associated with granitic pegmatites occurring as dikes and sills within the metamorphic and igneous rocks of the Alabama Piedmont. Mica-bearing pegmatites have been mined extensively in five major areas: the Pinetucky area, Randolph and Cleburne Counties; the Pyriton area, western Clay County; the Lineville area, eastern Clay County; the Rockford area, Coosa County; and the Dadeville area, Tallapoosa County. Large concentrations of flake mica also occur as finely disseminated flakes in mica schists of the Alabama Piedmont (Epperson and Rheams, 1984).

Sheet mica is used primarily in the electrical industry as insulation in a variety of electrical equipment. Scrap or flake mica is used by industry in dry-, wet-, or micronized-ground form. Major uses of dry-ground mica are in drilling muds for the petroleum industry, in the manufacture of asphalt roofing material, and as a filler-extender in gypsum plasterboard. Wet-ground mica is used principally by the paint industry as a specialized pigment extender. Micronized-ground mica is used similarly as a filler-extender in paints and plastics, and as a dusting agent in the manufacture of rubber products. A new mica recovery operation continues to be active at Micaville in Cleburne County. Scrap or flake mica produced at Micaville is used by industry in dry-, wet-, or micronized-ground form.

OCHER

Ocher is the clayey and unconsolidated form of the minerals limonite and hematite, with various impurities. Ocher in Alabama occurs in sedimentary and residual deposits. The sedimentary deposits are found in the Coastal Plain Province in Autauga, Barbour, Clarke, Monroe, and Tuscaloosa Counties. Residual ocher occurs in the Valley and Ridge Province and Piedmont Province in Calhoun, Cherokee, Elmore, Shelby, St. Clair, and Talladega Counties. Hematite used as iron oxide pigment is mined in eastern Tuscaloosa County.

QUARTZITE

Quartzite (recrystallized or silica-cemented sandstone) has been quarried at several sites in east Alabama and used for building stone, riprap, road metal, and in the manufacture of silica brick. The Cheaha Quartzite Member along the crest of Talladega Mountain in the Alabama Piedmont has been quarried in Clay County. Quartzite in the Weisner Formation has been quarried in Cherokee and Calhoun Counties. The Hollis Quartzite in Lee County is presently used as road metal and as a filler in manufacturing brick. Production in 2007 was 59,000 short tons (Alabama Department of Industrial Relations, 2007).

SALT

Salt deposits underlie much of southwest Alabama at depths from 400 feet to greater than 18,000 feet. Salt seeps in Washington and Clarke Counties were used to produce salt intermittently during the 1800s. Large-scale production of salt brine began in 1952 to supply a chlorine and caustic soda plant at McIntosh in Washington County. Salt is produced by solution mining for the manufacture of industrial chemicals. Numerous other salt structures occur deeper in the subsurface of southwest Alabama.

SAND AND GRAVEL

Alabama has an abundance of sand and gravel suitable for most construction needs and many industrial uses (fig. 7). The most extensive of many sand and gravel deposits distributed throughout the state occur in the Coastal Plain Province in an area extending from Dallas County through Montgomery County and into Russell County. These deposits have the potential for production of high-silica construction sand and industrial gravel (fig. 8). Sand and gravel deposits in the Valley and Ridge Province and the Interior Low Plateaus Province (figs. 2, 7) contain a high percentage of chert gravel, which is unsuited for most industrial applications or as aggregate in concrete. Chert gravel can be used for road-base material and fill.

Industrial and construction sand and gravel combined was the second leading industrial mineral commodity produced in Alabama during 2007, valued at $87.8 million (U.S. Geological Survey, 2008b). The Montgomery district, located in the Coastal Plain Province of south-central Alabama, was the largest sand and gravel producing area in the state during the period 2000-2007 (table 3). Sand and gravel resources occur principally in Quaternary alluvium and terrace deposits of the Alabama, Coosa, and Tallapoosa Rivers bordering Montgomery, Autauga, Lowndes, Elmore, and Macon Counties. Large-scale production of sand and gravel in the Montgomery district began in the early 1920s. Since 2000, the Montgomery district has produced about 2.2 million short tons of sand and gravel annually, about 14 percent of the entire production in Alabama (table 3).

The leading use of construction sand and gravel in Alabama was in concrete aggregate with a value of $36.7 million (unit value of $4.19 per metric ton). Other major uses include asphaltic concrete aggregate with a value of $10.1 million (unit value of $7.34 per metric ton), road base and coverings with a value of $1.9 million (unit value of $2.89 per metric ton), and fill sand and gravel with a value of $2.29 million (unit value of $2.50 per metric ton). Other uses totaled $19.5 million and include plaster and gunite sands (unit value of $6.27 per metric ton), concrete products (unit value of $7.10 per metric ton),

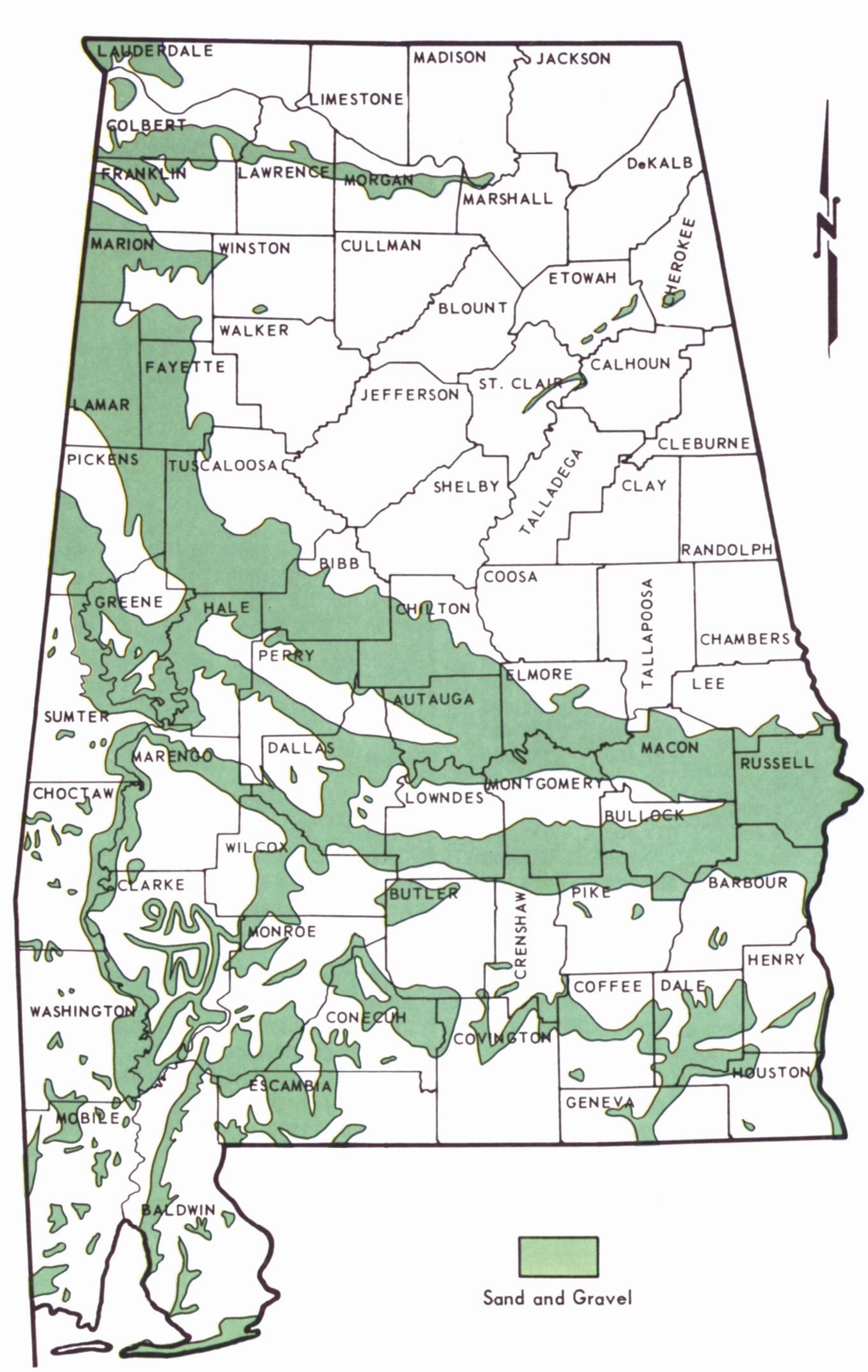

Figure 7.— General distribution of sand and gravel resources in Alabama (Dean, 2000).

Figure 8.—Quartz gravel aggregate.

road stabilization, and water filtration (U.S. Geological Survey, 2007a). A developing industry in Alabama is the use of offshore sand resources to renourish and restore eroding and hurricane-damaged beaches (see Minerals Related Activity section). In the past, small plants alone produced sand and gravel for a specific job or area. Recent trends have been to develop large, high-capacity plants that use long-distance transportation.

SANDSTONE

Sandstone is a medium-grained sedimentary rock typically composed of quartz sand grains cemented together by silica or iron oxide and frequently containing small-scale sedimentary structures. The Pennsylvanian Pottsville Formation is the most widespread unit containing sandstone and has been quarried throughout north Alabama for building stone and crushed aggregate for more than 160 years. Pottsville sandstone was quarried as early as 1827 at Tuscaloosa for building stone used in the construction of the State Capitol building. Pottsville sandstone has recently been quarried in Blount, Cherokee, Marshall, and Walker Counties for building stone, sand and gravel, and crushed aggregate. The Mississippian Hartselle Sandstone of north Alabama has been used as a source of building stone and silica sand. Production in 2007 was 1.7 million short tons (table 1). Recent annual sandstone production was valued at $7.69 million and a unit value of $5.96 per metric ton (U.S. Geological Survey, 2007a).

SILICON

High-grade silica sand and gravel (greater than 99 percent SiO_2) from Quaternary alluvial deposits are used in the ferroalloy furnace production of ferrosilicon and silicon metal at plants in Selma, Montgomery, and Bridgeport. Ferrosilicon is used as an additive to steel to achieve complete deoxidization, and silicon is used as an alloying element and as a component in silicone production.

SULFUR

Sulfur is produced as a by-product of gas-cleansing processes in plants operated in Escambia, Mobile, and Washington Counties. Sulfur recovery started in 1972 from south Alabama, and it is also currently recovered from petroleum refineries in Tuscaloosa County. Recent annual production of sulfur in Alabama was 236,000 metric tons valued at about $9.42 million (U.S. Geological Survey, 2006).

POTENTIAL MINERAL RESOURCES

A number of the state's mineral deposits are now classified as potential resources either because they are not presently mined commercially or because they occur in quantity and grade unacceptable for present commercial operations. As knowledge of the state's geology increases, or as economic circumstances change, mining of these minerals may become economically feasible.

ASPHALTIC ROCK

Asphalt-impregnated sandstone and limestone of the Mississippian Hartselle Sandstone, Pride Mountain Formation, and Tuscumbia Limestone underlie some areas of Colbert, Franklin, Lawrence, and Morgan Counties in northwest Alabama. Crushed asphaltic stone was first used for paving streets in Florence, Alabama. Later, Alabama was one of only three states producing native asphalt. For many years crushed asphaltic limestone from the Tuscumbia Limestone was produced at the Margerum quarry in Colbert County. From 1923 to 1982 about 14 million short tons of asphaltic limestone was mined from Colbert County. Renewed interest in the development of new energy resources has prompted investigations of these deposits as potential sources of petroleum (Wilson, 1987).

BARITE

Barite (barium sulfate) is a colorless to white, chemically inert nonmetallic mineral with a relatively high specific gravity. The majority of barite consumed in the United States is used as an additive to drilling mud for rotary drilling of oil and gas wells. Other uses include filler in paper, rubber products, paint, textiles, and as heavy construction aggregate. Barite is also used as a source of barium in the chemical industry.

In Alabama, barite occurs as epigenetic vein and breccia deposits in the Ordovician Chepultepec Dolomite, Longview Limestone, Newala Limestone, and possibly the Mosheim Limestone Member of the Lenoir Limestone (Hughes and Lynch, 1973). It also occurs in secondary residual deposits that are weathering products of dolomites and limestones. These deposits are situated in a 13-county area that extends from Bibb County in central Alabama to Cherokee County in northeast Alabama. In addition, barite occurs as a vein mineral within the Piedmont Province of eastern Alabama. It was mined in Alabama as early as the 1840s. Mining continued sporadically in Alabama until World War II, with most of the production from Bibb, Calhoun, and Shelby Counties. From 1915 to 1924, 28,600 tons of barite was mined, 80 percent of which came from Calhoun County.

COLUMBITE-TANTALITE

The columbite-tantalite (iron manganese niobium-tantalum oxides) series of minerals was only of mineralogical interest when discovered in the 1870s near Rockford in Coosa County. Detailed exploration led to the discovery of mineralization hosted by the Rockford Granite. Mining and production of tantalum concentrate in Coosa County occurred during 1989-91 for the national defense stockpile. There has been recent interest in assessing the mining possibilities of the deposits in Coosa County. The columbite-tantalite minerals are the principal sources of tantalum, which is a refractory metal with several strategic industrial applications.

GARNET

The garnet group of minerals occurs in schists and gneisses of the Piedmont Province in east-central Alabama. Rocks of the Wedowee, Mad Indian, Poe Bridge Mountain, and Higgins Ferry Groups contain garnets as ubiquitous minerals in Randolph, Clay, Tallapoosa, Coosa, Elmore, and Chilton Counties. Garnet crystals are usually well-formed dodecahedrons or trapezohedrons, ranging in size from microscopic to 0.5 inch in diameter. The larger crystals usually contain inclusions of mica, quartz, and feldspar. The smaller crystals tend to be purer and free of inclusions.

Garnet's resistance to weathering results in garnet-bearing zones of heavy minerals in the alluvial sediments associated with the Tallapoosa and Coosa River systems as well as in the coastal plain sedimentary apron on the crystalline rocks of the Piedmont Province. Garnets are used primarily as abrasives. The garnets occurring in the metamorphic rocks of the Piedmont Province possibly can be mined in areas where the schists contain up to 25 percent garnets.

GOLD AND SILVER

Gold was discovered in Alabama in the early 1830s. Recorded production to 1939 was about 49,000 troy ounces of gold; however, probably an equal amount has been mined but not reported. Gold has been produced from seven districts in the Alabama Piedmont Province:

1. the Chulafinnee-Arbacoochee district in southern Cleburne and northern Randolph Counties;
2. the Idaho district southwest of Pyriton in west-central Clay County;
3. the Cragford district in west-central Randolph and east-central Clay Counties;
4. the Riddles Mill district in southeastern Talladega County;
5. the Goldville-Hog Mountain district in north-central Tallapoosa County;
6. the Devil's Backbone-Eagle Creek district in Tallapoosa County; and
7. the western Coosa and eastern Chilton Counties district.

More than 100 prospects and mines are known in these seven districts (Lesher and others, 1989).

The towns of Arbacoochee, Chulafinnee, and Goldville, which developed from the gold mining rush of the 1830s, have now been abandoned. The Hog Mountain mine in Tallapoosa County was the most extensively developed gold mine in Alabama and is credited with a total production of about 24,000 troy ounces of gold.

Gold mining ceased in Alabama, except on an individual basis, during the late 1930s. Exploration of gold deposits in Alabama has been carried out intermittently during the past several years in the historic gold districts. In 2008, gold prices exceeded $1,000 per troy ounce, increasing interest in the historic gold districts of the state.

Silver deposits have not been authenticated in Alabama, although rumors of "silver mines" have been prevalent throughout the state. These rumors may be based on the occasional discovery of galena crystals (lead sulfide). Approximately 2,600 troy ounces of silver has been produced as a by-product of gold mining operations in Alabama (Cook and Smith, 1982).

GRAPHITE

Graphite is the most common mineral form of native, or naturally occurring, pure carbon. In Alabama, graphite generally occurs as disseminated flakes in the metamorphic rocks of the Piedmont Province in the east-central part of the state. The mineral is particularly abundant in Clay, Coosa, and southeastern Chilton Counties, and the graphite-rich rock units within these counties form one of the largest graphite deposits in the United States. The richest graphite occurrences are associated with micaceous quartzites and mica schists of the Poe Bridge Mountain and Higgins Ferry Groups, which may contain up to 5 percent disseminated graphite. The graphite-rich zones occur as elongate lenses or layers within the rock, and their thicknesses range from a few feet to more than 100 feet. Vanadium-bearing mica is commonly associated with graphite-rich zones.

Graphite is an important commodity used in the manufacture of electrical products and high-temperature refractory crucibles for the metals industry. Graphite is commonly used as a dry lubricant or is mixed with clay to form the "lead" of pencils.

Flake graphite was mined extensively in Alabama from 1890 to 1931. During World War I, graphite mining reached its peak with 7.8 million pounds of graphite produced in Clay and Coosa Counties in 1918 alone. Forty-three major mines and 30 processing plants were in operation during this period. From 1910 to 1929 roughly 50.8 million pounds of graphite was produced, and from 1942 to 1953 nearly 30 million pounds was produced. Technological advances led to the development and production of artificial graphite, and foreign production rendered Alabama's graphite deposits subeconomic. Graphite mines in the state ceased activity after 1953.

HEAVY MINERALS

"Heavy minerals" is a general term for a group of minerals which, because of their durability and relatively high specific gravity, are concentrated by natural stream or marine processes. Small concentrations of heavy minerals, sometimes called "black sands," occur in the sediment of most streams in the state. Large, concentrated deposits that may occur in beach and offshore sand in coastal areas are important because heavy minerals contain significant quantities of economically important and potentially critical rare elements. Some of the most common minerals included in this group are tourmaline, which contains lithium and boron; rutile, which contains titanium; zircon, which contains zirconium and hafnium; ilmenite, which contains titanium; monazite, which contains several of the rare earth elements; and magnetite, an oxide of iron.

IRON ORE

The development of Alabama's steel industry marked the beginning of the industrial era in Alabama in the late 1800s. First efforts at iron making employed massive stone furnaces and used local "brown iron ore" (limonite) and charcoal. Such furnaces were located near Russellville (1818), Tannehill (1830), Polkville (1843), Shelby (1848), Round Mountain (1853), and at several other localities in Alabama. The iron industry began to expand with the discovery of red ore (hematite) in the Birmingham area, and the mill camps together with the mining camps formed the basis for the present city of Birmingham. In 1967 hematite was designated as the official state mineral.

Iron ore mining was once the state's most important mineral industry, but now all underground mines have ceased operation because higher grade imported ores are available. Red iron ore from the Silurian Red Mountain Formation has been mined in Bibb, Blount, Cherokee, DeKalb, Etowah, Jefferson, and Tuscaloosa Counties. Brown iron ore has been mined in Barbour, Butler, Calhoun, Cherokee, Chilton, Colbert, Conecuh, Crenshaw, Franklin, Jefferson, Pike, Shelby, and Tuscaloosa Counties. Brown iron ore washing and screening plants were generally near the open-pit mine and were moved as mining operations shifted from one mine to another. In Talladega County specular hematite (gray iron ore) occurs in quartzite of the Cambrian Weisner Formation. This iron ore contains a low-grade metamorphic mineral assemblage, which contains pyrite and chalcopyrite. The total iron ore production for Alabama from 1840 to 1975 was about 376 million long tons (Dean, 2000).

Alabama has significant resources of iron ore. Although most outcrop areas of the major red ore beds have been strip mined, an estimated 4.2 billion tons of red ore underlie areas in DeKalb, Etowah, Jefferson, and St. Clair Counties. These iron ore resources could be mined underground if economic conditions became favorable or if it became strategically necessary. In addition, resources of brown iron ore in the southeastern, northwestern, and central counties are estimated at 925 million tons (Simpson and others, 1978).

PHOSPHATE ROCK

Phosphatic material occurs in the Coastal Plain Province at the contact between the Cretaceous Eutaw Formation and Mooreville Chalk in Perry and Dallas Counties. Phosphate occurs in nodules, grains, bone fragments, and shark teeth within a narrow sand and clay zone. This phosphatic zone represents only a potential reserve of low-grade phosphate.

Phosphate rock has been mined from Limestone County, but operations were discontinued in 1983. In this area phosphatic material occurs in Ordovician limestone, but it was mined only from the residuum and weathered portions of the phosphatic limestone. From 1978 to 1983 roughly 721,000 short tons of collophane, or phosphate-bearing residuum, was mined. The residual deposits contained appreciable amounts of phosphate, but no attempts have been made to recover phosphate economically from the unweathered limestone.

PYRITE

Pyrite (iron disulfide) is a common sulfide mineral in the Alabama Piedmont Province, occurring as "fool's gold" in metamorphic, igneous, and sedimentary rocks. Pyrite has a variety of uses including manufacture of iron sinter, sulfuric acid, and sulfur. Pyrite deposits in the Hillabee Greenstone in the vicinity of Pyriton, Clay County, were first mined in the 1850s, and production of pyrite for sulfur continued intermittently until World War I.

SLATE

Slate is a compact, fine-grained metamorphic rock formed by the alteration and recrystallization of clay minerals in sedimentary rock. Its most distinguishing feature is a pronounced cleavage along planes that are independent of original bedding. In Alabama, slate and phyllite with a slaty cleavage (will split into slabs and thin plates) crop out in parts of Shelby, Chilton, Talladega, and Calhoun Counties. Although slate was originally used for building stone, modern uses include industrial extenders, inert fillers, lightweight aggregate, and road aggregate. Slate with the physical properties necessary for use as roofing material has been reported in Talladega County. Also, slate for building stone and other applications has been mined in northern Chilton and southern Shelby Counties.

TALC

Talc (hydrated magnesium silicate) occurs in association with hydrothermally altered dolomite of the Shady Dolomite near Winterboro, Talladega County (Blount and Helbig, 1987). In the Winterboro area, prospecting for talc began as early as 1918, but the majority of production occurred between 1953 and 1976. From 1955 to 1976, the American Talc Co. mined nearly 130,000 short tons of talc from this area. In 1963, a flotation mill was constructed at nearby Alpine, where local and imported high-quality talc is processed for use as a filler in goods such as pharmaceuticals and cosmetics. Talc production from the Winterboro area resumed on a small scale from 1988 to 1992.

TRIPOLI

Tripoli (silicon dioxide) is a light-colored, porous, friable, sedimentary rock that results from the weathering of chert or siliceous limestone. Commercial tripoli averages 98 to 99 percent silicon dioxide with minor amounts of alumina (clay minerals), titanium, and iron dioxide. Large, undeveloped deposits of commercial-quality tripoli occur in the upper part of the Fort Payne Chert in western Lauderdale and Colbert Counties. The tripoli in northwest Alabama is composed of crystalline aggregates of quartz with generally less than 1.5 percent impurities. Smaller, scattered deposits of tripoli occur in cherts and dolomites in Calhoun and Talladega Counties. These deposits are composed principally of individual, frosted, subangular to rounded quartz grains.

Tripoli has excellent abrasive qualities and is used mainly as a component of buffing and polishing compounds. Because it is chemically inert and resists abrasion, tripoli is used as a filler and extender in paint, plastics, and enamels. During the mid-1960s, a small amount of tripoli was mined northeast of Waterloo in Lauderdale County, for use as foundry facing or silica brick.

ZEOLITE MINERALS

Zeolites are hydrated aluminosilicates of alkali and alkaline earth metals and are unique in that their crystal structure contains micropores. Zeolite minerals occur in the Pine Barren Member of the Clayton Formation, the lower clays of the Porters Creek Formation, the Grampian Hills Member of the Nanafalia Formation, and the Tallahatta Formation—all in the Paleocene and Eocene deposits in south Alabama (Beg, 1992). The zeolite minerals identified in these formations are heulandite, clinoptilolite, and phillipsite. The major occurrence of zeolites is in the Tallahatta Formation; zeolites have yet to be exploited commercially.

The discovery of unusual properties of zeolite minerals, particularly their ability to act as molecular sieves, their ion exchange capabilities, and hydration and rehydration properties, has created a great demand for zeolites by industry. Zeolites are used to purify natural and industrial gases, and for water filtration systems, soil conditioning, aquaculture systems, carriers of pesticides, desiccants, and many other uses requiring molecular capillaries. At Chickasaw in Mobile County, artificial zeolites are produced for use as molecular sieve absorbents.

FURTHER READING

Published reports on the state's geology and mineral resources are too numerous to include a complete citation in this report. A complete list of Geological Survey of Alabama publications can be accessed on the Survey's web site at http://www.gsa.state.al.us. Also, information on Survey publications is available from the Publications Sales Office, Geological Survey of Alabama, P.O. Box 869999, Tuscaloosa, Alabama 35486-6999 (telephone 205-247-3636). The Geological Survey Publications Sales Office is also a repository for U.S. Geological Survey topographic maps, which may be purchased. An index to topographic maps may be obtained free of charge.

The Geological Survey of Alabama reports listed below summarize information on the state's mineral resources and may be obtained from the Publications Sales Office.

Summary Report on the Mineral Resources of Southwest Alabama, 1986, by Mirza A. Beg, Bennett L. Bearden, Otis M. Clarke, Jr., Robert L. Barnett, and Thomas W. Daniel, Jr., Geological Survey of Alabama Information Series 65, 33 p.

Mineral Filler and Extender Resources in Alabama, 1990, by Karen F. Rheams, Geological Survey of Alabama Circular 145, 77 p.

Geologic Map of Alabama, 1988, compiled by Michael W. Szabo, W. Edward Osborne, Charles W. Copeland, Jr., and Thornton L. Neathery, Geological Survey of Alabama Special Map 220 (scale 1:250,000).

Geologic Map of Alabama, 1989, compiled by W. Edward Osborne, Michael W. Szabo, Charles W. Copeland, Jr., and Thornton L. Neathery, Geological Survey of Alabama Special Map 221 (scale 1:500,000).

Assessment of Nonhydrocarbon Mineral Resources in the Exclusive Economic Zone in Offshore Alabama, 1990, by Steven J. Parker, Geological Survey of Alabama Circular 147, 73 p.

Industrial Minerals of the Southeastern United States—Economic Mineral Resources in Central Alabama, 1990, by Karen F. Rheams and Guerry H. McClellan, Geological Survey of Alabama Guidebook 3-3, 60 p.

Selected Industrial Mineral Resource Sites and Processing Facilities in West Alabama, by Karen F. Rheams, 1991, Geological Survey of Alabama Guidebook 4, 56 p.

Industrial Minerals of the Southeastern United States—Proceedings of the 2nd Annual Symposium on Industrial Minerals, 1992, edited by Karen F. Rheams and Guerry H. McClellan, Geological Survey of Alabama Circular 161, 111 p.

In addition to these resources, online sources of minerals-related data, including current production statistics and companies now operating in the state, are listed in the "References Cited" section below.

REFERENCES CITED

Alabama Department of Industrial Relations, Office of Mine Safety and Inspection, 2007, Annual statistical report, accessed May 30, 2008, at http://dir.alabama.gov/mr/.

___2000-2006, Annual statistical reports: Montgomery, Alabama.

Alabama Department of Transportation, 2008, List I-1, Aggregates—Sources of coarse and fine aggregates, accessed May 30, 2008, at http://www.dot.state.al.us/Docs/Bureaus/Materials+and+Tests/Testing/MSDSAR/MSDSAR_Lists.htm.

Alabama Development Office, 2007, Alabama 2006 new and expanding industry report: Montgomery, Alabama, 24 p.

___2008, Alabama new and expanding industry announcements, 2007: Montgomery, Alabama, 23 p.

Beg, M. A., 1984, Limestone resources of Alabama: Alabama Geological Survey Special Map 172 with text, 24 p.

___1992, Zeolite minerals in the Tallahatta Formation, Alabama: Alabama Geological Survey Circular 160, 27 p.

Blount, A. M., and Helbig, S. R., 1987, Talc and chlorite in the Winterboro area, Talladega County, Alabama: Alabama Geological Survey Circular 129, 43 p.

Clarke, O. M., Jr., 1973, Bauxite and kaolin in the Eufaula bauxite district, Alabama: Alabama Geological Survey Bulletin 100, 90 p.

Clarke, O. M., Jr., and Tyrrell, M. E., 1976, Porters Creek lightweight aggregate: Alabama Geological Survey Circular 100, 35 p.

Cook, R. B., and Smith, W. E., 1982, Mineralogy of Alabama: Alabama Geological Survey Bulletin 120, 285 p.

Dean, L. S., 2000, Minerals in Alabama, 1998-99: Alabama Geological Survey Information Series 64Q, 44 p.

Epperson, R. S., and Rheams, K. F., 1984, Mica in Alabama: Alabama Geological Survey Atlas 18, 63 p.

Fousek, R. S., editor, 2002, The geology, mining methods, and processing of selected industrial minerals in northeastern Alabama: Alabama Geological Society 39th Annual Field Trip Guidebook, 123 p.

___2007, Locating, permitting, and operation of construction aggregate mining operations in Alabama: Alabama Geological Society 44th Annual Field Trip Guidebook, 105 p.

Geological Survey of Alabama, 2008, STATEMAP—Alabama Metadata Portal, accessed May 30, 2008, at http://portal.gsa.state.al.us/Portal/ptk?command=openchannel&channel=8.

Guthrie, G. M., 1989, Geology and marble resources of the Sylacauga marble district: Alabama Geological Survey Bulletin 131, 81 p.

Hosterman, J. W., 1984, Ball clay and bentonite deposits of the central and western Gulf of Mexico Coastal Plain, United States: U.S. Geological Survey Bulletin 1558-C, 22 p.

Hosterman, J. W., and Patterson, S. H., 1992, Bentonite and fuller's earth resources of the United States: U.S. Geological Survey Professional Paper 1522, 45 p.

Hughes, T. H., and Lynch, R. E., 1973, Barite in Alabama: Alabama Geological Survey Circular 85, 43 p.

Lesher, C. M., Cook, R. B., and Dean, L. S., eds., 1989 [reprint 1999], Gold deposits of Alabama: Alabama Geological Survey Bulletin 136, 229 p.

National Cooperative Geologic Mapping Program, 2007, accessed May 30, 2008, at http://www.gsa.state.al.us/documents/misc_gsa/Alabama.pdf.

Outdoor Alabama, 2008, Freshwater mussels in Alabama, accessed June 27, 2008, at http://www.outdooralabama.com/education/generalinfo/mussels.

Puckett, T. M., Roberson, K. E., and Tew, B. H., 1990, High calcium deposits in the Newala Limestone: Alabama Geological Survey Circular 149, 29 p.

Rheams, K. F., 1992, Mineral resources of the Valley and Ridge Province, Alabama: Alabama Geological Survey Bulletin 147, 263 p.

Rohrbach, R. P., 1989, The stars fell in Alabama: Lapidary Journal, v. 42, no. 12, p.20-22, 24-26, 28.

Simpson, T. A., McCarl, H. N., Hilleke, A. F., and Hanna, H. S., 1978, Assessment of iron ore availability in Alabama and the southeastern Appalachian region: Tuscaloosa, University of Alabama, Mineral Resources Institute, State Mine Experiment Station, 102 p.

U.S. Geological Survey, 2006, Sulfur—2005 Minerals Yearbook, accessed May 30, 2008, at http://minerals.usgs.gov/minerals/pubs/commodity/.

____2007a, The mineral industry of Alabama—2005 Minerals Yearbook, p. 3.1-3.6, accessed May 30, 2008, at http://minerals.usgs.gov/minerals/pubs/state/al.html.

____2007b, Stone, Dimension—2006 Minerals Yearbook, accessed May 30, 2008, at http://minerals.usgs.gov/minerals/pubs/commodity/.

____2008a, Alabama 2007 preliminary nonfuel mineral production data: Arnold Tanner, e-mail communication.

____2008b, Mineral Industry Surveys—Crushed stone and sand and gravel in the fourth quarter 2007, accessed May 30, 2008, at http://minerals.usgs.gov/minerals/pubs/commodity/.

Wilson, G. V., 1987, Characteristics and resource evaluation of the asphalt and bitumen deposits of northern Alabama: Alabama Geological Survey Bulletin 111, 110 p., accessed May 30, 2008, at http://www.gsa.state.al.us/online_pubs.aspx.

Published by

GEOLOGICAL SURVEY OF ALABAMA

Serving Alabama since 1848

Berry H. (Nick) Tew, Jr., State Geologist

For additional copies write:
Publications Sales Office
P.O. Box 869999
Tuscaloosa, Alabama 35486-6999
205/247-3636

e-mail: PubSales@gsa.state.al.us

A complete list of Geological Survey of Alabama and Oil and Gas Board publications can be obtained at the Publications Sales Office or through our web site at http://www.gsa.state.al.us/.


Geological Survey of Alabama
Information Series 64R