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INDUSTRIAL-MINERAL RESOURCES OF OKLAHOMA[1]

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INTRODUCTION

Industrial minerals (which are the nonfuel, nonmetallic minerals that have potential for economic use) are widely distributed in Oklahoma (Fig. 1), and many of them are being mined for local, regional, and national markets. Numerous and varied industrial-mineral industries are active in 69 of Oklahoma's 77 counties. Although such activity is widespread in the State, some of the most important regions are the Wichita, Arbuckle, and Ouachita Mountain uplifts in the south, and the Ozark uplift in the northeast (Fig. 2); it is in these areas where some of the State's unique rock and mineral deposits have been uplifted and are now exposed at the land surface.

Crushed-stone and building-stone resources include limestone, dolomite, granite, and rhyolite; other major construction resources are cement (made from limestone and shale) and the extensive sand and gravel deposits along modern and ancient riverways. Glass sand (a high-purity silica sand) is used for glass making, foundry sands, ceramics, and abrasives. Enormous resources of gypsum in the western part of the State are mined for wallboard, for plaster, as retarder in portland cement, and as soil conditioner. Thick layers of rock salt underlie most of western Oklahoma, and natural springs emit high-salinity brine to the several salt plains. Oklahoma iodine, produced from deep brines in the northwest, is the Nation's sole domestic supply. Other important industrial minerals in Oklahoma include clays and shales (to make brick and tile), and tripoli and volcanic ash (abrasive and/or absorbent materials). Gem-stone production includes fresh-water mussel shells and fresh-water pearls.

The total estimated value of industrial-mineral production in Oklahoma during 1997 was $411 million (Table 1), and the State ranked 34th in the Nation. Leading nonfuel commodities during 1997 were crushed stone ($134 million), portland and masonry cement ($131 million), sand and gravel ($33 million), glass sand ($27 million), iodine ($24 million), and gypsum ($18 million) (Table 1).

This report, modified from Johnson (1993), is a description of the State's industrial minerals, arranged alphabetically. Many of the data are based upon reports by Johnson (1969a, 1977), Morris (1982), and the Oklahoma Department of Mines (1991); the reader is referred to these reports, as well as other reports that are referenced separately for several of the commodities. The many companies that mine Oklahoma's mineral resources are listed in a "Directory of Oklahoma Mining Industry" (Arndt and Springer, 1993), and maps from that report are reproduced here (Figs. 3–6) to show the number of current mining operations for specified commodities in each county.

ASPHALT

Asphalt is an oil-based commodity, but, because it has been used mainly as a road-surfacing and tar material in Oklahoma, it is herein considered as a nonfuel-mineral resource. Asphalt forms where crude oil migrates upward near the land surface: the lighter hydrocarbons evaporate, leaving a thicker, heavy residue that impregnates the rocks as rock asphalt, or that fills voids as a tar-like substance called asphaltite.

The major sources of rock asphalt and asphaltite are in sedimentary rocks in and around the Arbuckle and Ouachita Mountains of southern Oklahoma (Jordan, 1964). Additional smaller deposits occur in sedimentary rocks surrounding the Wichita Mountains and in northeast Oklahoma. From the State's large resources, about 3 million tons of asphalt were produced between 1891 and 1960, chiefly from asphaltic sandstones and limestones

[1]Johnson, K. S., 1993, Industrial-mineral resources of Oklahoma, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 1–10.

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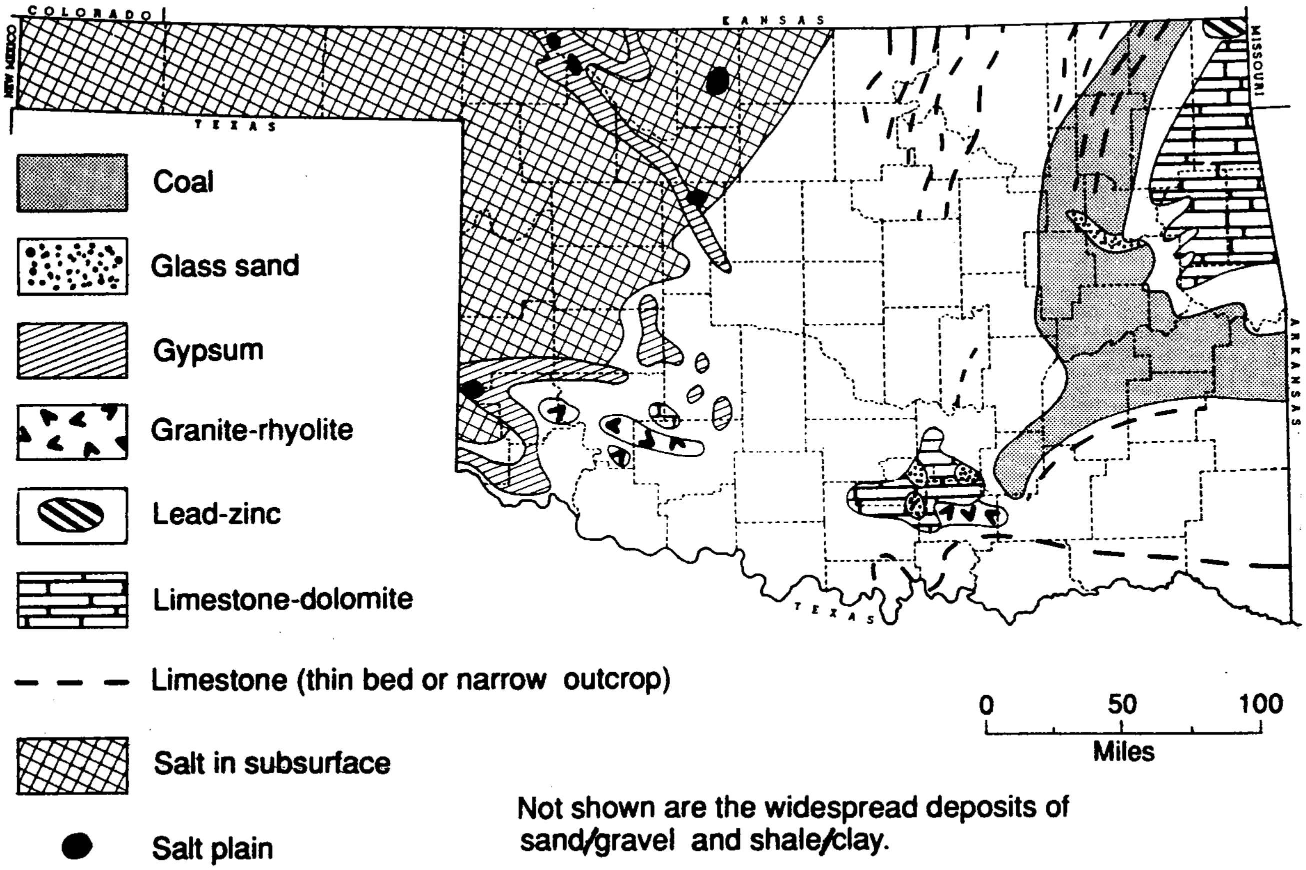

Figure 1. Selected nonpetroleum-mineral resources of Oklahoma.

in the Sulphur and Dougherty districts of the Arbuckle Mountains. Principal mines for asphaltite were operated near Page, Sardis, and Jumbo in the Ouachita Mountains; these shaft mines and surface mines operated between 1890 and 1916.

Most of the rock asphalt mined in Oklahoma was used as paving material for roads in Oklahoma and adjacent states. Petroleum refineries now produce the large quantities of asphaltic material needed for road construction and maintenance, and all natural-rock-asphalt quarries are currently inactive. Asphaltite was used mainly in making roofing pitch, paints, varnishes, rubber substitutes, and electrical-wire insulation. Future demands for asphaltic materials and/or heavy oils can readily be satisfied by the vast resources that remain in the State.

CEMENT

Raw materials for the manufacture of portland cement and masonry cement are limestone and clay or shale. Oklahoma has an abundance of both these resources, and they are discussed separately elsewhere in this report. Three cement plants currently are operating in Mayes, Pontotoc, and Rogers Counties: production in 1997 was estimated at 1.9 million metric tons, with a value of $131 million (Table 1).

CHAT

Chat, which consists of crushed limestone, dolomite, and chert, was produced as a waste byproduct of mining and milling of lead/zinc ores in the Tri-State district of northeast Oklahoma. The material, which now exists in large piles in the Miami-Picher area of Ottawa County, has been used as road metal, railroad ballast, concrete aggregate, and rock fill.

CHEMICAL RAW MATERIALS

Oklahoma has vast resources of certain high-purity minerals suitable as raw materials for various chemical industries (Johnson, 1969b). Major deposits of limestone, dolomite, and glass sand are in the south-central and eastern parts of the State, whereas gypsum and salt are widespread in the west; these individual resources are discussed elsewhere in this report. The abundance and purity of these minerals should enable manufacture of caustic soda, soda ash, chlorine, sulfur, sulfuric acid, lime, sodium silicate, and other chemical products. Oil, natural gas, and water, needed in the manufacture of these chemi-

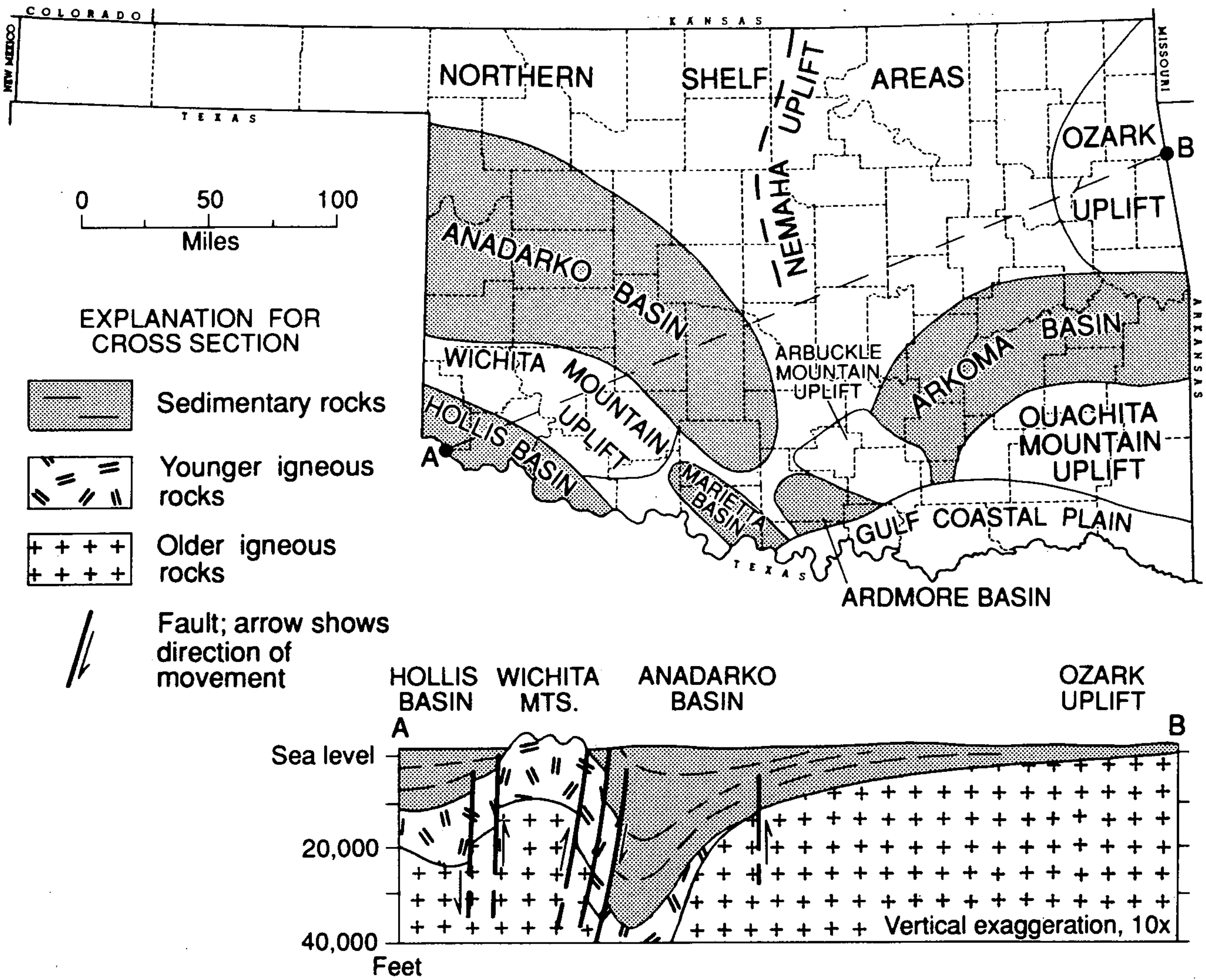

Figure 2. Major geologic provinces of Oklahoma.

cal products, are plentiful in most parts of the State, and bituminous coal is abundant in eastern Oklahoma.

CLAY AND SHALE

Clay and shale are present in almost every county in Oklahoma, and deposits suitable for manufacture of red brick and tile products are widely distributed (Fig. 3). Light-firing clays, low-grade refractory clays, and clays suitable for making pottery are present at a few localities, and clay suitable for making lightweight aggregate is common in the eastern portion of the State.

Most of the shale deposits in Oklahoma contain illite as the dominant clay mineral, and the illite is associated with varying mixtures of clay-sized quartz and other clay minerals. Chlorite, kaolinite, montmorillonite, and mixed-layer clays generally are of lesser importance, although each of these clays is predominant in certain localities. In addition to these common shales, there are several types of specialty clays in parts of Oklahoma: small- to moderate-sized deposits of bentonitic clay (montmorillonite) are associated with, and altered from, volcanic ash, mainly in northwestern Oklahoma. Recent reports on clays and shales in Oklahoma are by Bellis (1972) and Johnson and others (1980).

Shale has been an important part of the construction industry in Oklahoma since before Statehood. More than 120 brick plants have operated since 1888, with most of them being in the central part of the State (Morris, 1982). Also, shale is one of the major ingredients at the three cement factories now operating in the State. In 1993, 21 companies were producing clay and shale in many different parts of Oklahoma (Oklahoma Department of Mines, 1994), and in 1997 the State produced an estimated 772,000 metric tons of clay and shale valued at about $3.6 million (Table 1).

DIMENSION STONE

Oklahoma has a variety of sandstones, limestones, dolomites, and granites suitable for building and ornamental purposes, and native stone has been used extensively in residence and building construction. The quality of some sandstones in eastern Oklahoma and of oolitic limestone in southern Oklahoma compares favorably with any in the nation, and several of the limestones and dolomites have unusual beauty and texture. The various types of dimension stone are discussed further in this report under the rock names. In 1997, Oklahoma produced about 9,761 metric tons of dimension stone, valued at an estimated $2.2 million (Table 1).

DOLOMITE

Large resources of high-purity Cambrian dolomite are present in the Arbuckle Mountains (Ham, 1949); the stone is quarried for high-purity material at one site and is quarried for crushed stone at two other sites in the Arbuckle Mountain region (Fig. 6). The high-purity Royer Dolomite is about 500 ft thick in the area, and other dolomite units are also 400–500 ft thick. Smaller deposits or thinner beds, generally of lower purity, are known in the Wichita Mountains, in Delaware and Osage Counties, and in widely scattered Permian outcrops of western Oklahoma; several of these deposits are worked for dimension stone and/or for crushed stone.

Current and potential uses of dolomite are for fluxing stone, glass manufacture, refractories, dolomitic lime,

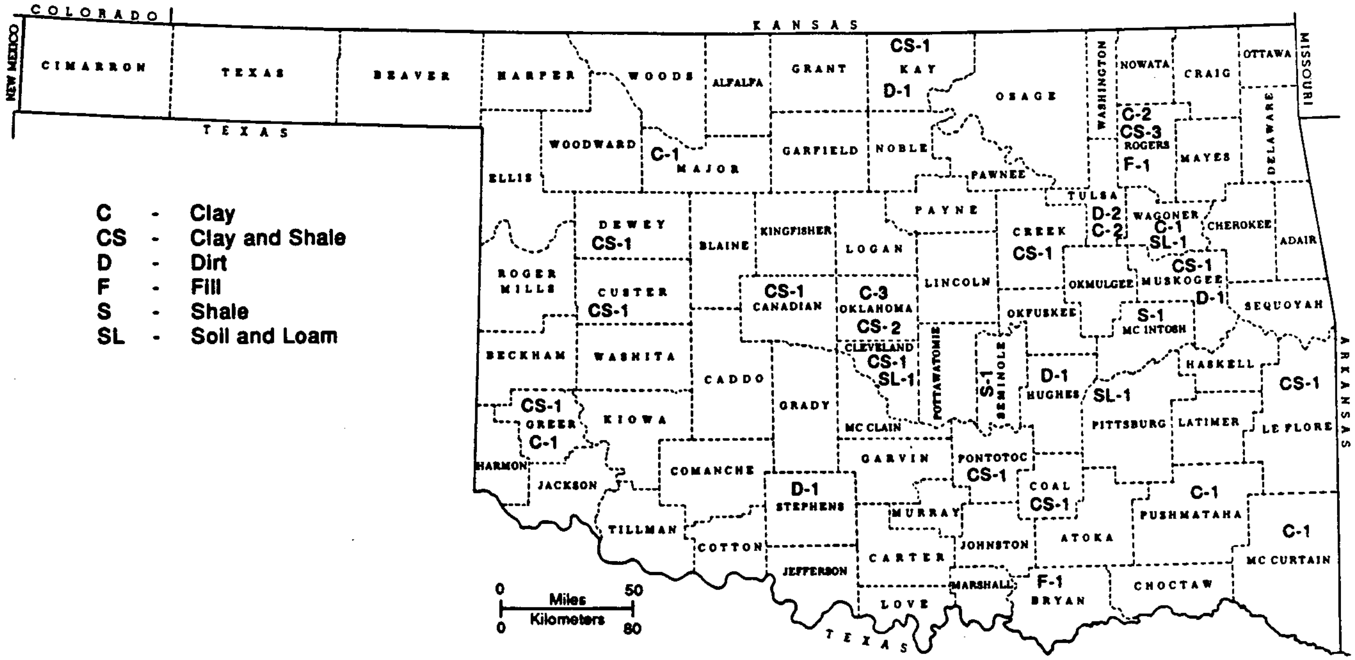

Figure 3. Number of clay, shale, and soil pits in each of Oklahoma's counties (from Arndt and Springer, 1993).

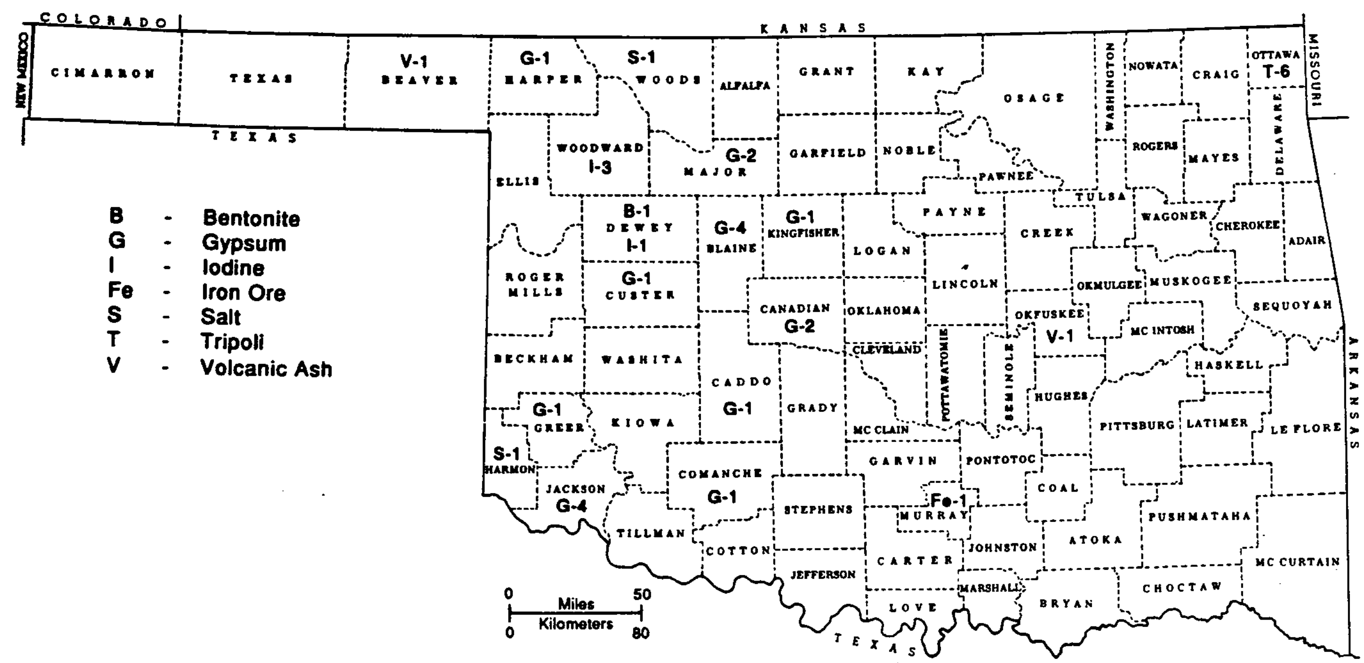

Figure 4. Number of bentonite, gypsum, iodine, iron ore, salt, tripoli, and volcanic-ash operations in each of Oklahoma's counties (from Arndt and Springer, 1993).

magnesium metal, fertilizers, feeds, and as a soil conditioner. Quantity and value of current production are included within the estimates for crushed and dimension stone (Table 1).

GEM STONES

Gem-stone production consists of the harvesting of fresh-water mussel shells from lakes and rivers, chiefly in eastern Oklahoma. The shells then are cut up and rounded, and the shell pellets are implanted in oysters for creating cultured pearls. Small quantities of fresh-water pearls are also recovered from the mussels, but these are only a minor byproduct of the shell production. Three firms are currently buying fresh-water mussels from independent divers in Oklahoma, and almost all the shell material is being exported to Japan. The value of fresh-water mussel shells and pearls harvested in 1997 was estimated at nearly $1 million (Table 1).

Although there are about 300 species of fresh-water mussels, only about 15–20 are suitable for use as shell pellets for implanting. Also, about 100 species are already

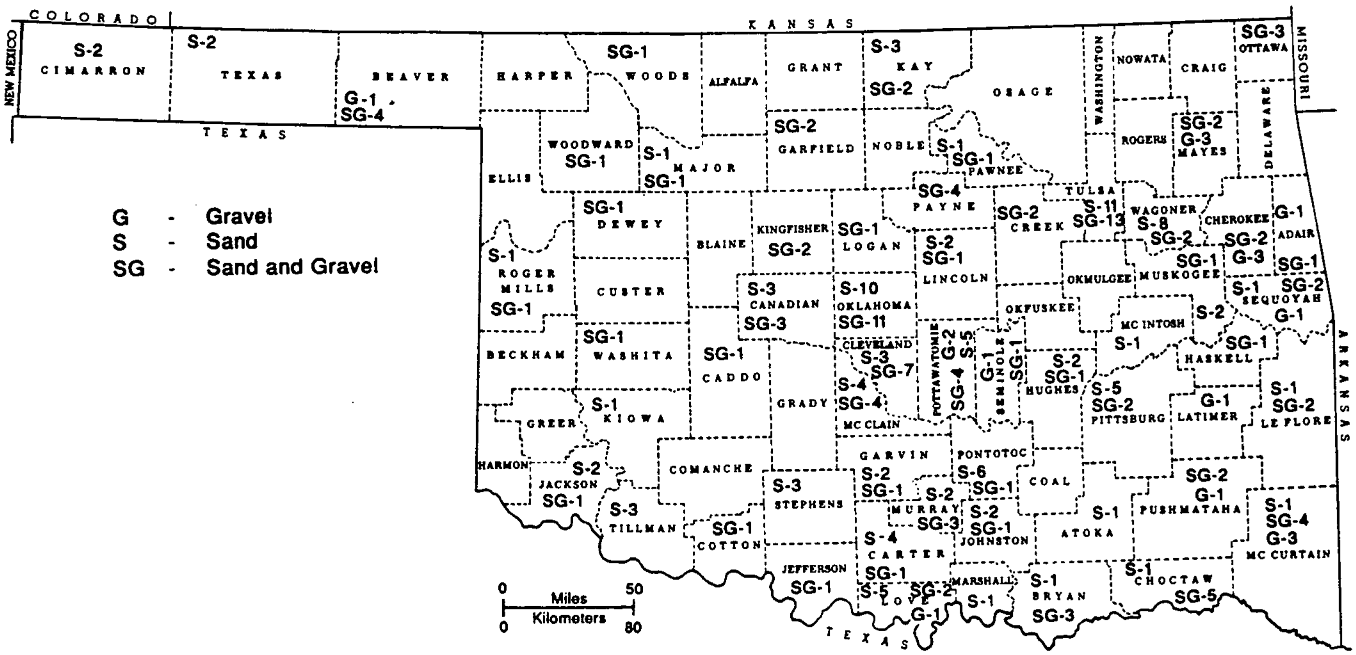

Figure 5. Number of sand and gravel operations in each of Oklahoma's counties (from Arndt and Springer, 1993).

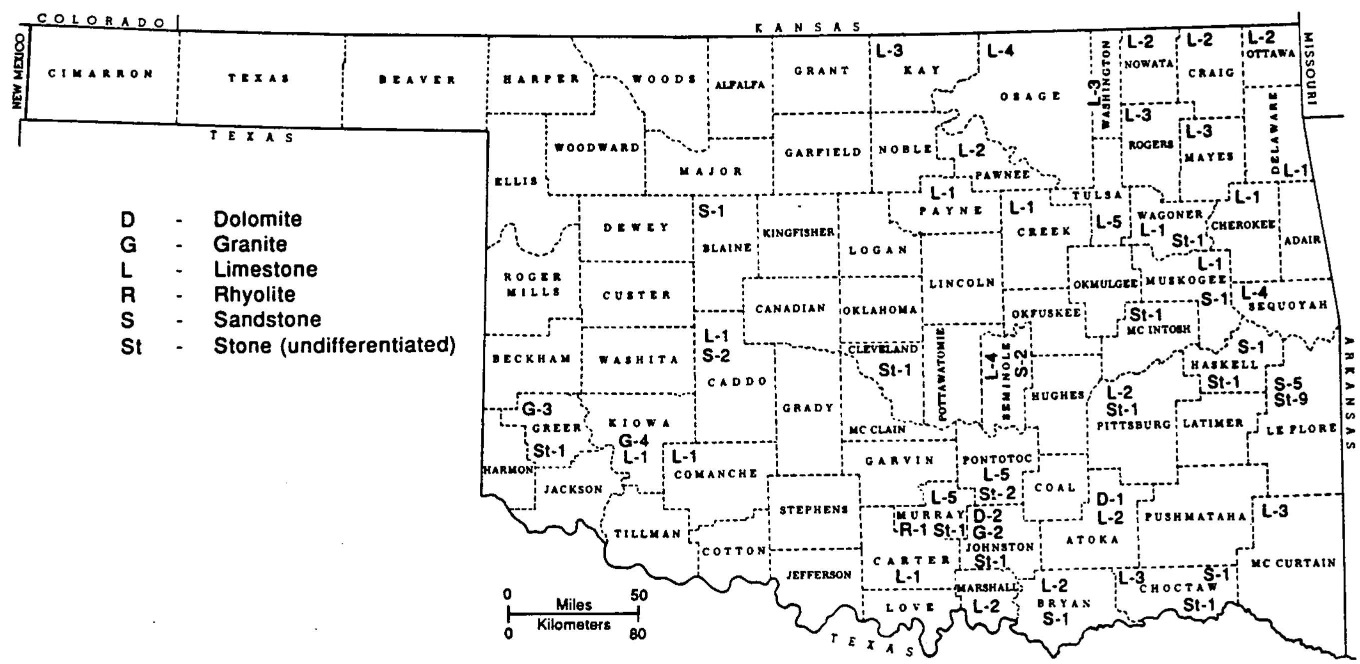

Figure 6. Number of stone quarries in each of Oklahoma's counties (from Arndt and Springer, 1993).

TABLE 1.—INDUSTRIAL-MINERAL PRODUCTION IN OKLAHOMA[a]
(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	1995		1996		1997[p]	
	Quantity	Value	Quantity	Value	Quantity	Value
Cement:						
Masonry	95	7,248	101	8,849[e]	103	9,203[e]
Portland	1,740	110,096	1,745	117,591[e]	1,780	122,295[e]
Clays:						
Common	674	3,579	799	4,090	772	3,550
Fire	–	–	23	W	–	–
Gemstones	NA	W	NA	603	NA	995
Gypsum, crude	2,831	17,003	2,694	16,549	2,613	18,425
Iodine, crude [metric tons]	1,207	12,466	1,274	14,617	1,327	23,976
Sand and gravel:						
Construction	7,800	25,107	7,905	27,686	9,120	32,700
Industrial	1,249	25,363	1,349	27,189	1,349	27,189
Stone:						
Crushed[b]	31,053	124,784	28,330	117,366	31,500	134,000
Dimension [metric tons]	9,172[b]	2,354[b]	9,710	2,220	9,761	2,231
Combined value of feldspar, helium [crude, Grade-A (1996–97)], lime, salt, stone [crushed shell and traprock, dimension quartzite and sandstone (1995)], tripoli (1995–96), and values indicated by symbol W	XX	28,676	XX	32,339	XX	35,967
Total	XX	356,676	XX	369,099	XX	410,531

Source: U.S. Geological Survey

[a]Production as measured by mine shipments, sales, or marketable production (including consumption by produers). Data are rounded to three significant digits; may not add to totals shown.

[b]Excludes certain stones; kind and value included with "Combined value" figure.

[e] - Estimated. [p] - Preliminary. NA - Not available. W - Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX - Not applicable.

declared endangered species, or are proposed for such a listing, so great care must be exercised in harvesting shells. Licensing of divers and shell buyers is carried out by the Oklahoma Wildlife Conservation Department.

GLASS SAND

Large deposits of high-purity silica sand (Ordovician Simpson Group) are worked at two places (Johnston and Pontotoc Counties) in the Arbuckle Mountains region (Ham, 1945) (Fig. 1), with plant-run sands containing 99.8% silica and normally only 0.01–0.03% iron oxide. Ordovician sand almost as pure is present in northeastern Oklahoma, and scattered exposures of Cretaceous sands with 98.5–99.5% silica are reported south and east of the Arbuckles. Alluvial sand from the Arkansas River is being specially treated in Muskogee County to produce a high-purity feldspathic sand for glass manufacture: the processed sand includes about 75% quartz (silica), about 25% feldspar, and less than 0.04% iron oxide. In 1997, Oklahoma's production of glass sand (reported as industrial sand in Table 1) was estimated at 1.35 million metric tons, with a value of about $27 million.

A number of glass-manufacturing plants in eastern and central Oklahoma produce a variety of glass products, including bottles, jars, window panes, tumblers, tableware, and pyrex glass. Sand also is shipped from the State for glass making, foundry sands, ceramics, and the manufacture of sodium silicate. One glass-sand plant produces ground silica for use in ceramics, abrasives, and inert filler.

GRANITE

Granite and similar rocks of the Wichita and Arbuckle Mountains of southern Oklahoma (Fig. 1) are extensively produced as dimension stone for the monument and building trades; crushed granite and rhyolite are produced mainly for railroad ballast (stone in the railroad bed), and intermittently for aggregate and rip-rap. Granite and similar rocks in Oklahoma are Precambrian and Cambrian in age. Colors are red, pink, gray, and black, and the textures range from fine to coarse crystalline.

At present, eight companies are regularly producing granite and rhyolite from quarries in Greer, Kiowa, Jackson, Johnston, and Murray Counties, (Fig. 6) and in 1993 the State produced about 3.6 million short tons of granite and rhyolite (Oklahoma Department of Mines, 1994). The major production (2.7 million tons) was from Johnston and Murray Counties, where granite and rhyolite are being quarried for railroad ballast. The value of granite and rhyolite production is divided among several categories (dimension stone and crushed stone) in Table 1.

GYPSUM

Enormous resources of high-purity Permian gypsum crop out in western Oklahoma (Fig. 1). Blaine Formation gypsums are 5–30 ft thick and 95–99% pure in the northwest and southwest, and the Cloud Chief gypsum of Washita-Caddo Counties is 25–100 ft thick and 92–97% pure. Anhydrite crops out only locally, but is present underground where overburden is 25–100 ft, or more.

Total gypsum resources in Oklahoma are estimated at 48 billion short tons. These resources are well suited for open-pit mining or quarrying, because gypsum typically forms hills in the semiarid climate of western Oklahoma, and the gypsum layers are nearly flat lying, without folds or faults (Johnson, 1978).

Oklahoma ranks first among the United States in crude gypsum production, with about 2.6 million metric tons produced annually by 14 companies in 9 western counties (Fig. 4). The value of gypsum produced in 1997 is estimated at about $18 million (Table 1). Present uses are for plaster, for wallboard, as retarder in portland cement, and as soil conditioner. In the future it may be used as a source of sulfur.

HELIUM

Helium, a colorless, odorless, and nonpoisonous gas, is the second lightest of all elements. Helium was extracted for many years from natural gas at the U.S. Bureau of Mines plant near Keyes, in Cimarron County, but production has ceased. The helium-producing field is largely depleted, although some resources still remain.

IODINE

Iodine is a grayish-black, nonmetallic element that is solid at ordinary temperatures. In Oklahoma, it is dissolved in iodine-rich natural brines (>300 ppm iodine) 6,000–10,000 ft below the land surface in the Woodward, Vici, and Dover areas in the northwestern part of the State (Johnson, 1994) (Fig. 4). The major production is in the Woodward and Vici areas, where iodine occurs in Morrowan (basal Pennsylvanian) sandstones preserved in a south-trending paleovalley called the Woodward "trench". Other iodine production comes from a variety of Paleozoic sandstones, limestones, and dolomites, as a byproduct of oil and gas production. Iodine-rich brines are produced from wells drilled into these rock units, and the iodine is then treated chemically and precipitated from the brine; after being stripped of its iodine, the waste brine is treated and then reinjected into the same producing formation (Cotten, 1978). The Oklahoma brines range from 100–1,560 ppm iodine, are 300–350 ppm iodine in most of the producing wells, and are the richest known iodine brines in the World (Johnson, 1994).

Oklahoma's production of iodine began in 1977, and, with the cessation of iodine production in Michigan in 1987, Oklahoma is now the sole source of domestic iodine in the United States. The U.S. (Oklahoma) produces about 12% of the World's annual output. At present, three companies operate three major plants and one miniplant in northwest Oklahoma, and annual production is about 1.3 million kg (kilograms), valued at about $24 million (Table 1). A new plant was built in Woodward to make about 50 iodine-derivative products from the iodine being produced. Major uses of iodine include catalysts, stabilizers, animal feeds, disinfectants, pharmaceuticals, photography, and colorants.

LIME

Quicklime, made by calcining high-purity limestone, has many chemical and industrial uses, as well as being used in construction and agriculture. High-calcium limestone is being mined to produce lime in Sequoyah County, and other deposits of high purity are present in northeastern, south-central, and southeastern Oklahoma.

LIMESTONE

Limestone is abundant in northeastern Oklahoma, in the Wichita and Arbuckle Mountain areas, and in southeastern Oklahoma (Rowland, 1972) (Fig. 1). It is used mainly as aggregate (crushed stone) in concrete, in building roads, and in other construction, but it also is used in making cement, dimension stone, and chemical-grade lime. In western and Panhandle districts, extensive deposits of caliche are acceptable substitutes for some purposes, and at other places dolomite is quarried for crushed stone.

Major limestone formations of the Arbuckle and Wichita Mountains are several hundred to several thousand feet thick, and, because they crop out over large areas, they are an almost unlimited resource of stone. The principal market for stone from these two areas is the

Oklahoma City metroplex, although some stone also is shipped to major cities out of the State. Usable limestones in the southeast, northeast, and north-central parts of the State commonly are 10–50 ft thick, and they are quarried to provide stone mainly for local markets.

At present, more than 30 companies are quarrying limestone at various sites in Oklahoma (Fig. 6), and the production in 1993 was 25–30 million tons (Oklahoma Department of Mines, 1994). Most of the limestone production is reported as crushed stone in Table 1, and the value of crushed stone produced in 1997 is estimated at about $134 million.

SALT

Thick sequences of Permian rock salt (NaCl) underlie most of western Oklahoma (Fig. 1), at depths ranging from 30 ft to more than 3,000 ft (Jordan and Vosburg, 1963). Individual salt beds are 5–25 ft thick and are interbedded with thinner layers of shale and anhydrite. The depth and thickness of salt beds in the region make them suitable for either underground or solution mining. No attempts have been made at opening a conventional underground dry mine in Oklahoma, but such mines have operated in the same salt beds for many years in Kansas, just 60 miles north of the State line. Solution mining of salt has been carried out intermittently near Sayre, in Beckham County, with marketing either of high-salinity brine or of salt that is precipitated from the brine by evaporation.

A number of major natural salt plains and salt springs are present along the rivers of western Oklahoma. Saturated brine, formed by dissolution of salt in the shallow subsurface, is discharged at 11 natural salt springs or salt plains in the State, with emissions ranging from 150 to 3,000 tons of salt per day at each salt plain. These natural springs have been used commercially since the beginning of this century, and even earlier by Native Americans. Several small salt producers have tapped salt plains in the northwest and southwest in the past, and each company produced about 2,000–10,000 tons of solar salt per year. At present, a single major producer of solar salt is operating on Big Salt Plain near Freedom, in Woods County, and a small company operated until recently in Harmon County (Fig. 4).

Oklahoma's vast salt resources, estimated at 20 trillion tons, are virtually untapped. Production from the one solar-salt plant in Woods County during 1993 was about 125,000 tons (Oklahoma Department of Mines, 1994). The salt was used primarily in recharging water softeners and for stockfeed, but other potential uses include chemical industries (chlorine, caustic soda, soda ash, and sodium), human consumption, and snow removal.

SAND AND GRAVEL

Sand and gravel, which are essential to almost all types of construction, are widespread and available in most parts of Oklahoma. Principal deposits are along present-day major rivers, in terrace-like remnants of Pleistocene river beds, and in Tertiary deposits covering much of the northwest. Gravels are common in the western third of the State, as well as in and around the Wichita and Arbuckle Mountains, and in Cretaceous rocks south of the Arbuckle and Ouachita Mountains.

Sand and gravel are used in the building industry chiefly as aggregate, which is the term used for inert and hard, fragmental material that is bound by a cementing material to form concrete, mortar, or plaster. In the paving industry, sand and gravel are used as aggregate in both asphaltic mixtures and portland-cement concrete.

In 1993, more than 170 companies operated sand and gravel pits in 53 of Oklahoma's 77 counties (Oklahoma Department of Mines, 1994) (Fig. 5). Construction sand and gravel produced in 1997 was estimated to be 9.1 million metric tons, and it was valued at about $33 million (Table 1). Industrial sand and gravel consists mainly of glass sand, described elsewhere in this report.

SANDSTONE

Sandstone is a common rock type in most parts of Oklahoma. Deposits in the eastern half of the State are mostly hard, are gray, brown, or buff, and some are suitable for dimension stone or aggregate. Those in the western half of the State are mostly soft or friable, are reddish-brown, and are only locally suitable for building material. Sandstone is quarried as dimension stone at several sites in east-central Oklahoma, and has been quarried for riprap and aggregate at several places in the east half of the State (Fig. 6).

STONE

The State has many types of stone that can be used in the construction industries. Sandstones, limestones, dolomites, and granites are widely distributed in most parts of Oklahoma, and each of these resources is discussed separately elsewhere in this report.

TRIPOLI

Tripoli is a white or cream-colored, microcrystalline form of high-purity silica that is porous, lightweight, and friable. It is derived from a partly siliceous parent sedimentary rock from which soluble carbonate minerals have been leached (Quirk and Bates, 1978). Important tripoli deposits are present in northeast Oklahoma, with the first mine having been opened in the Missouri–Oklahoma tripoli district in 1869. Tripoli deposits typically are 2–20 ft thick, and they occur in Mississippian-age cherty limestones beneath 2–10 ft of overburden.

After quarrying, tripoli is dried, crushed, and screened to various grain sizes. Ground tripoli is used mainly as a mild abrasive or in buffing and polishing compounds. It is prized for its abrasiveness, porosity, permeability, absorption, and low specific gravity. One company operated a number of pits during 1993 in Ottawa County (Fig. 4).

VOLCANIC ASH

Small to large deposits of uncemented volcanic ash occur in western and east-central Oklahoma (Burwell and Ham, 1949). They result from local accumulations of ash and dust blown from volcanoes that erupted in New Mexico, Wyoming, and other western states during Tertiary and Pleistocene times. Some of the ash deposits are altered in part to bentonite clays.

Volcanic ash is used as an abrasive, mainly in polishing powders, scouring soaps, and cleansing powders; it also can be used as an admixture in pozzolan cement and as an insulating compound. In recent years, two companies have been mining volcanic ash in Beaver and Okfuskee Counties (Fig. 4); production from 1990–1993 ranged from about 100–700 tons (Oklahoma Department of Mines, 1994).

MISCELLANEOUS MINERALS

Several other industrial minerals are present in small or low-grade deposits:

Barite nodules, veins, and concretions are sparingly present in some shales and sandstones south of the Wichita Mountains and in central and south-central Oklahoma (Ham and Merritt, 1944). At a few localities there are surface concentrations of high-grade nodules that may have possibilities for limited production.

Celestite and minor amounts of strontianite are associated with dolomite and gypsum in eastern Washita and Custer Counties, but these deposits apparently are small and are not commercial.

Diatomite deposits are small and of low grade, and are widely scattered in western Oklahoma.

Phosphate occurs as nodules, plates, and lenses in several limestones and black shales of eastern Oklahoma and the Arbuckle Mountains (Oakes, 1938). The P_2O_5 content of these nodules and plates is generally 15–30%, whereas that of selected whole rocks is commonly 1–10%.

Quartz occurs as large vein deposits in the Ouachita Mountains, especially in central McCurtain County (Honess, 1923).

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