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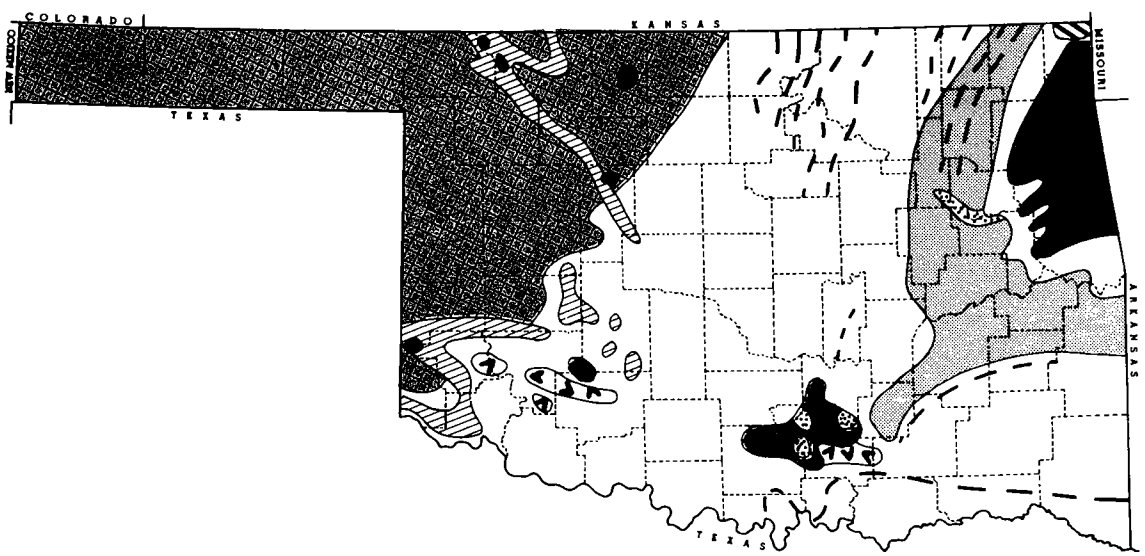
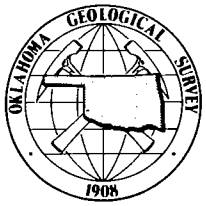
Industrial-Minerals Development in Oklahoma—A Symposium

Kenneth S. Johnson, ***Editor***





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Industrial-Minerals Development in Oklahoma—A Symposium

Kenneth S. Johnson
Editor

Proceedings of a two-day symposium (December 1–2, 1992) held in Norman, Oklahoma.

Co-sponsored by:
Oklahoma Geological Survey
Oklahoma Department of Mines
Oklahoma Mining Commission
U.S. Bureau of Mines

Oklahoma Geological Survey
Charles J. Mankin, *Director*
The University of Oklahoma
Norman, Oklahoma

1993

SPECIAL PUBLICATION SERIES

The Oklahoma Geological Survey's Special Publication series is designed to bring timely geologic information to the public quickly and economically. Review and editing of this material has been minimized in order to expedite publication, and author-prepared illustrations have been used throughout.

Front Cover

Map showing selected nonpetroleum-mineral resources of Oklahoma (from p. 2 of this publication).

Second Printing, 1994

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PREFACE

Industrial minerals are widely distributed in Oklahoma and they are being mined in 69 of the State's 77 counties. These industrial minerals, most of which are used in the construction industries, include limestone, granite, gypsum, salt, sand and gravel, clays, cement, silica sand, and iodine, among other minerals; they do not include metals, coal, or oil and gas. Industrial minerals are critical to the State's current and future development, for without ready access to these commodities, the costs of construction and manufacturing would increase sharply.

On December 1–2, 1992, a symposium was held in order to better understand the resource base, rules, regulations, and environmental issues related to wise development of Oklahoma's industrial minerals. The format established for the symposium was to have 17 speakers discuss the major factors involved in starting up and operating an industrial-mineral mine; these factors include exploration, leasing, permits, quality control, transportation, marketing, inspections, water quality, wetlands, air quality, reclamation, and future developments. The symposium was jointly organized and co-sponsored by the Oklahoma Geological Survey (OGS), Oklahoma Department of Mines (ODM), Oklahoma Mining Commission (OMC), and U.S. Bureau of Mines (USBM). About 125 people attended the symposium, including representatives of industry, government (city, state, and federal), academia (faculty and students), environmental organizations, and the general public. This symposium-proceedings volume contains the written papers of all who presented talks at the symposium.

Special thanks are expressed to the speakers (authors) who contributed to this symposium. Each was successful in making a special effort to synthesize years of work and many data into the report. Persons who assisted in the organization and planning of this symposium include: Ken Johnson, Charles Mankin, Ken Luza, and Bob Arndt of the OGS; Benny Cox and Bob Springer of the ODM; Virgil Smith and Merrill Hines of the OMC; and Aldo Barsotti and Zareh Mozian of the USBM.

Kenneth S. Johnson
General Chairman

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Industrial-Mineral Resources of Oklahoma

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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, and granite; other major construction resources are cement (made from limestone and shale) and the extensive sand and gravel deposits along the 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 a retarder in portland cement, and as a 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 1992 was $284 million (Table 1), and the State ranked 34th in the nation. Leading nonfuel commodities during 1992 were crushed stone ($100 million), portland cement ($63 million), iodine ($27 million), sand and gravel ($26 million), glass sand ($22 million), and gypsum ($14 million) (Table 1).

The many companies mining 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.

The remainder of the current report 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.

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 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 quan-

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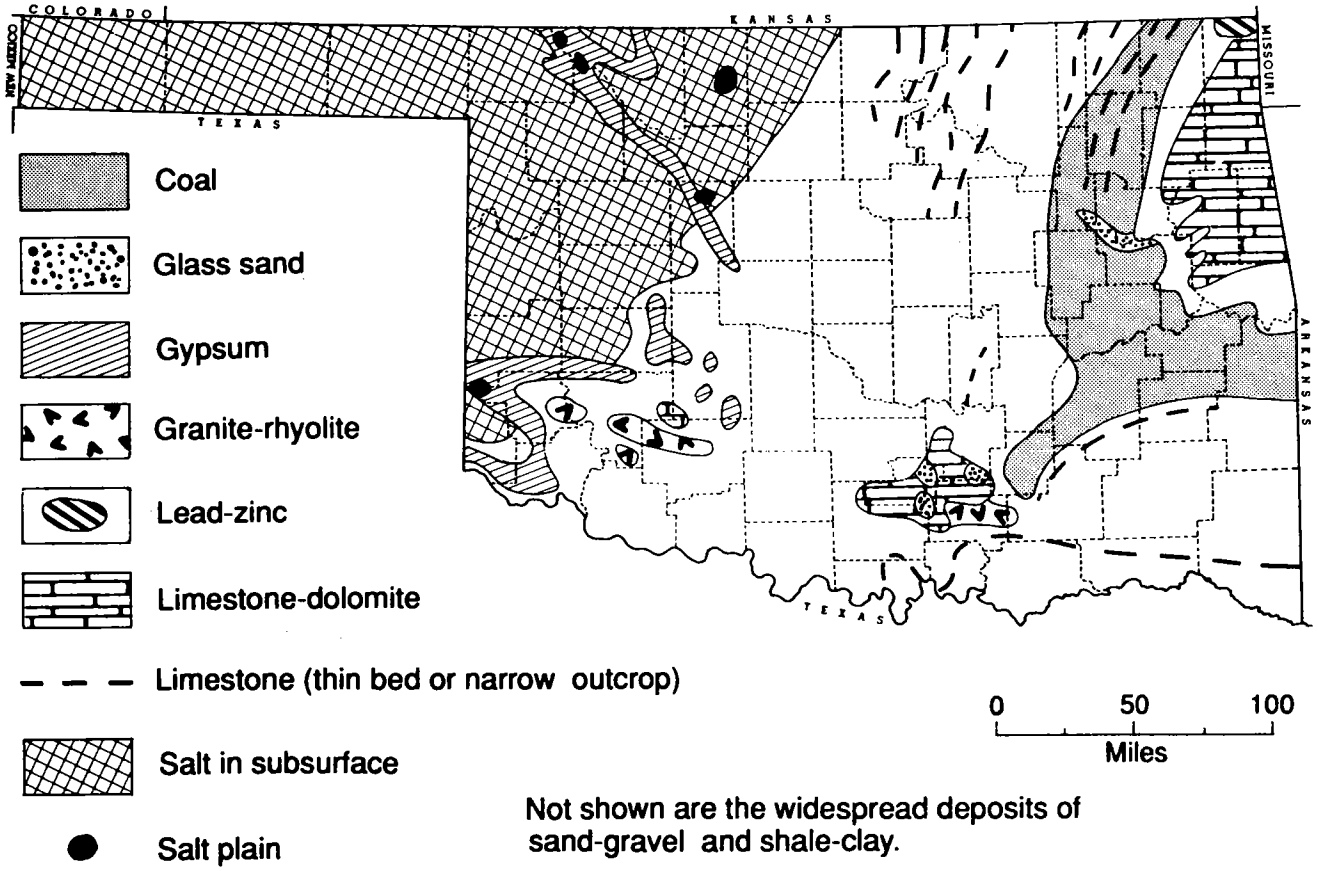

Figure 1. Selected nonpetroleum-mineral resources of Oklahoma.

tities 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 1992 was estimated at 1.6 million tons, with a value of $63 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 chemical 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. Light-firing clays, low-grade refractory clays, and clays suitable for making pottery are present at a few localities,

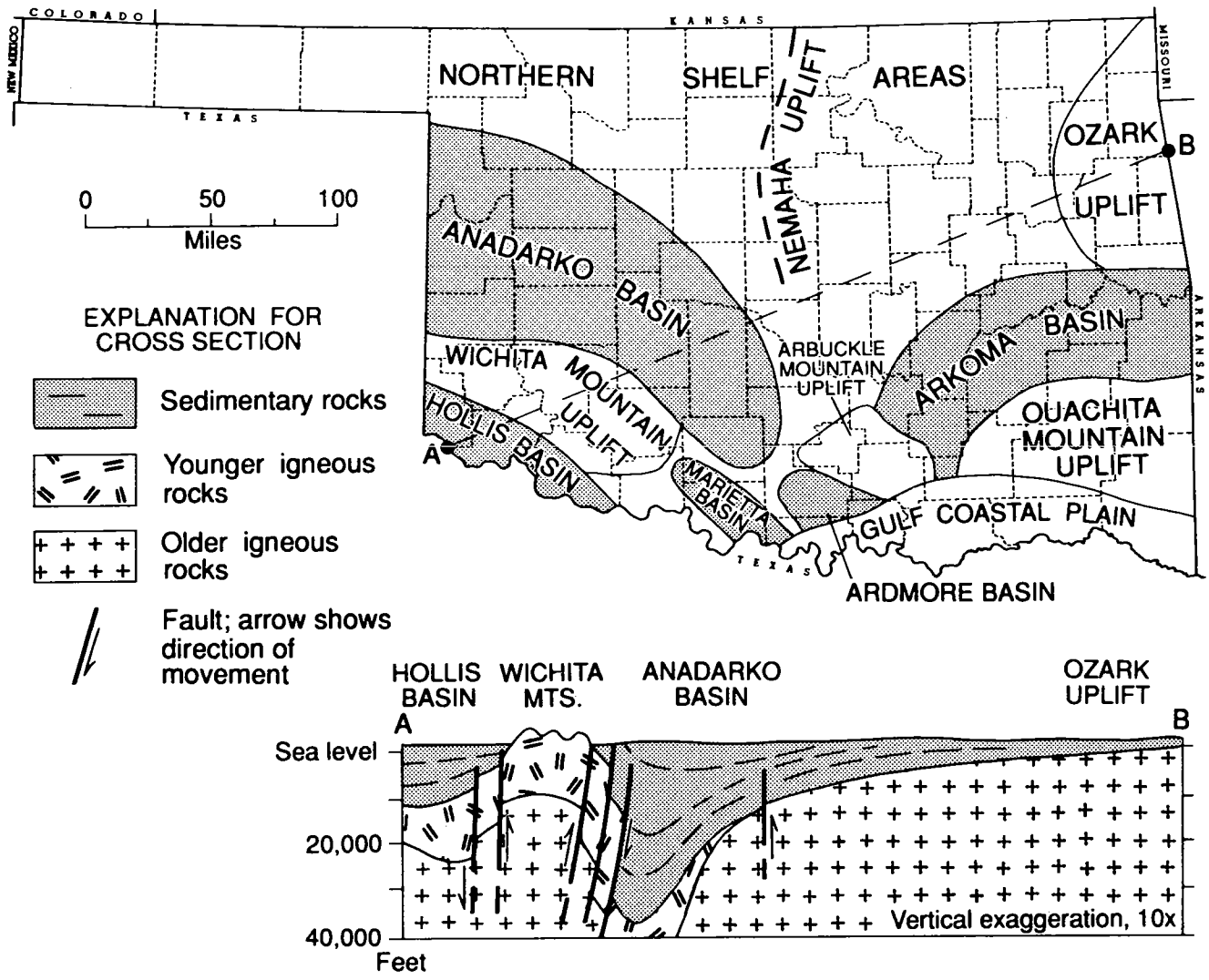

Figure 2. Major geologic provinces of Oklahoma.

and clay suitable for making lightweight aggregate is common in the eastern portion of the State (Fig. 3).

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 1990, 26 companies were producing clay and shale in many different parts of Oklahoma (Oklahoma Department of Mines, 1991), and in 1992 the State produced an estimated 786,230 metric tons of clay and shale valued at about $5.1 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 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 1992, Oklahoma produced about 5,182 tons of dimension stone valued at an estimated $706,000 (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 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

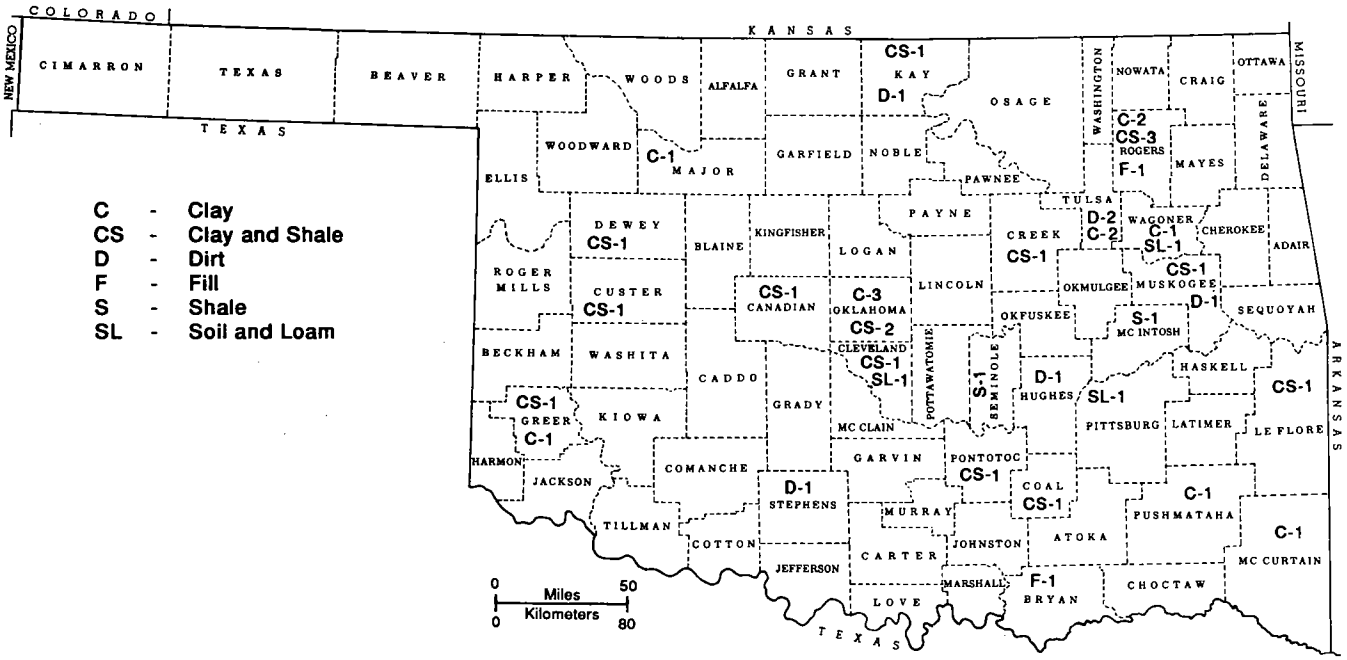

Figure 3. Number of clay, shale, and soil pits in each of Oklahoma's counties (from Arndt and Springer, 1993).

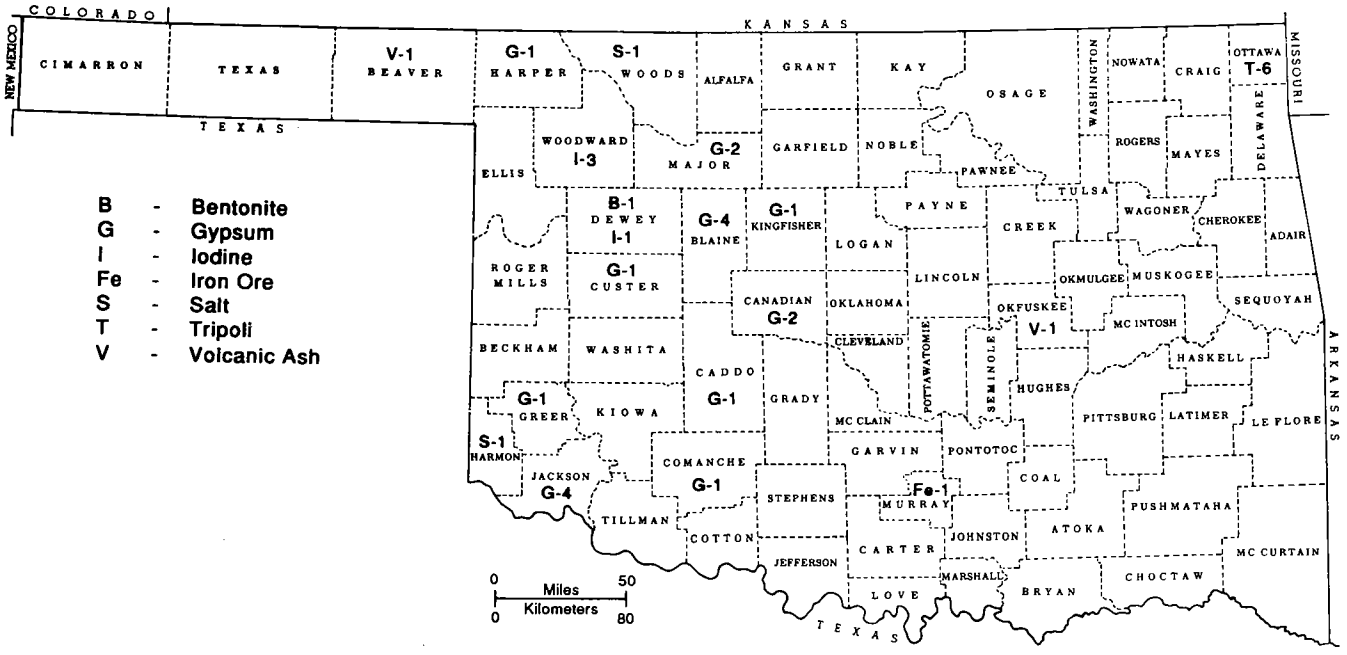

Figure 4. Number of bentonite, gypsum, iodine, iron ore, salt, tripoli, and volcanic-ash operations in each of Oklahoma's counties (from Arndt and Springer, 1993).

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, 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

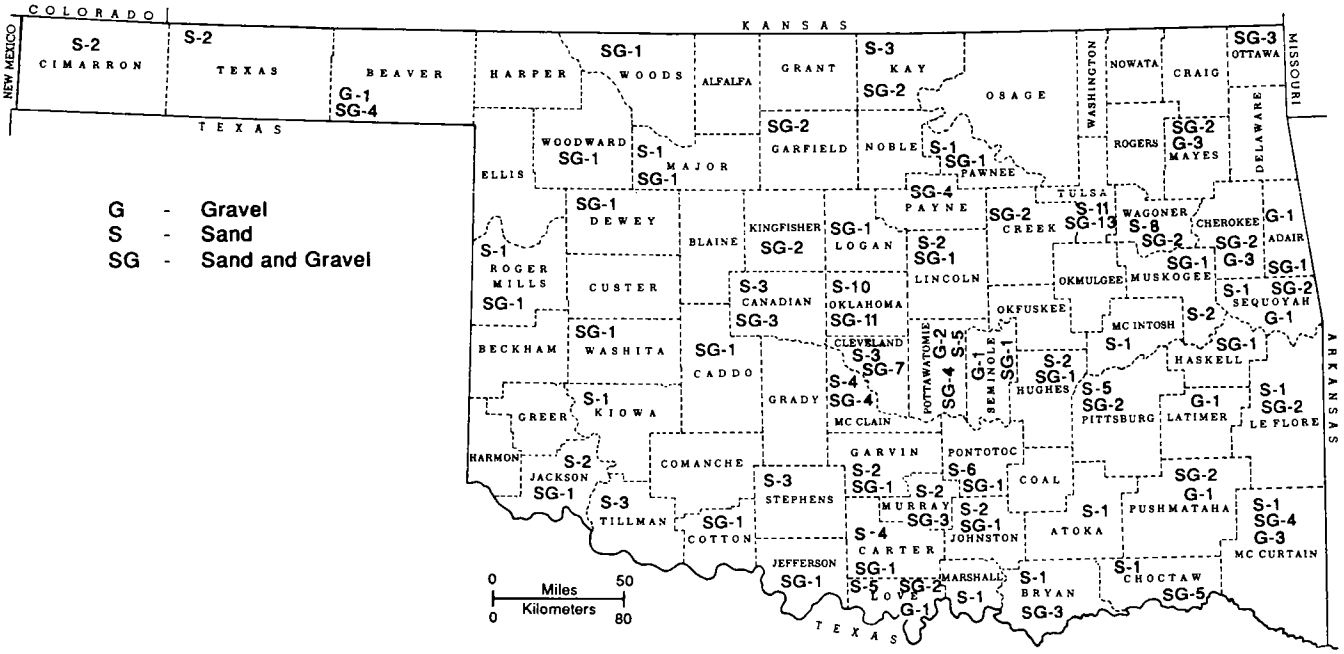

Figure 5. Number of sand and gravel operations in each of Oklahoma's counties (from Arndt and Springer, 1993).

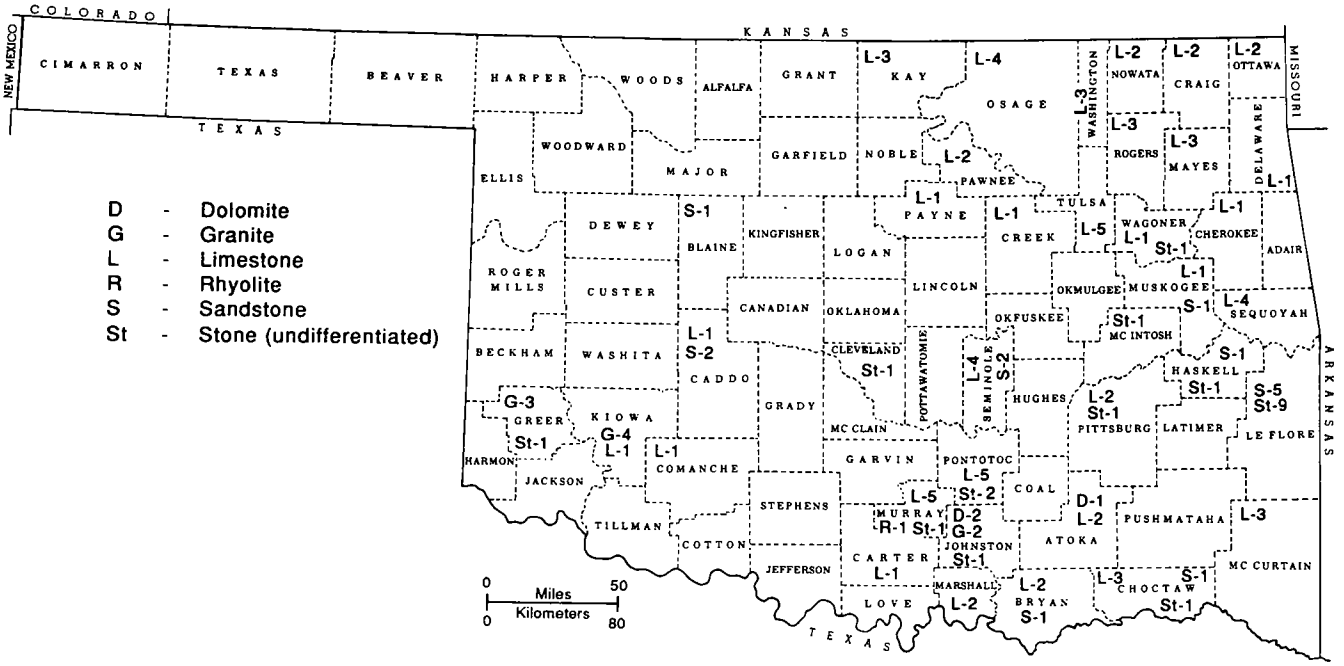

Figure 6. Number of stone quarries in each of Oklahoma's counties (from Arndt and Springer, 1993).

TABLE 1. — INDUSTRIAL-MINERAL PRODUCTION IN OKLAHOMA[a]

Mineral		1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)	1992[b] Quantity	1992[b] Value (thousands)
Cement (portland)	[thousand short tons]	1,544	$60,457	1,620[b]	$63,180[b]	1,627	$63,180
Clays	[metric tons]	631,302	3,156	824,176[b]	4,178[b]	786,230	5,135
Gem stones		NA	W	NA	W	NA	711
Gypsum (crude)	[thousand short tons]	2,184	11,154	2,356	12,925	2,485	13,642
Iodine (crude)	[kilograms]	1,972,849	30,486	1,998,914	31,389	2,041,500	26,619
Sand and gravel:							
Construction	[thousand short tons]	9,235	21,993	9,000[b]	22,300[b]	10,200	25,800
Industrial	[thousand short tons]	1,258	22,984	1,241	20,918	1,225	21,637
Stone:							
Crushed[c]	[thousand short tons]	25,300[b]	89,500[b]	25,678	95,509	26,100	100,000
Dimension	[short tons]	8,138[b]	684[b]	3,836[c]	596[c]	5,182	706
Tripoli	[metric tons]	18,801	155	15,885	141	NA	NA
Combined value of cement (masonry), feldspar, lime, salt, stone (crushed dolomite [1990-91], crushed unidentified [1992], dimension sandstone [1991]), and values indicated by symbol W		XX	19,608	XX	24,389	XX	26,833
	TOTAL		$260,177		$275,525		$284,263

Source: U.S. Bureau of Mines.

[a]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[b]Estimated.

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

NA - Not available.

W - Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure.

XX - Not applicable.

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 1992 was estimated at $711,000 (Table 1), and was more than $1 million in both 1990 and 1991.

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 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 1992, Oklahoma's production of glass sand (reported as industrial sand in Table 1) was estimated at 1.23 million short tons, with a value of about $22 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 igneous 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 building aggregate and riprap. 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, nine companies are regularly producing granite and rhyolite from quarries in Greer, Kiowa, Johnston, and Murray Counties (Fig. 6), and in 1990 the State produced about 3.5 million short tons of granite and rhyolite (Oklahoma Department of Mines, 1991). 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 granite) 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 2.5 million tons produced annually by 14 companies in nine western counties (Fig. 4). The value of gypsum produced in 1992 is estimated at about $13.6 million (Table 1). Present uses are for plaster, for wallboard, as a retarder in portland cement, and as a 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 (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 to 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.

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 2 million kg (kilograms), valued at about $27 million (Table 1). A new plant is under construction 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 20 companies are quarrying limestone at more than 30 sites in Oklahoma (Fig. 6), and the annual production is 25–30 million tons (Oklahoma Department of Mines, 1991). Almost all of the limestone production is reported as crushed stone in Table 1, and the value of crushed stone produced in 1992 is estimated at about $100 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 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 in Harmon County until recently (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 1990 was about 105,000 tons (Oklahoma Department of Mines, 1991). 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 portland-cement concrete, mortar, or plaster. In the paving industry, sand and gravel are used as aggregate in both asphaltic mixtures and portland-cement concrete.

In 1990, more than 180 companies operated sand and gravel pits in 52 of Oklahoma's 77 counties (Oklahoma Department of Mines, 1991) (Fig. 5). Construction sand and gravel produced in 1992 was estimated to be 10.2 million tons, and it was valued at about $26 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 eastern half of the State (Fig. 6).

STONE

The State has many types of stone that can be used in the construction industries. Sandstones, limestones, dolo-

mites, 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 1991 in Ottawa County (Fig. 4), producing 15,885 metric tons with a value of $141,000 (Table 1).

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 for the last five years has ranged from 543 to 3,775 tons (Oklahoma Department of Mines, 1991).

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 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 nodules and plates is generally 15–30%, whereas that of the whole rock 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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Geologic Exploration and Evaluation of Industrial-Mineral Deposits

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INTRODUCTION

Many issues must be resolved before reaching a final decision concerning the economic viability of starting to mine an industrial-mineral deposit (a deposit of nonfuel, nonmetallic minerals). These issues include:

1) Quality and quantity of the mineral resource;

2) Determination of mineral products that can be produced;

3) Market research to assess uses and needs for the products, as well as what and where the markets are;

4) Assessing the potential impact of competitive companies and alternative commodities;

5) Ownership or leasing of the mineral resource;

6) Permitting and environmental requirements of local, state, and federal entities;

7) Availability and types of labor, power supply, and support services;

8) Transportation methods and costs for delivering products to markets;

9) Funds needed to finance startup and ongoing operations; and

10) Determining whether the project will earn a profit.

This report focuses on the first issue, which deals with the role of a geologist in establishing the quality and quantity of the mineral resource. Most of the other issues are discussed in the other articles of this symposium volume.

To evaluate the quality and quantity of a mineral resource, several steps must be taken: a literature search and gathering of existing data, a preliminary field study, a detailed field study, and estimation of resources and reserves. Each of these steps is described in the sections that follow.

LITERATURE SEARCH AND DATA ACQUISITION

A study begins with a literature search on the commodity and the geographic area of interest, along with acquisition of appropriate base maps, geologic maps, and aerial photographs.

The literature search entails gathering and reviewing all published, unpublished, and open-file data on the geology of the area, and a review of appropriate data on the mineral resource of interest. Such information can be of great value: a basic study may have already been conducted at or near the prospect; the preexisting data can help direct all phases of the investigation; and the data may greatly reduce the time and cost to be expended in evaluating the prospect. Data may be available from the state geological survey, U.S. Geological Survey (USGS), U.S. Bureau of Mines, various geological societies, assorted journals and other publications, and theses and dissertations prepared at nearby universities. In addition, your own company, or other companies and individuals, may have information about the property in question, or nearby sites, and these data should be sought.

Various base maps and aerial photographs are needed to accurately compile and plot data concerning outcrops, sample localities, geology, and other essential information. Topographic maps and other base maps may be available from the state geological survey, the USGS, or other agencies that administer the land. The most useful, commonly available maps would be USGS 7.5′ quadrangle maps at a scale of 1:24,000 (1 in. = 2,000 ft), although maps at a scale of 1:62,500 or 1:100,000 also may be useful. Maps at a scale larger than 1:24,000 can be obtained on a contract basis, or perhaps an enlargement of the 7.5′ quadrangle map would be adequate.

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Aerial photographs commonly are available at a scale of 1:20,000 to 1:40,000 from the U.S. Department of Agriculture (Agricultural Stabilization and Commodity Service, ASCS) or the USGS. It is also possible to request enlargement of these photos to larger scales. Commercial aerial-photography firms are able to provide custom photos of a prospect area and to prepare detailed topographic base maps from the aerial photos.

PRELIMINARY FIELD STUDY

The purpose of the preliminary field study is to determine the overall character and suitability of the deposit at a relatively low cost. If there are sufficient exposures of the mineral deposit, this preliminary study may be conducted without drilling or excavation; however, if the deposit is poorly exposed, or not exposed at all, several cores, drill holes, or excavations will be necessary. Data gathered in the preliminary study enable an early assessment of the economic viability of the deposit, and also they are the foundation for future exploration and testing in the detailed field study. The preliminary field study consists of field observations, recording of data, collecting and analyzing samples, and making an estimate of the resource.

At this time, before significant expenditure of time, effort, and money, an agreement and contract should be made with the mineral-rights holder to assure mutually acceptable exploration, leasing, royalty, mining, and reclamation conditions.

Field observations need to be documented by recording and plotting all observable geologic features that may bear on the distribution, quality, and quantity of the deposit. These geologic features include the dip of strata or the mineral deposit, and the presence of faults, folds, and other structures; also, such characteristics as lithologies, rock weathering, impurities, facies changes, rock thicknesses, and the nature and thickness of overlying rock and soil units (overburden). Data to be plotted on base maps include all appropriate geologic information, along with the areas of rock exposures, sample localities, and any other important data.

Industrial-mineral deposits occur in a great variety of shapes and sizes: tabular or stratiform deposits, such as limestone or gypsum, that are subhorizontal or dipping; massive bodies, such as granite and some marbles; lenticular or lens-shaped deposits, such as channel sands and gravels; vein-type deposits, such as pegmatites and some barites; and pod-shaped or irregular bodies, that could include representatives of almost all types of industrial minerals. The probable shape and size of the mineral deposit should be understood from the beginning, in order to plan an effective sampling program.

Sample collection involves sampling of all parts of the deposit that can be reached reasonably and that may be part of the area to be mined. Samples should be collected for chemical, physical, and/or petrologic-mineralogic study. Outcrop sampling should produce either channel samples or chip samples: channel samples consist of a continuous cross section (1–4 $in.^2$ across) of material collected vertically, or perpendicular to bedding, through all or a portion of the thickness of a deposit; chip samples consist of collecting samples of uniform size (1–9 $in.^3$) at periodic intervals (perhaps 3, 6, or 12 in. apart) through all or a portion of the thickness of the deposit. In either case, the samples are aggregated into a composite sample representing the full thickness of the sampled interval. If there are no exposures, then coring, drilling, augering, or excavation will be necessary to obtain samples (these are described later in the Detailed Field Study).

Regardless of the sampling technique used, one must be sure that the samples are representative of the deposit: exposed rock may be partly weathered and of poor quality; weathered rock may be case hardened and more durable than fresh rock; perhaps only the more resistant layers crop out, whereas softer layers (such as shales) may be more eroded and covered (it will be necessary to remove the cover to sample even the softer layers); soluble rocks may be missing from outcrops; and, in sands and gravels, the finer-grained particles may be winnowed from the outcrops. If sampling is not representative of the rock or material that is to be mined throughout the deposit, there may be unpleasant and costly surprises when mining is undertaken.

Samples should then be analyzed and/or tested according to the intended use of the deposit. Tests may be chemical, physical, and/or petrologic-mineralogic, and these are discussed later under Detailed Field Study. Testing should be done by reliable and experienced persons or labs, chosen by mutual consent of the geologist and management.

The final step in the preliminary study is estimating the resource that is available within the specified property. This involves assessing both the tonnage (or volume) and the quality of the deposit. Based upon the best geologic data and interpretations for the deposit, the geologist estimates the thickness, area, volume, and tonnage of material that meets the physical and/or chemical requirements. The methods used in making those calculations are given later in Estimating Resources and Reserves.

Based on the data gathered to this point, and the estimate of the resource, a decision then must be made as to whether to continue the investigation or to cancel further work. Such a decision should be carried out in cooperation with a mining engineer in order to evaluate possible mining plans and the economics of mining the deposit. While conducting the preliminary study, plans should have been made as to how a subsequent, detailed study could best be carried out.

DETAILED FIELD STUDY

The steps necessary in the detailed study are similar to those in the preliminary study, but they are intended to fully characterize the deposit so that a final decision about economic viability can be made. These steps should involve: acquiring specialized base maps and aerial photos; setting forth the exploration and sampling program; planning the outcrop-examination, coring, drilling, augering, and/or excavation activities; performing geophysical studies, if appropriate; testing of samples; and making the final estimate of resources and reserves. While conducting the field study, sampling and characterization of the overburden, surface water, and ground water at the site must also be carried out. Data on these materials will enable developing a comprehensive mining plan that considers overburden removal, potential contaminants in the overburden, ground-water and surface-water control, and eventual reclamation/restoration activities.

Special base maps or aerial photos may be needed for the detailed field study. Large-scale maps or photos (scale of 1 in. = 100–1,000 ft), showing topographic contour intervals of 2–10 ft, can be obtained on a contract basis. The scale of these maps and photos should be large enough to enable plotting all necessary field data and making all appropriate calculations; they also can be used later to set up the mining plan.

The exploration and sampling program should be based upon all available data, upon the probable shape and size of the deposit, and upon consideration of a possible mining plan. Additional outcrops should be examined and sampled, and core-hole, drill-hole, and excavation sites should be selected in order to fully characterize the resource. But how many samples and how many measurements are enough for characterization? There are no specific numbers, because each deposit is different. However, sampling and measurements should be spaced close enough so that the geologic character of the deposit is understood, and that the size, shape, depth, and homogeneity are well understood. Enough samples should be collected so that the results of any additional random sampling are predictable. It is necessary to sample all parts of the deposit that are needed to establish adequate reserves for mining, and all areas, layers, or zones of the deposit must be sampled at least several times.

Outcrops should be reexamined, and those not sampled in the preliminary study should be considered for sampling. Channel samples or chip samples should be collected to fill in data gaps, and it may be advisable to drill several cores or drill holes just back from the outcrop to obtain fresh samples for comparison with outcrop data.

Coring is the most common method of exploration and sampling, especially where outcrops are poor. Ideally, the drilling crew and equipment will have prior experience in drilling the resource under investigation. Core sizes, which can be AX (1 3/16 in.), NX (2 1/8 in.), or 4-in. diameter, need to be sufficient to provide enough material for all testing, and still leave some material for a permanent file. The core size also should be based on the integrity of the material being cored, because core recovery should be 100%, or very close to it. Core should be handled carefully and boxed without reversing the order of core recovery. Soft material can be split right away (portions for chemical testing, for physical testing, and for storage), whereas indurated rock material may have to be sawed in a laboratory. A preliminary core description should be made immediately, during the coring, and then a more detailed description and log should be made after sawing or splitting the core.

Rotary drilling can be used to fill in between core holes for certain types of basic information, such as top and base of deposit, thickness, bulk samples (consisting of cuttings or small chips), and to enable geophysical logging. The cost for such drilling can be 50–75% of the cost of coring, and use of a company-owned shot-hole rig may be quite adequate at even lower costs. However, there may be some contamination of rotary-drilled samples because of churning and mixing of cuttings in the borehole, and because of overburden caving into the borehole.

Auguring can be used to obtain the same basic information as in rotary drilling, but is limited to use in unconsolidated, poorly cemented, or soft materials. The technique is rapid and inexpensive, does not preserve integrity of the samples, and probably will produce some sample contamination.

Excavations into the deposit can produce large quantities of material to be used for testing, and also can provide a good three-dimensional view of fresh material back from the outcrop. Excavations can be made with a bulldozer, backhoe, or other power equipment; or, at times, even manually by pick-and-shovel. Indurated (hard-rock) material may need to be drilled and blasted for excavation.

Geophysical testing may involve borehole-logging or surface-survey techniques. Geophysical logs useful in evaluating some industrial-mineral deposits include resistivity, gamma-ray, sonic, neutron, and caliper logs; these logs show acoustic, electrical-resistivity, radioactivity, and other physical/chemical properties of rock and fluids in and around the borehole. Logging should be done on cored holes first, in order to calibrate log values for the interpretation of the geophysical logs, and then logs can be made and interpreted for rotary-drilled and auger holes. Borehole logging is not commonly done in prospecting for near-surface industrial minerals, because the cost-per-foot can be high in the shallow holes normally drilled for surface-mine prospects.

TABLE 1. — DATA AND COMPUTATIONS IMPORTANT FOR CALCULATING RESOURCES AND RESERVES

VOLUME

Area	x	Thickness	=	Volume
feet^2	x	ft	=	ft^3
yards^2	x	yd	=	yd^3
acres	x	ft	=	ac-ft
miles^2	x	ft	=	mi^2-ft

TONNAGE

Volume	x	Density	=	Tonnage
ft^3	x	tons/ft^3	=	tons
yd^3	x	tons/yd^3	=	tons
ac-ft	x	tons/ac-ft	=	tons
mi^2-ft	x	tons/mi^2-ft	=	tons

DENSITY

Specific Gravity	x	Constant	=	Density
Specific Gravity	x	62.4	=	lb/ft^3
Specific Gravity	x	0.841	=	short tons/yd^3
Specific Gravity	x	1,357	=	short tons/ac-ft
Specific Gravity	x	868,500	=	short tons/mi^2-ft

TONNAGE WEIGHTS

1 short ton	= 2,000 lb
1 long ton	= 2,240 lb
1 metric ton	= 2,204.6 lb
	= 1,000 kg

AREA AND VOLUME RELATIONSHIPS

1 acre	=	43,560 ft^2
1 ac-ft	=	43,560 ft^3 = 1,613 yd^3
1 mi^2	=	640 acres
1 mi^2-ft	=	640 ac-ft = 27,880,000 ft^3 = 1,033,000 yd^3

Surface geophysical techniques commonly rely upon generating an artificial or man-made field of energy into the ground, and measuring or monitoring the effect upon that energy of its passage through soil, bedrock, and fluids. Common techniques are seismic-refraction, seismic-reflection, 3-D high-resolution seismic-reflection, and electrical-resistivity surveys. Gravity and radiometric surveys do not require artificial-energy input. There must be contrasts or differences between the physical properties of the soil, bedrock, and fluids that are sufficient to be detected by whatever geophysical method is used. Such differences may include the soil-bedrock contact (depth to bedrock), interbedded layers of different density, caves or other cavities, permeable materials, water-table depth, and variations in types of fluids in the subsurface. Determining these characteristics by surface-geophysical methods can be rapid, relatively inexpensive, and can provide useful data between boreholes.

Testing of samples should be done using methods and laboratories acceptable to management. Duplicate or known samples should be submitted to the laboratory occasionally to assure consistency of lab techniques and to create confidence in lab results. Most testing should be done to meet ASTM methods and standards, unless some variation is needed. The testing may include chemical, physical, and/or petrologic-mineralogic testing.

Chemical testing is done when chemical purity is important. This requires crushing, blending, and quartering of material (dividing the sample into fourths, then dividing one-fourth again into fourths, etc.), until an appropriate-sized sample is obtained that is still representative of the original sample. Chemical analysis is then performed to determine the purity of the sample and, perhaps, the presence of specific impurities.

Physical testing is necessary for aggregates and other rocks and minerals whose use is based on their physical properties. Examples of such testing are abrasion-loss and freeze/thaw characteristics of aggregates, grain-size distribution of sand and gravel, absorption of moisture by clays, and filtering of fluids through tripoli.

TABLE 2. — IN-PLACE DENSITY OF SELECTED ROCKS AND MINERALS

Rock or mineral	Specific gravity	Density		
		lb/ft^3	short tons/ac-ft	short tons/mi^2-ft (millions)
Anhydrite	2.9	181	3,940	2.52
Coal (bituminous)	1.2–1.5	75–94	1,630–2,040	1.04–1.30
Dolomite	2.5–2.8	156–175	3,400–3,810	2.17–2.43
Granite	2.6	162	3,530	2.26
Gypsum	2.3	144	3,130	2.00
Limestone	2.4–2.7	150–168	3,260–3,670	2.08–2.34
Marble	2.6–2.8	162–175	3,530–3,810	2.26–2.43
Potash	2.0	125	2,720	1.74
Salt (halite)	2.15	134	2,920	1.87
Sand and gravel	1.7–2.2	106–137	2,310–2,990	1.48–1.91
Sandstone	2.1–2.4	131–150	2,850–3,260	1.82–2.08
Shale	2.0–2.6	125–162	2,720–3,530	1.74–2.26

Petrologic and mineralogic examination and tests are important in establishing the basic lithology, mineralogy, and grain-size distribution of the deposit, and in determining the presence or absence of harmful (or beneficial) minerals. Examination and testing can be done on hand specimens, rock chips, or powders, and can be performed visually or with special microscopes or special equipment (such as X-ray diffraction, for mineral identification). Examination can be made by thin sections, by powders in immersion oils, or by staining the rock to show certain mineral or chemical constituents.

The final estimate of resources and reserves on the property are made using the methods described later in Estimating Resources and Reserves. Based upon all the data collected (and their interpretation), maps and cross sections should be prepared to show the three-dimensional relationships of the mineral deposit and the overburden. The maps and cross sections should summarize data on the lithology, homogeneity, and quality (or grade) of the deposits; they also should show the thickness and extent of the deposit, along with the location of boreholes, sample locations, and any special problem sites on the property. With these data and illustrations, it is possible to calculate the volume and tonnage of material in the deposit (the resource), and by factoring in the mining plan, production costs, marketing, and economics, it is possible to determine the amount of material that can be economically and legally mined (the reserves).

ESTIMATING RESOURCES AND RESERVES

One of the final steps in the Preliminary Field Study is estimation of the resource, and one of the final steps in the Detailed Field Study is estimation of the resource and/or the reserves. The term "resource" refers to the results of estimating tonnage and grade of a mineral deposit where economic extraction is currently or potentially feasible; the term "reserves," on the other hand, refers to that portion of a mineral resource that can be economically mined (and for which there are no legal or regulatory prohibitions) at the time of reserve determination (Abbot, 1985; Society for Mining, Metallurgy, and Exploration, 1991; Holmes and Abbott, in press). So the difference between these two terms is based upon whether an economic and regulatory analysis has been made, and whether the deposit can be mined at a profit.

Estimation of resources and/or reserves commonly involves two steps: first is determining the volume of material, and second is determining the tonnage.

The volume of a deposit equals its area times its thickness (Table 1). Volume may have to be measured or estimated in increments, especially if the deposit is irregular in thickness or distribution. For most large deposits of bulk minerals (limestone, granite, gypsum, clays, or sand and gravel), it is convenient to measure the area in acres, the thickness in feet, and the volume in acre-feet (ac-ft)

(Table 1). For smaller deposits, or where a large deposit consists of a number of small areas of irregular shape that each are best calculated in square feet, the volume may be measured in cubic feet or cubic yards. Four methods of determining volume are the average-thickness, triangular, contours, and cross-sectional methods.

The average-thickness method consists of multiplying the total area of the deposit by the average thickness of the deposit. This method is suitable in layered or massive deposits where the thickness, or the rate of change of thickness, is fairly uniform and can be determined.

The triangular method involves determining the average thickness of the deposit in three adjacent boreholes (or outcrop sites), and then multiplying that average thickness by the area enclosed between those three boreholes; this procedure is repeated for all triangular sets of three boreholes (and outcrop sites), and the volume is then summed up for all sets of three holes to determine the total volume of the deposit. This method is suitable in massive, layered, or irregular deposits where the thickness is irregular and/or the deposit was drilled on an irregular grid pattern.

The contours method can be used where the thickness of the deposit has been contoured. The area between successive contour lines is multiplied by the average thickness of the deposit between those contours. This procedure is repeated for the area between each pair of adjacent contour lines, and the total of the volumes under all the areas is then summed up. This method is suitable in massive, layered, or irregular deposits that do not dip too steeply and for which reliable thickness contours have been drawn.

The cross-sectional method requires determining the cross-sectional area of the deposit as shown on a number of parallel or subparallel cross sections. Then the average cross-sectional area of the deposit for each pair of adjacent cross sections is multiplied by the average perpendicular distance between that pair of cross sections. The volume is summed up for all areas between adjacent lines of cross section. This method may be most suitable in long and narrow deposits (channel-like deposits) that are prospected by boreholes in subparallel lines perpendicular to the long axis of the deposit.

Tonnage of a particular resource or reserve is determined by multiplying the volume of the deposit by the density of the material in place (Table 1). Examples of the density of selected rocks and minerals are given in Table 2. The density of a specific solid material (usually expressed in grams/cm^3 or pounds/ft^3) can be obtained from the literature or can be determined by laboratories, and this can then be converted to tons/yd^3, tons/ac-ft, or tons/mi^2-ft by use of a constant (Table 1).

CONCLUSIONS

In this report we have outlined the major steps involved in assessing the resources in an industrial-mineral deposit. By carrying out these steps, modified to suit the geology and conditions at any particular prospect, one can determine the quality and quantity of the resource and make recommendations or decisions about mining the deposit. This work should be carried out by a geologist experienced in such studies.

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Ownership and Leasing of Industrial Minerals

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ABSTRACT.—The owner of the surface of a tract of land owns all of the rights of mining, processing, or extracting any of its industrial minerals, unless the present or a prior owner has reserved or deeded some ownership right to one or more of the minerals. Such reservation of property rights involving minerals is called a severance of the mineral estate from the surface ownership.

The solution of the problem of determining ownership must be derived from examining the record of conveyances of the tract. The subject has been addressed in a substantial number of lawsuits in Oklahoma. Many of the cases involved oil and gas or coal, in one way or another, but the principles established tell us how to identify the owner of the industrial minerals. This report will discuss evolution of the law and the principles of determining ownership.

After ownership is determined, the next question is how best to acquire the right to develop the mineral. This is accomplished by leasing or by acquiring ownership by deed of the quantum of estate which contains the mineral. The lease between the owners and the developer is an agreement that establishes the length of time, the consideration to the owner, and often a host of other conditions of performance and restrictions.

INTRODUCTION

The purpose of this paper is to give the reader background and a sense of the legal developments and case decisions on the subject of how to determine ownership of industrial minerals. The law in Oklahoma has developed through a principle known as *ejusdem generis*. The Texas courts approach the problem from an "intent" point of view, which progressed from intent of the parties established by the written text of the instruments to a general-intent test which was advocated by Eugene Kuntz, a professor of oil and gas law at the University of Oklahoma.

THE OKLAHOMA APPROACH

Several of the following cases involve oil and gas or coal, and do not refer directly to industrial minerals. However, it is necessary to understand the principles established by these cases in order to determine the ownership of industrial minerals. The title investigator will most often be confronted with an instrument of conveyance which contains the words "reserving unto the grantor all or some percentage of *all the oil, gas and other minerals*." The courts have wrestled with the meaning of other minerals on many occasions. One of the latest pronouncements of the Oklahoma Supreme Court is in the case of *Claude R. Butler v. The State of Oklahoma ex rel. Commissioners of the Land Office*.[1] In that case, the State of Oklahoma sold a tract of land to the predecessor in title of Claude R. Butler. The sale was made at public auction and, in the notice of publication for the public auction, the buyers were advised that the State of Oklahoma was reserving 50% of all the oil, gas and other minerals, and that the purchaser would receive 50% of all the oil, gas and other minerals. In the actual instrument of conveyance there was a reservation of 50% of the oil, gas and other minerals, but no reference in the instrument that the purchaser would receive only 50% of the oil, gas and other minerals. At the trial court in Craig County, Oklahoma, the district judge was presented with an offer of proof of evidence to the effect that the purchaser in this case had dug a farm pond within one year after purchasing the tract. When the pond was dug there was a substantial quantity of coal that had to be removed. The pur-

[1]753 P.2d 1334 (Okl. 1988)

DeGraffenreid, Paul, 1993, Ownership and leasing of industrial minerals, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 17–34.

chaser thereafter remitted to the State of Oklahoma 50% of the market value of the coal so removed. The trial court refused to admit this piece of evidence, on the theory that the instrument of conveyance was clear on its face that the reservation did not include coal and that no extrinsic evidence regarding intent of parties was admissible. The case was appealed to the Oklahoma Supreme Court in 1977. In 1982, the Court, on a 5 to 4 decision, issued a decision to the effect that *other minerals* in this case did include coal. However, the Court, on a motion for rehearing, kept the case under advisement until December 1987, when they then decided a reservation of oil, gas and other minerals or mineral rights does not include coal. They made this determination under the theory of *ejusdem generis*. The Latin term *ejusdem generis,* according to the Butler case,

> ". . . is simply a rule of interpretation. It is guidance to the ordinary insight that when specific words are followed by general words those specific words restrict the meaning of the general. Thus, where the phrase 'other minerals' follows the enumeration of particular classes of minerals such as oil and gas, the general words will be construed as applicable only to minerals of the same kind or class of those specifically named."

This theory goes back to 1920 in Oklahoma where the Supreme Court applied *ejusdem generis* in *Wolf v. Blackwell Oil Company.*[2]

The facts in that case involved a lease which granted the right to explore for oil, gas and other minerals, and the Court held that "other minerals" means similar in character and class to oil and gas. Other cases leading up to the *Butler* case are *Beck v. Harvey*[3], which held gravel is not a mineral in a reservation of "mineral royalties." In *Cronkhite v. Falkenstein*[4], the Court held, under rule of *ejusdem generis,* gypsum is not included in a reservation of oil, gas and other minerals. However, the Court conceded gypsum was a mineral. In 1971, the Court held, in *Panhandle Cooperative Royalty Company v. Cunningham*[5], that metallics, such as copper, silver, and gold, were not included as other minerals; but the Court did say *ejusdem generis* would not be used to determine intent. Where intent was a consideration of extrinsic evidence, it would be allowed to determine the intent of the parties. Then in *West v. Aetna*[6] and *Allen v. Farmers Union Cooperative Royalty Company*[7], cases involving metallics, the Court held that the reservation of *oil, gas and other minerals* was not ambiguous and that no extrinsic evidence may be allowed to show intent.

One other Oklahoma case of note that does not involve *ejusdem generis* is *Holland v. Dolese Company*[8]; in this case it was stipulated that Dolese owned the real property less one-half of the mineral rights which was reserved by the grantor. The owners of the reserved interest brought an action in accounting, seeking payment for the limestone that had been commercially quarried. The Court held the limestone being quarried was a general part of the soil and sub-soil, and that the limestone had no peculiar properties so as to be rare and exceptional in character. Since it was not an exceptional substance, and therefore comparable to sand and gravel, the limestone was not included in the reserved mineral right.

THE TEXAS APPROACH[9]

Prior to 1971, Texas courts consistently held that the term "other minerals" was unambiguous and, therefore, limited the construction process to the face of the instrument. In *Hienatz v. Allan*[10], the Supreme Court of Texas held that only substances of rare and exceptional quality, or those possessing a peculiar property giving them a special value, apart from the land itself, would be considered as minerals for the purpose of a general conveyance of minerals. Texas courts generally held that all unnamed minerals were a part of the mineral estate, regardless of the method of extraction.

In 1971, the Texas Supreme Court rejected the use of *ejusdem generis* to ascertain the intent of the parties.[11] [12] The Texas approach recognizes the problems that Oklahoma experienced in the *Butler* case; however, the Texas approach leaves open the question of intent, which potentially gives rise to inconsistent determinations or methods of determining intent. The Texas courts adopted the "general intent" test advocated by Professor Eugene Kuntz in 1949.[13] Under the Kuntz test, each reservation is assumed to sever the entire mineral estate. The Court limited the Kuntz test by stating that a substance is not included in a reservation of minerals if any portion of the substance lies so near the surface that to be extracted it must be removed by methods that will consume or deplete the surface estate.[14] To state the "general intent" theory another way, a reservation of unspecified minerals does not in-

[2] 186 P.484 (1920)
[3] 164 P.2d 399 (1945)
[4] 352 P.2d 396 (1960)
[5] 495 P.2d 108 (1971)
[6] 536 P.2d 393
[7] 538 P.2d 204 (1975)
[8] 540 P.2d 549
[9] Lori Ann Merrill. Ownership of unspecified minerals in Texas and Oklahoma after *Reed v. Wylie II,* Volume 16, Page 511, Tulsa Law Journal, 1981.
[10] 217 SW.2d 994 (1949)
[11] *Acker v. Guinn*, 464 SW.2d 348 (Tex. 1971)
[12] Mark J. Pordos, "Minerals: after *Moser v. United States Steel:* A New Approach to Ownership of Unspecified Minerals in Texas and Oklahoma." Volume 37, Page 352, Oklahoma Law Review 1984.
[13] Kuntz; The law relating to oil and gas in Wyoming, 3 Wyoming Law Journal 107 1949.
[14] *Acker v. Guinn*, supra

clude sand, gravel, rock from quarries, or anything else that would consume or deplete the surface.

In 1980, the Texas Court of Civil Appeals rendered its decision in *Moser v. United States Steel Corporation*.[15] Moser was a suit to quiet title to an interest in uranium ore. The Court was called upon to interpret the language reserving "all of the oil, gas and other minerals of every kind and character, in, on, under and that may be produced from said tract." Substantial quantities of uranium were discovered, and the owners of the reserved minerals claimed that uranium was one of the other minerals reserved from the conveyance of the surface. The trial court ruled that the uranium was part of the mineral estate. The court also held that the uranium was near the surface and that the only reasonable method of extraction was by a process known as solution mining. The evidence showed that this process does not destroy or deplete the surface. The mineral owners were adjudged to own the uranium because the surface would not be destroyed or depleted.

The Court of Appeals decision was appealed to the Texas Supreme Court, which affirmed the lower court and determined that *minerals* includes all substances within the ordinary and natural meaning of the word, regardless of whether their presence or value is known at the time of removal. The Court did not explain the *ordinary and natural meaning* test. The Texas Court, in *Moser,* also stated that the meaning of the word "minerals" could not be ascertained either by resort to the doctrine of *ejusdem generis* or by reliance on the scientific or technical definition of the substance. The reason given in *Moser* was that "minerals" would necessarily include not only metallic minerals, but even the soil itself. Under this construction, the surface and the minerals would be indistinguishable.[16]

IODINE

The ownership of iodine was addressed by the District Court of Woodward County in the State of Oklahoma in a case styled *M.C. Eike, et al. v. Amoco Production Company, et al.* This case was decided in 1978 by the District Court, and was appealed to the Oklahoma Supreme Court. The Oklahoma Supreme Court affirmed the District Court, without any comment; the decision was not published. The facts in *Eike* were that Amoco and their joint-venture partner, Pittsburg Plate Glass (PPG), sought to secure a commercial supply of iodine. They selected a site in Woodward County known as the "Woodward trench," which is an old paleovalley containing basal Morrowan sandstones, approximately 7,000 ft below the surface.

Amoco purchased brine-water leases from the surface owners above the trench. The plan was to drill a number of wells similar to oil and gas wells, and then use them to bring the brine water to the surface. The water would then be processed through a plant which would extract the iodine. After the extraction process, the waste water would then be returned by injection wells into the same formation from which it was produced. A small amount of natural gas (methane) was expected to be produced along with the brine water, but no plans were made for the gas except to operate equipment at the plant.

When production began, some free gas came to the surface along with the gas in solution. Amoco had not originally obtained any oil and gas leases on the property. The Court found that none of the wells involved were commercial oil and gas wells, since the expense of operation would exceed any profit derived from the sale of oil and gas. In other words, none of the gas would ever have been produced, except for the project to bring brine water to the surface and extract the iodine therefrom. The Court found that there is no difference between solution gas and free gas, once the gas is released from the solution. Amoco did use some of the gas to operate the iodine plant and processing equipment for the plant. The Court held that the brine water and the iodine belonged to the surface owners, and that the oil and gas belonged to the mineral owners, whether or not it could have been produced, except in connection with the brine water. Therefore, the oil and gas owners were entitled to be paid the value of the gas produced, less certain costs that were attributable directly to separating the gas that was in solution.

INDUSTRIAL-MINERAL LEASE

Following are examples of a standard lease form that generally can be used in leasing of industrial minerals (Appendix 1), and a lease used by the Commissioners of the Land Office for brine water (iodine) combined with natural gas (Appendix 2).

[15]601 SW.2d 731

[16]26 Tex. Sup. Ct. J. 427, 428 (1983); See also footnote 12.

APPENDIX 1

M I N I N G L E A S E

THIS AGREEMENT made and entered into this _____ day of _____, 19__, by and between

hereinafter called "Lessor" (whether one or more) of _____, and _____, hereinafter called "Lessee", whose address is _____, _____.

WITNESSETH:

1. Grant. That the said Lessor for and in consideration of the sum of Ten Dollars ($10.00) and other good and valuable consideration, the receipt and adequacy of which is hereby acknowledged and of the covenants and agreements hereinafter contained has granted, demised, leased and let and by these presents does grant, demise, lease and let exclusively unto the said Lessee, its successors and assigns, the hereinafter described lands, including all necessary rights, with the exclusive right and privilege to explore for, develop, mine (by open pit, underground, strip mining, solution mining or any other method) extract, mill, store, remove and market therefrom all minerals, metals, ores and materials of whatsoever nature or sort (hereinafter referred to as "Leased Substances"), except only petroleum and natural gas, and of using so much of the surface of said land as may be necessary, useful or convenient for the full enjoyment of all rights herein granted; all of said lands hereinafter referred to as "Premises" being situated in the County of _____, State of Oklahoma, described as follows:

and containing _____ acres, more or less. This Lease covers not only such interests in the Premises as the Lessor presently owns therein but also such additional interests as Lessor may acquire in the future by operation of law or otherwise, provided, that if Production Royalty or Delay Rental (or rental under Section 8) has been reduced pursuant to Section 6, hereof, they shall be increased proportionately for the balance of the term of this Lease following receipt of

notice by Lessee of the acquisition by Lessor of such additional interest.

2. TERM. This Lease is granted for a primary term of ten (10) years from its date, plus any extension thereof effected pursuant to the next sentence, and for as long after said primary term (whether or not extended) as Leased Substances are mined from or other mining operations are conducted or are deemed to be conducted on the Premises or on other lands adjacent to the Premises or on lands included in a mine plan with the Premises, or any portion thereof, approved by the state or federal authority having jurisdiction over such mining plans and operations or this Lease is maintained in force in any other manner herein provided. The term "mining operations" shall include development and other operations preparatory to mining and operations for reworking, extending or repairing a mine, as well as operations for actual mining. Prior to the tenth anniversary of the date of this Lease, Lessee shall have the right, at its election, to effect an extension of the primary term for an additional ten (10) years by payment (or tender) to the Lessor or to Lessor's account in the depository bank of the amount of Twenty Dollars ($20.00) per acre for each acre of land contained in the Premises not theretofore released from this Lease, which payment will be consideration for the extension and include payment of the Delay Rental for the eleventh (11th) year of this Lease in accordance with Section 3. If the primary term is so extended and Lessor requests in writing, Lessee shall, within six (6) months thereafter, execute an instrument declaring such extension and file same for record in the County where the Premises are situated.

3. DELAY RENTAL. If mining operations are not commenced on the Premises within one (1) year from the date of this Lease, this Lease shall then terminate unless on or before such lease anniversary date Lessee shall pay (or tender) to Lessor or to Lessor's account in the depository bank the sum of Five Dollars ($5.00) per acre (herein referred to as "Delay Rental") for each acre of land contained in the Premises and not theretofore released from this Lease which shall grant Lessee the right to defer commencement of mining operations hereunder for a period of twelve (12) months from such anniversary date. In like manner and upon like payment or tender annually made, the commencement of mining operations may be further deferred for successive periods of twelve (12) months each during the primary term and any extension thereof; provided, however, that commencing with the sixth (6th) year hereof and for all subsequent anniversary dates occurring thereafter the amount of the Delay Rental payments shall be increased to Ten Dollars ($10.00) per acre for each acre of land contained in the Premises and not theretofore released from this Lease. If, at any time after commencement of mining operations, Lessee suspends such operations for a continuous period of ninety (90) days or more, Lessee may pay or tender Delay Rental, in the manner above provided, on or before the lease anniversary date next occurring after the end of said ninety (90) days, for the privilege of continuing such suspension of mining operations for an additional twelve (12) months period and in like manner Lessee may continue to suspend such operations for successive twelve (12) months periods by so paying or tendering Delay Rental on or before each successive lease anniversary date even though the primary term may have ended. Mining operations shall be deemed to be continuously conducted for all purposes of this Lease where there is a cessation of operations for less than ninety (90) days or a cessation of whatever duration due to Force Majeure.

One half of all sums paid Lessor pursuant to this Section 3 during the first five (5) years of this Lease and three-fourths of all sums paid Lessor pursuant to this Section 3 during the sixth (6th) and remaining years of this Lease, excluding sums paid to extend the primary term of the Lease pursuant to Section 2, shall constitute prepayment of the

production royalties reserved hereunder, and Lessee may credit said sums, including sums paid against lands subsequently released from this Lease or as to which this Lease has terminated, against any and all production royalties payable hereunder as they come due until Lessee has been repaid the full amount of the sums hereinabove provided. Upon the expiration or termination of this Lease, any such sum of Delay Rental not recovered by Lessee, subject to production royalty accrued but not paid as of the date of expiration or termination, shall be retained by Lessor.

4. PRODUCTION ROYALTY. (A) Lessee shall pay Lessor Production Royalty of five percent (5%) of Net Returns for all Leased Substances mined or otherwise recovered and removed from the Premises and thereafter sold by or for the account of Lessee before or after processing, concentrating, smelting or refining.

(B) "Net Returns" means the amount actually received by Lessee from sale of Leased Substances less, but only to the extent actually incurred and borne by Lessee:

(i) charges and costs, if any, for transportation to places where Leased Substances are milled, treated, processed, concentrated or otherwise beneficiated, smelted, refined and sold;

(ii) charges and costs, if any, for milling, treatment, processing, concentrating or other beneficiation, including but not limited to crushing and screening but excluding all mining costs; and

(iii) charges, costs and penalties, if any, for smelting, refining and marketing.

In the event milling, treatment, processing, concentrating or other beneficiation or smelting or refining are carried out in facilities owned or controlled, in whole or in part, by Lessee, charges, costs and penalties for such operations, including transportation, shall mean the amount that Lessee would have incurred if such operations were carried out at facilities not owned or controlled by Lessee then offering comparable custom services for comparable products on prevailing terms. If any product or products derived from the Leased Substances following such milling, treatment, processing, concentrating, or other beneficiation, smelting or refining thereof are used by Lessee as raw material in its own or an affiliate's facilities and plants rather than being sold to a third party, such product(s) shall be deemed to have been sold upon shipment to such facility or plant at a price based on the current price for such products as published in Industrial Minerals, currently published by Metal Bulletin Journals, Ltd., f.o.b. the mill, plant or concentrator where such product is first obtained, or if said publication should cease to be published or the product(s) recovered from the Leased Substances does not conform to the schedules published therein, such similar publication as the parties hereto shall mutually agree upon, provided if the parties are unable to agree on such a substitute publication, the sales price shall be deemed to be the actual market value for such product f.o.b. the mill, plant or concentrators where such product is first obtained.

(C) Royalties shall be paid on or before the 30th day after the last day of the calendar quarter in which Lessee receives payment for the Leased Substances.

(D) Within ninety (90) days after the end of each calendar year, Lessee shall deliver to Lessor an unaudited statement of royalties paid Lessor during the year and the calculation thereof. All year-end statements shall be deemed true and correct ninety (90) days after presentation, unless within that period Lessor delivers notice to Lessee specifying with particularity the grounds for each exception. Lessor

shall be entitled at Lessor's expense to an annual independent audit of the statement by a certified public accountant, but only if Lessor delivers a demand for audit to Lessee within sixty (60) days after presentation of the related year-end statement.

(E) All Leased Substances for which a royalty is payable shall be weighed or measured, sampled and analyzed in accordance with good practice, and where mine facilities serving the Premises also serve other properties, such procedures shall be employed prior to mixing or commingling the ores, materials or products mined or produced from such other properties with Leased Substances from the Premises.

(F) The royalties provided above shall be the total payments due Lessor for Leased Substances mined and removed from the Premises hereunder.

5. MANNER OF PAYMENT. The payment or tender of any Delay Rental and Production Royalty (or rentals under Section 8) may be made by mailing, tendering or delivering currency or Lessee's check or draft therefor to Lessor at Lessor's address provided herein for delivery of notices or to Lessor's credit in Lessor's below designated depository bank; and payment or tender of payment in such manner shall be binding on the representatives and successors in interest of a deceased Lessor. When mailed, payment shall be deemed made as of the time Lessee's check or draft therefor is deposited in the United States mail addressed to Lessor or the depository bank. If the Lessor's interest is jointly owned, Lessee may make any payment to the said parties "Lessor" jointly (without responsibility for distribution of such payment) until such time as they shall deliver to Lessee a recordable agreement, specifying to whose account and in what proportions Delay Rentals and Production Royalties (and rentals under Section 8) hereunder shall be paid; or, at Lessee's option such payments may be made to the parties "Lessor" severally in the proportions in which their respective interests appear of record as of the date of this Lease, or, as to any such interest, as of any later date to which title thereto is determined by abstract certified to a later date supplied to or obtained by Lessee and/or by evidence of changes in ownership furnished Lessee in accordance with Section 11.

6. LESSER INTEREST. If Lessor owns a lesser interest in and to any part of the land included in the Premises than the entire fee simple mineral estate then as to such part of the Premises any royalties provided to be paid by Lessee on Leased Substances produced from, or Delay Rental (or rentals under Section 8) to be paid by Lessee with respect to, the acreage contained in said part of the Premises shall be reduced and shall be paid to Lessor only in the proportion which Lessor's mineral interest in said part of the Premises bears to the entire fee simple mineral estate therein.

7. CONDUCT OF OPERATIONS. Lessee's operations on the Premises shall be conducted in a careful and miner-like manner and in compliance with applicable laws and governmental regulations. Exploration, development, mining, extraction, processing and other operations conducted on the Premises shall be only those which Lessee elects to conduct; this Lease has no implied covenants or conditions and the Delay Rental provisions are in lieu of any obligation, express or implied, to explore, develop, mine or operate the Premises. Lessee shall conduct all operations with due regard for good land management so as to avoid unnecessary damage to improvements, grass, timber, crops or other cover, and shall fence all sump holes, ditches and other excavations and remove or cover all debris. If Lessee's mining operations sever or disrupt Lessor's roadways or interfere with Lessor's right of ingress or egress to and from any portion of the Premises not affected by such mining operations, Lessee shall provide Lessor with a roadway or

roadways of equal quality and construction to those severed or disrupted. Lessee shall install a suitable gate or cattle guard at each location where it desires a passageway through Lessor's fence.

8. REMOVAL OF PILLARS AND CROSS-MINING RIGHTS. Lessee shall have and is hereby granted the right to mine and remove such pillars as it may elect from any underground working area and the right, without further consideration for such right or any charge or cost for the exercise thereof, to use any mine shaft, haulage ways or other facilities Lessee may elect to install in, on or under the Premises for or in connection with the mining, removing, transporting and or storing of ores, minerals and waste materials from other lands as well as the right to mine and remove Leased Substances and waste materials from the Premises through or by means of shafts, haulage ways and other facilities located in, on or under other lands.

Lessee may continue to have and hold the Premises and facilities located thereon for the purpose of exercising the cross-mining rights granted under this Section notwithstanding the termination of this Lease for as long as such rights are desired by Lessee by giving Lessor written notice of such continuation within ninety (90) days after the termination of this Lease, designating that portion of the Premises as to which Lessee elects to continue such rights and tendering therewith the first payment of the annual rental provided for next below. If these rights are so continued after Lease termination, then thereafter until such time as Lessee shall advise Lessor by written notice that Lessee no longer desires the use of such rights, Lessee shall pay Lessor annual rental (due on the Lease anniversary date except as otherwise above provided for the first payment) with respect to that portion of the Premises designated in Lessee's said notice of continuation at the same rate per acre and in the same manner set out in Section 3 for Delay Rental payments.

9. COMMINGLING. Where facilities serving the Premises also serve other properties, methods and procedures consistent with practices in the mining industry shall be employed to determine the quantity and quality or grade of the Leased Substances from the Premises that may be mixed or commingled with minerals from other lands.

10. LESSOR'S TITLE AND TAXES. Lessor hereby warrants and agrees to defend the title to the Premises herein described. Lessee may elect to pay any mortgages, taxes or other liens or encumbrances on the Premises, and in such event, Lessee shall be entitled to reimburse itself therefor out of any Production Royalty or Delay Rental (or rentals under Section 8) becoming due Lessor. Lessee shall be fully subrogated to the rights of the holders of any liens and encumbrances so paid.

Lessor agrees to pay promptly when due all property taxes levied and assessed upon the property except as hereinafter provided, and during the term of this Lease, Lessee agrees to pay promptly when due all taxes levied and assessed upon any improvements placed by Lessee upon the Premises. As to any sales, use, gross receipts, severance or other taxes that are now or may hereafter be payable on or with respect to the severance, production, removal, sale or disposition of Leased Substances, but excluding any taxes on net income, Lessor and Lessee shall bear their pro rata share, provided the pro rata share of Lessor shall be determined by multiplying the gross amount of Production Royalties paid unto Lessor during the taxing period by the applicable tax rate, the balance of the tax being Lessee's pro rata share. If Lessor fails to pay taxes chargeable solely to Lessor or its pro rata share of taxes when due, Lessee may, at its option, pay Lessor's taxes or Lessor's pro rata share of taxes as herein defined and deduct said payment or payments from royalties or rentals due or to become due unto Lessor hereunder.

11. ASSIGNMENT. The estate of either party to this Lease may be assigned or transferred in whole or in part and the provisions and covenants hereof shall extend to, inure to the benefit of, and be binding upon not only the parties hereto but also their respective heirs, devisees, executors, administrators, personal representatives, successors and assigns. No change or division of ownership in the Premises or in the Production Royalties or Delay Rentals (or rentals under Section 8) payable under this Lease shall (except at Lessee's option in any particular case) be binding upon Lessee until thirty (30) days after Lessee shall have been furnished, at its address shown above, with the original recorded instruments, or duly certified copies thereof, properly evidencing the same. No such change or division of ownership shall operate to enlarge the obligations or diminish the rights of Lessee.

12. TERMINATION BY LESSOR. If Lessor, at any time, considers that Lessee is in default, Lessor shall give to Lessee written notice of such alleged default and, Lessee shall have sixty (60) days after actual receipt of such notice within which to commence action to cure such default; provided that if within such sixty (60) day period either Lessor or Lessee institutes action in a court of competent jurisdiction for the judicial determination of the validity of Lessor's claim, then Lessee will have sixty (60) days after any final judicial determination that it is in default within which to commence curative action. If Lessee shall not have made payment of any amounts due or shall not have entered upon the correction of any other actual default within such sixty (60) day period, as appropriate, then Lessor may, at his option, terminate the unexpired portion of this Lease by notifying Lessee of such election in writing.

13. TERMINATION BY LESSEE. Lessee may at any time (or times, in case of partial releases) release and terminate this Lease as to all or any portion of the Premises by mailing to Lessor or by filing for record, in the official records of the County in which the Premises are situated, a release to that effect, describing the portion of the Premises as to which this Lease is so released and terminated, whereupon Lessee shall have no further obligations whatsoever to Lessor as to such released portion of the Premises, except for any Production Royalty accrued hereunder prior to such surrender which remains unpaid. Each such termination shall be subject to Lessee's continuing rights to remove its property from the released portion of the Premises (as provided in Section 14 below) and to continue to use facilities therein and thereon in connection with operations on or in other lands, as provided in the final paragraph of Section 8 above.

14. REMOVAL OF PROPERTY. After termination of this Lease, Lessee's right to remove all property, tailings, fixtures or structures erected or placed by or for Lessee on the Premises or used in connection with any mining facilities located in or under the Premises shall continue until one (1) year after Lessee shall have abandoned said facilities. Property of Lessee remaining in or under the Premises after expiration of the time herein allowed for its removal shall become the property of Lessor (only, however, proportionately to Lessor's interest in the area where such property remains should Lessor not own the full fee simple estate therein).

Upon termination of all rights under this Lease, including the cross-mining rights which survive lease termination, Lessee shall seal all mine openings and perform all required reclamation of the Premises in accordance with then applicable laws and regulations, and Lessee is hereby granted such easements in and rights of ingress and egress to the Premises as are reasonably necessary for such purposes.

15. OWNERSHIP DISPUTE. In case of any dispute or question regarding ownership of the Premises or of any Production Royalty, Delay Rental or rentals payable under this Lease, Lessee shall be entitled to withhold payment of such royalties, Delay Rentals and rentals, without interest, until thirty (30) days after receipt by Lessee of appropriate proof that the dispute or question has been properly settled.

16. FORCE MAJEURE. Lessee shall not be deemed in default for failure to perform or comply with any of the covenants or conditions hereof when such failure is caused by explosion, accident, the elements, damage to mining, treatment or processing facilities, fire, governmental authority, strikes or other labor difficulties, riots, shortages or interruptions of transportation facilities, acts of God or any circumstance or condition (whether or not similar to those here enumerated) beyond the reasonable control of Lessee (any such cause being for purposes hereof "Force Majeure") and where required to maintain this Lease in effect, it shall be deemed that mining operations are being conducted on the Premises during any such period of Force Majeure including allowance of a reasonable time thereafter within which to commence or resume operations. Any settlement by Lessee of a strike or other labor difficulty shall be solely at Lessee's discretion.

17. NOTICES. Notices required or permitted hereunder may be mailed to Lessor and Lessee at their respective addresses set forth in the introduction of this Lease. Any party may change addresses upon written notice to the other party.

18. DEPOSITORY BANK. Lessor hereby designates, as Lessor's depository bank, the _____ Bank at _____, Account Number _____, which bank (and its successors) shall be deemed Lessor's agent for the purpose of receiving, collecting and receipting for Delay Rental and Production Royalty payments under this Lease and for any Section 8 rental payments. Said bank, and its successors, shall continue as the depository bank for such purposes regardless of changes in the ownership of the Premises or of the right to receive any such payments; provided Lessor may designate a new depository bank by filing an appropriate written instrument making such designation with Lessee and obtaining Lessee's written consent thereto (which consent will not be unreasonably withheld). If Lessor's designated depository bank at any time is unable or unwilling to serve in such capacity, Lessor will promptly designate a new depository bank in the manner above specified and Lessee shall not be required to make any further payments accruing to Lessor until thirty (30) days after receipt of a proper designation of a new depository bank.

19. SUBSEQUENT GRANTS. Lessor agrees that any leases, grants or conveyances made by it affecting or pertaining to surface uses or any minerals other than those herein granted shall contain appropriate provisions to insure that all operations of Lessee under this Lease may be carried on without undue interference.

20. DAMAGES. Except as herein provided, Lessee shall not be liable for any damage to the surface or subsurface of the lands comprising the Premises or to any improvements thereon, the rentals and production royalty payments made to Lessor hereunder being recognized to include full payment therefor. If any portion of the Premises is permanently removed from agricultural production (including pasture lands) due to Lessee's mining, construction or mineral processing activities, then Lessee shall pay or tender to Lessor as full payment for damages the sum of one hundred fifty percent (150%) of the Fair Market Value for each acre of surface land (pro rata for fractions of an acre) permanently removed from agricultural production, or at Lessee's option at any time or from time to

time, Lessee may purchase such part of the surface of the property so removed at three hundred percent (300%) of the Fair Market Value thereof (pro rata for fractions of an acre) with any amounts previously paid by Lessee for such lands pursuant to the one hundred and fifty percent (150%) damage provision above to be credited against such purchase price. If any portion of the property is temporarily removed from agricultural production in conjunction with Lessee's mining operation, including but not limited to excavation of the surface for open pit mining and the construction of haulroads, Lessee shall pay to Lessor annually the amount of One Hundred Dollars ($100) per acre for pasture land and One Hundred Fifty Dollars ($150) per acre for crop land (pro rata for fraction of an acre) for such land temporarily removed from agricultural production. If Lessor owns less than the entire and undivided interest in the surface estate removed from agricultural production, the payments to be made shall be proportionately reduced and paid to Lessor only in the proportion that Lessor's interest bears to the entire undivided ownership interest in such surface lands. If Lessor and Lessee are unable to agree as to the Fair Market Value of lands removed from agricultural production, an independent appraiser, chosen by mutual consent of the parties and whose fee shall be borne equally by the parties, shall be retained to make a final and binding determination of such Fair Market Value. Fair Market Value is herein defined as the value, at the time of calculation, of comparable agricultural lands in the same or a similar area used for the activities for which the land or property in question was used, calculated without regard to mineral values or mineral activities on such lands.

21. INSPECTION. Lessor and authorized agents of Lessor, at Lessor's risk and expense, may enter the Premises to make reasonable inspections of Lessee's operations.

22. ABSTRACTS OF TITLE. Upon request of Lessee, Lessor shall provide to Lessee any abstracts of title to which Lessor has access. Lessee agrees to promptly return such abstracts following reasonable use thereof, but in no event shall Lessee keep such abstracts for more than one (1) year without the prior written consent of Lessor. If such abstracts are lost, damaged or destroyed Lessee shall furnish new abstracts to Lessor covering the lands involved certified to date of the abstracts lost, damaged or destroyed. Lessee upon written request of Lessor shall from time to time supplement Lessor's abstract to include this Lease and all instruments recorded by Lessee or others, related thereto, or at Lessee's option pay to Lessor the reasonable cost of updating Lessor's abstract for any instruments recorded by Lessee or others related to this Lease, including the release thereof upon termination, as to all lands included herein.

23. SECTION HEADINGS. Section headings in this Lease are for convenience only and shall not be considered a part of this Lease or used in interpretation of the provisions hereof.

24. OTHER PROVISIONS: _____

_____

_____

_____

_____

_____

_____

_____

Lessor hereby releases and waives all rights under and by virtue of the homestead laws of this State.

This instrument constitutes the entire agreement between the parties hereto and each party has received a copy of the same. The parties agree to execute a memorandum of this Lease, for purposes of recording same in the land records of the

County where the Premises are located, in the form "Memorandum of Mining Lease", attached hereto and made a part of this Lease. Lessor agrees not to record this Lease without the prior written consent of Lessee. Any changes, modifications or amendments to this Lease shall not be effective unless reduced to writing and signed by the parties hereto.

In Witness Whereof, this mining lease is executed effective the day and year first above written.

LESSOR(S)	LESSOR(S)
_____	_____
(Signature) SS#_____	(Signature) SS#_____
_____	_____
(Typed or Printed Name)	(Typed or Printed Name)
_____	_____
_____	_____
(Address)	(Address)
LESSOR(S)	LESSOR(S)
_____	_____
(Signature) SS#_____	(Signature) SS#_____
_____	_____
(Typed or Printed Name)	(Typed or Printed Name)
_____	_____
_____	_____
(Address)	(Address)

ACKNOWLEDGMENTS

(Individual)

STATE OF _____)
) SS.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this ___ day of ____, 19_____, by _____ _____.

_____
Notary Public

My Commission Expires:

_____

(Husband and Wife)

STATE OF _____)
) SS.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this ___ day of ____, 19_____, by _____ _____, husband and wife.

_____
Notary Public

My Commission Expires:

_____

(Corporation)

STATE OF _____)
) SS.
COUNTY OF _____)

The foregoing instrument was acknowledged before me this ___ day of ____, 19_____, by _____ President of _____, a _____ corporation, on behalf of the corporation.

_____
Notary Public

My Commission Expires:

_____

APPENDIX 2

The State of Oklahoma

BRINE WATER AND ASSOCIATED SOLUTION GAS AND FREE GAS LEASE

THIS LEASE, made and entered into in duplicate, on this_____day of_____, A.D., 19_____, by and between the Commissioners of the Land Office of the State of Oklahoma, acting for and in behalf of the State of Oklahoma, parties of the first part, hereinafter designated as Lessor, and _____ _____party of the second part, hereinafter designated as Lessee, whose address is _____ _____. Under and in pursuance of the provisions of the Constitution and Laws of the State of Oklahoma relating to leasing school and other public lands belonging to the State of Oklahoma, WITNESSETH:

1. The Lessor, for and in consideration of _____ ($_____) DOLLARS, the receipt of which is hereby acknowledged does hereby grant, demise, lease and let exclusively unto Lessee for a term of five (5) years from the date hereof and as hereinafter extended, for the purpose of exploring, producing, and operating for free gas and/or brine water and its constituent elements, including compounds thereof, and including, but without being limited to, such iodine, bromine, magnesium, potassium, lithium, boron, chlorine, calcium strontium, sodium, sulphur, barium, solution gas, free gas and other elements, or compounds thereof, that shall or may be extracted, processed, refined or recovered from said brine water, the following described land in _____ County, State of Oklahoma, to wit: _____ _____ containing_____acres, more or less, together with the right of ingress and egress to and from said land and the right to lay pipelines, construct roadways, and electrical power lines on, over, through and across said land and the right to use said land at all times for the purpose of exploring by geological, geophysical and other methods, operating, transporting by pipelines or other methods water, brine water and gas over, through, and across said land and developing said land for said brine water and its constituent elements or compounds thereof together with the right to pipe, store, extract through ion exchange beds and remove brine water (and its constituent elements) and to occupy and use so much only of the surface of said land as may reasonably be necessary to carry on the work of extracting, recovering, transporting and marketing the same therefrom. Inclusive is the right to inject water into any subsurface strata to the extent permitted by governmental regulations; provided, however, no quantity of water may be injected for purposes of disposal (as distinguished from water flooding, pressure maintenance operations or formation repressure operations) that is in excess of the quantity of water that is produced from the leased premises, or acreage unitized therewith. The term "brine water," as herein used, shall mean subterranean salt water having at least 5,000 MG/L total dissolved solids and a minimum chloride content of 1000 MG/L; it shall not mean water normally suitable and used for human or animal consumption nor for irrigation purposes nor shall said term include brine water produced as an incident to oil and gas operations unless so produced by Lessee. This lease does not grant the right to refine brine water or its constituent elements on the leased property. Lessor expressly reserves all formations underlying the described lands except the Basal Morrow Formation, and reserves the non-exclusive right to geophysically explore and drill through the Basal Morrow Formation.

2. Subject to the other provisions of this lease, this lease shall remain in force for a term of five (5) years from this date and as long thereafter as free gas, brine water and its constituent elements, including compounds thereof, shall be produced in paying quantities from this lease or from land unitized therewith within a voluntary unit or within a brine water or gas unit created by a state court or governmental agency. If after the expiration of said term of five (5) years production in paying quantities shall cease, this lease shall terminate. As more particularly set forth in paragraph 19 hereof, a brine injection well shall be considered the same as a brine production well for purpose of maintaining this lease in force.

If Lessee shall commence to drill a well or commence reworking operations on an existing well within the term of this lease or any extension thereof, or on acreage unitized therewith, Lessee shall have the right to drill such well to completion or complete reworking operations with reasonable diligence and dispatch, and if free gas, brine water and its constituent elements, or either of them, be found in paying quantities, this lease shall continue and be in force with like effect as if such well had been completed within the term of years first mentioned.

3. If operations for the drilling and production of brine water are not commenced on this lease on or before one year from date hereof, this lease shall terminate as to both parties unless the Lessee, on or before the expiration of said one year period shall pay to the Lessor, during office hours, at its office in Oklahoma City, Oklahoma, the sum of Five Dollar ($5.00) per acre for the privilege of delaying the commencement of drilling and production operations for a period of one year. In like manner and upon like payments or tenders, the commencement of drilling and production operations may be further deferred for like periods successively not exceeding five (5) years from the date hereof. For purpose of calculation of the rental payments, the acreage listed in paragraph one (1) above shall be controlling. The payment or tender of such sums may be made in currency, or check at the option of the Lessee and the delivery of such currency, or check to the Commissioners of the Land Office on or before the date such payment is due shall be deemed payment as herein provided.

4. Lessee and the undersigned Lessor covenant and agree that to accomplish an impartial means of voluntary unitization, the parties agree as follows:

(a) Within Six months from the date the first well is drilled in the governmental section in which the property subject to this lease is located or in any contiguous governmental sections, Lessee shall notify Lessor in writing of the properties it proposes to be placed within a unitized area and the revenue allocation to be used therein. Lessee shall make available to Lessor all geological information and data used by Lessee in designating its proposed unitized area and the revenue allocation. Lessor and Lessee agree that revenues allocable to the various tracts within the unit shall be based on the prorata share of net acre feet of the productive formation having porosity of 8% or greater which underlies each tract.

(b) Within Six months of receipt by Lessor of such notification, Lessor shall, if Lessor objects to the proposed unitized area or the revenue allocation, notify Lessee in writing of any objection and suggest Lessor's proposed unitized area and revenue allocation. In such event, Lessor shall make available to Lessee all geological information and data used by Lessor in designating the proposed unitized area and revenue allocation.

Failure to object within the Six months period shall be deemed an acceptance by Lessor of Lessee's proposed unitized area and revenue allocation. Lessee shall thereupon file with the County Clerk wherein the lands are located an appropriate instrument designating the area and revenue allocation as unitized hereunder. If Lessor does object to the Lessee's proposed unitized area or revenue allocation, then the parties shall attempt to agree upon a unitized area and if they do so, shall file jointly with the County Clerk wherein the lands are located an appropriate instrument designating the area and revenue allocation as unitized hereunder. If however, the parties cannot agree as to the unitized area or revenue allocation within ninety (90) days of Lessee's receipt of Lessor's objection, then Lessee shall file with the District Court, wherein part of the land of their proposed unitized area lie, an appropriate action for determination by said Court of a unitized area and revenue allocation encompassing all lands which will contribute to production of brine and/or solution gas. All royalties shall then be deposited with the Court for disposition per Court order.

(c) If any new wells are completed in the proposed unitized area subsequent to notification by Lessee of the proposed unit boundary and prior to the final determination of the unit, Lessee shall send out a new notification and proposal within thirty (30) days of the completion of such new well and the approval or rejection process shall commence again.

(d) Any unit and resulting revenue sharing formula so established shall be effective retroactively to the date of first production from the unit.

Subsequent to the unit formation Lessee will notify Lessor of any new well drilled or any well changed from producing to injection (or vice versa) in the unit or in lands contiguous to the unit. Lessor shall have sixty (60) days from receipt of such notice to determine if the operation of such well will result in drainage to lands outside the unit and to notify Lessee in writing. If Lessee receives such notification from Lessor or any of its Lessors of other land then Lessee shall present to its Lessors affected a suggested plan of allocation. Such plan shall become binding on all Lessors within sixty (60) days of its receipt by such Lessors unless any Lessor notifies Lessee of an objection. If an objection is received, Lessee shall file a Petition of Interpleader in the District Court of the county wherein at least part of the lands are located, naming all potential affected Lessors as parties. All royalty proceeds shall then be deposited with the Court for disposition per Court order.

5. Notwithstanding any provision hereof to the contrary, drilling operations on or production from a unit or units established under the provisions of this lease, or pursuant to any judicial or governmental order shall maintain this lease in force only as to the land included in such unit or units.

6. The Lessee shall have the right to construct and maintain, below thirty-six (36) inches of depth, a pipeline or pipelines, impervious to salt water for the purpose of transportation of salt water through or across the leasehold premises upon furnishing Lessor a plat showing the exact location of said pipeline or pipelines. Lessee shall pay Lessor the sum of Thirty-Five and no/100 Dollars ($35.00) per rod for a pipeline easement, which sum shall also be inclusive of ordinary construction damages payable to Lessor on easements, and said easements shall not exceed Fifty (50) feet in width. Lessee shall pay Lessor the sum of Twenty and no/100 Dollars ($20.00) per rod to replace or add a pipeline in an easement, which sum shall also be inclusive of ordinary construction damages payable to Lessor on the easement. Lessee shall settle pipeline surface damages with other surface tenant(s) as set forth in paragraph seven (7).

7. Lessee shall pay for all damages caused by its operations on the leasehold premises. The Lessee shall settle with other surface tenant(s) of the Lessor, for their crop and improvement damages for the remaining term of said surface tenant(s) contract resulting from operations on said premises or any part thereof. For purposes stated herein, Lessor is entitled to all other damages and provided further that if there be no other surface tenant(s), then the Lessor is entitled to crop and improvement damages as well. Further, Lessee agrees to do all things necessary for the protection of the leasehold premises from pollution from salt water or other deleterious substances, and shall be liable to the Lessor for any damages to said land by reason of pollution caused by Lessee's operations. No well shall be drilled or pipeline laid nearer than two hundred (200) feet to any house or barn now on said premises without the written consent of the Lessor. Lessee shall not have the right to use fresh water for drilling, production, water flooding and pressure maintenance operations. Well sites, including reserve pits, shall be fenced during drilling operations. Upon completion of the well and filling of the reserve pit the fenced area shall be reduced to the area surrounding the well head and production equipment and any area necessary for reworking operations. All roadways shall be surfaced with gyp rock and maintained. Any road entering the property and/or crossing a division line fence shall have a sixteen (16) foot cattle guard with pipe swing gate installed. All gates entering the property from a public access road shall be kept locked and keys furnished to Lessor and the surface tenant. During the primary term hereof, Lessee shall pay Five Thousand and no/100 Dollars ($5,000.00) per lineal mile for an electrical line easement not to exceed Fifty (50) feet in width and Twenty-Five and no/100 Dollars ($25.00) per rod for a Thirty-three (33) foot roadway easement. After the primary term, the damage amounts referenced for pipeline easements, electrical line easements and roadway easements shall be adjusted for the percentage change in the cost of living index from January 1, 1988 to January 1, 1993, and thereafter for every subsequent Five (5) year period the lease is in effect. Damages for well locations shall not be a fixed amount, but shall be negotiated on a case by case basis.

8. It is agreed and understood that Lessor shall not in any manner be answerable or accountable for any loss or damage arising from the operations of Lessee or its assigns, agents, employees and representatives to any person or persons and/or any property, and that Lessee shall and will save Lessor harmless from any and all claims or demands for damages arising out of Lessee's operation and/or use of said premises, or any part thereof.

9. Lessee shall carry on the development and operation of the lease in a prudent and workmanlike manner, and shall neither commit nor suffer to be committed waste upon or offset drainage from this lease or the unit(s) encompassing this lease. Upon the termination of this lease, Lessee shall promptly surrender and return the premises to Lessor.

10. All tools, derricks, boilers, boiler houses, pipelines, roads, pumping and drilling outfits, tanks, engines and machinery, and the casing of all dry or exhausted wells, shall remain the property of the Lessee, and may be removed at any time prior to or sixty (60) days following termination of the lease; provided, if Lessee desires to leave any said equipment, improvements, or injection well(s) upon the land following termination of this lease, Lessee must first obtain new easements and leases by paying the then current fair market value as established by the Commissioners of the Land Office. If Lessee chooses not to exercise this option then any equipment and improvements not removed within sixty (60) days after termination of this lease shall, at the option of Lessor, become the property of Lessor. Lessee shall not

permit any nuisance to be maintained on the premises, and shall not use said premises for any purposes other than those authorized in the lease. Before abandoning any well, Lessee shall securely plug the same to protect the surface, ground water and oil, gas and iodine-bearing stratum, which in no event shall be less than required by the rules and regulations of the Oklahoma Corporation Commission and the laws of the State of Oklahoma. Further, the surface will be restored, as nearly as possible, to the original topography, plant and/or cropland conditions.

11. Before this lease shall be in force and effect the Lessee shall give a good and sufficient surety bond, to be approved by the Commissioners of the Land Office, in accordance with the oil and gas lease bond requirements of Commissioners of the Land Office Rule 3-119, conditioned upon the faithful performance of the covenants and conditions of this lease.

12. No transfer or assignment of this lease, or any part thereof, shall be valid, or convey any right to the assignee without the consent in writing of the Commissioners of the Land Office; and such assignee shall furnish a bond to be approved by the Commissioners of the Land Office, conditioned upon the faithful performance of the covenants and conditions of this lease.

13. This lease shall be subject to the Constitution and laws of the State of Oklahoma and the rules and regulations of the Commissioners of the Land Office now or hereafter in force relative to mining, brine and/or oil and gas leases, all of which are made a part and condition of this lease; provided, that no regulation made after the execution of this lease affecting either the length of the term hereof, the rate of royalty or payment hereunder, or the assignment hereof, shall operate to alter the term and condition of this lease.

14. Upon the violation of any substantial term or condition of this lease, the Commissioners of the Land Office shall have the right at any time to declare this lease null and void after hearing upon fifteen (15) days notice, by registered mail to the last known address of Lessee, specifying the term or condition violated; provided, any person affected thereby may appeal in the manner provided by law. Upon Lessee's failure to comply with the provisions of this lease, Lessor shall be entitled to recover from Lessee's bondsman all accrued royalties, charges, and claims of every kind and nature due and owing and arising out of and by reason of this lease.

15. Lessee may at any time hereafter surrender and wholly terminate this lease, in whole or in part, upon payment of all liabilities then accrued and due hereunder, and may exercise such right by filing a formal relinquishment and release of the said lease, or portion thereof, with the Secretary to the Commissioners of the Land Office. Lessee specifically agrees to release this lease upon expiration; provided, that if such lease has been recorded in the county, the release thereof must be recorded in the county prior to filing with the Secretary to the Commissioners of the Land Office.

16. Lessee shall exercise diligence in sinking wells for brine water on the land covered by this lease, and any acreage unitized therewith, and shall drill a sufficient number of wells to directly offset the brine wells upon adjoining premises. In the event a brine well should be completed on adjacent land within thirteen hundred twenty (1,320) feet of the leased premises (or acreage unitized therewith), Lessee agrees to commence operations for the drilling of an offset well on the leased premises (or acreage unitized therewith) within sixty (60) days after commencement of marketing of brine production from the well upon such adjoining land, and to thereafter prosecute the drilling and completion thereof with reasonable diligence and dispatch; provided, however, Lessee may defer indefinitely the drilling of such offset well so long as it pays Lessor a compensatory royalty on production from the well on such adjacent land in an amount equal to Lessor's net revenue royalty interest in the leased premises, or acreage unitized therewith, multiplied times the fair market value of that portion of the production from the offset well which is attributable to drainage from the leased premises or acreage unitized therewith. Lessee shall operate the leased premises for the production of brine water according to the standard of a prudent operator. Failure to faithfully comply with any of these provisions shall be cause for cancellation of this lease.

17. Lessee shall keep an accurate account of all drilling, production and injection operations, including a log of each well drilled, duly sworn to by the contractor or driller, which shall be filed with the Secretary to the Commissioners of the Land Office within thirty (30) days after said well is completed. Accurate and reliable information concerning all wells and their operation and management shall be furnished to the Commissioners of the Land Office or their representative upon demand. Lessee shall also keep an accurate account showing the sales, prices, dates, purchases, and the whole amount of brine water and its constituent elements (as defined in paragraph 1) mined or removed, and all sums due as royalties shall be a lien upon the implements, tools and movable machinery or personal chattels used in operating said property, and also upon all the unsold brine and its constituent elements obtained from the land herein leased as security for the payment of said royalties.

18. If Lessor owns a lesser interest in the minerals in the described land than the entire and undivided fee simple estate therein, then the royalties and rentals herein provided shall be paid to Lessor only in the proportion which its mineral interest ownership bears to the entire and undivided mineral fee estate. Lessor makes no warranty of title either express or implied.

19. The royalties to be paid Lessor for all products extracted from the brine and sold by Lessee (excluding free gas and solution gas) shall equal one twentieth (1/20th), free and clear of costs, of the fair market value of production attributable to the lease for said products (excluding free gas and solution gas) F.O.B. Lessee's refinery at the tailgate. The royalties to be paid Lessor for all free gas and solution gas produced and sold, flared or used in Lessee's plant shall equal three sixteenths (3/16ths) of the market value of the gas produced that is attributable to the lease. Gas production royalties shall be made without deduction for costs associated with transportation, compression, dehydration, treating or otherwise making gas ready for sale or use. Lessee shall pay Lessor the above referenced royalties within the time limitations contained in Title 64, Oklahoma Statutes, Section 293. Lessor shall have the right of taking all gas royalties in kind. On or before each anniversary date of this lease before there is brine production, Lessee shall pay a minimum annual royalty for brine equal to Five Dollars ($5.00) per surface acre. On or before each anniversary date after there is brine production, Lessee shall pay a minimum annual royalty for brine equal to Ten Dollars ($10.00) per surface acre. During the first year of production, the minimum annual royalty shall be pro-rated between Five Dollars ($5.00) per acre per annum preproduction and Ten Dollars ($10.00) per acre per annum postproduction. For purposes of pro-ration the 1st day of the month in which first production is commenced shall be considered to be the date of first production.

For the purpose of maintaining this lease in force, a brine injection well shall be considered to be the same as a brine production well. However, when there is only brine injection within the lease, or unit encompassing the same, Lessee shall be obligated to pay "injection royalty" to Lessor as hereinafter set forth. If a brine injection well is located on this lease, then "injection royalty" shall be the sum of Five Thousand Dollars ($5,000) per year and Five Dollars ($5.00) per net brine mineral acre per year for all net brine mineral acreage in excess of 160 acres that is owned by Lessor within the leasehold premises, and on which tract the injection well is located. If a brine injection well is located within a unit encompassing this lease, but not on this lease, then "injection royalty" shall be Five Dollars ($5.00) per net brine mineral acre per year for all net brine mineral acreage that is owned by Lessor

within the unit. All of said injection royalty payments shall be paid annually on or before the anniversary date of this lease after the expiration of ninety (90) days from the date actual brine injection first commenced on the leased premises or on lands unitized therewith. Provided, however, in no event shall this lease, or any portion thereof, be maintained in force under the provisions of this paragraph for a period longer than five (5) consecutive years, unless Lessee notifies Lessor 30 days prior to the end of one five (5) consecutive year period that Lessee elects to maintain the lease by injection only for an additional period of five (5) years. In the event that Lessee exercises the option to extend the lease into a second five (5) year period with injection only, the annual injection royalty shall increase as follows:

a) If a brine injection well is located on this lease, then injection royalty shall be the sum of Five Thousand Dollars ($5,000) per year and Seven Dollars and fifty cents ($7.50) per net brine mineral acre per year for all net brine mineral acreage in excess of 160 acres that is owned by Lessor within the leasehold premises, and on which tract the injection well is located.

b) If a brine injection well is located within a unit encompassing this lease, but not on this lease, the "injection royalty" shall be Seven Dollars and fifty cents ($7.50) per net brine mineral acre per year for all net brine mineral acreage that is owned by Lessor within the unit.

All of the injection royalty for each year of the five (5) year extension shall be due and payable within ninety (90) days of exercising said option. It is understood and agreed by the parties hereto that in the event that the lease is returned to production prior to the end of the five (5) year extension, there will be no refund of the advanced payment of injection royalty requested or granted; however, Lessee shall be allowed to credit production royalty against advanced payments of injection royalty according to the following schedule:

YEAR PRODUCTION COMMENCED IN SECOND 5 YEAR INJECTION PERIOD	PERCENTAGE OF ADVANCED INJECTION ROYALTY RECOVERABLE
1st year	50%
2nd year	40%
3rd year	30%
4th year	20%
5th year	0%

If Lessee exercises the option to extend the lease for the additional five (5) year period by brine injection, Lessee shall be required to post an additional surety, sufficient to plug and secure all wells located on Lessor's lands, in a form approved by the Commissioners of the Land Office. Further provided, brine injection shall not be used to cause the subterranean movement of commercial quantities of brine water from beneath the leased premises, or acreage unitized therewith, to offset wells unless Lessee shall pay Lessor compensatory royalties for such drainage in accordance with the formula set forth in paragraph #16 hereof.

Notwithstanding any provision hereof to the contrary, if after the expiration of the primary term hereof Lessee suspends all production or injection of brine (including its component parts) from or into the lands covered hereby or acreage unitized therewith (or any part thereof), then Lessee shall pay or tender to Lessor a shut-in royalty of Ten Dollars ($10.00) per year per net surface acre. Payment or tender of shut-in royalty shall be made on or before the anniversary date of this lease next ensuing after the expiration of ninety (90) days from the date the well is shut-in or Lessee suspends production or injection operations. When such payment or tender of shut-in royalty is made it will be considered that brine is being produced within the meaning of the lease. The payment of shut-in royalty, after the expiration of the primary term, shall not maintain the lease for more than five (5) consecutive years, unless Lessee notifies Lessor thirty (30) days prior to the end of one five (5) consecutive year shut-in period that Lessee elects to maintain the lease for an additional shut-in period of five (5) years. In the event that Lessee exercises the option to extend the lease into a second five (5) year shut-in period, the annual shut-in royalty shall increase to Twelve dollars and 50/100 ($12.50) per acre. All of the shut-in royalty for each year of the five (5) year extension shall be due and payable within ninety (90) days of exercising said option. It is understood and agreed by the parties hereto that in the event the lease is returned to production prior to the end of the five (5) year shut-in extension, there will be no refund of the advanced payment of shut-in royalty requested or granted. If Lessee exercises the option to extend the shut-in period for the additional five (5) year period, the Lessee shall be required to post an additional surety, sufficient to plug and secure all wells located on Lessor's lands, in a form approved by the Commissioners of the Land Office. If Lessee returns the lease to production during the second 5 year shut-in period, Lessee shall be allowed to credit production royalty against advanced payments of shut-in royalty according to the following schedule:

YEAR PRODUCTION COMMENCED IN SECOND 5 YEAR PERIOD	PERCENTAGE OF ADVANCED SHUT-IN ROYALTY RECOVERABLE
1st year	50%
2nd year	40%
3rd year	30%
4th year	20%
5th year	0%

20. If, within the primary term, production of brine from lands covered hereby or acreage unitized therewith should cease from any cause, this lease shall not terminate if Lessee commences or resumes the payment or tender of rentals or commences operations for drilling or reworking operations on or before the rental payment date next ensuing after the expiration of ninety (90) days from the date of cessation of production. If, after the expiration of the primary term, brine production ceases from lands covered hereby or acreage unitized therewith, this lease shall remain in force so long thereafter as Lessee is engaged in drilling or reworking operations, or in drilling any additional well, with no cessation between operations or between such cessation of production and additional operations of more than ninety (90) days, and if brine production results therefrom, then as long as such production continues or as long as this lease is held in force by the provisions of paragraph #19 hereof. IN WITNESS WHEREOF THE said parties have caused their signature to be subscribed hereto this_____day of _____, 19_____.

COMMISSIONERS OF THE LAND OFFICE
OF THE STATE OF OKLAHOMA

By:_____
Secretary.

NON-COLLUSION AFFIDAVIT

STATE OF _____)
)
COUNTY OF _____)

_____, of lawful age, being first duly sworn on oath says, (s)he is authorized by LESSEE to submit this contract to the State of Oklahoma; Affiant further states that to his(her) knowledge there has not been paid, given, or donated or agreed to pay, give or donate to any officer or employee of the State of Oklahoma any money or other thing of value, either directly or indirectly, in obtaining this lease. Furthermore, affiant states that to his(her) knowledge no person conspired or colluded with, gave or received anything of value to, or agree to give or receive anything of value to any bidder or potential bidder, directly or indirectly, relative to obtaining this Lease.

_____
Lessee.

ATTEST:_____ By:_____
Secretary.

Tax I.D. No.:_____

STATE OF _____)
)
COUNTY OF _____)

Personally appeared before me, the undersigned Notary Public, within and for said County and State _____, to me known to be the person who subscribed the name of the **Commissioners of the Land Office** of the State of Oklahoma, to the foregoing instrument, as its Secretary, and acknowledged to me that(s)he executed the same as his(her) free and voluntary act and deed and as free and voluntary act and deed of such Commissioners of the Land Office for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and notarial seal on this _____ day of _____, 19___.

My Commission expires _____ _____
Notary Public.

ACKNOWLEDGEMENT FOR INDIVIDUAL

STATE OF _____)
)
COUNTY OF _____)

Personally appeared before me, the undersigned Notary Public, within and for said County and State _____, to me known to be the identical person who executed the within and foregoing instrument, and acknowledged to me that (s)he executed the same as his(her) free and voluntary act and deed, for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and notarial seal on this _____ day of _____, 19_____.

My Commission expires _____ _____
Notary Public.

ACKNOWLEDGEMENT FOR CORPORATION

STATE OF _____)
)
COUNTY OF _____)

Personally appeared before me, the undersigned Notary Public, within and for said County and State _____, to me known to be the identical person who signed the name of the _____to the above and foregoing instrument as its _____ President/Attorney-in-Fact, and acknowledged that (s)he executed the same as his(her) free and voluntary act and deed, and as the free and voluntary act and deed of the said corporation for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and notarial seal on this _____ day of_____, 19_____.

My Commission expires _____ _____
Notary Public.

Non-Coal (Industrial-Minerals) Permitting Requirements of the Oklahoma Department of Mines

Douglas J. Schooley
Administrator, Non-Coal Division
Oklahoma Department of Mines
Oklahoma City, Oklahoma

ABSTRACT.—The Oklahoma Legislature empowered the Oklahoma Department of Mines with the jurisdiction for permitting and regulatory authority over non-coal (industrial-minerals) mining operations with passage of "The Mining Lands Reclamation Act" of 1971. This act required all operators to file with the State, through the Department, written application for a permit to engage in non-coal mining. Such an application consists of a mining plan that includes location maps and a reclamation plan for the area to be covered. Additionally, a reclamation bond is required prior to issuance of a permit, to insure that the site will be reclaimed.

Since that time, the act has been amended to include public notification and public participation in the review process of any application. Also, the operator can request that the Department review the mining plan based on a five-year plan instead of the original one-year plan. Even though the operator is granted a five-year mining plan, the permit is reviewed annually for compliance, as required by law.

In 1983, the Department promulgated rules and regulations for the Non-Coal Division of the Department of Mines (Title V DOM/RR Parts 100–243): these rules consist of permitting and bonding requirements, reclamation-release procedures, State authority, and inspection requirements.

PERMITTING REQUIREMENTS

Specific statutory requirements for permitting of non-coal (industrial-minerals) mining operations are found under Title 45, Chapter 8A "The Mining Lands Reclamation Act," Sections 721–738. Non-Coal Rules and Regulations, OAC 460:10, Sections 1–31, covers the permitting process, bonds, and blasting plan. The required documents for an application package are as follows:

1) FORMAL APPLICATION PAGE: This form is used to disclose the operator's name, address, and phone number, as well as the method of mining, legal description, and bonded and permitted acreage requested. Landowner disclosure is referenced on the document, along with the statement of certification pertaining to legal right of entry. An attachment to this document is the compliance information form, which requests disclosure of past practices and operations, and corporate or individual disclosure. An instrument of legal-estate verification is a required attachment.

2) RECLAMATION PLAN: This form references the post-mine land use of the permit area. Useful attachments for the plan's justification can be topographic maps, flood-prone-area maps, soil data, and planned reclamation cross sections and maps.

3) LOCATION MAPS: State law requires that grid-location maps be filed with the application, and that there be a separate map for each section (square mile) of land. These maps will have the permit area outlined, as well as the bonded area indicated. Transmission lines are required to be plotted on these maps. Useful attachments would be aerial photos, topographic maps, or a meters-and-bounds survey.

4) BLASTING PLAN: When explosives are to be used, a blasting plan requires disclosure of the blaster's name and certification number. Types and amounts of explosives are to be referenced, as well as procedures for control of site, blasting signals, and blasting procedures. A copy of the blaster's recording form is be attached to the plan for retention requirements of each shot fired.

Schooley, D. J., 1993, Non-coal (industrial-minerals) permitting requirements of the Oklahoma Department of Mines, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 35–36.

5) RECLAMATION BOND: Statutory law requires an operator to post a reclamation bond to insure reclamation of the permit site. The State will accept either a surety bond or a collateral bond. Each bond amount, form, and duration must be accepted by the Department prior to permit issuance.

According to Title 45, Section 724(f), and Non-Coal Rule 460:10-17-15:

> "Upon filing the application with the Department, the applicant shall place an advertisement in a newspaper of general circulation in the vicinity of the mining operation, containing such information as is required by the Department. Any property owner or resident of an occupied dwelling who may be adversely affected located within one (1) mile of the mining operation shall have the right to protest the issuance of a permit and request a public hearing."

Prior to any permit being issued, an applicant must publish the public notice and submit an affidavit of publication. If a hearing is requested, than all conferences will be held in accordance with the Non-Coal Rules of Practice and Procedures, as well as the Administrative Procedures Act. Once all permitting documentation has been received and is considered complete, a copy of the documents is submitted to the appropriate field inspector for site evaluation and recommendations. Based on the field inspection or hearing determination, the plan may be modified or conditioned. All permits issued by the Department are approved by the Director of the Department, and are considered final orders of the Department. Please refer to the flow chart (Fig. 1) for the permitting procedures as detailed.

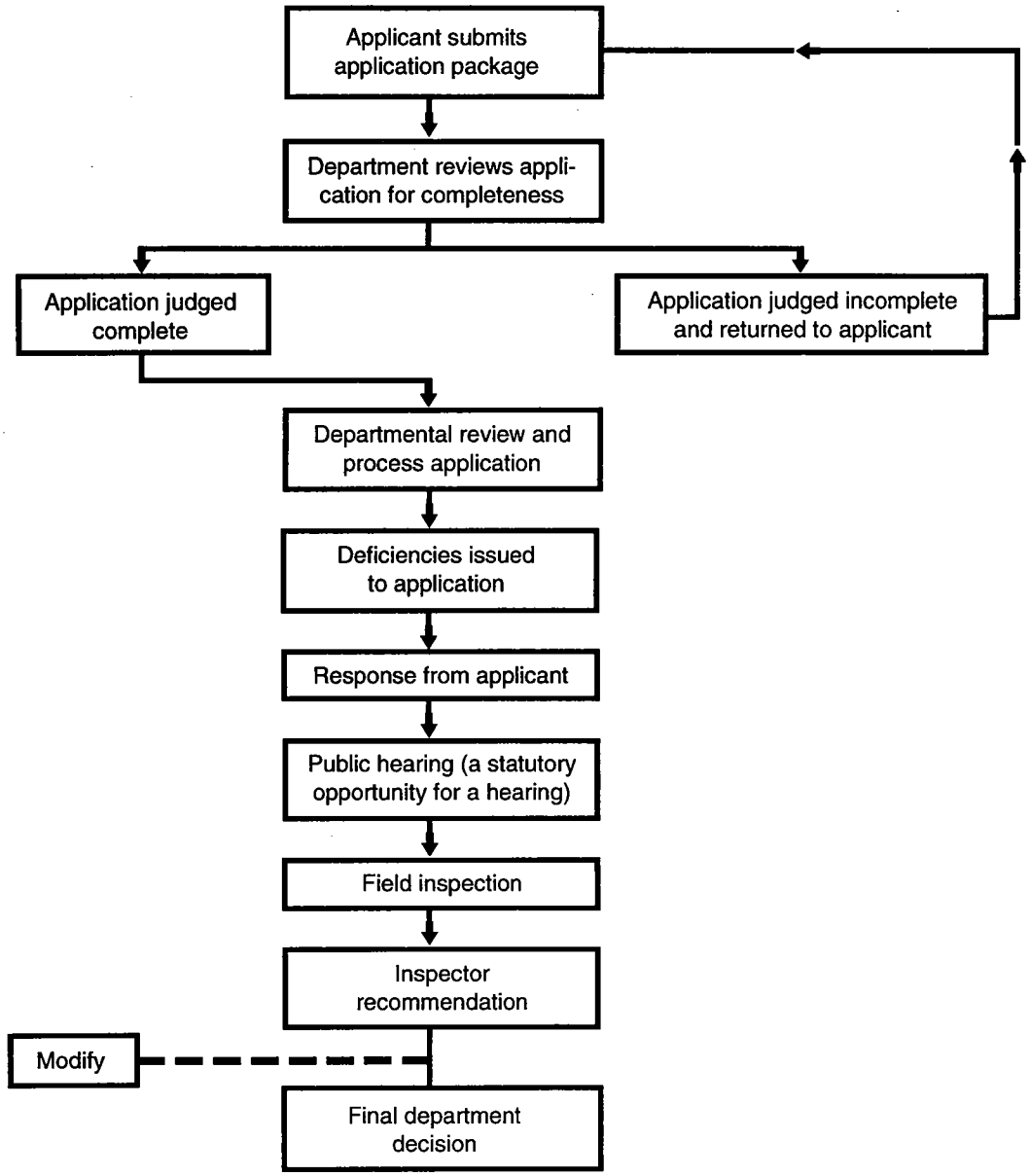

Figure 1. Flow chart showing non-coal (industrial-minerals) permitting procedures of the Oklahoma Department of Mines.

Quality Control in Industrial-Mineral Operations

Andrew S. Lain
Assistant General Superintendent
Dolese Brothers Co.
Oklahoma City, Oklahoma

ABSTRACT.—Quality control, as defined in Webster's Dictionary, is a "system for ensuring quality output involving inspection, analysis, and action to make required changes." The qualities of Oklahoma industrial minerals that are to be evaluated are based upon their physical and chemical properties.

Quality control is the activity performed by the producer and customer to monitor whether or not a product meets or exceeds the standards specified. Quality control begins with the initial plans of starting an industrial-mineral operation. When evaluating a prospective property for industrial-mineral production, samples are evaluated to make intelligent decisions on securing the property. Quality control is then used in the initial plant design for determining the type, size, and quantity of process machinery necessary to ensure an efficient operation while producing a quality product. Once an operation is producing, quality control is used each day to monitor the performance of the plant so adjustments can be made to ensure that specifications are met or exceeded.

Quality control is only as good as the data on which it is based. Sampling is a method for obtaining objective information for a large quantity of product. Since it is impractical and nearly impossible to test the entire product, samples must be taken. Sampling must be performed in a manner to ensure it is representative of the product being produced. Sampling a full cross section of the product at random intervals is the best procedure for ensuring a representative sample. Procedures on how a representative sample is obtained are specified by either American Society for Testing and Materials (ASTM) or American Association of State Highway and Transportation Officials (AASHTO) standard specification books.

Once a sample is obtained, testing is the next step. Care must be taken while performing the test so the sample does not become contaminated. Equipment used for testing must be specified by the owner/agent. When using the proper equipment in the prescribed manner, repeated testing should accurately represent the product being produced.

"Quality control is everybody's business." This is a favorite saying of most industrial-mineral producers. But, alas, some think that "if it's everybody's business, it's nobody's business." Quality control is a comprehensive undertaking and is almost everybody's business. Leadership must set the example in encouraging quality. For a quality-control program to be effective, guidelines must allow employees to both understand and act in ways to promote quality.

QUALITY CONTROL

What is quality control? Webster's Dictionary defines it as a "system for ensuring quality output involving inspection, analysis, and action to make required changes."

A classic example of an industry forgetting this definition is that of the domestic automobile manufacturers. For many years, U.S. automakers ignored quality control, and they have been suffering the consequences ever since—even though most experts agree their quality is now at least as good as, if not better than, foreign automobiles. The perception of an inferior product still lingers in the mind of the consumer. This is a good example of how important a good quality-control program is to economic survival.

The first step to any quality-control program is to find out the specific requirements of your customers. Examples, procedures, and equipment described in this re-

Lain, A. S., 1993, Quality control in industrial-mineral operations, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 37–40.

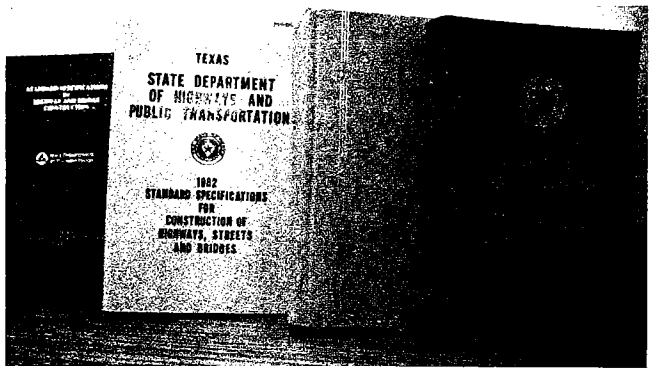

Figure 1. Examples of state publications that provide specifications for construction materials.

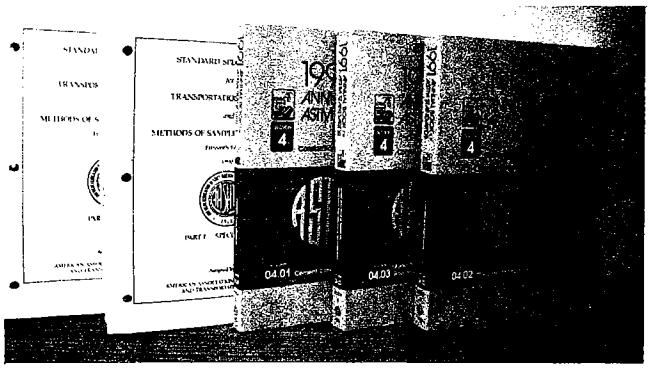

Figure 2. Examples of manuals prepared by ASTM and AASHTO.

Figure 3. Standard sample splitter used to randomly reduce a large quantity of sample to a smaller sample.

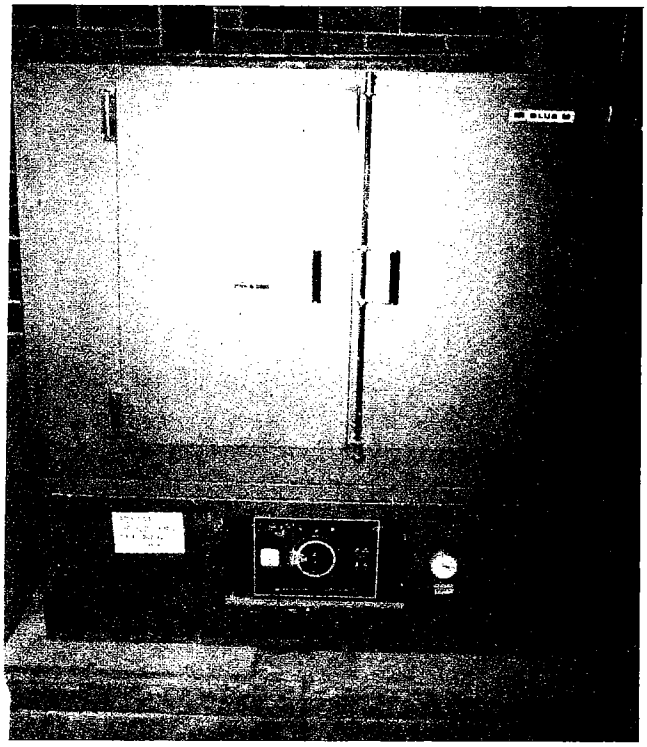

Figure 4. Oven in which samples are dried before further testing can be performed. If the sample is not dried properly, test results can be affected.

port will relate mainly to the aggregates industry, inasmuch as aggregates is the major interest of the company for which I work. Oklahoma and its surrounding states are our largest customers. Each of these states have publications which detail specifications for the different products they use (Fig. 1). These various state publications also specify how samples are to be obtained by referencing manuals of the American Association of State Highway and Transportation Officials (AASHTO) and the American Society For Testing and Materials (ASTM) (Fig. 2). These manuals set procedures for sampling and testing.

U.S. Silica Co. provides a good example of a glass manufacturer's concern for quality control over the size range of the silica sand they produce. This manufacturer has strict guidelines with respect to +50 mesh particle size and –140 mesh particle size, due to the fact that, at glass manufacturing temperatures, the +50 mesh does not melt and the –140 mesh forms glass on the furnace walls, creating unmeltable particles. They also are concerned with the chemical content of the sand and how it affects molten viscosities, and thus their production rates, glass clarity, and creation of unwanted stones within the glass.

Quality control is only as good as the data on which it is based. Sampling is a method for obtaining objective information for a large quantity of product. Sampling

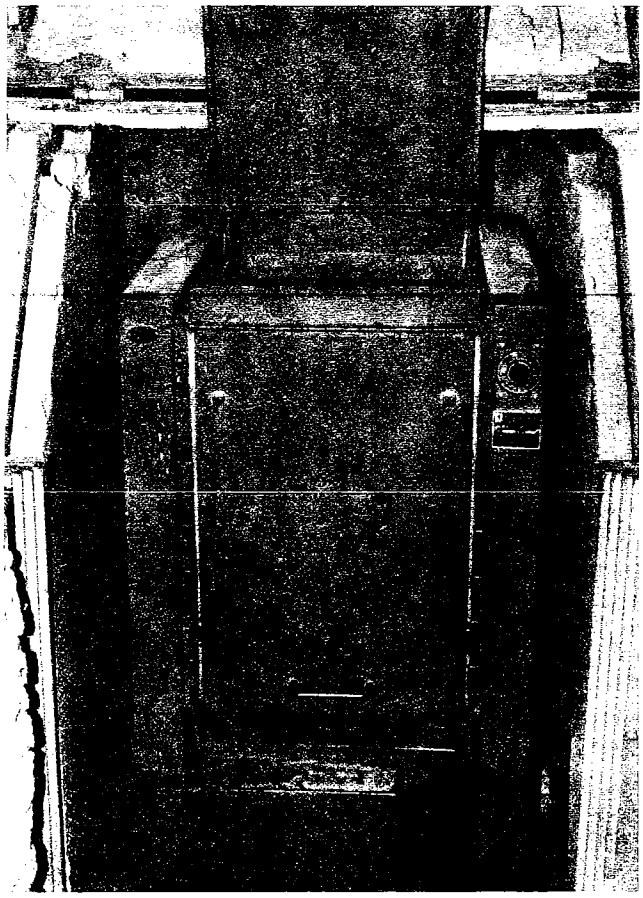

Figure 5. View of a Gilson shaker, which is probably the most common test shaker for running sample gradations. Such tests are very common and are performed on a daily basis to monitor product quality.

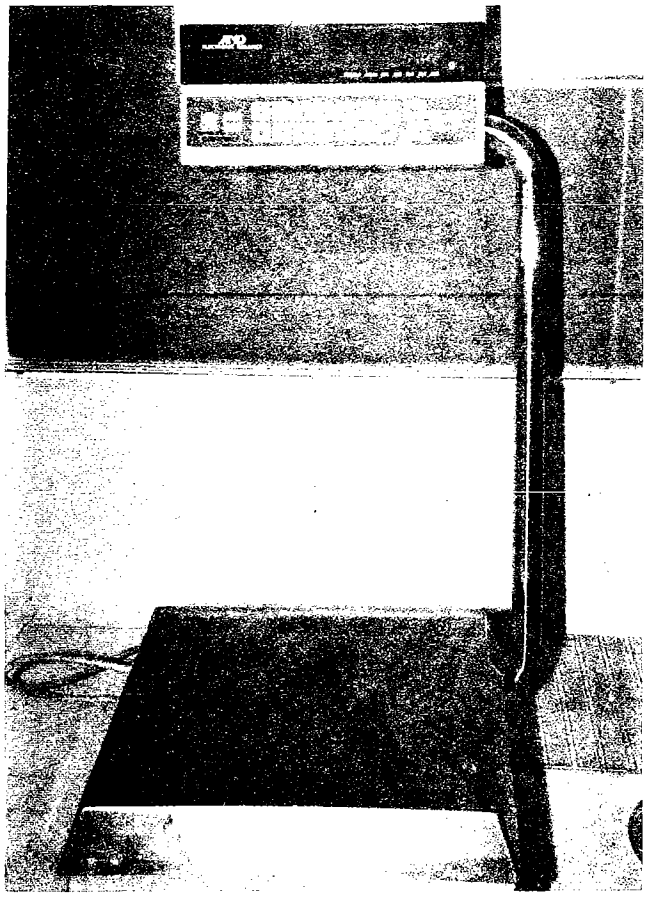

Figure 6. A good set of scales is critical to maintaining accuracy in weighing samples.

must be performed in such a manner as to ensure that it is representative of the product being produced. Sampling a full cross section of the product at random intervals is the best procedure for ensuring a representative sample. Most problems arise from improper sampling techniques. If a large quantity of sample is obtained, a sample splitter (Fig. 3) can be used to randomly reduce the quantity to a smaller sample.

Once a sample is obtained, testing is the next step. Care must be taken while performing the test so the sample does not become contaminated. Involved in routine testing procedures are drying (Fig. 4), sample grading (Fig. 5), and weighing (Fig. 6).

Most other tests (other than gradations) in the aggregates industry are performed at longer intervals. Examples of these other tests, mainly durability tests, are abrasion tests (Fig. 7), and freeze-thaw tests (Figs. 8,9). These durability tests must be passed before the Oklahoma Highway Department will approve concrete aggregate for use from any quarry wanting to supply the aggregate.

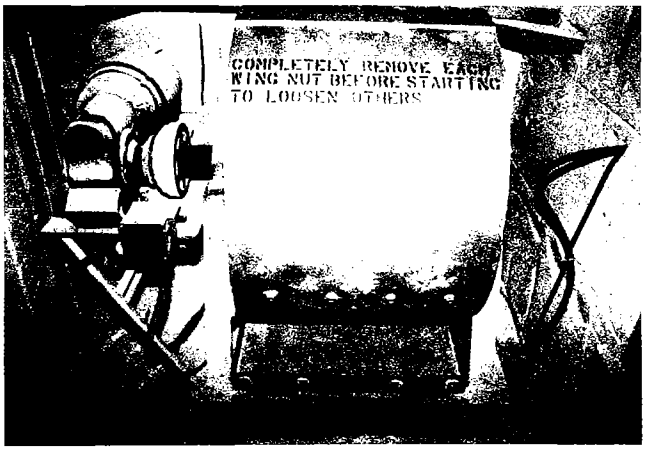

Figure 7. Los Angeles (L.A.) abrasion-testing machine. A specific amount of aggregate, of a certain particle size, is placed inside the drum with a given number of sized steel balls. The drum is then rotated a specific number of rotations over a given span of time and the sample is then retested to determine the degradation (size reduction) of the aggregate.

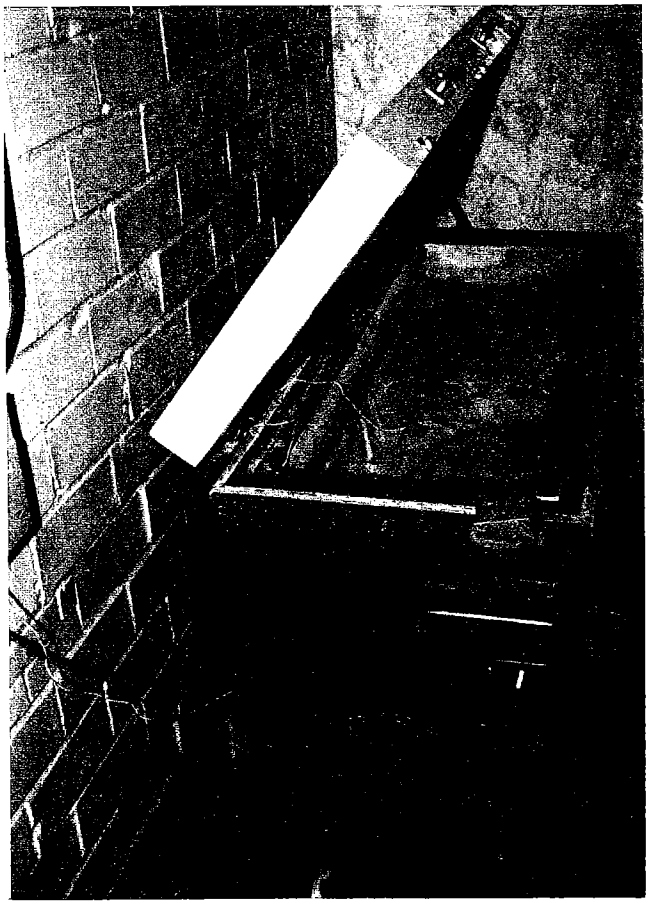

Figure 8. Freeze-thaw cabinet in which small concrete test beams are placed and are alternately frozen and thawed for 350 cycles.

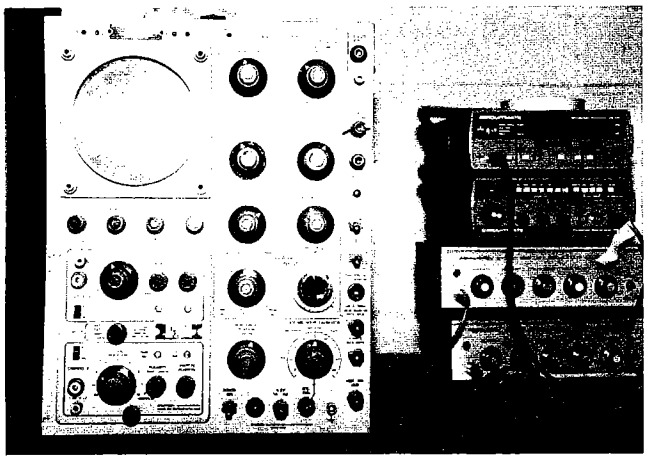

Figure 9. Instruments for freeze-thaw testing. The concrete test beams are periodically measured with these instruments to graphically show their deterioration.

CONCLUSIONS

This report was intended to provide a brief overview of some of the tests and equipment required for the aggregate industry.

In conclusion, let me cite a famous saying among industrial-minerals producers: "Quality control is everybody's business. But, alas, if it's everybody's business, it's nobody's business." What is meant by this quotation? Basically, if everybody is in charge of quality control, then when something goes wrong, nobody is going to take responsibility for the particular problem. Somebody needs to be in charge of quality control. Leadership must set the example in encouraging quality. Quality control is a comprehensive undertaking, and is almost everybody's business. For a quality-control program to be effective, guidelines must allow employees to both understand and act in ways to promote top quality.

Place yourself in your customer's position. How would you respond to inconsistent quality? Think of products you've used that have worked well and those that have not. Which would you rather use?

SELECTED REFERENCES

National Stone Association, 1991, The aggregate handbook, Chapter 16.

Lough, M., 1992, Quality concerns with silica sand products: U.S. Silica Co. report.

Transportation of Industrial Minerals

Mike Hagen
President
Midwest Motor Carriers Bureau, Inc.
Oklahoma City, Oklahoma

The transportation of industrial minerals in Oklahoma is big business; but is it really as big as it could be? I may raise more questions to consider than answers, but I will give you some exciting things to think about, and transportation will play a big part in all of them.

The Transportation Division of the Oklahoma Corporation Commission was created in 1941, in Title 47 of the Oklahoma statutes, in order to insure the public an efficient transportation system. Keeping in mind that the public lives in places such as Slapout, Oklahoma, the Commission's job has not been made any easier with the rural population being city-bound for a number of years.

Efficiency is everyone's goal; however, the feasibility of a plan is determined by the final costs, or the "bottom line." Sporadic needs and fluctuating shipping volumes create havoc in the transportation industry, and havoc in the transportation industry creates problems for the industrial-mineral industry.

It's obvious that our roads in rural Oklahoma could stand substantial improvement; the question is, how much of an increase in the tax base would be required to replace wooden and steel bridges and to widen the roads with an adequate black top or gravel base?

Oklahoma is an ideal place to do business; it has reasonable labor rates, a plentiful and available work force, lots of sunshine, reasonable taxes, favorable winds to alleviate environmental air problems, and the list goes on.

So, if Oklahoma is the place to do business in the United States, why haven't the movers and shakers of the world been beating down our doors to get in? It's a fair question, since we've even offered incentives to several businesses and subsequently have seen them choose other locations. The problem Oklahoma is having in attracting businesses is much simpler to understand than most people realize—base-cost information being used for cost comparisons is flawed. The labor rates, real estate values, warehousing costs, building costs, etc., are boom-cost figures, pre-bust costs collected by the Bureau of Labor Statistics. Therefore, all the old rates and costs presented to potential businesses are significantly higher than today's rates and costs.

Where am I going with these questions, and what do these questions have to do with industrial minerals? They have everything to do with shipping minerals. Transportation companies and mineral businesses occasionally have seemed to be at odds: at times the carriers seem to be protected by the Corporation Commission, from the mineral company's point of view, and at times the mineral companies have driven rates below actual shipping costs by playing one carrier against the other.

Provided that Oklahoma gathers the correct information about the cost of doing business within its borders, and disperses this corrected information to the businesses performing site-location comparison studies, we can expect as much growth in the 1990s as Texas had in the 1980s. What would that kind of growth do for your business, whether your business is industrial minerals or transportation? It would produce new buildings, new parking lots, new residential areas, new highways, improved roads, replaced bridges, etc.

If we work together, the transportation companies and businesses, we are at the beginning of a new era for Oklahoma. If we continue on a "free for all," our tough times will continue. I've talked to the Lieutenant Governor's office, the Corporation Commission, the State Department of Commerce, the Oklahoma City Chamber of Commerce, and all of these agencies express interest in a cooperative effort.

Oklahoma has the location, resources, and proper attitude (a desire to attract new business, to aid our economy). We need to collect data on the actual costs of doing business in Oklahoma, and then distribute the information to the people who will use it. Growth will help the mineral industry increase its sales volume and stimulate the economy; growth will help the transportation industry first by utilizing equipment to capacity, and then by adding more equipment and personnel.

Midwest Motor Carriers Bureau, Inc. publishes tariffs as an agent for motor carriers; as President of Midwest, I

Hagen, Mike, 1993, Transportation of industrial minerals, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 41–42.

pledge to you a cooperative attitude and concerted effort to help any of you, should you call. Some tariff bureaus have not had the same attitude, but I believe those bureaus erred in their judgment that they were in a "win/lose" situation. My attitude is a team effort, and the best deal is a "win/win" situation. Ultimately, helping the mineral industries also helps the carriers for which Midwest is agent.

Most of us have a fear of the unknown, and the Oklahoma Corporation Commission has been an unknown government entity to many. Midwest Motor Carriers Bureau, Inc. also has been unknown to many of you. The Commission and the Bureau are here to help, and as a team we can produce a "win/win" partnership.

Marketing Industrial Minerals

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Former Director
Center for Economic and Management Research
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ABSTRACT.—Eight of the more than 25 nonmetallic minerals found in Oklahoma have deposits of a size and quality sufficient for development of new and/or broader markets. These minerals are asphalt, dolomite, glass sand (or silica sand), iodine, limestone, tripoli, salt, and volcanic ash. These minerals are briefly described in the paragraphs which follow.

Asphalt: The asphalt referred to here is rock asphalt which, until 1960, was used in road and street maintenance. Despite its earlier use, sufficient deposits remain to supplement asphalt now being produced by crude-oil refineries. This mineral is found where crude oil migrates upward toward the land surface and the lighter hydrocarbons evaporate, leaving a residue which permeates the rock and fills voids as a tar-like substance.

Dolomite and *Limestone:* Present production of these minerals in Oklahoma is almost completely consumed by the construction industry. However, both minerals are important sources of lime which is a basic industrial chemical. Large high-purity dolomite deposits exist in the Arbuckle Mountains, and smaller deposits of lower purity are in the Wichita Mountains, as well as in Delaware County, Osage County, and in Permian outcrops of western Oklahoma. Limestone deposits which exist in the Arbuckle and Wichita Mountains are of excellent quality and represent an almost unlimited reserve of stone. Deposits in the southeast, northeast, and north-central parts of the State are presently being quarried, mainly for local markets.

Glass Sand: Current production of glass sand is being utilized primarily by manufacturers of glass and ceramic products in Oklahoma and other states. Large deposits of high-purity silica sand are presently being quarried in Johnson and Pontotoc Counties. Other deposits have been reported in areas south and east of the Arbuckle Mountains. A total of about 1.23 million tons of this mineral, with a value of $22 million, was produced in 1992.

Iodine: Oklahoma is, at the present time, the sole producer of iodine in the United States. Current markets for iodine produced in the State are small and are essentially agriculture related. Large deposits of iodine-rich brines are located in Woodward, Garfield, and Dewey Counties. Annual production from the three current producers has totaled about 2 million kilograms, with a value of approximately $27 million.

Salt: Oklahoma's salt reserves are almost limitless, but, as yet, the production of salt in the State is minimal. To date most, if not all, of the salt produced in the State is used in water softeners and cattle feed. Thick deposits of rock salt underlie most of western Oklahoma. In addition, a number of natural salt plains and springs are present along major rivers of the western part of the State. At present, one producer is operating in Woods County.

Volcanic Ash and *Tripoli:* These minerals differ in geologic classification, but they tend to have similar characteristics and markets. Volcanic ash deposits of various size are present in western and east-central Oklahoma. Two companies have mined this mineral in Beaver and Okfuskee Counties in the past, with annual production in the past five years varying from 543 to 3,775 tons. Tripoli is a form of high-purity silica. Important deposits of this mineral are present in northeastern Oklahoma.

Marketing Problems: Expansion of the markets for these minerals cannot occur until processors and users locate facilities either in Oklahoma or neighboring states. This situation is due to the long distances which these raw minerals must be shipped to be processed and refined. The resultant transportation costs of such shipments render the minerals noncompetitive (in terms of price) with the same minerals located nearer to the current processors.

Dikeman, N. J., Jr., 1993, Marketing industrial minerals, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 43–48.

INTRODUCTION

Significant deposits of more than 25 nonmetallic (industrial) minerals have been identified as being found in Oklahoma. These minerals are being mined in most of the State's 77 counties (Fig. 1). Each of these minerals is, or can be, utilized as a raw material by a variety of industries. Production of these minerals in 1992, including cement produced in Oklahoma and using Oklahoma minerals, contributed an estimated $284 million to the State's economy (Table 1). Eight of these minerals have deposits of a size and quality necessary for the development of new and broader markets. These eight minerals are: asphalt, dolomite, glass sand, iodine, limestone, tripoli, salt, and volcanic ash, and they are discussed in the following sections of this paper.

PURPOSE

The purpose of this paper is three-fold. First, it describes those nonmetallic minerals with deposits of sufficient quantity and quality in Oklahoma to have the potential for expanding present markets and entering new markets. Second, it describes the markets which can be expanded and those that can be entered for the first time. Finally, it points out the problems faced in marketing these minerals, both in expansion of present markets and in the penetration of new markets for these minerals. The last purpose (i.e., problems faced in marketing the minerals) presents the biggest barrier to creating an increase in demand for these minerals. In the most simplistic terms, marketing, either in terms of expanding present markets or in entry into new markets, requires that the producer of the minerals make them readily available to the user or purchaser of raw materials at a competitive price and quality, and in sufficient quantity to support long-term demand. The location of these minerals in Oklahoma, the lack of a broad manufacturing base in the State, and the economic conditions that have plagued the State and nation in recent years, are the bases for many of the problems inherent in successfully marketing these minerals.

THE MINERALS

Asphalt

The asphalt referred to here is rock asphalt which, until 1960, was used in road and street maintenance. Despite its earlier use, sufficient deposits remain to supplement asphalt now being produced by crude-oil refineries in the event that crude-oil refining in the United States would decline to extremely low levels in the future.

The major sources of rock asphalt and asphaltite are in and around the Arbuckle and Ouachita Mountains in southern Oklahoma and, to a lesser extent, in areas surrounding the Wichita Mountains in southwestern Oklahoma (Johnson, 1993). Currently, reserves of these minerals are sufficient to support long-term demand both for paving and for use as surfacing of roofing and other asphalt-impregnated products (Johnson, 1993).

Dolomite and Limestone

Production of these minerals in Oklahoma is almost completely consumed by the construction industry. However, both minerals are important sources of lime, a basic industrial chemical. Potential new uses for lime produced from dolomite and limestone mined in Oklahoma include: neutralization of industrial and agricultural wastes; high-temperature and dehydration processes; the sulfate process of papermaking; water softeners and purification; and the manufacture of petrochemicals and insecticides. In the metals industry, it is used to remove silica from bauxite for the production of alumina. Lesser markets are the production of syrup, refined sugar, soap, glue, greases, and gelatins, and uses by the leather industry involving the removal of hair from hides and for plumping animal skins (Cotter, 1965). Dolomite and limestone are mainly exposed in the Arbuckle and Wichita Mountains, with other outcrops scattered throughout most other parts of Oklahoma (Johnson, 1993).

Glass Sand

Most of the present production of glass sand is being utilized by manufacturers of glass and ceramic products in Oklahoma and other states (Johnson, 1993). Because of its silica content and its abrasive qualities, it has potential new markets among producers of sodium silicate, polishes, and soil conditioners. Specific products in these markets include mineral wool, optical fiber, optics, silicon products, polishes, and abrasives used in soap and toothpaste (Morning, 1965). There is some indication that at least one Oklahoma firm has begun to expand into these new markets.

Iodine

Oklahoma is, at the present time, the sole source of supply of iodine in the United States. Currently, iodine is being produced by three companies in northwestern Oklahoma. The output of these plants provides ~12% of the world's supply and ~50% of the needs of the United States (White and Arndt, 1990; Johnson, 1993). Current markets for iodine produced in the State are small and, except for exports to Germany, are essentially agriculture and pharmaceuticals related. The exported iodine is for radiopaque-media production. Because of its medicinal qualities, however, it has the potential for future market expansion in the pharmaceutical, medical, metals, and photographic-supply industries (Miller, 1965).

Salt

Oklahoma's salt reserves are estimated to total 20 trillion tons but, despite these large reserves, the production of salt in the State is minimal. To date, most, if not all, of

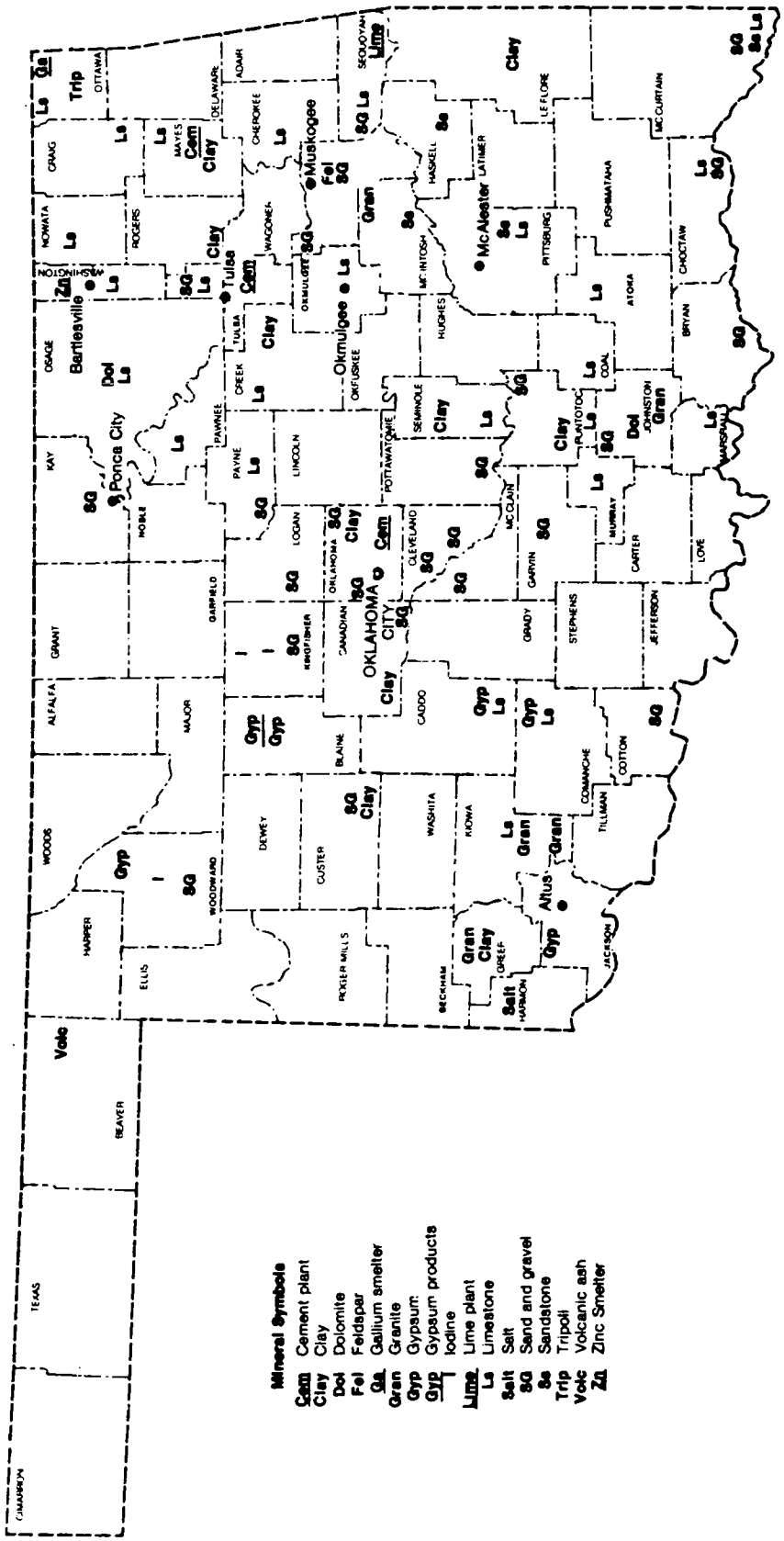

Figure 1. Principal mineral-producing localities in Oklahoma (from Ohl and Arndt, 1988).

TABLE 1.—NONFUEL MINERAL PRODUCTION IN OKLAHOMA[a]

Mineral		1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)	1992[b] Quantity	1992[b] Value (thousands)
Cement (portland)	[thousand short tons]	1,544	$60,457	1,620[b]	$63,180[b]	1,627	$63,180
Clays	[metric tons]	631,302	3,156	824,176[b]	4,178[b]	786,230	5,135
Gem stones		NA	W	NA	W	NA	711
Gypsum (crude)	[thousand short tons]	2,184	11,154	2,356	12,925	2,485	13,642
Iodine (crude)	[kilograms]	1,972,849	30,486	1,998,914	31,389	2,041,500	26,619
Sand and gravel:							
Construction	[thousand short tons]	9,235	21,993	9,000[b]	22,300[b]	10,200	25,800
Industrial	[thousand short tons]	1,258	22,984	1,241	20,918	1,225	21,637
Stone:							
Crushed[c]	[thousand short tons]	25,300[b]	89,500[b]	25,678	95,509	26,100	100,000
Dimension	[short tons]	8,138[b]	684[b]	3,836[c]	596[c]	5,182	706
Tripoli	[metric tons]	18,801	155	15,885	141	NA	NA
Combined value of cement (masonry), feldspar, lime, salt, stone (crushed dolomite [1990-91], crushed unidentified [1992], dimension sandstone [1991]), and values indicated by symbol W		XX	19,608	XX	24,389	XX	26,833
	TOTAL		$260,177		$275,525		$284,263

Source: U.S. Bureau of Mines.

[a]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[b]Estimated.

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

NA - Not available.

W - Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure.

XX - Not applicable.

the salt produced in the State is used in water softeners and cattle feed (Johnson, 1993). Potential markets for the reserves of this useful and important mineral exist in a variety of industries, the most important of which are chemical and food manufacturers and producers of pharmaceuticals. Some of the more important industrial uses of salt are chlorine gas and bleaches, liquid sodium hydroxide, sodium sulfate, detergents, ice control, table salt, metallic sodium, and leather conditioning (Kerns, 1965).

Volcanic Ash and Tripoli

Although these minerals differ in geologic classification, they tend to have similar characteristics and markets. Volcanic-ash deposits exist in Oklahoma as a result of high winds which blew these particles eastward from volcanic eruptions in western areas of the country. Tripoli, on the other hand, is a microcrystalline form of silica. Deposits of both ash and tripoli are abundant and are of high quality (Johnson, 1993). Current production of both of these minerals is used primarily to make abrasives. However, since both are porous, permeable, and absorptive, the market potential for these minerals can be expanded to include: the production of filters, and as polishing elements in toothpaste and hand soap; also as carriers for insecticides, fillers for lightweight brick and concrete block, absorbents, paint extenders, and in the production of paper and rubber goods (May, 1965).

THE MARKETING PROBLEM

The major problem encountered in both the creation of new, and the expansion of the existing, markets for Oklahoma's industrial minerals is their location, with respect to the processors of these minerals and the end-use manufacturers that use the refined-mineral products. Therefore, because the sales value of these minerals to users is largely added by the refining processes, and the processors are generally located significant distances from Oklahoma deposits, transportation costs of the raw materials from Oklahoma to the processors renders the price of the processed products so high as to be noncompetitive with identical (or at least similar) processed minerals produced closer to the existing processors. In short, the current cost of using processed Oklahoma minerals is above the market, and thus Oklahoma minerals in their raw state are not readily marketable.

The solution to this problem is not easily found. This is due, initially, to the State's lack of a large industrial base that would support the additional firms required to create markets for these minerals. For instance, users of the processed minerals will not set up facilities in Oklahoma until the processors of the minerals are located in Oklahoma, or possibly in a nearby state. The same is true, possibly to a lesser extent, with the processors who prefer to have the users nearby. In either case, the reasons for the location requirements are essentially cost/price and time of delivery. The latter requirement (i.e., time of delivery) regulates inventory requirements of the users, thereby affecting their cost outlays to support a large inventory; the closer the processor is to the industrial user, the smaller the user's inventory requirements.

A second problem then evolves from the basic problem: why have processors and users not located facilities in Oklahoma, to any appreciable degree? Some answers to this question were obtained and publicized in 1982, in the results of a study involving high-technology firms and their reasons for locating where they did (England and Dikeman, 1982). Described below are the attitudes and views of three types of industrialists and industrial-development specialists towards location in Oklahoma: economic-development specialists, industrial firms located in Oklahoma, and out-of-state industrial firms.

Economic-Development Specialists

Nearly two-thirds of the economic-development specialists contacted during the course of the study cited above indicated that the shortage of venture capital needed to either relocate or start a new facility was a major impediment to the establishment of industry in Oklahoma.

Half of these specialists cited the shortage of professional and scientifically trained personnel as being a hindrance to the attraction of new industry to the State.

Half of the specialists indicated that the lack of availability of working capital precluded any major attraction of new industry to the State.

More than one-third of these specialists were of the opinion that current State and local development policies did not satisfy the requirements of firms considering new plant locations.

Industrial Firms Located in Oklahoma

Nearly one-third of these firms viewed State and local economic-development policies as being major impediments to the ability of a firm to grow.

More than one-fourth of these firms indicated that the present level of State and local taxes tended to restrict their growth.

One-fourth of these firms stated that both the economic base and the stability of the State were so erratic as to provide an impediment to their growth. A number of these firms alluded to the fact that Oklahoma's dependence on, and interest in, the oil and gas industry were somewhat responsible for the erratic nature of the State's economy and the narrowness of its economic base.

Out-of-State Industrial Firms

It is noteworthy that all of the managers of out-of-state firms contacted viewed the lack of stability of the State's economy and the lack of a broad manufacturing base in the State as reasons for not locating in Oklahoma.

Another large segment of this group of industrialists cited the apparent high cost of doing business in the State as being an impediment to new plants locating in Oklahoma. Also mentioned along this line were high labor costs (with emphasis on workers compensation) and high taxes.

Solutions to the Problem

Given the above reasons, it becomes apparent that several steps can be taken to improve Oklahoma's ability to attract new industry. First, the State Legislature and Executive Office must examine the State's economic-development policies, practices, and activities to determine what actions or elements of these policies are repulsive to, or at least not conducive to, favorable plant-location decisions. Next, the labor policies, especially those pertaining to workers compensation costs, should be examined and, if necessary, brought into line with those of other states who have successfully attracted new industry. Finally, industrial development activities of both the State and local entities must place greater effort into analyzing the costs of doing business in Oklahoma and comparing them with those of other states: by doing this, it is likely that those involved in economic development will discover that the general perception among plant managers, that the cost of doing business in Oklahoma is high, is not always necessarily true. This, then, will provide an important sales tool for the State's economic-develop-

ment specialists and will assist them in developing new approaches to the attraction of mineral-processing facilities to Oklahoma.

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Markets for Oklahoma Industrial Minerals

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ABSTRACT.—Oklahoma contains many natural and mined resources. Commodities such as coal, crude oil, and gypsum have generally found industrial and consumer markets without much outside assistance. Unfortunately, not all of Oklahoma's mineral resources find their way to markets so easily. This presentation will focus on the opportunities for several other significant (or potentially significant) Oklahoma minerals. These include the following: asphalt, dolomite and limestone, glass sand, iodine, salt, and volcanic ash and tripoli.

This report is designed to give Oklahoma businesses a feel for selected minerals. This will be done by outlining three types of information: first, the report shows the international demand for these minerals; second, there is a presentation of potential domestic markets and their anticipated growth; and finally, there is discussion on the sources of information on names of firms involved in each mineral commodity. Throughout the report, there will be examples for particular minerals, as well as mention of other sources of information.

Based on this report, readers can expect to gain some appreciation of: the size of foreign markets' demand for U.S. minerals; the location of potential industrial customers by state; and the entities capable of providing the names of specific firms that may serve as a customer base.

INDUSTRIES LIKELY TO UTILIZE OKLAHOMA MINERALS

Table 1 provides a brief summary of the uses of the minerals covered in this report. The range of usages is extremely broad. There are few manufacturing industries (outside of some heavy-metal processing) which could not utilize at least one of these items.

U.S. EXPORTS OF MINERALS PRESENT IN OKLAHOMA

According to the U.S. Department of Commerce, the six mineral categories discussed in this presentation account for U.S. exports of more than $320 million in 1991. This total breaks down as follows:

1) Asphalt and asphalt products amounted to about $43 million; half of this is to Canada and the rest is distributed around the world. Included among these products are: articles of asphalt or similar materials in rolls; roofing and siding of asphalt or similar materials; and articles of asphalt or similar materials, not elsewhere specified or included.

2) Exports of dolomite totaled $3.5 million, whereas lime and limestone exports totaled $19.2 million, with Canada accounting for the lion's share (>75%). This total includes: dolomite not calcined, calcined dolomite, agglomerated dolomite (including tarred), quicklime, slaked lime, and hydraulic lime.

3) Exports of glass sands exceeded $81 million, with more than half being shipped to Japan.

4) Iodine and iodides exports from the U.S. exceeded $18 million. Three countries (Germany, Mexico, and Japan) represent >80% of this export market.

5) Surprisingly, U.S. salt exports amounted to $30.0 million. More than $7 million of this went to countries beyond North America.

6) Ashes and residues comprised $128.5 million of U.S. exports (these ashes are not volcanic ash, but are chiefly fly ash, bottom ash, and other industrial-waste ashes). Leading recipients of these commodities include Japan, Canada, Belgium, Germany, and Mexico. Among these products are ashes and residues containing primarily zinc, lead, copper, and aluminum.

SOURCES OF INDUSTRY INFORMATION

There are many sources of industry information relating to minerals and their markets. Four sources discussed below are valuable for their accessibility. The first two—

Gorin, D. R., 1993, Markets for Oklahoma industrial minerals, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 49–54.

TABLE 1.—SELECTED MINERAL RESOURCES AND THEIR MAJOR USES

Asphalt: Used primarily in road and street construction. Mostly a function of government contracts and major national firms in the road-construction industry.

Dolomite and Limestone: Sold as lime, and found in products for soil treatment, water softening, fluxing agents for iron and steel industry, petrochemicals, and insecticides.

Glass Sand: Valuable in glass making, foundry sands, ceramics, and the manufacture of sodium silicate, abrasives, and inert fillers.

Iodine: Used for catalysts, stabilizers, animal feeds, table salt, pharmaceuticals, medical supplies, photographic solutions, and colorants.

Salt: Required by the chemical industry, agriculture, and the food industry.

Volcanic Ash and Tripoli: Used for abrasives, industrial filtration, insulation, absorbents, fillers, and soil conditioners.

the *U.S. Industrial Outlook* and the *Encyclopedia of Associations*—provide networks and sources for further research efforts.

Data from the *U.S. Industrial Outlook*

Industry information comes from many sources. Industrial overviews can be found among federal government sources (such as the Bureau of the Census and the International Trade Administration) as well as from private sources (such as DRI, a subsidiary of McGraw-Hill). Information obtained from these sources will be based on industry aggregates. For example, consider Table 2, which details U.S. industrial growth rates reported in December 1991 (the table includes estimates for 1992). The forecast predicted a slight upturn in new construction and a slowdown in the decline of construction-materials production for 1992. Chemical-industry output was forecast to be among the slowest growing manufacturing industries for 1992.

Several manufacturing industries with ties to mineral production are tracked by the International Trade Association (ITA). A summary of their growth potential is found in Table 3.

The ITA also employs a substantial number of trade specialists to track the industries it reports on; some of these are listed in Table 4. These individuals serve as valuable resources by providing information and analysis of trends for their particular fields. These specialists are frequent speakers at major industrial trade shows, and often have established substantial networks throughout their areas of specialization. Perhaps the single best thing I can do for an existing businessman in Oklahoma is refer them to one of these individuals.

Data from the *Encyclopedia of Associations*

Industry associations are great places to ask about the latest happenings in a given field. Furthermore, there is an association (or even more than one) for just about everything. Consider the number of non-worker groups found under listings for Ash (4), Asphalt (16), and Lime and Limestone (9) (Table 5). There are also more than 75 listings to be found under Glass. The *Encyclopedia of Associations* provides the address, phone number, and contact person for each association. Also provided are a history of the organization, the number of members, listings of publications, and convention information.

Data from the Bureau of Economic Analysis and Bureau of Labor Statistics Forecasts

Every five years, the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce does a detailed, long-term forecast of the national economy. This forecast covers a 40- to 50-year period (with decennial data) and provides projections for employment and personal earnings at a 2-digit level of detail. Table 6 is a partial summary of the earnings forecast through the year 2010. The earnings growth rate of the nonmetallic-mineral-mining industry is expected to exceed that for all of mining. Earnings growth rates for many mineral-related manufacturing industries is expected to be similar to that for all of manufacturing.

Employment and output forecasts (Table 7) from the Bureau of Labor Statistics (BLS) mirror those of the BEA for earnings. Output growth for the drug and plastics industries are expected to exceed the average for all manufacturing. Glass production doesn't appear to be a source for major inroads, although it is certainly possible that specialty glasses will see markedly higher growth.

Data from the *Census of Manufactures*

The *Census of Manufactures* contains much historical industry information. The following data (Table 8) can be found in a single report on glass products. This report is one of a series detailing U.S. industrial production at the 4-digit industrial level. Output, employment, and payroll data are available by state. Also, some data are available

TABLE 2.—GROWTH RATES FOR SELECTED INDUSTRY GROUPS, 1989–92
(in constant dollars)

Industry	1989 (%)	1990 (%)	1991 (%)	1992[a] (%)	Production in 1992 as compared to 1989 (%)
New construction	–1.3	–1.7	–5.6	0.2	93.0
Construction materials	0.0	–2.1	–4.5	–1.2	92.4
Food and beverage	–1.6	2.0	0.8	1.5	104.5
Wood products	–2.7	–3.4	–4.3	2.3	94.5
Paper and allied products	1.1	1.6	0.7	2.2	104.6
Printing and publishing	–1.1	–0.9	–1.0	2.5	100.6
Chemicals and allied products	1.3	2.8	0.6	1.4	104.9
Plastic and rubber products	1.7	–2.0	–2.4	3.0	99.1
Steel mill products	–2.6	1.4	–10.0	3.9	94.8
Metalworking equipment	5.7	–8.3	–9.2	5.0	88.2
Computers and peripherals	–4.8	0.0	–2.1	4.3	102.1
Industrial machinery	4.7	1.0	–1.8	2.2	101.3
Radio commun. and detections equip.	–5.3	1.2	0.3	5.0	107.6
Electronic components	4.5	–2.3	3.0	4.7	105.3
Motor vehicles and parts	–1.1	–5.4	–8.3	7.5	93.3
Electrical equipment	0.1	–0.8	–1.2	0.8	98.8
Aerospace	1.3	4.8	–4.2	–3.4	97.0
Scientific and medical equipment	3.6	4.7	2.9	3.8	111.8
Household consumer durables	2.9	–2.5	–2.6	4.9	99.6

[a]1992 rates are estimates.
Source: 1992 *U.S. Industrial Outlook*, U.S. Dept. of Commerce, International Trade Administration.

TABLE 3.—FORECAST GROWTH RATES FOR 15 SELECTED MANUFACTURING INDUSTRIES: RANKS BASED ON 168 INDUSTRIES IN FORECAST

Industry	1992 Shipments ($ millions)	Growth rate 1991–92 (%)	Growth rate 1991–92 (Rank)	Growth rate 1987–92 (%)	Growth rate 1987–92 (Rank)
Medicinals and botanicals	4,925	3.0	55	8.0	3
Agricultural chemicals, nec	7,800	1.3	109	4.4	17
Pharmaceuticals preparations	38,956	3.1	48	4.0	20
Industrial inorganic chemicals, except pigments	20,555	3.1	47	3.4	26
Adhesives and sealants	5,349	5.0	22	2.7	39
Synthetic rubber	3,490	–1.0	144	1.2	68
Nitrogenous fertilizers	2,597	1.1	111	1.2	69
Plastics materials and resins	27,561	1.7	98	1.0	72
Phosphatic fertilizers	3,926	0.0	136	0.6	86
Surface-action agents	2,913	5.1	17	–0.6	112
Ceramic wall and floor tile	678	2.1	84	–1.1	121
Paints and allied products	11,999	2.0	92	–1.1	123
Concrete block and brick	2,091	0.3	130	–1.4	129
Gypsum products	2,412	1.6	101	–2.0	140
Flat glass	2,300	0.0	137	–2.0	142

Source: 1992 *U.S. Industrial Outlook*, U.S. Dept. of Commerce, International Trade Administration.

TABLE 4. — A PARTIAL LISTING OF ITA INDUSTRY SPECIALISTS

Industry	Specialist	Phone number
Alloys/advanced materials	J. Eugene Quinn	202-377-0578
Chemicals, adhesives & sealants	Raimundo Prat	202-377-0128
Chemicals, agricultural	Frank P. Maxey	202-377-0128
Chemicals, inorganic	Anthony Kostalas	202-377-0128
Chemicals, organic	Michael Kelly	202-377-0128
Chemicals, paints	Raimundo Prat	202-377-0128
Construction, wood & concrete	C. B. Pitcher	202-377-0132
Construction, glass	Wm. E. Franklin	202-377-0132
Mining equipment	George Zanetakos	202-377-0552

for the nation at the 5-digit product level. Indeed, this partial listing of product shipments for the glass industry from the 1987 *Census of Manufactures* shows details about leading products, important states, and most recent growth.

SOURCES OF FIRM NAMES

As can be seen from the information presented above, a lot of industry intelligence can be found simply from federal-government sources. The private sector, however, is the source for most firm-specific data. The following are three major sources which are available without cost from many resource centers (including the Oklahoma Department of Commerce): (1) *Standard and Poor's Register* and *Dun and Bradstreet Directory,* (2) *Thomas Register,* and (3) *Oklahoma Directory of Manufacturers and Processors.*

TABLE 5.—A PARTIAL LISTING OF MINERAL ASSOCIATIONS

ASH

Ash Assn.; Amer. Coal
Ash Assn.; Natl.
Ash Corp.; Amer. Natural Soda
Ash Export Assn.; U.S. Soda

ASPHALT

Asphalt Assn.
Asphalt Assn.; Canadian Technical
Asphalt Assn.; European Mastic
Asphalt Assn.; Intl.
Asphalt and Coated Macadam Assn.
Asphalt Emulsion Mfrs. Assn.
Asphalt Inst.
Asphalt Pavement Assn.; European
Asphalt Pavement Assn.; Natl.
Asphalt Paving Technologists; Assn. of
Asphalt Recycling and Reclaiming Assn.
Asphalt Roofing Industry Bur.
Asphalt Roofing Mfrs. Assn.
Asphalt Rubber Producers Group
Asphalt Tile Inst.
Asphalt and Vinyl Asbestos Tile Inst.

LIME & LIMESTONE

Lime Assn.; Natl.
Lime Producers Brazilian Assn.
Limestone Assn.; Natl. Agricultural
Limestone Assn.; Pulverized
Limestone Inst. of America; Indiana
Limestone Inst.; Natl.
Limestone Inst..; Natl. Crushed
Limestone Assn.; Pulverized
Limestone; Natl. Assn. for Indiana

TABLE 6.—INDUSTRY EARNINGS FORECASTS, 1988–2010, FOR SELECTED INDUSTRIES

	In millions of 1982 dollars			Annual rate of change	
Industry	1988	2000	2010	1988–2000	1988–2010
Total	2,388,823	3,008,955	3,423,887	1.9%	1.6%
Mining	24,666	25,541	26,388	0.3%	0.3%
Nonmetallic minerals, except fuels	2,926	3,558	3,975	1.6%	1.4%
Construction	153,065	184,226	205,062	1.6%	1.3%
Manufacturing	484,725	555,529	605,040	1.1%	1.0%
Stone, clay, and glass products	14,485	16,168	17,675	0.9%	0.9%
Chemicals and allied products	35,629	41,497	45,512	1.3%	1.1%

Source: *Regional Projections to 2040,* U.S. Dept. of Commerce, Bureau of Economic Analysis.

TABLE 7.—EMPLOYMENT AND OUTPUT FORECASTS, 1986–2000, FOR SELECTED INDUSTRIES

Industry	Annual rate of change 1986–2000 (%) Employment	Output
Total	1.3	2.4
Mining	–0.6	–0.2
Nonmetallic minerals, except fuels	–0.5	1.4
Construction	1.2	1.4
Manufacturing	–0.3	2.3
Stone, clay, & glass products	–0.6	1.4
Glass & glass products	–0.8	1.2
Concrete, gypsum, & plaster products	–0.1	1.5
Stone, clay, & misc. mineral products	–1.0	1.6
Chemicals & allied products	–0.5	2.6
Industrial chemicals	–0.9	1.9
Plastic materials & synthetics	–1.7	3.0
Drugs	0.6	4.0
Soaps, cleaners, & toilet goods	0.3	2.4
Paints & allied products	–1.2	1.6
Agricultural chemicals	–1.9	1.6

Source: *Projections 2000*, U.S. Dept. of Labor, Bureau of Labor Statistics.

Standard and Poor's Register and Dun and Bradstreet Directory

Standard and Poor's Register (S&P) and *Dun and Bradstreet Directory* (D&B) each provide detailed listings of firms in the U.S. Whereas both are available on electronic media for a fee, many resource centers maintain reference copies of these listings. Using S&P's 1992 register, one will find 81 firms listed as producers under standard industrial classification (SIC) 2952 (Asphalt Felts and Coverings). Consider one of these firms taken at random: Mineral Fiber Manufacturing Corp. S&P identifies this firm's address (301 S. Sixth St., Coshocton, Ohio), phone number, leading officers (including president, vice president, plant manager, and chief engineer), sales range, ($5–$10 million), employment estimate (40), and a listing of products (pipeline wrapping products and roofing materials).

Thomas Register

The information in Table 9 represents summaries of the listings found in the *Thomas Register* for asphalt, iodine, and glass. These summaries exemplify the range of detail found in this source.

TABLE 8.—PRODUCT SHIPMENTS FOR THE GLASS INDUSTRY IN 1982 AND 1987

Product class and area	1987 Value of product shipment ($ millions)	1982 Value of product shipment ($ millions)
32115, Flat glass		
U.S.	1,469.9	869.9
California	170.5	82.4
32293, Glass fiber, textile-type		
U.S.	1,226.0	768.2
California	18.8	13.6
Tennessee	85.6	(NA)
32296, Machine-made lighting and electronic glassware		
U.S.	637.1	(NA)
Ohio	335.3	(NA)
Pennsylvania	153.0	(NA)
32298, Handmade pressed and blown glassware		
U.S.	102.9	(NA)
California	12.8	(NA)
New Jersey	15.5	(NA)
32318, Other glass products, made of purchased glass		
U.S.	2,377.9	1,189.2
Arizona	11.5	9.4
Arkansas	25.1	(NA)
California	162.1	155.3
Colorado	8.7	(NA)
Connecticut	26.2	12.8
Florida	45.3	26.1
Georgia	117.6	24.8
Illinois	79.1	59.7
Indiana	114.6	34.9
Iowa	83.3	18.7
Massachusetts	52.7	(NA)
Michigan	217.5	101.5
Minnesota	131.3	37.3
Missouri	20.7	(NA)
New Jersey	57.8	30.0
New York	98.0	38.4
North Carolina	180.5	52.4
Ohio	248.8	155.2
Oklahoma	30.0	6.4
Oregon	4.9	5.4
Pennsylvania	183.9	148.6
South Carolina	18.6	(NA)
Tennessee	125.7	48.7
Texas	71.6	55.1
Virginia	16.7	30.6
Washington	49.4	24.3
West Virginia	9.4	(NA)
Wisconsin	94.1	17.7

Source: *Census of Manufactures.*

TABLE 9.—LISTINGS IN THE *THOMAS REGISTER*

ASPHALT

Actual asphalt manufacturers listed in the 1992 *Thomas Register* include four from Oklahoma. But what about value-added production? The *Thomas Register* lists seven producers of chemical-resistant asphalt (three with toll-free numbers). Consider some of the following entries (addresses and asset amounts are provided as well):

Lion Oil Co., Protective Coatings Division, in El Dorado, Arizona
Manufacturers and developers of asphalt-based protective coatings. Acid and alkali resistant; resistant to chemical fumes; roofing materials and sealers.

Elsro, Inc., in Evans, Colorado
Maker of heavy-duty industrial floor for areas requiring extreme durability as well as under-foot comfort and safety. [Also listed under: flooring, asphalt; flooring, industrial; and flooring, wood block.]

Gibson-Homans Co., in Twinsburg, Ohio
Producer of roof and foundation coatings and cements; wall covering, flooring and construction adhesives; caulks and sealants; waterproof sealers; driveway maintenance products.

There are also 29 producers of emulsified asphalt listed.

IODINE

The 1992 *Thomas Register* has 11 entries under iodides, 17 under iodine, one under iodine pentaflouride, and eight under iodine (salts of). Many of these companies are listed more than once. Following is the listing of firm names, locations, and relative size (as measured by estimates of tangible assets) for iodides manufacturers.

Company name	State	City	Assets ($ million)
Deepwater, Inc.	CA	Irvine	1+
Great Western Inorganics	CO	Golden	1+
Mackay, A.D., Inc.	CT	Darien	1–
APL Engineered Materials, Inc.	IL	Urbana	1+
Admiral Chemical Co.	MA	Peabody	(not rated)
Mutchler Chemical Co.	NJ	Westwood	1–
Atomergic Chemetals Corp.	NY	Farmingdale	5+
Leico Industries, Inc.	NY	New York	1+
Barium and Chemical, Inc.	OH	Steubenville	5+
GTE Chemicals and Metallurgical Div.	PA	Towanda	50+
King's Laboratory, Inc.	SC	Blythewood	1+

GLASS

The 1992 *Thomas Register* lists a startling number of companies engaged in glass production. Indeed there are more than 370 different categories of products listed on over 150 pages under the headings of glass, glasses, and glassware.

Oklahoma Directory of Manufacturers and Processors

The *Oklahoma Directory of Manufacturers and Processors* lists more than 3,800 manufacturing establishments throughout the State. These establishments are sorted by industry and city. Entries include a brief listing of products. For example, there are six listings under SIC 2952 (Asphalt Felts and Coatings); one in Ardmore, four in Oklahoma City, and one in Pryor. The following products are listed for these six manufacturers: (1) asphalt roofing products; (2) roof coating, flex seal, cool-flex, shingle sealer; (3) commercial roofing products; (4) asphalt products, driveway sealer, roof coating; (5) industrial and asphalt roofing material; and (6) dry felt for asphalt roofing.

Addresses, phone numbers, contact names, and employment ranges are also included for each. Manufacturers directories for other states are similar in their presentation.

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Industrial-Minerals Health-and-Safety Inspections by the Oklahoma Department of Mines

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The Oklahoma Legislature empowered the Oklahoma Department of Mines with the State jurisdiction over health and safety standards in 1978. The Non-Coal Division is required by law to inspect each permitted site a minimum of 12 times per year. The health and safety standards can be found under Title 45 O.S. Chapter 11. Specific blasting requirements are found under the Non-Coal Rules and Regulations, Subchapter 31. In addition to surface-mining standards, inspections are conducted to insure safe conditions in underground mines. The Department of Mines, through inspections and education courses offered to the industry, is given the task to make the work place a safe and productive area. The Department of Mines shall inspect all mine sites that are required to obtain a mining permit under Title 45 O.S. (see 724).

The following compliance standards must be taken into consideration when an inspection is conducted:

1) health and safety compliance;
2) miner certification;
3) proper ground control;
4) explosives: handling, use, and storage;
5) drilling for blasting;
6) loading, hauling, or dumping;
7) travelways;
8) equipment;
9) personal protection;
10) citizens' complaints;
11) reclamation standards and releases; and
12) permit compliance.

For the year of 1991, a total of 4,309 inspections were conducted by the Oklahoma Department of Mines for health and safety purposes.

The federal government, through the Mine Safety Health Administration (MSHA), inspects sites within the State for health and safety compliance. The requirements of Federal Law may be found under Code of Federal Register (CFR) 30 Parts 40, 41, 45, 47, 48, 50, and 56. A total of approximately 500 inspections were conducted by MSHA during 1991.

Pugh, J. W., 1993, Industrial-minerals health-and-safety inspections by the Oklahoma Department of Mines, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 55.

Water-Related Issues for Industrial-Mineral Operations

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ABSTRACT.—The Oklahoma Water Resources Board (OWRB), under State law, issues permits for facilities' waste-water discharges for a wide variety of mining-industry discharges. The program covers discharges related to mining, including coal, sand, gravel, limestone, and gypsum (SIC Codes 1000–1499). The U.S. Environmental Protection Agency (EPA) also requires permits under their NPDES (National Pollutant Discharge Elimination System) Permit Program. EPA and OWRB programs have historically included storm-water discharges from mining facilities. However, EPA has recently implemented rules specifically geared toward "storm water discharges associated with industrial activities." These rules clarify that virtually all mining operations require both a federal and state discharge permit.

Permits are required because mining discharges can affect water quality. Primary water-quality concerns related to mining include suspended solids and siltation, sulfates, pH, and, in some cases, dissolved metals. The OWRB issues and periodically updates Oklahoma's Water Quality Standards (OWQS), which are rules that protect the State's waters by defining the quality which must be maintained to protect the waters' uses. The OWQS also classify the State's water according to their appropriate uses, such as public and private water supply and fish and wildlife propagation.

In-stream mining operations can also damage or destroy habitat necessary for fish and wildlife propagation. If mining is performed in a stream (i.e., below the "ordinary high water mark" a §404 permit from the Corps of Engineers (Tulsa District Office) is also required. Before a §404 permit may be issued, the OWRB must certify that §404 permits meet requirements of OWQS. Future EPA initiatives may require that OWQS more directly protect aquatic habitat. Ground water is also likely to receive more scrutiny in future OWQS revisions.

The OWRB's Permit (and Enforcement) Program will be transferred to the newly created Department of Environmental Quality (DEQ) in July 1993. The DEQ is expected to continue the State's efforts to obtain EPA's approval to operate a State NPDES program, in lieu of the existing Federal Program.

Other water-related programs may also affect mining activities. The OWRB manages surface-water rights and ground-water rights (two separate rights systems under Oklahoma law), and participates in the Wellhead Protection Program, which will move to DEQ. Mining operations may wish to check with the Department of Mines and local government entities to determine if any wellhead protection restrictions or requirements apply to a potential mine site. Handling of hazardous waste at mine sites is regulated by OSDH; this program will also move to DEQ.

PERMIT REQUIREMENTS FOR MINING DISCHARGES

Since the early 1970s the Oklahoma Water Resources Board (OWRB) has required a permit for facilities which discharge waste waters into the waters of the State. The U.S. Environmental Protection Agency (EPA) also requires facilities to obtain a permit under its National Pollutant Discharge Elimination System (NPDES) Permit Program. This requirement also became effective in the early 1970s. Both programs cover discharges from mining of coal and non-coal minerals (e.g., sand, gravel, limestone, and gypsum).

EPA has established national rules, called "effluent

Eaton, P. P., 1993, Water-related issues for industrial-mineral operations, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 56–58.

guidelines," which control NPDES permit limits for discharges from a number of categories of mining operations. The OWRB also uses these effluent guidelines in its permits.

EPA and OWRB have historically covered storm-water discharges from mining facilities in addition to process discharges. In November 1990, EPA issued rules to specifically regulate what they have defined as "storm water discharges associated with industrial activities." The definition specifically covers SIC Codes 1000–1499, and includes active or inactive mining operations until they "have been released from applicable State or Federal reclamation requirements after December 17, 1990." The rules clarify that they do not apply to storm-water discharges "which are not contaminated by contact with or that have not come into contact with any overburden, raw materials, intermediate products, finished product, by-product or waste products."

EPA recently (September 9, 1992, *Federal Register*) issued a general permit for storm-water discharges associated with industrial activities. (The general permit is an administrative tool for simplifying the application and permitting process.) Since many mining categories and their storm-water discharges are covered by effluent guidelines and/or NPDES permits, many operations are not eligible for the general permit.

The new Federal Stormwater Regulations, despite the "exemption that isn't an exemption," seem to remove any doubt that virtually all mining operations must obtain a NPDES permit (and an OWRB permit). Facilities which have a current NPDES permit in effect should ascertain that the permit covers all their storm-water discharges associated with industrial activities, then file the appropriate additional form when the permit comes up for renewal. If a mining operation is not currently covered by a state and federal permit, the facility should contact EPA and the OWRB to obtain and file the appropriate forms. If you have questions, contact EPA's storm-water hotline at 1-800-841-8285, or the OWRB at (405) 231-2545.

WATER-QUALITY ISSUES AND OKLAHOMA'S WATER-QUALITY STANDARDS

Mining operations can affect water quality. Primary water-quality concerns include suspended solids and siltation, sulfates, pH, and, in some cases, dissolved metals.

Oklahoma's Water Quality Standards (OWQS) are rules which have the full force and effect of law. They protect the State's waters by defining the quality which must be maintained to protect the waters' uses, including fish and wildlife propagation. EPA must approve the OWQS. The standards are reviewed at least every three years, and EPA normally identifies issues which must be addressed.

In-stream mining operations can also damage or destroy fish and wildlife habitat. If mining is performed in a stream (i.e., below the "ordinary high water mark"), a §404 permit from the Tulsa District Office Corps of Engineers is also required; also, the OWRB must certify that §404 permits meet requirements of OWQS.

OWQS are currently geared mainly toward protection of surface waters, although ground water is addressed. Toward the development of comprehensive ground-water standards, the OWRB conducts a well-sampling program in a statewide network of 224 wells. Samples are analyzed for 36 organic compounds and 19 inorganic compounds.

Future EPA initiatives may require that OWQS more directly protect habitat. This would have a direct bearing on mining operations conducted in the stream. In addition, ground water is likely to receive more scrutiny in future revisions of the OWQS.

WELLHEAD-PROTECTION PROGRAM: ITS EFFECT ON THE MINING INDUSTRY

OWRB participates in the Wellhead Protection Program. The Department of Pollution Control is currently the lead agency for this program, which will move to the new Department of Environmental Quality (DEQ). The program delineates areas for protection of ground-water sources for public water-supply entities (PWS), such as cities and rural water districts. The PWS initiates the delineation by requesting that the State perform a study. The delineation study gives State and local governments the opportunity to examine potential sources of pollution within the wellhead-protection areas, then prescribes strategies necessary to protect the ground-water source. Strategies could include prohibiting certain activities within the delineated area, or adding more stringent monitoring requirements or construction standards.

To date, 16 wellhead protection areas have been delineated by the OWRB; seven delineations have been completed by the Oklahoma State Department of Health; and 12 additional wellhead protection areas are undergoing delineation by the two agencies. The Wellhead Protection Program is aimed at preventing pollution of wells that provide public water supply, or lessening the impact of any problems which might occur. It is not designed to deal with remediation of existing problems.

Mining operations may wish to check with the Oklahoma Department of Mines and local government entities to determine if any wellhead protection restrictions or requirements apply to a potential mine site.

THE NEW DEQ TRANSITION AND NPDES DELEGATION: ITS EFFECT ON THE MINING INDUSTRY

The Oklahoma Department of Environmental Quality (DEQ) came into existence January 1, 1993, as mandated by House Bill 2227 of the 43rd Oklahoma Legislature.

The transition to DEQ will begin with reorganization of the environmental activities of three State agencies—the Oklahoma Water Resources Board, the Department of Pollution Control, and the State Department of Health. On January 1, the Department of Pollution Control, will be abolished and four of its employees transferred to the new agency.

A timeline developed by the Oklahoma Environmental Quality Act Task Force will recommend that Governor David Walters appoint members of the Environmental Quality Board by March 1. The Board will appoint an executive director by July 1, 1993. Also on that date, Water Resources Board and State Department of Health employees with responsibilities in permitting and enforcement will transfer to the DEQ. By February 1994, the Environmental Quality Board is expected to promulgate Rules and Regulations necessary for the effective administration of the DEQ.

The Federal Clean Water Act contains a mechanism for the states to assume responsibility for the National Pollutant Discharge Elimination System and the Corps of Engineers' §404 Program pertaining to dredge and-fill operations. Oklahoma is pursuing a goal of obtaining NPDES delegation from the EPA during Fall 1994.

Now, I want to tell you why Governor Walters and I believe consolidation of some activities is necessary. As you are aware, one of the chief missions of the Water Resources Board is abatement of water pollution. Unfortunately, pollutants have become so complex, and the lines drawn between jurisdictions so vague, that a half-dozen other State agencies also claim similar responsibilities. It is this splintering of pollution-abatement activities in Oklahoma that is most distressing to Governor Walters and to me, as Secretary of Environment. The State Department of Health, Corporation Commission, Conservation Commission, Department of Agriculture, Department of Wildlife Conservation, and the Department of Mines have shared responsibilities in pollution abatement. With Oklahoma's confusing laws and overlapping jurisdictions, how can we expect a citizen to know which of these agencies to call if he sees a truck dumping wastes into a stream out in the country? How can a farmer, an oilman, a building contractor, or any other citizen know which agency to see to get the right permit or license? How do you know if you need a permit at all?

If Oklahomans are confused, imagine how this maze of environmental regulations puzzles outsiders. It is one of Governor Walters' goals, and a priority of mine as Secretary of Environment, to replace confusion with coordination and consolidation. I believe we lose our industrial-development prospects in a shuffle of bureaucratic paper. If industry executives, with a staff of corporate attorneys to help them, get lost in our confusing labyrinth of laws, I believe they'll shop elsewhere for a new plant site. How can Oklahoma recruit the kind of industry we want if regulation is so complex, unpredictable, and costly?

Now, as Transition Coordinator, I want to tell you how I perceive the advantages this consolidation will bring to the citizens of Oklahoma, especially to municipalities, business, and industry. Consolidation in the DEQ will streamline permitting procedures, clarify jurisdictions in answering pollution complaints, assist Oklahoma in obtaining NPDES delegation, increase efficiency, and avoid duplication; it will provide advocates for business, municipal, and citizen interests; and it will improve response to pollution complaints.

Perhaps we as Oklahomans have erred in perceiving economic development to be in conflict with environmental quality. As we make progress in environmental matters, we will advance economically. Environmental progress and economic growth can complement each other. We can invite industry, and they will come if we can show them an orderly environmental program. A wholesome environment invites economic growth, and new business and industry will provide us the means to maintain and improve environmental quality.

I am excited with the challenge of these coming months, as the Department of Environmental Quality is set in place. I look forward to it as an opportunity to develop a long-term, comprehensive policy aimed at enhancing and protecting the environment for all Oklahomans.

Federal Permits for Wetlands and Other Environmental Concerns

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ABSTRACT.—The U.S. Army Corps of Engineers has been involved in regulating certain activities in the nation's waters since 1890. Until 1968, the primary thrust of the Corps' regulatory program was the protection of navigation. As a result of several new laws and judicial decisions, the program has evolved to one involving consideration of the full public interest by balancing favorable impacts against the detrimental impacts. The program reflects the national concerns for both the protection and utilization of important resources.

The regulatory program utilizes three primary laws to maintain the integrity of the nation's waters. Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) regulates all work or structures in or affecting the course, condition, or capacity of navigable waters of the United States. Any activity proposed in, on, over, under, or adjacent to a navigable body of water is subject to Department of the Army authorization.

Section 404 of the Clean Water Act of 1977 (33 CFR 1344) regulates the discharge of dredged or fill material into waters of the United States, and establishes a permit program to ensure that such discharges comply with environmental requirements.

Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 authorizes regulatory jurisdiction over the transportation of dredged material for the purpose of ocean disposal.

The regulatory program evaluates the potential impacts of proposed projects involving rivers, streams, lakes, reservoirs, estuaries, territorial seas, and wetlands. Wetlands may also be known as swamps, marshes, bogs, or similar areas. These areas warrant special attention due to the important and sensitive functions they provide. Within the previous 200 years, more than half of the wetlands in the lower 48 states have been lost to agriculture, forestry, oil and gas production, mining, urbanization, and water-resource development.

INTRODUCTION

The regulatory program is a permit-evaluation process. Department of the Army permits are requested by prospective applicants who wish to perform work or activities in, on, or adjacent to water. Ultimately, most projects are permitted; however, some permits contain restrictive conditions to prevent or offset expected adverse resource impacts.

AUTHORITY

Provisions written in three federal laws give the Corps of Engineers the responsibility to assess and control the impacts of human activities within specific water-resource areas in the United States. These laws are: the Rivers and Harbors Act of 1899; the Clean Water Act of 1977; and the Marine Protection, Research, and Sanctuaries Act of 1972. The objective of Congress is to protect waterway navigation and the quality of surface water and ocean habitat.

The authority to administer the program to issue, revoke, modify, or deny Department of the Army permits has been delegated to the Secretary of the Army through the Chief of Engineers.

The U.S. Army Corps of Engineers has been involved in regulating certain activities in our nation's waters since 1890. The plural term "waters" is often used by the Corps when referring collectively to various types of waterways and waterbodies, such as lakes, streams, and swamps. Until 1968, the primary thrust of the Corps' regulatory

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program was the protection of navigation. The Corps' regulatory program now reflects national concerns for both the protection and utilization of important resources. As a result of several new laws and judicial decisions, the program has evolved into one involving the consideration of the full public interest by balancing favorable impacts against the detrimental impacts.

GEOGRAPHIC SCOPE

Section 10 of the Rivers and Harbors Act of 1899 regulates virtually all activities proposed in, on, over, under, or adjacent to all navigable waters of the United States which have the potential to impact the course, condition, capacity, or location of those waters. Navigable waters include those historically used for transportation of commercial goods.

Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into all waters of the United States. Waters of the United States include navigable waters and all their tributaries, such as rivers, lakes, streams, estuaries, territorial seas, isolated waters, and wetlands. The geographic limits for waters of the United States are much broader, when compared to navigable waters of the United States.

The scope of regulated activities proposed in navigable, or Section 10, waters is diverse compared to the scope of activities regulated in non-navigable, or Section 404, waters. In contrast, Section 404 waters are greater in quantity but are more restricted as far as scope of regulated activities.

Section 103 of the Marine Protection, Research, and Sanctuaries Act authorizes regulatory jurisdiction over the transportation of dredged material for the purpose of disposal in the ocean. The geographic scope of this act includes those waters of the open seas lying seaward of the baseline from which the territorial sea is measured.

Under the auspices of these acts, the Corps of Engineers responsibility has grown from just the protection of navigation to restoring and maintaining the chemical, physical, and biological integrity of our nation's waters.

REGULATED ACTIVITIES

Section 10 Waters

Activities requiring Section 10 authority, which have the potential to impact commercial navigation, may include, but are not limited to, the construction, installation, or placement of weirs, powerlines, tunnels, dolphins, breakwaters, booms, bulkheads, revetments, pipelines, dikes, groins, jetties, permanent mooring structures, aids to navigation, permanently moored floating facilities, excavation, mining, and filling. Certain activities do not require a Section 10 permit, but may require authorization under other agencies' responsibilities. These include bridges or causeways, hydroelectric facilities, and Superfund cleanup sites.

Section 404 Waters

Activities requiring Section 404 permits consist of discharge of fill materials into regulated waterbodies. Proposed activities must involve the placement of fill below the ordinary high-water mark before Section 404 authority is invoked. The ordinary high-water mark is defined as a horizontal plane, extending from shoreline to shoreline, to which the water surface rises during an average annual precipitation event. This mark or plane can be identified using such field characteristics as: the point at which non-aquatic vegetation ceases to grow; soil discoloration caused by water fluctuation; staining; exposed root systems of vegetation; and linear erosion lines. Examples of activities requiring a permit may include, but are not limited to, road fills, access ramps, poured concrete, backfill, beach nourishment, levees, breakwaters, revetments, riprap, causeways, dams and dikes, artificial islands, bulkheads, reclamation devices, site-development fills, boat ramps, bridges, and bank-stabilization activities. Proposals in waters of the United States not requiring Section 404 permits include those not involving fill discharge or placement, waste disposal, nonpoint-source discharges, and aqueous-solution discharges.

Statutory Exemptions

Specific statutory allowances are set forth in the regulations exempting certain activities from requiring Section 404 authorization. These activities are typically performed in conjunction with normal farming, silvicultural, and ranching practices as part of an ongoing operation. Activities such as plowing, seeding, cultivating, minor drainage, crop harvesting, upland soil- and water-conservation practices, construction of farm or stock ponds, irrigation ditches, drainage ditch maintenance, temporary sedimentation basins, and the construction or maintenance of farm, forest, or temporary roads used for the movement of farming and/or mining equipment. The intent of the act is not to interfere with economic growth, but to protect overall water quality.

Section 103 Waters

Section 103 of the Marine Protection, Research, and Sanctuaries Act requires a permit for the transportation of dredged material excavated from navigable waters of the United States for the purpose of dumping into ocean waters. Regulated activities can include: loading of dredged material that will be shipped by truck to a port site for ocean disposal after placement into ocean-going vessels, or placement of dredged material directly into vessels destined for ocean disposal.

WETLANDS

The United States is losing one of its most valuable, and perhaps irreplaceable, resources—its wetlands. These wetlands typically include swamps, bogs, marshes, estuaries, arctic tundra, bottomland hardwood forests, and other types of semi-aquatic areas.

Approximately 200 million acres of wetlands have been destroyed in the lower 48 states since colonial times. Wetlands provide a myriad of functions vital to continued existence for many species, and man has the most to gain from their preservation. Wetlands perform a major role in maintaining and regulating hydrology of our nation's waters. Roles such as flood storage, water-quality improvement, sediment trapping, erosion control, food production, fish and wildlife habitat, and the binding and holding of toxic elements are some of the intricate processes that wetlands perform.

Wetlands function like natural reservoirs, storing initial flood surges and then slowly releasing water after flooding has peaked. In addition to the aforementioned, a very large percentage of threatened and endangered species depend on wetlands at some time during their life-cycle. These extremely diverse ecosystems are among the world's most productive and fertile environs.

Currently, no comprehensive federal law exists for protecting wetlands. The major federal regulatory program for wetlands is Section 404. Section 404 regulates wetlands under the same purview as other waters of the United States. However, the criteria used to evaluate permit applications for activities proposed in wetlands is more stringent. All wetlands function similarly; however, not all wetlands are regulated. For a wetland to be protected, the Corps must first determine if the wetland is jurisdictional.

Jurisdictional Wetlands

Jurisdictional wetlands are defined as: "those areas which are saturated by surface or groundwater at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically suited for life in saturated soil conditions."

Wetlands are determined to be jurisdictional by using survey techniques established by the Corps of Engineers Wetland Delineation Manual. The manual utilizes a three-parameter approach to define a boundary between wetland and upland, consisting of assessments of hydrology, hydric soils, and hydrophytic vegetation. In order for the Corps to classify a wetland as jurisdictional, all three characteristics must be identified.

Hydrology

The driving force and the most important facet of wetlands is hydrology. Without water inundating or saturating an area, no hydric soil conditions would develop, nor would conditions be suited for wetland or aquatic vegetation. Hydrology may be provided by streams, rivers, lakes, surface water runoff, ground water, or ponding. Hydrology can be identified and understood onsite by using several field characteristics, including: water marks, drift lines, encrusted detritus, water-stained leaves, scour areas, oxidized root zones, and inundation. The manual requires an area to be inundated approximately 12% of the growing season before the hydrology parameter is satisfied. Variances in growing seasons prompt special attention geographically.

Hydric Soils

Hydric soils are developed after prolonged saturated or inundated conditions. With the introduction of water, hydric soil metamorphosis occurs under anaerobic conditions. Intricate biological activity decreases, due to the lack of oxygen, and this causes the reduction of iron. Under this process, ions of iron are transformed from the ferric valence state to the ferrous. This lack of oxygen is one of the limiting factors which preclude non-aquatic vegetation from establishing. Evidence of hydric soil can be derived by identifying low-chroma colors, observation of gleying (a sticky clay layer formed under the surface of some waterlogged soils), presence of mottling, sulfidic odor, or iron and manganese concretions. Hydric soil is typically a heavy clay, but it can include organic or sandy material, depending on the geographic locale. County soil survey information can provide an accurate indication of the potential for hydric soil presence.

Hydrophytic Vegetation

Only plants which are morphologically adapted to life in saturated soils can thrive in wetlands. Continued existence requires that plants be capable of coping in oxygen-deficient soils. Plant adaptation can consist of buttressed tree trunks, adventitious roots, shallow root systems, inflated leaves, floating leaves or stems, and multitrunks.

The manual classifies vegetation into five categories. These categories, or indicator status, range from the wettest to driest and are termed obligate, facultative wetland, facultative, facultative upland, and upland. The hydrophytic vegetation parameter requires that the majority of the plants species be classified between facultative and obligate, with a preference toward obligate. Extensive lists have been developed describing a species' tolerance to water by providing the species' indicator status.

TYPES OF PERMITS

The Corps of Engineers uses four types of permits to authorize regulated activities. These include nationwide permits, general permits, letters of permission, and standard or individual permits. The Corps is mandated to meet specific time-frame goals in administering the regulatory program.

Nationwide and General Permits

A nationwide permit authorizes a project, occurring in both Section 10 and Section 404 waters, which is expected to not have more than minimal individual or cumulative adverse impact to the aquatic ecosystem. Nationwide permits have been issued by the Office of the Chief of Engineers and are designed to authorize projects with very little administrative delay. General permits are used in similar situations, but are developed by each District Engineer, and are tailored to authorize repetitive projects having little or no adverse environmental impact. If a project can be authorized by a nationwide or general permit, most evaluations can be completed within two weeks. Some nationwide permits require notification procedures, in which the District Engineer must contact selected state and federal resource agencies, advise them of the proposed activity, and solicit their comments regarding the agencies' mission. Proposals involving notification require the District Engineer to provide a response to the applicant within 30 days.

Letters of Permission

Letters of permission are used to authorize projects occurring on Section 10 waters, when, in the opinion of the District Engineer, the proposed work would be minor, not have significant adverse impacts, and would not encounter opposition from the general public or resource agencies. Letters of permission may also be used to permit activities on Section 404 waters using similar criteria after specific activities have been evaluated by selected state and federal resource agencies. Letters of permission require notifying the resource agencies, describing the proposed project, and requesting comments concerning the proposal. Activities qualifying for letters of permission can typically be authorized in fewer than 30 days.

Individual Permits

The basic form of authorization used by the Corps District Office is the individual permit. Individual authorization is required for projects which are expected to have more than minimal impact to the aquatic environment, to have the potential for public opposition, and to raise significant concerns for resources. Projects of this nature cannot be authorized using any of the aforementioned permits, based on the potential for significant adverse impacts.

If the project requires individual evaluation, a public notice is issued within 15 days and forwarded to interested parties, soliciting comments for usually no more than 30 days. Upon comment-period closure, the Corps reviews the comments and evaluates the proposed project in light of information gained. Noncontroversial projects, those not involving concerns of resource overcommitment or mitigation, require approximately 60 days for thorough proposal evaluation. Proposals which are controversial, or require mitigation plan development, can require more than 120 days before reaching a decision.

Most projects are eventually permitted. Depending on the severity of environmental degradation, significant mitigation is required prior to permit issuance. Compensatory mitigation is considered the last alternative to offset adverse impacts. Avoidance mitigation is the primary tool used to prevent adverse impacts. Second, potential impacts of a proposal must be minimized by selecting a project design to decrease the amount of environmental degradation. Compensatory mitigation is designed to replace unavoidable losses of important resources, and is not generally considered if impacts are unavoidable. After careful consideration of the pertinent information, a decision to issue or deny the permit is made.

APPLICATION EVALUATION

Permit evaluation requires a determination of regulatory jurisdiction. If the proposed activity does not involve any regulated waterways, the project does not fall under the Corps' purview. Additionally, the District Engineer must determine if an activity would be exempt by policy, regulation, or law.

After determining that a proposal requires a permit, the District Engineer must select the most appropriate method for permit review. Generally, if a project is minor and has no potential adverse impact to the aquatic environment, the project may be authorized pursuant to one or more nationwide or general permits. The greater the potential for adverse or significant environmental impact, the more stringent the evaluatory criteria. If significant impact, the involvement of irretrievable resources, public dissent, or resource-agency concerns are expressed, the application may be reviewed under individual permit review.

Once an evaluation method is selected, the Corps and the applicant can enter into a preapplication consultation. During this phase, the Corps can perform a preliminary review of the proposal and offer or suggest alternatives or project modifications to avoid, minimize, or compensate for expected adverse impacts. Contact with the Corps prior to project initiation is encouraged, to minimize delays associated with application evaluation.

Application Review

Once a complete application is received, the Corps initiates the evaluation process. If the project cannot be authorized by a nationwide permit, a general permit, or by a letter of permission, the proposed project is subject to an individual permit review. After a complete application is received, a public notice is issued, comments are received, evaluation is performed, and a decision is made.

Comment periods, typically not exceeding 30 days, serve as an avenue to ensure public review. This com-

ment period provides concerned parties with the opportunity to express substantive comments regarding the proposed project. The received comments are reviewed, considered, and addressed during the evaluation stage.

During evaluation, the proposal must undergo rigorous examination. Before a permit can be issued, a review balancing the potential positive impacts against the expected and foreseeable detrimental impacts must be performed. This facet of evaluation is known as the "public interest review." To ensure all designated parameters are addressed, an environmental assessment is typically required.

Environmental assessments are performed to ensure compliance with the National Environmental Policy Act (NEPA), which includes coordination with the agencies designated to administer the Fish and Wildlife Coordination Act, Endangered Species Act, National Historic Preservation Act, and the Section 404 (b) (1) Guidelines. Additionally, state water quality certification, pursuant to Section 401 of the Clean Water Act, must be obtained before a Section 404 permit can be issued.

Assessments include a statement focusing on alternatives to accomplish the applicant's stated objective, by determining if a less damaging alternative exists. If an alternative is identified, and the project is not modified, the permit is denied. The assessment also includes documentation that each of the 26 "public interest review" factors has been satisfactorily addressed, using the criteria set forth in the aforementioned acts.

The Corps is the decision-making agency for the regulatory program. The Environmental Protection Agency (EPA) has the authority to veto a Corps decision, but program administration is performed by the Corps. The Corps, EPA, U.S. Fish and Wildlife Service, National Marine Fisheries Service, state fish- and wildlife-conservation agencies, and state water quality agencies cooperate closely to ensure adverse impacts to the environment are prevented. Occasionally, conflicts arise as to the most feasible utilization of important resources. Once resource negotiation and problem resolution have occurred, the Corps proceeds with project evaluation.

COMPLIANCE AND ENFORCEMENT

Permit Compliance

Permit compliance is an integral facet of the regulatory program whereby the District Engineer ensures and maintains compliance with permit conditions, project modifications, and any required mitigation. Compliance is monitored using two forms of inspection: onsite and aerial. Onsite inspections allow project managers access to the entire permit area to physically view all components of the permit area. Aerial inspection is performed by fixed- and rotary-wing aircraft, and this allows coverage of the entire District to determine conformance with permit conditions and to locate unauthorized activities.

Violation of Permit Conditions

If any component of an issued permit is found not in compliance during an inspection, the permittee is considered to be in violation of permit conditions. Once located, the permittee is contacted and informed that the activity is not in compliance. The District Engineer can issue a Cease and Desist Order, requiring the permittee to halt all operations until permit compliance is achieved. The Corps also has the administrative authority to levee fines of up to $10,000 per day against the permittee for every day of continued noncompliance beyond the receipt of the Cease and Desist Order. Most violations are resolved through voluntary compliance. However, some cases require United States court proceedings to determine final resolution.

Unauthorized Activities

Ongoing or completed activities that have not received an appropriate Department of the Army permit are considered unauthorized. The responsible party is notified with a Cease and Desist Order, and is informed that unless activities are immediately halted, a potential maximum fine of $25,000 per day may be leveed. Onsite visits are scheduled after contacting the responsible party. The EPA has the administrative authority to levee fines, as deemed appropriate, after the Corps opts to relinquish the enforcement authority to the EPA.

Depending on the nature of the violation, perpetrator knowledge of the regulatory program, the waterway involved, and environmental consequences, the violator may be ordered to restore the area to previolation conditions, or may be given an opportunity to request appropriate authorization. The evaluation process for unpermitted activities requires submission of an After-the-Fact permit application. After-the-Fact procedures follow similar review sequences as letters of permission and individual permits.

Modification, Suspension, or Revocation of Permits

Issued permits, including nationwide and general permits, are subject to the following procedures. The District Engineer may reevaluate terms or conditions of an issued permit, on his own, at the request of a third party or permittee, or as a result of an onsite inspection. To properly evaluate a project, the District Engineer should consider permittee compliance, altered circumstances, adequacy of permit conditions, law revisions, commitment of resources, and significant objections not considered during initial permit evaluation. Major project modifications may result in the reissuance of a public notice describing the altered activity. If an agreement cannot be achieved, the District Engineer will notify the permittee the work is suspended. During suspension, the permittee, in cooperation with the District Engineer, will be given an opportu-

nity to modify the activity to avoid or minimize detriment to the public interest. If the activity still cannot be altered, the District Engineer may revoke the issued permit.

ADDITIONAL INFORMATION

Because the regulatory program is complex, and application of regulations and policies to specific cases is often fact-oriented, those interested in obtaining additional information about the program or wetlands, should contact the appropriate Corps of Engineers District Office.

REFERENCES CITED

33 United States Code 403, Section 10 of the Rivers and Harbors Act of 1899.

33 United States Code 1344, Section 404 of the Clean Water Act.

33 United States Code 1413, Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended.

42 United States Code 4332, National Environmental Policy Act of 1969 (NEPA).

33 Code of Federal Regulations Parts 320 through 330, Regulatory Programs of the Corps of Engineers.

40 Code of Federal Regulations Part 230, Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 404 (b) (1) Guidelines.

Air-Quality Inspection of Industrial-Mineral-Processing Facilities

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INTRODUCTION

The Oklahoma Clean Air Act, 63 O.S. 1991 S.S. 1-1801 et. seq., designates the Oklahoma State Department of Health (OSDH) as the State agency responsible for air quality. The Air Quality Service (AQS) consists of approximately 46 people in two divisions: the Air Monitoring and Analysis Division and the Permits and Enforcement Division. Annual compliance inspections are performed by the Enforcement Section.

The purpose of an inspection is to determine the continuing compliance status of each point within a facility. There are three types of air-quality inspections performed by OSDH inspectors:

LEVEL I.—A medium-depth look at the facility to determine if the facility is still operating, if visible emissions are present, if the facility has same ownership, and other general information. This inspection usually is performed by local county inspectors; approximately 400 facilities are inspected annually.

LEVEL II.—An in-depth look at the facility that may view or examine all, or only one, point source(s) at a facility. This examination normally includes taking visible-emissions evaluations, checking equipment serial numbers for manufacture dates, reviewing operating hours and records, and checking control equipment and operating parameters. This type inspection normally is performed by air-quality inspectors.

LEVEL III.—Very in-depth and comprehensive inspection that normally determines the exact compliance status of each point source at a facility. It includes review of control equipment, examination of operation records, material-processing rate, control-equipment-operating efficiencies, fan RPMs, pressure drops across control equipment, observation of control-methods effectiveness, wet cyclones water-circulation rates, settling-basin and control-equipment state-of-repair and maintenance records, and production records. This type inspection may be performed by an AQS or Environmental Protection Agency (EPA) inspector, usually to demonstrate achievement of compliance after an enforcement action, or for an EPA multi-media and rule-effectiveness program.

Presently, AQS inspects 197 facilities per year. These facilities are targeted for inspection by a computerized inspection-targeting model which weighs several factors, including the time period since the last inspection, compliance history, amounts and type of pollutants emitted, etc. The average inspection takes 18–20 hours to perform.

An inspection involves more than simply going to the facility and taking a random look at it. There are five phases of an inspection: (1) pre-inspection file review, (2) on-site inspection, (3) exit conference, (4) follow-up office documentation, and (5) enforcement (if necessary).

PRE-INSPECTION FILE REVIEW

The pre-inspection file review is performed to assure that the inspector will be familiar with the facility and know the most current information about the facility. This information includes plant management, perhaps the identity of environmental-staff members, the plant location and directions to it, a review of compliance history (determine if certain processes or equipment are known to have compliance problems), and a review of emission-inventory data. It is necessary to know if the facility or any points therein have a permit; if so, the inspector will take a copy of the specific conditions and applicable rules along on the inspection.

Applicable State rules for the nonmetallic-mineral-process industry are included in Oklahoma Department of Health Bulletin 0550. These rules normally include:

SUBCHAPTER 7. Permits.—Any new installation or modification which results in increased emissions of 1 lb/hr, emissions of toxics exceeding the deminimis require-

McWhirter, Doyle, 1993, Air-quality inspection of industrial-mineral-processing facilities, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 65–67.

ment of 310:200-41-43(a)(5) or the new source or modification is subject to a NSPS or NESHAP. A permit may be required. The best way to determine if a permit is required is to request an applicability determination. A permit is normally required when emission increases 10 tons per year, or more.

SUBCHAPTER 25. Smoke, Visible Emissions, and Particulates.—The rule establishes a 20% equivalent opacity allowable limit. Except for five minutes during 60 consecutive minutes, or 20 minutes during any 24-hr period, emissions are not to exceed 60% opacity at any time. These limits are applicable to process-fugitive emissions, such as those emitted at a crusher discharge, transfer point, or screening operation.

SUBCHAPTER 27. Particulate-Matter Emissions from Industrial and Other Processes and Operations.—This rule establishes an allowable particulate-emission rate, based upon the process-weight rate. For instance, a 100 ton/hr crusher's allowable would be 51.2 lbs/hr, or a 500 ton/hr process rate would be allowed 69.0 lbs/hr emissions.

SUBCHAPTER 29. Control of Fugitive Dust.—Basically, this rule requires that reasonable precaution or measures be taken to minimize emissions, and that visible emissions not be allowed to cross plant-boundary lines.

Applicable federal rules may include New Source Performance Standards (40 CFR Part 60):

SUBPART 000. Nonmetallic-Mineral-Processing Industry.—This rule is applicable to any construction, reconstruction, or modification commenced after August 31, 1983, where crushing or grinding are occurring at the site. It also specifies that if existing equipment is replaced with equipment of equal or smaller size, only Section 60.676 (which requires reports) is applicable until the complete production line is replaced. This rule establishes allowables of 7% opacity and 0.06 g/dscm (grams/dry standard cubic meters) for stack emissions, 15% opacity for crushers, 10% opacity for transfer points and other affected facilities, and 7% and 0.05 g/dscm for buildings which house affected facilities. A building can only be exhausted through a forced-air vent.

SUBPART Y. Title V Permit.—Any facility which has annual emissions of 100 tons/year, or more, is a federal major source and will be required to obtain a Title V permit. (This topic is discussed more fully in the next article in this volume, "Title V Part 70 Permits; Implementation of the 1990 Amendments to the Clean Air Act," by Joyce Sheedy.)

The pre-inspection file review will also note any item which may be pending, such as enforcement resolution, performance testing, or permit issuance; these items may need to be updated or discussed during the inspection. There may be other rules applicable to a particular industrial-mineral facility; therefore, the best rule-of-thumb is to request an applicability determination, if there are any doubts.

ON-SITE INSPECTION

The on-site inspection is the physical observation of the plant site. Upon arriving at the plant site, the inspector should check in at the plant office. At this time, the inspector will notify plant staff of his/her presence and request permission to perform an inspection. If permission is not granted, the inspector has been trained to leave the plant site and call the AQS office for legal advice, which could include acquiring an administrative search warrant served by the county sheriff's office. Normally, permission for an inspection is granted.

The next steps for the inspector are: make observations of plant processing equipment, take visible-emissions evaluations, look at control equipment and methods (fugitive-dust controls), and determine if new equipment or processes have been installed. The inspection form will also be completed during the on-site inspection. The inspector will determine if operating parameters specified by the permit are being complied with: these parameters include process-operating rates, hours of operation, annual throughputs, control-equipment-pressure crops, and control-equipment-maintenance records (if controls are being utilized).

EXIT CONFERENCE

The exit conference portion of an inspection allows the plant staff an opportunity to ask questions and have a general understanding of the outcome of the inspection. The inspector may request to review additional records or reports, and completion of the inspection form, before the exit conference can begin. Bear in mind that final evaluation of data usually has not been made at this point. However, the inspector should be able to discuss observations, let plant staff review the inspection form, discuss any process changes, and inform plant staff of any potential violations. This is the appropriate time for plant staff to request copies of inspection forms and reports to be provided upon final drafting.

FOLLOW-UP OFFICE DOCUMENTATION

Follow-up office documentation is done upon return to the AQS office. The inspector will make a final comparison of inspection data to applicable rules and permit conditions, and will consult with the supervisor and other staff, if necessary. A summary report of the inspection will then be written, filed in the company file, and requested copies forwarded to the plant staff.

Data on each inspection performed by AQS are submitted to the National Computer Center in Raleigh, North Carolina. This is an EPA grant-objective reporting requirement.

If a violation has been documented during the inspection, a violation referral form will be completed for referral to the compliance-support group within the Air Quality Service.

ENFORCEMENT

Enforcement action will be initiated upon determination of a violation. The primary purpose of an enforcement action is to return the facility to compliance status. Enforcement actions consist of:

Letter of Warning.—This is utilized for minor violations, such as violations which are corrected during the day of the inspection or some other short time period of less than 45 days.

Notice of Violation.—An NOV can result from any violation. Violation of a federal rule will receive an NOV. An NOV normally requests submittal, within 15 days, of a schedule and plan for compliance, and demonstration of a capacity to achieve compliance. This time period may be extended for a specified time, upon written request.

Administrative Order.—This is issued when an NOV has not been responded to, or the compliance schedule or plan has not been complied with. An A.O. will require compliance within 15 days, or an appropriate penalty will be assessed. The State's and EPA's Memorandum of Understanding for enforcement stipulates that a significant violation can only be resolved by collection of an appropriate penalty. Significant violations include NSPS, PSD, NESHAP, and SIP major sources. Therefore, if the State does not collect an appropriate penalty in these instances, there is a threat of EPA's over filing. Any company or source that receives an A.O. has the right to request a hearing.

Consent Order.—An order (or consent agreement), agreed upon by the source and by the Air Quality Service, wherein the violations cannot be corrected in a short time frame (within 6 months or less). It calls for a complete and comprehensive plan of compliance, including specific information on equipment, purchase orders, and construction details. It also calls for a schedule of compliance that shows the dates when various parts of the plan will be completed, and specifies the penalty that must be paid if the order is violated.

Variance.—An order, agreed upon by the source and the Air Quality Council, that allows for a plan and schedule wherein the violations cannot be corrected in a short time frame (in 6 months or less). The normal variance will not exceed 12 months.

Air Impact Analysis.—This is an economic analysis of the impact of activities upon the source and upon the community. It specifies that a penalty must be paid if an order is violated. It is approved by the Air Quality Council after a public hearing, and is subject to EPA approval and SIP revision (it is published in the *Federal Register*).

Title V Part 70 Permits; Implementation of the 1990 Amendments to the Clean Air Act

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ABSTRACT.—The Clean Air Act Amendments of 1990, signed into law on November 15, 1990, not only attempt to rectify the shortcomings of the previous amendments, and expand many existing features of the federal air-quality-control program and add many new programs, but also remove much of the direct regulatory responsibility from the states and place it with the U.S. Environmental Protection Agency (EPA). The 1990 Amendments contain seven major titles: Title I—Nonattainment; Title II—Mobile Sources; Title III—Hazardous Air Pollutants; Title IV—Acid Deposition Control; Title V—Operating Permits; Title VI—Stratospheric Ozone and Global Warming; and Title VII—Enforcement. The 1990 Amendments also contain several other miscellaneous provisions.

The 1990 Amendments mandate almost all significant stationary sources to obtain consolidated five-year renewable operating permits. Major sources that will be required to have a Title V Part 70 permit include: sources subject to Title IV (acid rain); sources (including area sources) subject to standards or regulations under Section 111 (new source performance standards) or 112 (hazardous air pollutants); sources required to have a permit under Parts C (prevention of significant deterioration) or D (nonattainment areas) of Title I; or any other stationary source in a category designated by regulations promulgated by EPA. This will include sources with emissions as small as 10 tons per year (tpy) (and in some cases smaller) of a listed hazardous air pollutant.

Sources subject to Title V must submit complete permit applications within one year after a state program is approved by EPA or, when a state program is not approved, within one year after a program is promulgated by EPA. EPA promulgated Part 70 of Title 40 of the Code of Federal Regulations (40 CFR 70) on June 25, 1992, detailing the Title V operating permit program.

The 1990 Amendments require that state programs demonstrate that their fee program is adequate to cover the costs of administering the provision of the Title V permit program promulgated by EPA. This fee will be based on a per ton cost for each regulated air pollutant (except carbon monoxide) emitted by any source up to 4,000 tpy. The 1990 Amendments provide for stronger penalties, including fines and imprisonment. Nearly all intentional violations are subject to criminal penalties, including imprisonment for up to 15 years and fines as much as $250,000 per day for individuals and as much as $1,000,000 per day for corporations.

HISTORY OF THE FEDERAL CLEAN AIR ACT

The Clean Air Act, as passed in 1963 and amended in 1965, 1966, and 1967, did little more than set requirements for newly manufactured motor vehicles and provide incentives for states to implement their own air-pollution-control programs.

The 1970 Amendments established the basic regulatory framework that was used during the following 20

Sheedy, J. D., 1993, Title V Part 70 permits; implementation of the 1990 Amendments to the Clean Air Act, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 68–74.

years. National Ambient Air Quality Standards (NAAQS) were promulgated by the U.S. Environmental Protection Agency (EPA) in 1970 for particulate matter, sulfur dioxide, carbon monoxide, nitrogen dioxide, and photochemical oxidants (ozone). The states were required to submit State Implementation Plans (SIP) in 1972, demonstrating attainment of the NAAQS by the end of 1975 with a possible extension to 1977. The SIPs were to include an inventory of emissions, enforceable emission limitations, and a permit program requiring review of significant new sources prior to their construction. EPA was given the responsibility for developing and promulgating requirements for control of hazardous emissions (NESHAP) and standards of performance for new sources (NSPS). EPA review and approval of SIPs submitted by the state made the requirements contained in those plans enforceable by EPA, as well as the respective state. Federal court decisions, which ruled that protection against degradation of existing air quality was required by the 1970 statute, resulted in the prevention of significant deterioration (PSD) program being promulgated in 1974 and 1975.

By 1977 it was apparent that not all nonattainment areas would meet the deadline set by the 1970 Amendments. Nearly all major urban areas remained in noncompliance for one or more standards, which translated into approximately 70 million people residing in nonattainment areas. The Clean Air Act was amended again in 1977. SIP revisions were required by 1979, demonstrating that areas remaining in nonattainment would comply with the applicable standard by 1982, with the possibility of an extension to 1987. The amendments also codified the PSD program as Part C of the statute.

Ozone nonattainment persisted under the amendments of 1977, and public concern over the emissions of toxic materials increased markedly. It appeared that an effective program for control of hazardous air emissions was impossible under the risk-based NESHAPS program. In an attempt to address these concerns, and to rectify the shortcomings of the 1977 Amendments, the 1990 Amendments were signed into law on November 15, 1990. These amendments have been characterized as the most comprehensive environmental legislation passed to date, with the potential for profound and far-reaching consequences for the nation's health and economy. Not only do they expand many existing features of the federal air-quality-control program, and add many new ones, but they also remove much of the direct regulatory responsibility from the states and place it with EPA. The law gives EPA specific authority to veto the issuance of any particular permit that would violate the underlying statute. The 1990 Amendments contain seven major titles, as well as several other miscellaneous provisions dealing with research and development activities, unemployment benefits for certain displaced workers, and visibility-improvement programs.

THE 1990 AMENDMENTS

Title I—Nonattainment

Almost all major U.S. cities are in nonattainment for one or more of the NAAQS. The 1990 Amendments sort nonattainment areas into categories with deadlines for compliance, and control requirements mandated for cities not meeting the NAAQS. State and local governments in nonattainment areas must identify and implement additional measures, if the mandated ones do not work. EPA must issue rules to reduce emissions of volatile-organic compounds and address emissions limitations for various source categories.

Title II—Mobile Sources

It is estimated that motor vehicles contribute approximately 50% of the volatile-organic compound (VOC) emissions, 43% of the nitrogen oxide emissions, and 90% of the carbon monoxide emissions in urban areas. In an attempt to reduce tailpipe emissions by 40%, the amendments impose new restrictions on emissions of hydrocarbons, carbon monoxide, and nitrogen oxides from new cars beginning with the 1994 model year. If these restrictions are not effective, a more stringent set of emissions limitations will be required early next century. Emissions reductions are required from fuels as well as vehicles. New inspection and maintenance programs must be established in some cities.

Title III—Hazardous Air Pollutants

The 1990 Amendments implement a major philosophical shift from risk-based to technology-based regulations, based on an initial list of 189 chemicals and limited to a promulgated listing of source categories.

Title IV—Acid Deposition Control

The 1990 Amendments provide for control of acid rain through a market-place-incentives program, to reduce annual sulfur dioxide and nitrogen oxide emissions.

Title V—Operating Permits

The 1990 Amendments require almost all significant stationary sources to obtain consolidated operating permits, renewable every five years.

Title VI—Stratospheric Ozone and Global Warming

The 1990 Amendments add to the existing program for global protection contained in EPA's regulations to eliminate substances considered responsible for adverse global impacts, such as global warming and ozone depletion.

Title VII—Enforcement

The 1990 Amendments provide for a substantial increase in statutory enforcement authority. Nearly all intentional violations are subject to criminal penalties, including imprisonment for up to five years and daily fines as much as $250,000 for individuals and as much as $500,000 for corporations. The "knowing endangerment" of another person may lead to imprisonment for up to 15 years, as well as a potential liability of $250,000 per day; corporations may be fined as much as $1,000,000 per day. Nearly all violations of recordkeeping requirements constitute crimes under this title.

TITLE V—OPERATING PERMITS

Introduction

Title V of the Clean Air Act Amendments of 1990 provides that, after the effective date of any permit program approved or promulgated under the title, it shall be unlawful for any person to violate any requirement of a permit issued under this title. It will also be unlawful to operate any of the following: an affected source (defined in Title IV on acid deposition), a major source, any source (including an area source) subject to standards or regulations under Section 111 (NSPS) or 112 (hazardous air pollutants), any source required to have a permit under Parts C (PSD) or D (nonattainment areas) of Title I, or any stationary source in a category designated by regulations promulgated by EPA, except in compliance with a permit issued by a permitting authority under Title V. This does not alter the applicable requirements of the act, that a permit be obtained before construction or modification.

Operating Permit Contents and Reporting

Title V Part 70 sources must obtain an operating permit that addresses all applicable pollution-control obligations under the SIP, the acid rain program, the hazardous air-pollutant program, and/or other applicable provisions of the act, such as NSPS. Sources must submit periodic reports to the state and/or EPA concerning the extent of their compliance with permit obligations. The permit application, the permit, and the compliance reports will be available to the public, subject to any applicable confidentiality protection procedures similar to those contained in Section 114(c).

Permit Revisions

A provision for permit revision was adopted to ensure that the permit requirements are consistent with the legal basis, but not so much so that the permits have to be continuously revised to track every new EPA requirement or regulation.

Permit "Shields"

Compliance with the terms and conditions of a valid permit will "shield" permittees from actions that might otherwise arise under the Clean Air Act.

Fees

Sufficient fees must be collected by the permitting entities to cover the direct and indirect costs of processing applications and monitoring compliance with the regulations. The minimum fee was set at $25 per ton for each regulated pollutant (except carbon monoxide), unless it can be demonstrated that a lesser fee will cover the program costs. Emissions of any particular pollutant in excess of 4,000 tons per year (tpy) need not be counted from one source. This implies a discretionary cap of $100,000 annually on single-source emissions. If a state program does not meet EPA standards, it may be preempted and EPA will collect the appropriate fees. Owners of facilities that fail to pay fees assessed by the agency are required to pay, in addition to the fees, a penalty equal to 50% of the fee, plus interest.

Small Businesses

States are given some degree of flexibility in administering the program as it applies to small businesses. Waivers of some of the more onerous rules may be available, and states are to provide assistance with technical- and environmental-compliance issues.

Timeframes

State

Within three years of enactment (no later than November 15, 1993), states must submit proposed permit programs to EPA for approval. EPA must approve or disapprove a state program within one year of submittal, but in some cases can grant programs an interim approval for a period of up to two years. If a state fails to submit a fully approvable program within the three-year period (or by the end of the interim approval period), EPA, in addition to applying specific sanctions, must establish a federal operating-permit program two years after the end of the three-year program submittal period. Under the most optimal scenario, industry could be required to submit a Title V permit application by November 15, 1995.

Title V Sources

Sources subject to the Part 70 program must submit complete permit applications within one year after a state program is approved by EPA, or, if a state program is not approved, within one year after a program is promulgated by EPA. In the case of new sources, complete permit applications would generally be due 12 months after the source commences operation, unless the permitting authority sets an earlier deadline.

Permit Review

Permitting authorities have a maximum of 18 months to either approve or deny an application, once it has been filed. Anticipating that a huge number of applications will be filed at the start of the program, a phase-in clause was added. This provides that one-third of the applications filed during the first year that permits are required, must be processed during each of the following three years.

Title V Minimum Program Elements

EPA was given 12 months after the date of the enactment of the Clean Air Act Amendments of 1990 to promulgate regulations establishing the minimum elements of a permit program to be administered by any air-pollution-control agency. The minimum elements will include the following:

1) Requirements for permit applications, including a standard application form and criteria for determining completeness of applications in a timely fashion.

2) Monitoring and reporting requirements.

3) Requirement that the owner or operator of all sources subject to the requirement to obtain a permit under Title V pay an annual fee, or the equivalent, over some other period, sufficient to cover all reasonable costs required to develop and administer the permit-program requirements of Title V, including the reasonable costs of: (a) reviewing and acting upon any application for such a permit; (b) implementing and enforcing the terms and conditions of any such permit; (c) emissions and ambient monitoring; (d) preparing generally applicable regulations, or guidance; (e) modeling, analyses, and demonstrations; and, (f) preparing inventories and tracking emissions.

The state must demonstrate that the program will result in the collection from all sources, subject to Title V permitting, of an amount not less than $25 per ton of each regulated pollutant, or some other amount that has been determined to adequately reflect the reasonable costs of the permit program. "Regulated pollutant," for purposes of fees, means a VOC; each pollutant regulated under Section 111 (NSPS) or 112 (hazardous pollutants), and each pollutant for which a national primary ambient-air-quality standard has been promulgated, except carbon monoxide. The permitting authority is not required to include any amount of regulated pollutant emitted by any source in excess of 4,000 tpy of that pollutant. The fee shall be increased, as necessary, to cover the reasonable costs of the program in each year (beginning after the year of the enactment of the Clean Air Act Amendments of 1990) by the percentage, if any, by which the Consumer Price Index for such year exceeds the Consumer Price Index for the calendar year 1989. If EPA determines that the fee program is not adequate, or that the permitting authority is not adequately administering or enforcing an approved fee program, EPA may collect reasonable fees from the sources designed solely to cover the costs of administering the provisions of the permit program promulgated by EPA.

4) Requirements for adequate personnel and funding to administer the program.

5) A requirement that the permitting authority have adequate authority to do the following: (a) issue permits and assure compliance of all sources required to have a permit under Title V, with each applicable standard, regulation, or requirement of the act; (b) issue permits for a fixed term, not to exceed five years; (c) assure, upon issuance or renewal, that permits incorporate emission limitations and other requirements in an applicable implementation plan; (d) terminate, modify, or revoke and reissue permits for cause; (e) enforce permits, permit-fee requirements, and the requirement to obtain a permit, including authority to recover civil penalties in a maximum amount of not less than $10,000 per day for each violation, and provide appropriate criminal penalties; and (f) assure that no permit will be issued if EPA objects to its issuance in a timely manner under Title V.

6) Adequate, streamlined, and reasonable procedures for expeditiously determining when applications are complete, for processing such applications, for public notice, and for expeditious review of permit actions, including applications, renewals, or revisions, and including an opportunity for judicial review in state court of the final permit action.

7) Adequate authority and procedures to provide that the failure of the permitting authority to act on a permit application, or permit-renewal application, shall be treated as a final permit action, solely for purposes of obtaining judicial review in state court.

8) Authority to make available to the public any permit application, compliance plan, permit, and monitoring or compliance report under Section 503(3), subject to the provision of Section 114(c) of the act.

9) A requirement that the permitting authority, in the case of permits with a term of three or more years, shall require revisions to the permit to incorporate applicable standards and regulations promulgated under this act after the issuance of such permit. Such revision shall occur not later than 18 months after the promulgation of such standards and regulations.

10) Provisions to allow changes within a permitted facility without requiring a permit revision, if the changes are not modifications under any provision of Title I and the changes do not exceed the emissions allowable under the permit, provided that the facility provides EPA and the permitting authority with written notification at least seven days in advance of the proposed changes.

Title V Program Approval

Title V of the Clean Air Act Amendments of 1990 contained provisions for the content of a partial permit program and interim approval, when a partial permit program substantially meets the requirements of Title V, but is not fully approvable. The effective date of a permit program, or partial or interim program, was set as the effective date of the approval by EPA.

Title V Administration and Enforcement

EPA is given the authority to apply sanctions whenever the determination is made that a permitting authority is not adequately administering and enforcing a program or portion thereof. Unless the state corrects such deficiency within 18 months after the date of such finding, EPA shall, two years after the date of such finding, promulgate, administer, and enforce a program under Title V for the state.

Permit Application

Applicable Date

The applicable date is the effective date of a permit program, or partial or interim-permit program, applicable to the source or the date such source becomes subject to Title V permitting, which ever is later.

Compliance Plan

The permit applicant shall submit with the permit application a compliance plan describing how the source will comply with all applicable requirements under the act. The plan shall include a schedule of compliance and a schedule of progress reports, to be submitted to the permitting authority no less frequently than every six months. The regulations shall require the permittee to at least annually certify that the facility is in compliance with any applicable requirement of the permit, and to promptly report any deviations.

Deadline

Not later than 12 months after the date the source becomes subject to a Title V Part 70 permit program, the owner/operator must submit a compliance plan and an application for a permit, signed by a responsible official. The permitting authority shall approve or disapprove a completed application and issue or deny the permit within 18 months after the date of receipt, except during the first round of permit applications. At least one-third of the first-round permits will be acted on annually, over a period not to exceed three years after the effective date.

Timely and Complete Applications

Except for sources required to have a permit before construction or modification, the lack of a permit will not be a violation of the act, if an applicant has submitted a timely and complete application for a permit for which final action has not been taken. Delays in final action, due to the failure of the applicant to submit (in a timely manner) information required or requested to process the application, may be considered a violation.

Availability of Copies

A copy of each permit application, compliance plan (including the schedule of compliance), emissions or compliance monitoring report, certification, and each permit issued under Title V, shall be available to the public. Although the contents of a permit must be available to the public, certain trade-sensitive information may be protected from disclosure in accordance with Section 114(c).

Title V Permit Requirements and Conditions

Conditions

Each permit issued under Title V shall include enforceable emission limitations and standards, a schedule of compliance, a requirement for submission of the results of any required monitoring, and other conditions that are necessary to assure compliance with applicable requirements of the act.

Monitoring and Analysis

EPA may, by rule, prescribe procedures and methods for determining compliance and for monitoring and analysis of pollutants regulated under the act. Continuous emissions monitoring may not be required, if alternative methods are available that provide sufficiently reliable and timely information for determining compliance. The continuous emissions monitoring requirement contained in Title IV, or elsewhere in the act, are not affected by these provisions.

Inspection, Entry, Monitoring, Certification, and Reporting

Each permit issued under Title V shall set forth inspection, entry, monitoring, compliance certification, and reporting requirements to assure compliance with the permit terms and conditions. These monitoring and reporting requirements shall conform to any applicable regulation. All required reports must be signed by a responsible corporate official, who, by signing, will certify its accuracy.

General Permits

The permitting authority may, after notice and opportunity for public hearing, issue a general permit covering numerous similar sources. Any general permit shall comply with all requirements applicable to permits under the

title. Sources covered by a general permit must file an application as described in Section 503.

Temporary Sources

The permitting authority may issue a single permit authorizing emissions from similar operations at multiple temporary locations. This permit will include conditions that assure compliance with the requirements of the act at all authorized locations. The permitting authority must be notified in advance of each change in location, and separate permit fees may be required for operations at each location.

Permit Shield

Compliance with a permit issued in accordance with Title V shall be deemed compliance with Section 502 (Permit Program). Except as otherwise provided by rule, the permit may also provide that compliance with the permit shall be deemed compliance with other applicable provisions of the act. This will apply if: (1) the permit includes the applicable requirements of the provisions; or (2) the permitting authority makes a determination in the permit that other provisions are not applicable and the permit includes, at a minimum, a summary of the determination.

Notification to EPA and Contiguous States

Notification to EPA

The permitting authority will send a copy of each permit application for a new source, modification of an existing source, or permit renewal, as well as each permit proposed to be issued and each final permit issued to EPA.

Notification to Contiguous States

The permitting authority will also notify all states whose air quality may potentially be affected by the emissions of any permit application or proposed permit. These states may, in turn, submit written recommendations respecting the issuance of the permit and its terms and conditions. If any part of those recommendations are not accepted by the permitting authority, the state submitting the recommendations and EPA must be notified of the decision in writing.

Objection by EPA

EPA may object to the issuance of a permit in writing within 45 days after receiving a copy of the proposed permit or notification. A copy of the objections, and reasons for the objections, shall be provided to the applicant. If EPA does not object in writing to the issuance of a permit, any person may petition EPA, within 60 days after the expiration of the 45-day review period, to take such action. A copy of such petition shall be provided to the permitting authority and the applicant by the petitioner. The petition shall be based only on objections to the permit that were raised with reasonable specificity during the public-comment period (unless the petitioner demonstrates in the petition that it was impracticable to raise such objections within such period, or unless the ground for such objection arose after such period). EPA shall grant or deny petitions within 60 days after filing. If the permit has been issued by the permitting agency, such petition will not postpone the effectiveness of the permit. EPA must issue an objection within such period if it is demonstrated that the permit is not in compliance with the requirements of the act. Any denial of a petition shall be subject to judicial review under Section 307. Upon receipt of an objection by EPA, the permitting authority may not issue the permit without revision. If the permit has been issued prior to receipt of an objection by EPA, EPA can modify, terminate, or revoke the permit.

Issuance or Denial

If the permitting authority fails, within 90 days after the date of an objection by EPA, to submit a permit revised to meet the objection, EPA shall issue or deny the permit in accordance with the requirements of Title V.

Other Authorities

Nothing in Title V prevents a state from establishing additional permitting requirements which are more restrictive, but not inconsistent with, the act.

Small Business Assistance Program

The state implementation plan (SIP) shall be revised to establish a small- business, stationary-source technical- and environmental-compliance-assistance program. For purposes of Title V, "small business stationary source" means a stationary source that: (1) is owned or operated by a person that employs 100 or fewer individuals; (2) is a small-business concern, as defined in the Small Business Act; (3) is not a major stationary source; (4) does not emit 50 tpy or more, of any regulated pollutant; and (5) emits less than 75 tpy of all regulated pollutants. It is envisioned that small businesses will be able to obtain technical information and referrals through the program.

EFFECTS OF THE IMPLEMENTATION OF THE PART 70 PERMIT PROGRAM

Title V required EPA to promulgate regulations by November 15, 1991, that require and specify the minimum elements of state operating-permit programs. EPA promulgated, on June 25, 1992, a new Part 70 of Title 40 of the Code of Federal Regulations (40 CFR 70), which outlines the requirements under which states are to develop programs for issuing operating permits to major

stationary sources, sources covered by New Source Performance Standards (NSPS), sources covered by emissions standards for hazardous air pollutants pursuant to Section 112 of the act, and affected sources under the acid-rain program. These state program plans must be submitted to EPA for review and approval by November 15, 1993.

The Oklahoma Clean Air Act was substantially amended by the 1992 Oklahoma Legislature on May 15, 1992. The new act gives the Air Quality Service the authority to implement the Title V Part 70 permit program, as well as the other provisions of the federal act.

Permit-application development, recordkeeping, and self-reporting for compliance may require several additional manyears of effort for industry and government alike. It has been estimated that nationally as many as 60,000 new jobs may be created, 5,000 of them in engineering. The demand for consultants is also expected to increase. Loss of operational flexibility may result from the new requirements. EPA has estimated that the national cost of implementation of the Clean Air Act Amendments of 1990 will range from $11 to $22 billion per year, while industry estimates are between $35 and $50 billion per year by 2005. This could result in an added cost of $300 to $400 per year per household being passed on to consumers.

The effects of the Clean Air Act Amendments of 1990 will be far reaching and are expected to have substantial impact on many areas, including economy and health for a good many years to come.

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Reclamation and Sequential Use of Mined Lands

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ABSTRACT.—Successful reclamation of mined lands is required by Oklahoma Statutes and depends on the integration of several factors into a reclamation plan. The regulations and these factors determine how the operators should methodically approach planning and carrying out the reclamation. These factors include: mining methods used (quarry, dredging, or strip mining); the expected post-mining land use; the amount of grading and revegetation required; and the local precipitation and soil conditions. Proper planning and execution of the reclamation plan will ensure quick bond release for the operator and leave a satisfied landowner with valuable property.

INTRODUCTION

Mining of industrial minerals includes several different mining methods: dredging, strip (or surface) mining, and quarrying. The type of mining method used usually depends on the type of material, the local conditions where mining is conducted, and the general location of the mine site in the state.

Dredging

Dredging, especially if the mining operation is conducted in the floodplain of a major river or stream, results in the least disturbance to the land surface. The processes of the river naturally reclaim the mined areas. Only the plant site, processing site, and any constructed roads need to be reclaimed.

Quarrying

Quarry mining is usually practiced when removing granite, limestone, or similar material from deep, extensive formations. The land disturbance is extensive and, because of a limited amount of available fill material, usually permanent. Except for the plant site, and possibly some haul roads, reclamation for these operations consists mainly of activities to make the area safe for people or animals, such as: preventing access into the mine site; creating or providing protective barriers around highwalls; cleaning the floor of the quarry site; and possibly reducing the slope of the highwalls (benching the highwall during mining is effective).

Strip Mining

Strip or surface mining for industrial minerals involves removing the soil and overburden above the desired material. Some operations screen their product from the soil overburden. This type of mining may result in extensive disturbance to the land. If the disturbed land is not carefully reclaimed, the disturbed property will not be agriculturally productive and may cause serious environmental problems to the local soil and water environments.

FACTORS AFFECTING RECLAMATION PLANS AND METHODS

Regulatory Program

Oklahoma's regulatory program requires that performance bonds be posted in advance of mining. The amount must be sufficient to cover the cost of reclaiming the site in the event an operator fails to complete reclamation. The regulation also provides reclamation-performance standards. The bond is not fully released until successful reclamation, in accordance with the performance standards, is completed. The bond can be partially released when defined, separate, and identifiable phases of reclamation at the mine site are completed. Also, as a portion of the mine site is reclaimed, a percentage of the performance bond may be returned to the operator. For example, as grading is completed on a portion of the disturbed area, a percentage of the bond may be released. The procedure for reclaiming land is described in Section

Gilbert, T. S., 1993, Reclamation and sequential use of mined lands, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 75–77.

725 of Title 45 of the Oklahoma Statutes, titled Mines and Mining. This section describes the performance standards that must be met in order for reclamation to be successful. With proper reclamation, mined land can be returned to its original use or to a valuable new use.

Post-Mining Land Use

During the reclamation-planning process, the operator shall determine, after discussions with the property owners, what the post-mining land use shall be. The options are: forest, pasture, cropland, horticultural, residential, recreational, industrial, and wildlife habitat. The post-mining land use can also be a combination of these options, with portions of the permit area designated as having different post-mining land uses. For example, the post-mining land use of one permit may consist of separate areas of pastureland and wildlife habitat. The revegetation requirements and standards for success would be different for each area.

Grading Requirements

The regulations require that the grade of the ridges and peaks formed during mining must be reduced to the approximate original contours (AOC) of the surface prior to mining. The elevations do not have to be the same; just the slope, and direction of the slope, of the surface. If, especially in sand and gravel mining, the pit is deep and backfill is not available to adequately fill the depression, operators have the option of benching the pit. This may be the best way to reclaim the land and leave the landowner with useful property, depending on the slope of the banks, the material that will form the walls and floors of the benches, and the post-mining land use. Any other deviation from the approximate original contours, such as ponds, berms, channels, and stream diversions, should be described in the permit and lease, and be approved by the landowner.

Revegetation

All mined lands should be revegetated, in order to successfully achieve the selected post-mining land use. Quick revegetation should be accomplished with a permanent species, or a temporary species if the permanent species is not available or if the time of year is not in the recommended planting dates for the permanent species. Established vegetation will minimize erosion and loss of soil, reduce stream siltation, and help stabilize the soil. Unless the post-mining land use is for cropland, the selected species should be a permanent species, not an annual or biannual, regardless of the suspected persistence of the species. The species selected for revegetation should be selected in conjunction with the landowner's comments, the post-mining land-use requirements, and the suspected level of management the property will receive. A great deal of consideration should be given to the species selected for the area. Drought resistance, winter hardiness, and predominance of warm-season grasses or cool-season grasses in the pre-mining vegetation are some of the selection criteria.

Rainfall amounts vary greatly across Oklahoma, as do winter and summer temperatures and the number of cool or warm days that occur during these seasons. Oklahoma also has diverse soils, ranging from fertile soils of the prairies and river valleys, to poor sandy, clay, and stoney soils. All these factors affect the type of vegetation that can be used to successfully revegetate a mined area. The characteristics (drought resistance, winter hardiness, soil pH tolerance, etc.) of the native species existing in these weather and soil conditions are good indicators of the type species that should be selected for revegetation. The species selected should also be a tested variety that is proven to be capable of establishing itself in the weather and soil conditions of the permit area. State universities and local agricultural extension offices can provide this information.

Topsoil Restoration

Salvaging, properly storing, and redistributing topsoil is not required in industrial-mineral mining regulations, but it is highly recommended. On reclaimed surface mines, topsoil is essential for quickly and properly re-establishing vegetation, because topsoil provides a good natural medium in which to initiate revegetation. When attempting to establish vegetation on regraded sub-soils, without any topsoil, required fertilization and land management will be critical and intensive. Due to this, some mined land may not be reclaimed quickly to its full potential. Natural weathering will reconstruct a layer of topsoil, but this will require many years, and erosion will be a constant problem. During this time, crop or forage production for the landowner would be extremely poor, as compared to production from land with topsoil. The topsoil should be stripped from the surface of the area to be disturbed, stockpiled, protected against erosion (with a temporary species, such as rye grass or a permanent species if the topsoil will be stored for an extended duration), and then redistributed evenly over the disturbed area after regrading is completed. In some areas of Oklahoma, naturally existing, potentially toxic materials, such as high-sulfur coal and shales with a high content of heavy metals, exist in close proximity to the surface. Sampling and analysis of the overburden should be conducted to determine if these materials exist, and, if exposed during mining or otherwise present, should be capped to prevent damage to soil and water environments. The presence of these materials will also substantially hinder revegetation efforts.

Contemporaneous Reclamation

Contemporaneous reclamation of mined land should be practiced. All grading of disturbed land should be completed one year from the end of mining in that area.

The initial planting or seeding should be completed at the first opportunity following grading. As a portion of the permit is mined out, it should be regraded and revegetated at the earliest opportunity, even if mining is continuing adjacent to the reclaimed site. The benefits of contemporaneous reclamation are substantial, including the opportunity for incremental bond releases. Upon completion of all mining in the permit area, if contemporaneous reclamation has been practiced, the final area to be reclaimed should be small. Complete bond release, and release of liability, can be accomplished quickly upon completion of mining. Also, due to the variations in precipitation amounts, soil types, and general conditions across Oklahoma, the time required to successfully establish vegetation can be long. If reclamation is initiated as soon as practical, total revegetation of the entire site can be accomplished more quickly.

SUMMARY

Reclamation Factors

To summarize, the items that should be considered when forming the reclamation plan are:

1) The regulations that describe the requirements and standards for reclamation.

2) The mineral type, mining method, and location of the product within Oklahoma.

3) The landowner comments and their requirements for the post-mining land use.

4) The average annual precipitation for the area.

5) Winter and summer temperatures and their duration.

6) Possibly, the effects of wind and evaporation on the available moisture for revegetation.

7) The pre-mining and/or native-vegetation characteristics (drought resistance, winter and/or summer hardiness, management requirements, etc.).

8) The quality and characteristics of the soils and overburden that will be used in the reclamation.

Benefits of Reclamation

Returning the land to a productive capacity benefits the landowner by creating property that can provide a variety of agricultural and/or industrial products. The local area benefits from salaries and taxes paid, as well as purchases of agricultural and petroleum products and machinery parts during the reclamation. The potential for increased land productivity after reclamation is completed benefits both the landowner and the local area. The operator benefits from quality-reclamation practices. An early release from liability can result from quickly reclaiming mined land and receiving both phased and incremental bond releases. Successful reclamation can also be used as a sales tool to potential lessors; a company that practices, and is known to practice, successful reclamation techniques is more likely to get consent to mine from a concerned landowner.

Potential for Increased Regulation

In this era of growing environmental awareness, operators have a responsibility to reclaim any land disturbed as part of a mining operation. Some other industries, other than industrial-mineral operators, have not taken responsibility for reclamation or protecting other environmental issues. Now, industries are currently saddled with such massive regulatory legislation such as:

SMCRA—Surface Mining Control and Reclamation Act of 1977

RECRA—Resource Conservation and Recovery Act of 1976

Clean Air Act, amended in 1990

Clean Water Act, amended in 1987

NEPA—National Environmental Policy Act of 1969

Mining today requires you to operate within the guidelines of some of these regulations, and probably several others, that were established to protect the environment. Regulatory expansion into industrial-mineral mining is probable, if the industry fails to protect itself by adequately reclaiming mined land; protecting the soil, water, and air environments, and then promoting these positive actions to a concerned public.

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Public Perception of Industrial-Minerals Operations

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The first effort I made to determine the public perception of industrial-minerals mining was to question individuals who might be identified as a "man on the street." None of the people had any strong feelings or perceptions of the kind of job the industrial-minerals operators were doing. A check of the records of violations at the Oklahoma Department of Mines yielded only five violations in the past two years; four violations were for blasting and one for dust emissions. These are almost unbelievable statistics, when one considers the tremendous amount of industrial-minerals mining taking place in every county in Oklahoma.

In searching for the reason for so few complaints, it makes sense to assume that it is partly due to the economic value of mining to the local economy. Local residents operate the machinery and drive the trucks, and so they realize that there may be a few minor problems associated with their industry. Also, the public realizes that the rock, sand, and gravel will be used in constructing new highways, bridges, buildings, homes, parking lots, and shopping centers. There is also very little public concern about reclamation of these sites. Mining operations generally have been in the same area for many years, and the gradual removal of the sand, rock, and gravel does not shock people; the landscape does not change suddenly.

When employees of other State agencies were questioned, none expressed any opinion on the perception of the industrial-minerals operations. That is, with one exception: individuals who are professional wildlife employees had some rather strong opinions on what had been done and what needed to be done. Also, members of support groups of the wildlife programs pointed out some problems caused by industrial-minerals mining. These problems revolved around sand and gravel operations which caused turbidity in the water downstream from the mining operation. They pointed out the damages done to fish-spawning areas and nesting areas for certain types of fowl.

The wildlife groups will continue to seek remedies through legislation to correct these problems. When you question these highly trained, knowledgeable, and professional wildlife workers, you fall back to the perceptions of the general public.

This effort to determine the public perception of industrial-minerals operations almost defies all methods of canvassing the population. I have come to the conclusion that most people don't have a perception of industrial-minerals mining. In fact, when I asked a farmer/rancher in Cotton County, "What is your perception of industrial-minerals mining?", he said, "Am I supposed to have one?"

Soloman, L. A., 1993, Public perception of industrial-minerals operations, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 78.

U.S. Bureau of Mines' Role in Industrial Minerals

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ABSTRACT.—Headquartered in Washington, D.C., the U.S. Bureau of Mines operates research centers and field offices throughout the country. Its staff can thus keep in touch with the people who mine, process, and use minerals, and assist with the problems they face. An active technology-transfer program gives mining and mineral-processing companies quick access to the Bureau's latest technical developments. Publications, seminars, and films help the Bureau present the results of its research, fact-finding, and analytical work to the widest possible audience. The Branch of Industrial Minerals in the Division of Mineral Commodities is responsible for the analysis of mineral information and statistics for more than 50 industrial-mineral commodities. These statistics and their interpretation are published in a series of periodic and special publications. The Bureau not only gathers data concerning mineral production and mineral resources, it uses that information to analyze issues involving these minerals and the industries associated with them.

INTRODUCTION

The U.S. Bureau of Mines is pleased to be a cosponsor of this industrial-minerals symposium. From its beginning in 1910, the Bureau has been, and continues to be, the leading source of mineral-technology and mineral data. Its overall mission is to help insure that the United States has an adequate and dependable supply of minerals to meet its defense and economic needs at acceptable social, environmental, energy, and economic costs.

The Bureau consists of three directorates: Finance and Management, Information and Analysis, and Research. Finance and Management deals solely with the internal administrative functions of the Bureau. Information and Analysis and Research are responsible for conducting statistical surveys, special studies and research related to the mining industry, and disseminating this information to the general public.

Research is composed of the Division of Health, Safety, and Mining Technology, Division of Minerals and Materials, and Division of Environmental Technology.

The Division of Health, Safety, and Mining Technology is concerned with occupational health and safety and engages in a wide variety of studies. These include studies on such diverse topics as ergonomics, dust and ground control, roof bolting, mine communications, fire prevention, automated mining machines, and blasting techniques.

The Division of Minerals and Materials Science looks for ways to improve mining and processing, and conducts studies on materials conservation or substitution. Areas of research include the recovery of platinum from automobile catalysts, the processing of tantalum tailings for scandium, particle-liquid interactions during flotation processing, and producing ceramic powders using microwave-induced plasma and arc plasma reactors.

The Division of Environmental Technology is concerned with minimizing the impact of mining and mineral-processing operations. It conducts studies in a variety of areas, including toxic-metals cleanup in mine wastes, treatment of battery wastes and contaminated soils, neutralization of mine drainage, bacterial treatment of contaminated waters, and tailings stabilization.

Information and Analysis is divided into five divisions. These are the Division of International Minerals, Division of Policy Analysis, Division of Resource Evaluation, Division of Statistics and Information Services, and the Division of Mineral Commodities. Each of these divisions has a distinct function.

Mozian, Zareh, 1993, U.S. Bureau of Mines' role in industrial minerals, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 79–84.

TABLE 1.—PRODUCTION AND VALUE OF SELECTED MINERAL COMMODITIES FOR THE UNITED STATES

Commodity	Production (million short tons) 1991	1992	% change	Value (million dollars) 1991	1992	% change
Crushed stone	1,102.9	1,155.2	+5%	5,186.8	5,575.0	+4%
Construction sand & gravel	780.3	805.7	+3%	2,805.5	2,929.7	+4.5%
Cement	71.300	76.484	+7%	3,529.0	3,801.0	+7%
Common clay	40.123	38.106	–5%	1,500.0	1,900.0	+27%
Gypsum	15.456	16.300	+5%	94.2	99.0	+5%
Iodine	1.999[a]	2.042[a]	+2%	31.389	27.000	–16%

[a]Million kilograms.
Source: USBM Mineral Commodity Summaries 1992, 1993. USBM Annual Reports: Crushed Stone, Sand & Gravel (Construction), Cement, Clays, Gypsum, Iodine, 1991 and 1992.

The Division of International Minerals follows mining activities in 168 countries. Their reports cover mining, imports, exports, trade, and industry events within each country; they are published each year in the Minerals Yearbook and in Mineral Perspectives.

The Division of Policy Analysis evaluates the impact of items such as regulations, trade agreements, and national policy that could affect the mineral industry. Several issues that the Division has studied include the 1986 Comprehensive Anti-Apartheid Act, Mine Safety and Health Administration's (MSHA) NOx regulations, the Basel Convention, and the General Agreement on Tariffs and Trade (GATT) agreement.

The Division of Resource Evaluation is responsible for assessing the availability of minerals essential to U.S. industry and defense. Their studies focus mainly on strategic and critical minerals, and provide policymakers with information that is vital for long-range planning.

The Division of Statistics and Information Services has the task of physical distribution, collection, tabulation, compilation, and editing the thousands of canvass forms sent out all over the nation to the participants of the Bureau's volunteer surveys.

The Division of Mineral Commodities is responsible for analyzing the data and other information provided by these surveys on the mining industry. Within the Division of Mineral Commodities are the Branch of Industrial Minerals, Branch of Metals, Branch of Materials, and the Office of State Activities.

The Branch of Materials was created to cover a new area of interest for the Bureau. While the Bureau has traditionally followed the minerals and metals industries, there is a growing interest in materials that are displacing minerals and metals in manufacturing. As a result of this interest, the Bureau created the Branch of Materials. Its primary function is to monitor the manufacture and use of ceramics and polymers that could displace minerals and metals in the manufacturing sector.

The Branch of Industrial Minerals and the Branch of Metals, along with the Office of State Activities, report on events, regulations, production, sales, and trade pertinent to the mining and manufacturing industry for more than 100 commodities and all 50 states and U.S. territories. Much of this is accomplished by the commodity specialists, who are in daily contact with the thousands of mining-company officials, industry trade associations, independent consultants, brokers, and principals from plants, mills, and other processing facilities, so as to be apprised of the most current events and trends concerning these commodities and their associated industries.

Each January the Bureau publishes "Mineral Commodity Summaries," which reviews events and presents statistics on mineral operations for the previous year. This publication presents a two-page summary of salient information on each of approximately 90 mineral commodities.

A companion annual publication entitled "State Mineral Summaries," was published for the first time in February 1989. It provides a summary review of mineral developments of the preceding year on a state-by-state basis.

Monthly and quarterly data on select commodities are published as "Mineral Industry Surveys," each of which covers significant mineral-industry events for a single mineral commodity; these surveys are published as soon as the statistical data are available, usually 45 working days after the close of the period reported.

Annual data, which are more detailed than the monthly and quarterly data, are published in the three-volume "Annual Report," formerly entitled "Minerals Yearbook." Volume I contains a separate chapter on each of the mineral commodities reported. Volume II contains

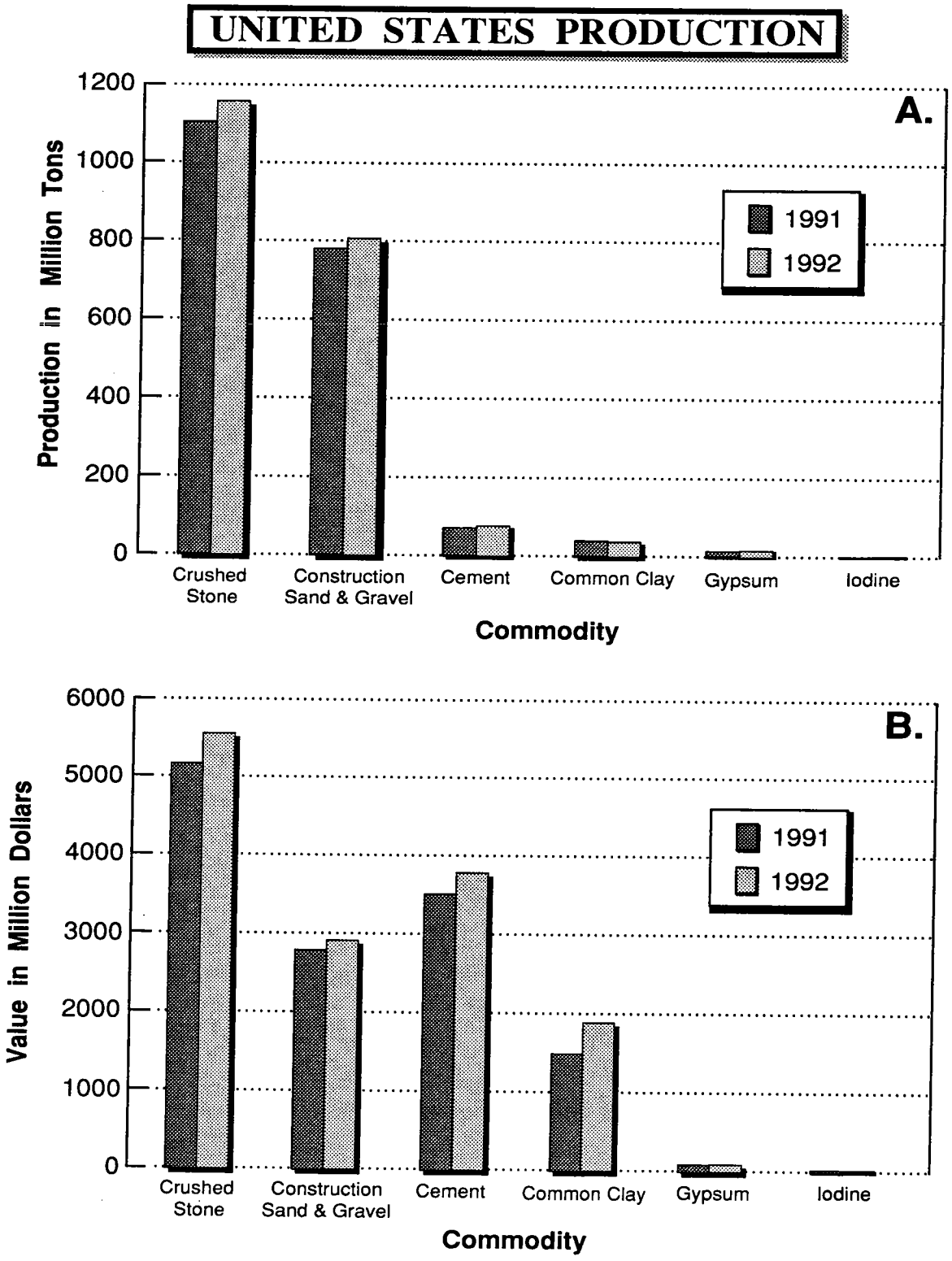

Figure 1. Production (A) and value (B) of selected mineral commodities for the United States (see Table 1).

TABLE 2.—PRODUCTION AND VALUE OF SELECTED MINERAL COMMODITIES FOR OKLAHOMA

Commodity	Production (million short tons) 1991	1992	% change	Value (million dollars) 1991	1992	% change
Crushed stone	25.7	26.1	+7.5%	95.5	100.0	+5%
Construction sand & gravel	9.000	10.200	+13%	22.3	25.8	+13%
Cement	1.665	1.680	+1%	65.5	65.9	+0.5%
Common clay	0.747	0.713	–5%	4.2	5.1	+21%
Gypsum	2.400	2.500	+4%	12.9	13.6	+5.5%
Iodine	1.999[a]	2.042[a]	+2%	31.389	27.000	–16%

[a]Million kilograms.
Source: USBM Mineral Commodity Summaries 1992, 1993. USBM Annual Reports: Crushed Stone, Sand & Gravel (Construction), Cement, Clays, Gypsum, Iodine, 1991 and 1992.

chapters on the nonfuel-mineral industry of each of the 50 states, the island possessions of the United States in the Pacific Ocean and the Caribbean Sea, and the Commonwealth of Puerto Rico. Volume III is international in scope, covering activity of the mineral industries in each of the 168 countries for the reporting year.

ISSUE ANALYSIS

The Bureau not only gathers data concerning mineral production and mineral resources, it uses that information to analyze issues involving minerals in the United States. Bureau analysts prepare special studies in response to requests from Congress and other federal agencies. They conduct an ongoing, comprehensive assessment of the nation's "mineral position."

An example of a recent analysis is a study of the crystalline-silica issue. In the 1980s, several health studies concluded that crystalline silica was a probable human carcinogen. As a result of these findings, OSHA was required to regulate crystalline silica under its Hazard Communication Standard (HCS). The standard requires that all materials handled by OSHA-regulated facilities be labeled according to the requirements of HCS, and that workers receive proper training on the handling of the material if the crystalline-silica content equals or exceeds 0.1%.

The Bureau became involved because of the number of inquiries being received from industry on the occurrence, definition, and analysis of crystalline silica in mineral production. We decided it would be appropriate to write a paper that reviewed the mineralogy of silica, its occurrence, and the analysis of bulk content by X-ray diffraction techniques.

An Information Circular (IC 9317) was published in 1992, entitled "Crystalline Silica Overview: Occurrence and Analysis." The first part of the paper explains the differences between crystalline, amorphous, and glassy materials; the differences between the different silica species (quartz, cristobalite, tridymite, opal, and chert); and the occurrences of silica in igneous, sedimentary, and metamorphic rocks, and in soils.

The second part of the paper deals with quantitative X-ray diffraction analysis for crystalline silica. It covers standards and conditions that may complicate mineral identification; it also covers our concerns about the accuracy of the quantitative X-ray diffraction techniques at low silica concentrations.

Since X-ray diffraction is dependent on diffraction of X-rays from crystal lattice planes, an X-ray diffraction standard that matches the crystallinity of the quartz in the sample should be used when performing quantitative analysis. The problem arises when the crystallinity of the quartz in the sample and standard do not match. If the quartz in a sample is better crystallized than the standard, then an apparent concentration exceeding 100% may be obtained. Conversely, low determinations may be obtained for samples containing poorly crystallized quartz. Our second concern is mineral identification. Mica, kaolin, feldspar, and graphite have X-ray diffraction reflections that coincide with some of the major quartz reflections. These can either mask or reinforce the quartz reflections, making it difficult (and sometimes impossible) to quantify, unless the analyst is very familiar with that particular deposit.

Our final concern is the accuracy of the quantitative technique at low levels. Quantitative analysis is somewhat routine when the concentration of quartz is high. When it is below 1% or 2%, quantification becomes difficult.

The effect that OSHA'S HCS has had on the mining industry is different for each segment of industry. The

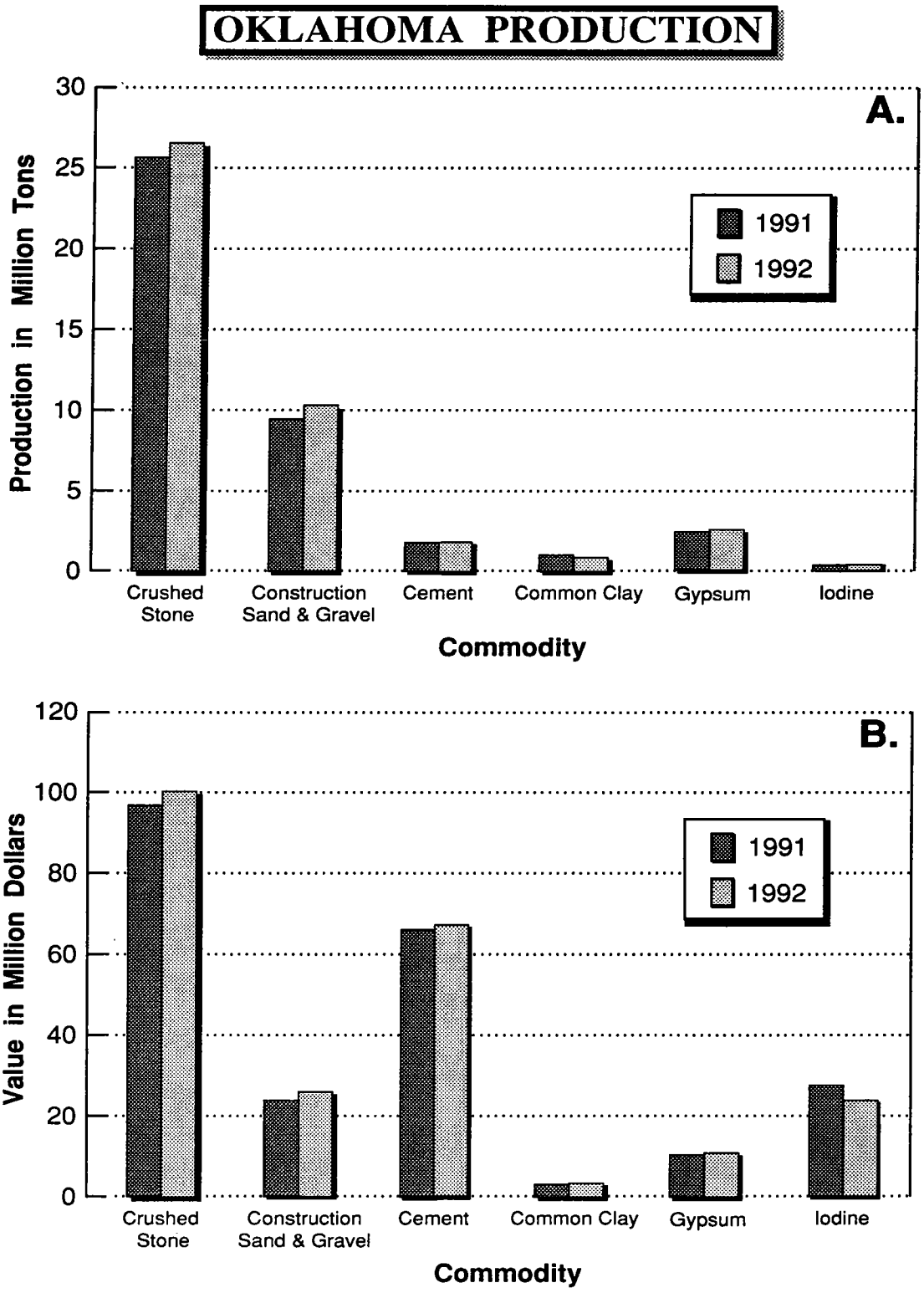

Figure 2. Production (A) and value (B) of selected mineral commodities for Oklahoma (see Table 2).

tripoli producers indicate that the regulation has had no net impact. All producers label their products, and substitution of other materials for tripoli has not been a serious matter. The impact on portions of the clay industry are different. Some producers are labeling and others are not. The net effect is that some of the companies that label their product are losing customers to competitors who do not label.

Even of more concern is the expense of litigation. Several of the mineral producers have had to defend themselves against asbestos-related litigation. They are concerned that, by labeling crystalline silica as a possible human carcinogen, the asbestos scenario will be repeated on a much larger scale.

What we wanted to stress in IC 9317 was: (1) that the classification of crystalline silica as a possible human carcinogen is not a trivial matter, considering the effect that it could have on the mining industry; (2) that the selection of a quartz standard should be undertaken carefully, if the analysis is to be accurate; (3) that proper analytical techniques should be used when identifying minerals to ensure accuracy at low concentrations; and (4) that some familiarity with samples is required, if quantitative analysis is to be attempted at low silica concentrations.

A special publication entitled "Crystalline Silica Primer" was also published by the Bureau in the latter half of 1992. The report addresses, in lay terms, the definition of the words silica and crystalline, discusses the abundance and occurrence of silica, and discusses the regulation of this material.

U.S. MINERALS PRODUCTION AND VALUE

The estimated value of U.S. nonfuel-mineral production (including metals and industrial minerals) in 1992 was 31.7 billion metric tons. This is a 3% increase over the 1991 figure of 30.8 billion metric tons. Industrial minerals in the United States are produced in more than 12,000 domestic mines, quarries, brine facilities, and processing plants; they are produced by 8,000 companies; and the industry produced minerals with a value of about $22.3 billion in 1991. This represents about 75% of the total value of domestic nonfuel-mineral production in the nation for 1991. This percentage is about the same for 1992. The Bureau's preliminary estimate for 1992 (based on the first three quarters) is about $20.7 billion, a decrease of about 8%.

Three main groups have traditionally been identified as the principal industries within the category of industrial minerals. These are the construction industries (combining building, transportation, and infrastructure), the agricultural industries (which includes the fertilizer industries), and the chemical industry. Together, these groups account for almost 90% of the value of all industrial minerals, or 67% of all nonfuel-mineral production in the United States. Construction minerals account for more than 60% of the value of production of all industrial minerals and, of these, crushed stone, construction sand and gravel, and cement dominate the list (Table 1; Fig. 1).

Minerals obviously contribute to the Oklahoma economy, and some of these minerals are important nationally (Table 2; Fig. 2). For example, brine wells in northwest Oklahoma are the country's sole domestic source of iodine. The Bureau's preliminary estimate for 1992 shows that Oklahoma is the leading gypsum-producing state. Also, Oklahoma is one of only seven states with feldspar production.

OUTLOOK

Mining, following the economy as a whole, experienced little growth in 1992. However, with modernized plants, efficient workforces, and lower operating costs, the mining industry is well-positioned to take advantage of an expected improvement in the general economy in 1993. Industry analysts predict that the nonfuel-minerals industry is ready for a turn-around. A period of sustained, moderate expansion of the economy is the impetus needed. Producers also ended 1992 with a somewhat optimistic view. However, there are concerns that the industry could be unduly burdened with the implementation of new environmental regulations or energy taxes.

Over the five-year period through 1997, it is expected that the high vacancy rate in office buildings, hotels, and other commercial buildings that existed in most major cities in 1992 will be considerably reduced. Consequently, increased commercial-building construction will result, which in turn will increase, to some extent, the demand for crushed stone, sand and gravel, and iron ore.

Infrastructure projects will provide a major stimulus for crushed-stone, sand-and-gravel, and iron-ore output through 1997. These projects will stimulate demand for steel of many types and, in turn, result in increased iron-ore consumption. Sustained improvement in the construction and motor-vehicle industries over the next several years could result in the value of U.S. nonfuel-minerals production (including metals) approaching $40 billion by 1997.

Future Development of Industrial Minerals in Oklahoma

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INTRODUCTION

Present and future utilization of most of Oklahoma's industrial-mineral resources is dependent upon the following factors: (1) the general economic climate, (2) consumer confidence, (3) construction activities, and (4) the potential for developing chemical industries. Federal and State governments have a major effect upon all four of these factors. By creating a feeling of confidence among the public and business, and a sense that jobs and incomes are not threatened, consumers will spend and build, thus providing the impetus to improve the economy and increase construction. Most Oklahoma industrial minerals are destined to go into construction projects in and around Oklahoma: such projects include highways, bridges, homes, commercial buildings, and large public projects. However, the potential also exists to use some of the State's high-purity industrial minerals, energy resources, and water resources to develop a strong chemical industry.

MINERAL-RESOURCE BASE FOR OKLAHOMA

As pointed out in the first article of this symposium volume (Johnson, 1993), Oklahoma has a large and varied resource base of industrial minerals. There are tremendous resources of most of the commodities that now are being produced, and these resources should support a viable mineral industry well into and, for some commodities, throughout the next century.

Stone resources are enormous in the Wichita and Arbuckle Mountains and in northeastern Oklahoma. Thick shales are widely distributed throughout most parts of the State. Gypsum and salt resources are measured in the billions of tons in western Oklahoma, and glass sands are plentiful in the Arbuckle Mountains and in the Arkansas River near Muskogee. Sand and gravel deposits are readily available in many of the alluvial and terrace deposits that cover much of Oklahoma. The reserves of iodine, tripoli, and volcanic ash are probably large enough for decades of production.

So, the mineral-resource base for Oklahoma exists. In some cases, however, the minerals are not where we want them to be. We must, therefore, transport most construction minerals 60—100 mi to the Oklahoma City metroplex and pay the extra transportation charges as part of the cost of construction. Fortunately, the Tulsa area contains a large resource base of limestone, shale, cement, and sand and gravel; therefore, transportation costs are much lower in supplying construction minerals to the Tulsa metroplex. By improving our knowledge of the distribution, quality, and quantity of Oklahoma's mineral resources, we can assist industry in developing the best resources in an economical manner. This knowledge of our mineral-resource base will be improved by detailed geologic mapping, and by sampling, testing, and describing potentially usable mineral deposits.

ECONOMIC CLIMATE

According to the U.S. Department of Commerce, orders for durable goods rose nationwide in October 1992 by 3.9% over the previous month, the largest increase in 15 months; orders then rose again in November and in December. Also, the nation's economy posted a stronger growth during the third quarter of 1992 than during any time in the past four years, with total goods and services growing at an annual rate of 3.9%.

Another favorable indicator is seen in reports that retail sales nationwide have been rising slowly, but steadily, since last spring, and Christmas spending in 1992 was higher than in the previous year.

Mankin, C. J.; and Johnson, K. S., 1993, Future development of industrial minerals in Oklahoma, *in* Johnson, K. S. (ed.), Industrial-minerals development in Oklahoma—a symposium: Oklahoma Geological Survey Special Publication 93-2, p. 85–88.

A significant indicator of the economic climate is in unemployment figures. During the second week of November, the Labor Department reported that 3% fewer people nationally filed initial claims for unemployment benefits. During each week for the preceding two months, the number of such claims has held steady or has dropped slightly.

CONSUMER CONFIDENCE

All these factors dealing with the economic climate have worked towards improving consumer confidence to some degree. A business-research group reported that consumer confidence rose about 20% in November 1992 over the previous month, and remained at a similar high level through January 1993; this confidence probably reflects the various economic factors described above, as well as some optimism over the presidential election of November 1992. There appears to be an expectation that the new administration will do something to improve the economy, although we don't know what it will be.

Further evidence of consumer confidence is seen in recent rising of the Dow-Jones averages on the stock market. For the 12-month period ending June 1993, the Dow has risen 248 points, an increase of almost 8%.

CONSTRUCTION ACTIVITY

Construction activity is poised, ready for an increase in the near future. Home construction, public buildings, and highway construction all have seen some favorable signs lately, and this bodes well for the industrial minerals used in construction.

National sales of existing homes rose about 20% during October–December 1992, compared to the first nine months of the year, thus helping the sagging real-estate market. With mortgage rates averaging about 8% (a 20-year low) in the beginning of 1993, home-buying in 1993 should improve significantly. New-home starts increased nationally in 1992 for the first time in six years. Housing starts rose 18.5% in 1992 over the previous year, according to the U.S. Department of Commerce; this was the largest increase in housing starts since 1983, when the economy was emerging from the previous recession.

The prospects for public-building activity is promising. The State of Oklahoma passed a $350-million bond issue in 1992 to fund capital improvements for higher education. Inasmuch as most of these dollars are to be matched, to some degree, by private funds, the total available for construction will be well in excess of $350 million. These construction funds will be spread widely around the State among the 25 colleges and universities. Where additional funds are needed to begin a project, startup of construction may be delayed until some or all of those funds are raised.

There probably will be very little construction of commercial buildings in Oklahoma over the next few years, or maybe even through the end of this century. Commercial buildings were overbuilt during the frenzied building days of the 1970s and early 1980s, and much of this space is not being used at the present time.

Highway construction has a potential to increase over the next few years, depending mainly upon political activity. Our nation's interstate system is aging and much of it is in need of major renovation: many of the highways should be resurfaced or rebuilt, and many of the bridges need to be replaced. Federal legislation, passed early in 1992, called for an increase in highway construction beginning October 1992, and the amount of money going into such construction is to increase a little bit each year for six years. However, the allocation of moneys for the first quarter of fiscal 1992 (October–December 1992) was limited by the federal government to only 15% of the year's authorization, instead of the anticipated 25%: this will cause deferral of some of the construction that had been planned for this quarter, and if such reduced allocations continue, it will push back highway construction even further.

President Clinton had announced plans to pump $20 billion per year nationwide into building projects, including transportation, communications, and environmental projects. He also announced plans for tax breaks for businesses that buy new equipment. The economic stimulus package that was proposed by the President early in 1993 would have increased demand for highway and bridge construction materials, but that proposal did not survive Congressional action. Nevertheless, the expected increase in release of federal highway construction funding will have a positive effect on the demand for required construction materials. Because of the dominant role of construction materials in the State's industrial-mineral economy, an increase in federal highway funds will have a very positive effect on industrial-mineral production in the State.

The Oklahoma Turnpike Authority may also continue building new turnpikes, so there is a possibility of another $200–$300 million being funneled into new toll roads in the next several years.

So, with all these factors impacting highway construction, it is clear that increased spending on highways is quite dependent upon political decisions in Washington and in Oklahoma.

Another construction-type activity is the servicing of oil and gas wells drilled in Oklahoma. Cement is used in completion activities, such as setting casing, etc., and crushed stone is used in making access roads to the drill sites. There is no general indication of significant recovery in Oklahoma oil-and-gas drilling activity at this time, although in late 1992 and early 1993 the rig count was up about 50% over the previous year. Increases in wellhead

prices of natural gas, spurred by increased demand, should trigger an increase in drilling during 1993.

THE POTENTIAL FOR CHEMICAL INDUSTRIES

Oklahoma has vast amounts of certain high-purity minerals that are suitable as raw material for various chemical industries. Major deposits of high-purity limestone, dolomite, and silica sand are in the south-central and eastern parts of the State, whereas gypsum and salt are widespread in the west. These resources are currently being worked, but chiefly for nonchemical products. Ample room is available for major expansion into chemical fields, with Oklahoma minerals as potential sources for caustic soda, soda ash, chlorine, sulfur, sulfuric acid, lime, sodium silicate, and other chemical products. Oklahoma also is blessed with large supplies of energy and water needed for chemical processing. Oil, natural gas, and water are plentiful in most parts of the State, and bituminous coal is abundant in the east. Most high-purity mineral deposits are near highways and railroads, and the Arkansas River navigation system has opened eastern Oklahoma to low-cost barge transportation on the Mississippi River, and to ocean-going vessels.

VIEWS OF OKLAHOMA COMPANIES

An informal survey of companies involved in mining the major industrial minerals of Oklahoma provides a mildly to moderately optimistic outlook for 1993, and beyond. Oklahoma producers of stone, sand and gravel, cement, gypsum, and brick all look for increased production in 1993, and most of them anticipate production increases of about 3–10%. This projected increase results in part from the companies' mildly optimistic views of the State's general economic climate, the upturn in consumer confidence, and the likely increase in construction activity, mainly of public buildings and highways.

Among the specific concerns of some Oklahoma companies are regulations and certain other activities that affect business. At times, regulations are drawn up by persons unfamiliar with mining activity and the minerals business. Regulators need to continue to work with, and have input from, industry in developing and refining regulations. This will improve our ability to mine our needed resources in an environmentally sound manner and in ways that ensure worker safety.

Also, sometimes it is difficult to secure permits for mining lands in some areas, particularly in urban and developed areas. The distribution of mineable resources is dictated by the geologic history of Oklahoma, and the minerals needed to maintain our infrastructure and to continue our growth can be obtained only in certain areas. For example, we cannot require that all mining be limited to the Panhandle, where it would impact the least number of people. Most industrial minerals have a "high place value"; that is, they have economic importance, or high value, because of their "place," because they are located at, or near, the market areas. Most Oklahoma industrial minerals also are bulky materials, and the cost to ship them great distances would be substantial. This means that the costs for construction would rise markedly as the distance from the mine to the market area increases, and the consumer or taxpayer ultimately has to pay these extra costs.

A non-geologic factor important to present and future mining activity in Oklahoma is Workman's Compensation. There undoubtedly are cases of fraud and abuse of the system, and the awards and legal fees can be quite a heavy burden. One company estimates that about 15% of all its labor costs are a result of Workman's Compensation activity. If awards for compensation should be made in the future for intangibles, such as stress, it could greatly impact the ability of a company to do business in Oklahoma.

CONCLUSIONS

Since the Industrial Minerals Workshop was held in December 1992, a number of emerging national policies and expected tax changes will have an effect on the demand and cost of industrial minerals in the nation. In order to address the critical issue of national-deficit reduction, some form of energy tax is expected to be implemented. Regardless of its form, any tax on energy is likely to have a negative effect on the economics of industrial-minerals production and transportation. The magnitude of that effect will depend upon the manner in which the tax is levied and the size of the tax.

The uncertainties concerning the future of industrial-mineral development in Oklahoma are coincident with the uncertainties of the region's and nation's economy. Oklahoma's economy rests heavily on the export of raw materials to other parts of the nation. More than two-thirds of our natural gas is exported to other states, and most of our crude oil is refined elsewhere. Almost all of our agricultural raw materials (grain and livestock) are shipped out of state for processing. Even many of the industrial minerals that are extricated in Oklahoma are shipped out of state for final use. Thus, the demand for these commodities regionally and nationally bears heavily on the State's economic well-being. A positive economic condition for the State is an essential requirement for those industrial minerals that are used in construction; cement, stone, sand and gravel, clay and shale, and gypsum. These commodities accounted for about 80% of Oklahoma's total industrial-mineral production during 1992. Thus, expanded demand for construction materials will require good economic conditions to exist in the State, and these conditions in turn are dependent upon a positive national economy.

In summary, there is an air of mild optimism among Oklahoma's industrial-mineral producers. Additional downstream processing of mineral commodities within Oklahoma would increase the economy and jobs in the State, and thus would further accelerate expansion of the mineral industries.

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