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G U I D E T O M I N E R A L R E S O U R C E S A L O N G I-44

R O L L A T O S T. L O U I S, M I S S O U R I

by

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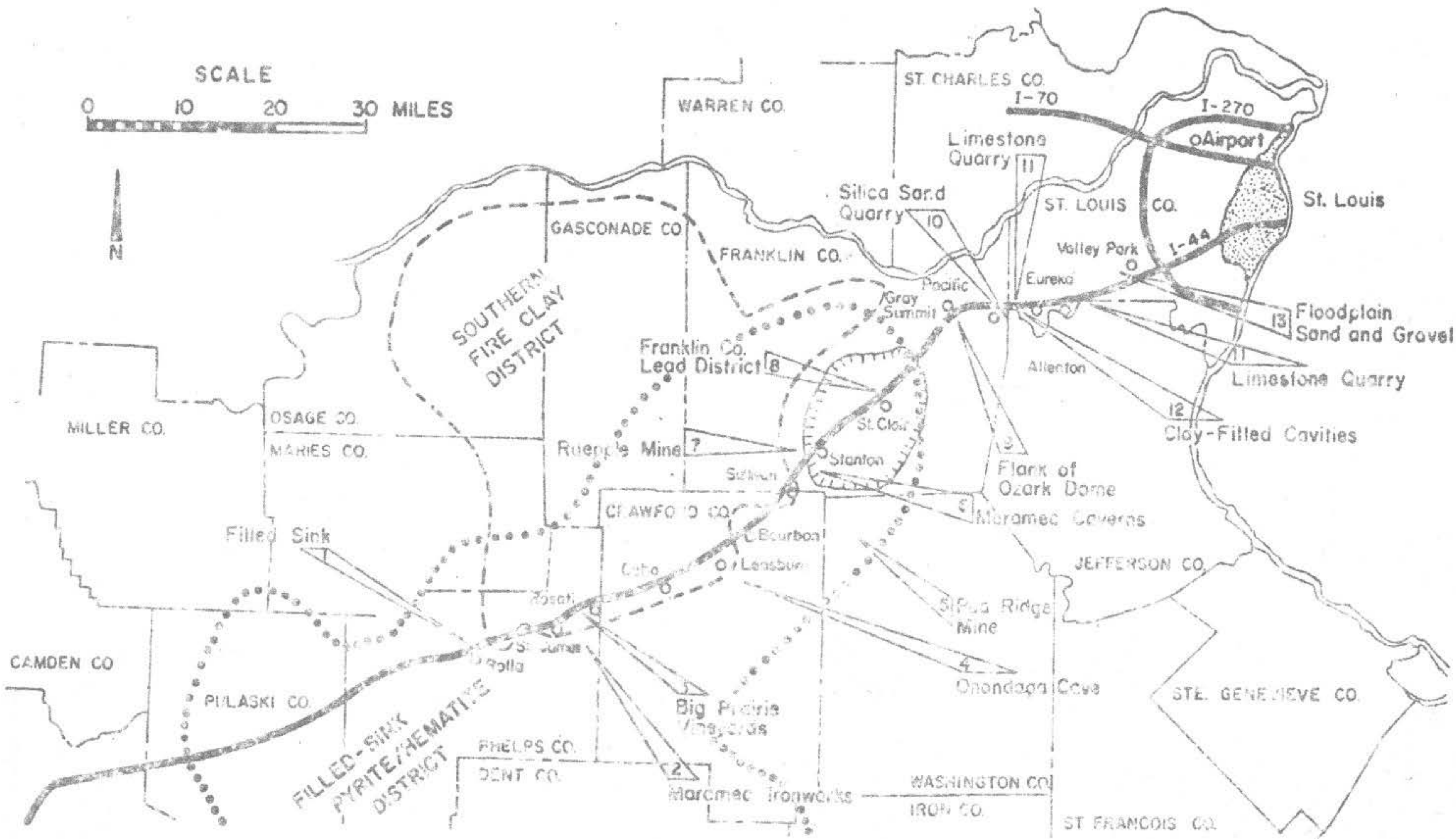
GUIDE TO MINERAL RESOURCES ALONG I-44
ROLLA TO ST. LOUIS, MISSOURI



PREFACE

This guide is not intended to be (and certainly is not) a comprehensive, outcrop-by-outcrop account of the geology from Rolla to St. Louis. Its simple purpose is to locate and summarily describe those mineral deposits and ore districts which lie adjacent to the tour route. Not all of the sites or areas discussed are of major economic significance today - - - but they were - at one time - to someone. If your trip is made a bit more interesting or enjoyable, the guide will have served its purpose.

INTRODUCTION

Most of the route from Rolla to St. Louis traverses a ruggedly dissected upland plain called the Salem Plateau, which throughout this area is undertain by nearly flat-lying Lower Ordovician dolomite and sandstone. A major unconformity exists at the top of the Lower Ordovician strata, and they are directly overlain by Pennsylvanian shale and sandstone. In general, these later sediments are but a thin veneer, the bulk having been removed by the forces of erosion.

The most prominent characteristic of the Salem Plateau is the extensive development of karst features - - - upland sinkhole plains, major cavern systems, and large, deep-circulating springs exist throughout the area. Paleokarst features - filled sinkholes and filled caves - are quite common in the upland areas.

Virtually all of the rocks exposed in roadcuts along I-44 from Rolla to Gray Summit (70 miles) are either Lower Ordovician dolomite and sandstone or Pennsylvanian sandstone and shale. Paleokarst features are well exposed in several roadcuts. East from Gray Summit to St. Louis, I-44 traverses the more-steeply dipping strata that constitute the northeast flank of the Ozark dome. Roadcuts in this area expose successively younger sediments ranging in age from Middle Ordovician to Middle Mississippian.

1. SMALL SINKHOLE-FILL DEPOSITS OF COMMON CLAY, SANDSTONE OR REFRACTORY CLAY

Immediately east of the Vichy Road overpass in Rolla, roadcuts on both sides of I-44 beautifully expose a filled-sink structure. Pennsylvanian shale, sandstone, and common clay fill a solution void in Early Ordovician argillaceous dolomite. Contorted, steeply dipping beds within the sink at the east end of the structure (on the south side of the highway) are dramatic evidence of stratigraphic displacement.

Some controversy exists as to whether overlying Pennsylvanian beds were let down slowly as solution progressed in the underlying dolomite, or whether they literally "fell in" as a cavern roof collapsed. Perhaps both mechanisms were responsible to varying extents, but evidence seems to favor the former.

This well-exposed structural feature is of more than just local interest - - - altogether more than 1000 such filled-sink deposits are known to exist on the north and west flanks of the Ozark Dome. They contain, at various places, shale, sandstone, chert, common clay, refractory clay, diaspore, coal, hematite, limonite, pyrites, galena, sphalerite, and other minor minerals. In any number of instances the fill material has significant commercial value.

In this immediate area and for 50 miles to the north and northeast, numerous of these sink structures are filled with valuable refractory materials, and constitute what is called the Southern Fire Clay District. Individual pits range in size from 100 feet in diameter to several acres in extent with depths ranging from 25 to more than 100 feet. The majority are small, and the average pit contains from 5,000 to 20,000 tons.

Quality ranges from 25-percent Al_2O_3 for low-grade plastic fire clay to 70+ percent for first-grade diaspore. Diaspore reserves, however, are virtually exhausted, and most clays produced today contain between 30 percent and 60 percent alumina. The filled-sink refractory "clays" are thought to be derived from common clay and shale by the process of groundwater leaching - - - soluble salts, calcium, magnesium, silica, iron, and other constituents are removed, leaving a material more or less high in alumina. The entire process of deposition and "laterization" is thought to have occurred during Pennsylvanian time (McQueen, 1943).

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1. SMALL SINKHOLE-FILL DEPOSITS OF COMMON CLAY, SANDSTONE OR REFRACTORY CLAY continued. . .

The Southern Fire Clay District annually produces about 280,000 tons of refractory clay valued at nearly $4 million, about one third of the state's total fire clay production. Missouri refractory products, especially the diaspore refractories, have always been in big demand, and have played several important roles in history. The boilers of many World War II Liberty Ships and U.S. Navy warships were lined with high-alumina, 60-percent, diaspore "bricks" from Missouri. More recently, the Cape Kennedy launching pads of Apollo lunar missions were surfaced by Missouri refractories (Keller, 1978).

SELECTED REFERENCES

McQueen, H.S., 1943, Geology of the Fire Clay Districts of East Central Missouri: Missouri Geological Survey and Water Resources, v. 28, 250 p.

Keller, W.D., 1978 (in press), Diaspore - A Depleted Non-Renewable Mineral Resource of Missouri: Missouri Geological Survey and Water Resources.

2. HISTORIC MARAMEC IRONWORKS - 1829 to 1876

The Maramec Ironworks, established in 1826, was the first iron-making establishment of economic importance west of the Mississippi River. It was organized as a self-contained iron plantation, and had many of the characteristics of a feudal manor. The owners, Thomas James and Samuel Massey, owned all lands, buildings, and equipment, including the homes of their approximately one hundred employees.

The first furnace, blown-in in 1829, was a cold-blast charcoal furnace with a capacity of 9 tons of pig iron per day. Besides the furnace,the works included three forges - refinery, ancony, and chaffery. In addition to pig iron, Maramec produced charcoal-wrought iron - bars, blooms, and anconies - and castings such as kettles, dutch ovens, stoves, cannonballs, railroad equipment, etc.

The major source of iron ore was the Maramec Mine, located only a half mile west of the furnace. Reports indicate that 375,000 tons of high-grade hematite ores were mined from this filled-sink deposit developed in Lower Ordovician dolomite. (For detailed information on filled-sink iron deposits, see discussion in this guidebook relative to the Ruepple Mine [7.] located at Stanton, Missouri.) Ore was mined, sorted, and sized by hand, and hauled by wagon to the furnace.

All power for the Maramec Ironworks was provided by wooden, undershot waterwheels powered by the waters of Maramec Spring. "In the never-ending torrents of water lay the requisite power to crank the giant pistons of the air compressors, to lift in endless repetition the heavy refining hammers, - - - "(Norris, 1964). This beautiful spring emerges two-tenths of a mile south of the furnace from a deep circular pool at the base of a bluff of Lower Ordovician dolomite, and flows north to the Meramec River nearly one mile distant. Maramec Spring has an average flow of 96 million gallons per day (149 cfs), and is the seventh largest spring in Missouri.

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2. HISTORIC MARAMEC IRONWORKS - 1829 to 1876 continued . . .

In 1857 the ironworks, then managed by William James, was enlarged and much improved. A new 14-ton-per-day furnace (the one still standing) replaced the old, and a powerful blowing-engine of new design was installed. About one hundred times each day the furnace was charged from the top with about 640 pounds of hematite, 100 pounds of flux, and 18 bushels of charcoal. Four times each day the molten iron was drawn off and run into the casting bed in front of the furnace. Yields from the rich hematite ore were good, regularly exceeding 50 percent.

Business boomed through the Civil War and Reconstruction years, but the ironworks was unable to keep up with rapidly advancing technology. The antiquated works could not compete with hot-blast, coal-fired furnaces or with rolling mills, and it declined until a nationwide financial crisis forced its closing in 1876.

For nearly half a century the Maramec Ironworks played an important role in the development of frontier Missouri. Today the relics of that history, and the beautiful spring are tastefully maintained for all to enjoy at "Maramec", a privately owned park administered by the James Foundation of New York.

SELECTED REFERENCES

Grawe, O.R., 1945, Pyrites Deposits of Missouri: Missouri Geological Survey and Water Resources, v. 30, 482 p.

Norris, J.D., 1964, Frontier Iron: The Maramec Iron Works, 1829-1876: State Historical Society of Wisconsin, 206 p.

Vineyard, J.D., 1974, Springs of Missouri: Missouri Geological Survey and Water Resources, WR 29, 272 p.

3. THE BIG PRAIRIE
VINEYARDS PLANTED ABOUT 1890

One of the first books published by the Missouri Geological Survey was an 1859 study by State Geologist G.C. Swallow entitled "Geological Report of the Country Along the Line of the South-Western Branch of the Pacific Railroad". The observant Dr. Swallow was struck by the abundance of wild grape varieties thriving on the cool upland areas of the Ozark Plateau. He described seven kinds of Missouri grapes - more wild vine species than anywhere else on earth.

Enthusiastically he proposed the planting of domestic varieties, and prophesied the development of a large wine-making industry for Missouri - - - "the day is not far distant when the purple vineyards will cover our hills, and the song of the vine-dresser will fill the land with joy, and the generous juice of the grape will improve our moral, intellectual, and physical powers".

For awhile viniculture boomed in Missouri, and for several years in the 1860's this state was one of the premier wine producers of the United States. Wineries were located in as many as forty-eight Missouri counties, and a few produced fine vintages that were world's fair gold-medal winners. Then came the nationwide prohibition law in 1920, effecting the closing of all wine-making establishments until its repeal in 1933. A maturing industry had been destroyed, and all across Missouri vines were pulled out to make room for other crops.

One area described by Dr. Swallow as favorable for viniculture was the central Missouri upland known as the Big Prairie - - - an area now traversed by I-44, and centered around the towns of Rosati and St. James. Grapes were first planted here in the closing years of the 19th Century, and today, most of Missouri's 2500 acres of vineyards are located in this area. While Concord grapes (for unfermented grape juice) constitute the bulk of production, wine grapes including French and New York State hybrids are being grown successfully. Once again there is wine-making fever in the area, and at last count the Big Prairie region boasted four bonded wineries, with a total annual production exceeding 50,000 gallons.

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3. THE BIG PRAIRIE
VINEYARDS PLANTED ABOUT 1890 continued . . .

Even if this state's own wine industry ultimately fails to fulfill Dr. Swallow's ambitious 125-year-old dream, Missouri can proudly and legitimately claim to be a part of most of the world's fine wines. Beginning sometime in the late 1850's the devastating phylloxera vine pest attacked vines in France, and by the turn of the century the plague had all but destroyed the vineyards of Europe and California. Two Missouri grape breeders, knowing the great disease resistance of Missouri wild grapes, advised foreign viniculturists and shipped millions of rootings (scores of train-carloads) to re-establish the dying vineyards of Europe and the American west coast. One of the men was awarded the Cross of the French Legion of Honor by the appreciative people of that country. Today, virtually all Vinifera vines in the western world are grafted to disease-resistant Missouri wild grape root-stock - - - the same hardy vines that so excited Missouri's first state geologist back in 1859.

SELECTED REFERENCES

Swallow, G.C., 1859, Geological Report of the Country Along the Line of the South-Western Branch of the Pacific Railroad: Missouri Geological Survey and Water Resources, 93 p.

Adams, L.D., 1973, The Wines of America: Houghton Mifflin Co., 465 p.

4. ONONDAGA CAVE

About seven miles southeast of the Leasburg interchange, and situated in the bluffs of the Meramec River, is Onondaga Cave. While caves are certainly not mineral resources in the strict sense of the term, their secondary mineral deposits often provide scenic and esthetic values enabling their development as financially rewarding tourist attractions. Onondaga Cave, developed in Upper Cambrian and Lower Ordovician dolomite, is one of this state's more impressive and successful tourist caves.

Missouri is often called "the cave state" because she has within her boundaries more known caves than any other state in the U.S., at last count 3,719. Most of these are developed in the Cambrian and Ordovician dolomites of the Ozarks region, or in Mississippian limestones of central, southwestern, and northeastern Missouri. While some of our caves are small, many include two or three miles of surveyed passages; the largest is an integrated karst drainage network with a total of nearly 25 miles of passages.

SELECTED REFERENCE

Bretz, J H., 1956, Caves of Missouri: Missouri Geological Survey and Water Resources, v. 39, p. 197-211.

5. PEA RIDGE IRON MINE (MAGNETITE/HEMATITE)

About 10 miles southeast of Sullivan is the Pea Ridge Mine, Mill, and Pellet Plant, a facility of the Iron Ore Division of St. Joe Minerals Corporation. The Pea Ridge ore deposit is a nearly vertical, dike-like mass of magnetite, situated discordantly within a series of steeply dipping rhyolite porphyry volcanics of Precambrian age. The magnetite body is a half mile long, has a maximum width of 600 feet, and a vertical extent of at least 2000 feet. The top of the ore body is truncated by a pre-Upper Cambrian erosion surface, and is buried beneath 1100 to 1400 feet of Upper Cambrian and Lower Ordovician sediments.

Fine-grained massive magnetite is the dominant mineral of the ore deposit, which also contains significant specular hematite, and lesser amounts of quartz, apatite, fluorite, pyrite, barite, calcite, sericite, and actinolite. In the major portion of the ore body, grade exceeds 60 percent iron, approximately 55 percent being magnetic iron.

The Pea Ridge ore deposit is Precambrian in age, and is classified a magmatic segregation of the Kiruna-type. More specifically, it is thought to be the forcefully injected, iron-rich differentiate of a silicic or intermediate magma, with associated, end-phase hydrothermal alteration and replacement of wall rock (Emery, 1968).

The deeply buried Pea Ridge deposit was discovered by aeromagnetics in 1950. The modern, 2-million-ton-per-year mine and pellet plant went on stream in 1964, and produced more or less continuously until December of 1977, when economic considerations forced its closing. The Pea Ridge Mine was at that time the largest underground iron mine in the United States. Hopefully, an improved economic climate will favor its reopening sometime in the not-too-distant future.

SELECTED REFERENCE

Emery, J.A., 1968, Geology of the Pea Ridge Iron Ore Body in Ore Deposits of the United States, J.D. Ridge, Ed., AIME, New York, p. 359-369.

6. MERAMEC CAVERNS

Three miles south of Stanton, on the Meramec River, is Missouri's most famous and most successful tourist cave, Meramec Caverns. Opened commercially in 1933, this cave now attracts nearly a half million tourists annually. (At $4.50 per admission, who would deny that this is an <u>economic</u> mineral resource? And, there is zero depletion. A perfect "ore" deposit!)

Meramec Caverns owes its phenomenal success to the showmanship and promotional genius of its owner, Lester Dill, referred to by many as the P.T. Barnum of the cave world. The cavern is billed as the hideout of the infamous 1870's Missouri outlaw, Jesse James.

SELECTED REFERENCES

Bretz, J H., 1956, Caves of Missouri: Missouri Geological Survey and Water Resources, v. 39, p. 166-184.

Weaver, H.D., 1977, Meramec Caverns - Legendary Hideout of Jesse James: Discovery Enterprises, Jefferson City, Mo., 126 p.

7. RUEPPLE MINE
SMALL SINKHOLE-FILL DEPOSITS OF PYRITE AND HEMATITE

About two miles northwest of Stanton is the long-abandoned Ruepple Mine, a large and well-defined filled-sink iron deposit. The large solution structure. developed in Lower Ordovician and Upper Cambrian dolomite and sandstone, measures 500-feet long, 350-feet wide, and 300-feet deep. The fill consists predominantly of common iron oxide and iron sulfide minerals - hematite, pyrite, and marcasite.

The Ruepple Mine was worked by open pit and underground methods - always with difficulty; backs and faces were hard to hold, and sulfurous gases were a serious problem. Production of iron ore (hematite) began in 1917 and continued to 1943 with a total yield of 367,000 tons. Pyrite and marcasite (for sulfuric acid manufacture) were produced from 1932 to 1934; yield was 19,000 tons. Total value of ores produced was $1.4 million.

The Ruepple ore body is just one of about 125 filled-sink iron deposits located in the north-central Ozark Plateau. All are structurally and mineralogically similar and are thought to have a common genesis. The original deposit or fill consisted entirely of the iron sulfides, pyrite and marcasite. Grawe (1945) suggests a primary origin involving mixing of downward-circulating, iron-rich waters, with groundwater containing hydrogen sulfide. He believed that the sink structures themselves acted as large leaching basins or "funnels", and the iron was leached from overlying Pennsylvanian-aged sediments. The age of mineralization is post-Pennsylvanian, possibly Cretaceous. When later erosion exposed the deposit to the atmosphere, the upper part (or in some cases, all) of the sulfide body was oxidized to a "gossan" of hematite and, to a lesser extent, limonite.

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7. RUEPPLE MINE
SMALL SINKHOLE-FILL DEPOSITS OF PYRITE AND HEMATITE continued . . .

At least one group of ancients (American Indians of unknown cultural affiliation) developed shallow but rather extensive underground workings in a filled-sink deposit for the purpose of obtaining hematite for red paint pigment. Modern mining of the filled-sink iron ores began in 1826 at the Maramec Mine (2.), and continued intermittently through 1960; pyrites were produced during the periods 1911 to 1920 and 1932 to 1940. It is estimated that the total production from all filled-sink pyrite/hematite deposits in Missouri is 3.6 million tons hematite (Hayes, 1967), and 250,000 tons pyrites (Grawe, 1945).

SELECTED REFERENCES

Grawe, O.R., 1945, Pyrites Deposits of Missouri: Missouri Geological Survey and Water Resources, v. 30, 482 p.

Hayes, W.C., 1967, Iron in Mineral and Water Resources of Missouri: Missouri Geological Survey and Water Resources, v. 43, p. 74-88.

8. FRANKLIN COUNTY LEAD DISTRICT
SMALL LEAD/ZINC/BARITE DEPOSITS

The area immediately about St. Clair, Missouri, and extending 6 to 8 miles in all directions, comprises what is formally known as the Franklin County Lead District. Earliest mining here is said to have been conducted by the Spanish in the closing years of the 18th Century. The district's most productive years extended from about 1830 to the mid-1890's, and very little ore has been removed since 1900.

Ore deposits are for the most part fissure veins in Lower Ordovician dolomite and sandstone. Veins are usually vertical, almost always narrow (only 2 to 4 feet wide), and consist of massive, coarsely crystalline white barite enclosing crystals and masses of galena and sphalerite. Some secondary cerussite, anglesite, and smithsonite were also taken as ore. In a recent study to determine genesis of closely related barite deposits in nearby Washington County, Wagner (1973) suggests an origin involving mixing of shallow meteoric waters with introduced, warm saline brines of unspecified origin.

All deposits were worked as shaft mines, the deepest operating below 400 feet, but most less than 150 feet deep. Mining was primarily by primative hand methods, and the average mine produced less than 4000 tons of ore - - - the largest produced only 13,000 tons. The total 100-year production of the district was probably less than 50,000 tons of lead metal, or about the same as the eight Viburnum Trend mines produce each month.

SELECTED REFERENCES

Winslow, Arthur, 1894, Lead and Zinc Deposits: Missouri Geological Survey and Water Resources, p. 693-699

Wagner, R.J., 1973, Stratigraphic and Structural Controls and Genesis of Barite Deposits in Washington County, Missouri: Unpubl. Ph.D. diss., University of Michigan

9. FLANK OF THE OZARK DOME

Throughout the 70 mile interval from Rolla to Gray Summit, I-44 traverses virtually flat-lying, Lower Ordovician sediments characteristic of the Salem Plateau, a dissected upland plain that defines the bulk of the interior of the Ozark uplifted area. East from Gray Summit to St. Louis, I-44 traverses the more-steeply dipping sedimentary strata that constitute the northeast flank of the Ozark dome. In the 25 mile drive from here to the west edge of St. Louis we will descend about 150 feet topographically, and pass through roadcuts exposing successively younger sediments, Middle and Upper Ordovician, Devonian, and Lower and Middle Mississippian in age.

SELECTED REFERENCES

McCracken, M.H., 1971, Structural Features of Missouri: Missouri Geological Survey and Water Resources, RI 49, 99 p.

10. ST. PETER SANDSTONE - - - SILICA SAND

Immediately south of I-44 and within the city limits of Pacific is the silica-sand mining facility of the Pennsylvania Glass Sand Corporation. Production is from a remarkably pure bed of quartz sandstone (99+ percent SiO_2) known as the St. Peter Sandstone. The massive, friable, 50- to 100-foot thick, mature Middle Ordovician sand outcrops in a narrow belt averaging one to three miles wide, and extending for more than 150 miles along the eastern edge of Missouri.

This facility is one of five in Missouri, all in the St. Louis region, that produce the St. Peter Sandstone. Their combined annual production approaches one million tons and is valued at $5.5 million. About half of this production is used in the manufacture of glass, the remainder as abrasives, molding sand, foundry sand, and for glass-polishing.

The St. Peter Sandstone is the major industrial sand resource in Missouri, and reserves are considered more than adequate to meet all future needs.

SELECTED REFERENCES

Wharton, H.M., et. al., 1969, Missouri Minerals - Resources, Production, and Forecasts: Missouri Geological Survey and Water Resources, Spec. Pub. 1, p. 95-101, 197-208.

11. LIMESTONE QUARRIES

The 2 stone quarries located on the route map are representative of several in this area developed in thin- to medium-bedded, dense to sublithographic limestone of Middle Ordovician age. This is one of the better-quality aggregate limestones produced in Missouri, and is characterized by low-percentage absorption, and excellent wear qualities. It finds use as aggregate for portland cement and asphaltic concrete, in cement manufacture, for terrazzo chips, as agricultural lime, riprap, and for all grades of common aggregate.

Stone quarrying is a very important business in the metropolitan St. Louis market area; current annual production is about 8.5 million tons valued at $14.5 million. The nearly 300 quarries operating in the State of Missouri last year produced more than 45 million tons of stone with a value approaching $100 million.

SELECTED REFERENCES

Wharton, H.M., et.al., 1969, Missouri Minerals - Resources, Production, and Forecasts: Missouri Geological Survey and Water Resources, Spec. Pub. 1, p. 106-121, 197-208.

12. CLAY-FILLED SOLUTION CAVITIES

Even a casual inspection of the sedimentary beds exposed in the deep roadcuts between Pacific and Allenton will reveal the existence of many clay- and sand-filled solution voids. These prominent filled-sink and cavern-fill structures are developed in Middle Ordovician limestone, and filled with Pennsylvanian sediments. They are genetically similar to the filled-sink structures discussed earlier in this guidebook.

This type of solution structure has economic significance also, but of a negative kind. The incompetent nature of the fill material makes highway construction in this area more difficult and more costly, and imposes serious maintenance problems. Local quarry operators producing the valuable Middle Ordovician limestone must carefully avoid the filled sinks, or be content with a much inferior, diluted product.

13. FLOODPLAIN SAND AND GRAVEL DEPOSITS

Just north of I-44 and west of the Highway 141 interchange at Valley Park, sand and gravel are produced from alluvial deposits in the floodplain of the Meramec River. The alluvium consists predominantly of chert gravel and quartz sand derived from Mississippian and Ordovician limestones and dolomites traversed by the meandering Ozark stream.

Meramec River gravels are of a superior quality, and in high demand for use as aggregate in ready-mix concrete, and for virtually all other aggregate uses. Floodplain and in-channel deposits of the Meramec River are the major source of construction gravel for the St. Louis metropolitan area, and about 3 million tons per year are produced by the dozen or so operators working within its banks.

While the natural supply of Meramec River gravels is for all practical purposes inexhaustible, urban sprawl, zoning ordinances, and increasing environmental concern are restricting development of this valuable construction resource. Today, it is all but impossible to open a new sand and gravel facility in the lower Meramec River Valley.

SELECTED REFERENCES

Wharton, H.M., et.al., 1969, Missouri Minerals - Resources, Production, and Forecasts: Missouri Geological Survey and Water Resources, Spec. Pub. 1, p. 86-94, 197-208.

ST. LOUIS AREA MINERAL PRODUCTION

The St. Louis region, including Jefferson, Franklin, St. Charles, and St. Louis Counties and the City of St. Louis, annually produces minerals and mineral products valued in excess of $50 million. No metallic mineral deposits are known in this area - all production is of construction or industrial minerals.

The following table summarizes current annual mineral production of the St. Louis region.

MINERAL OR MINERAL PRODUCT	ANNUAL PRODUCTION	ANNUAL VALUE	PERCENTAGE OF STATE TOTAL
cement	3 million ton cap.	(withheld)	50%
clay and shale	270,000 tons	$1 million	15%
crushed stone	8.5 million tons	$14.5 million	20%
construction sand & gravel	4 million tons	$6 million	30%
industrial sand	1 million tons	$5.5 million	100%

It is interesting to note that several abandoned quarries and worked-out clay pits in the St. Louis area are now being profitably utilized as solid waste disposal sites (trash dumps). In some cases they are so profitable that their value as a fill-site surpasses the total value of the mineral produced.