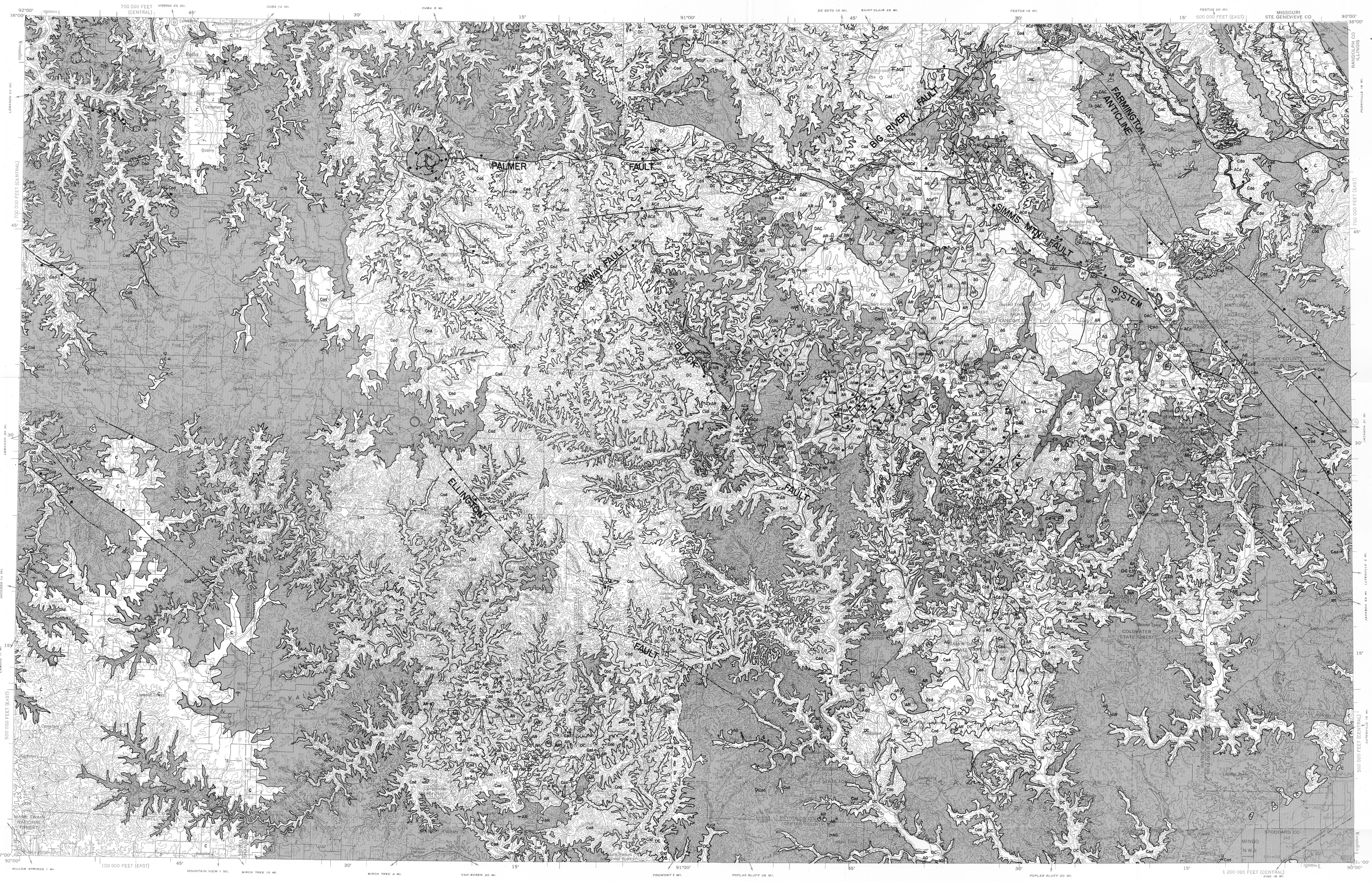
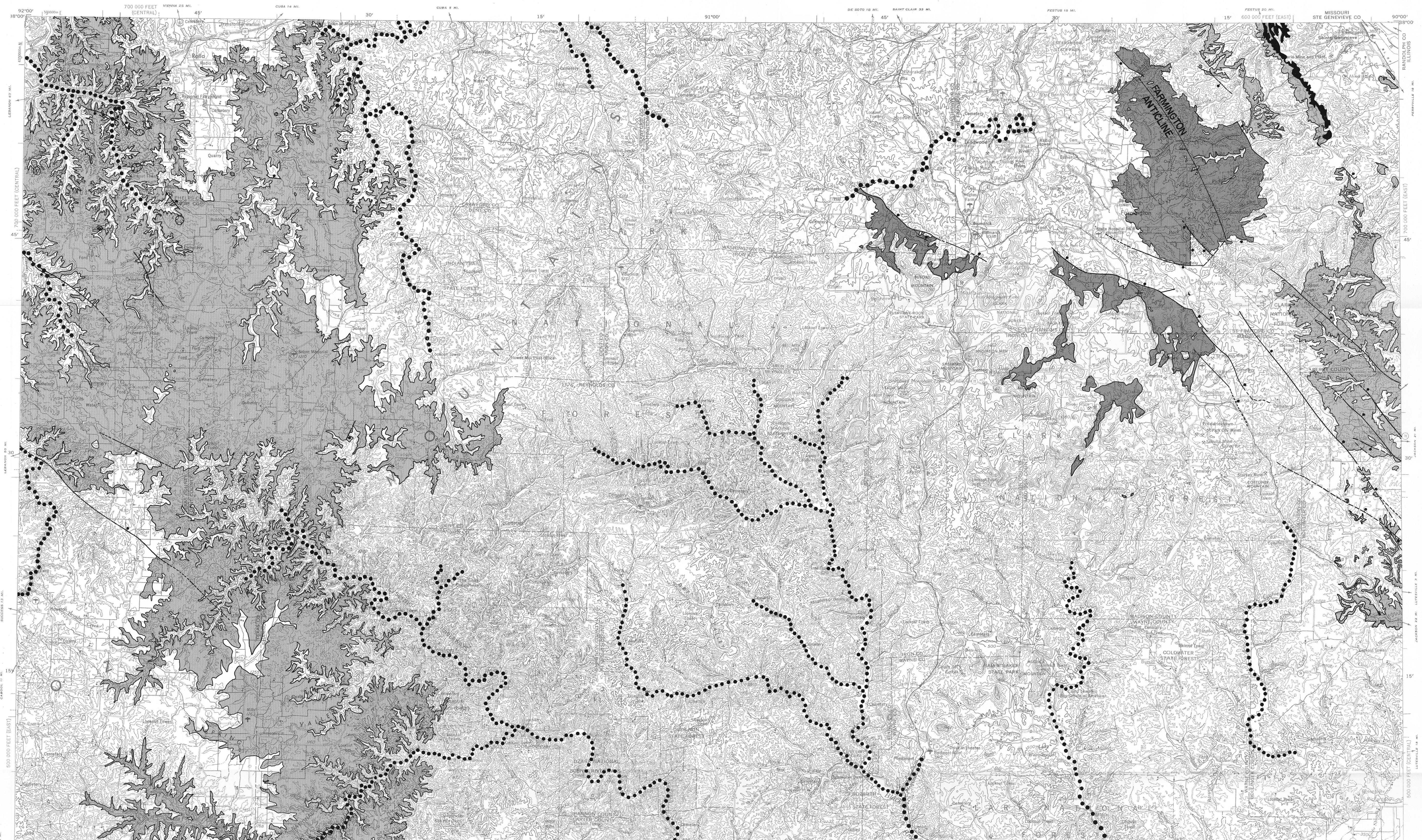
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE MISSOURI DEPARTMENT OF NATURAL RESOURCES, DIVISION OF GEOLOGY AND LAND SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1005-C
FOLIO OF THE ROLLA 1° X 2° QUADRANGLE, MISSOURI



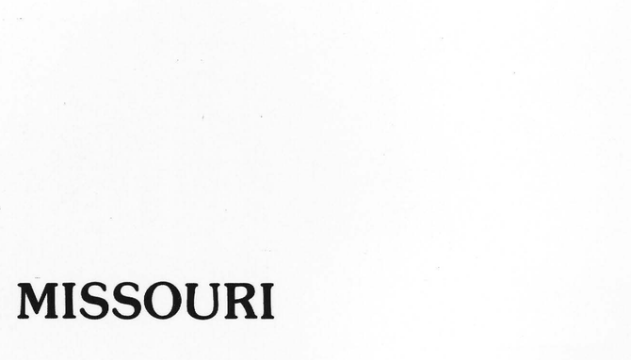
MAP A. CRUSHED STONE RESOURCES



Base from U.S. Geological Survey, 1954-69

Compiled in 1985

CONTOUR INTERVAL 100 FEET
WITH SUPPLEMENTARY CONTOURS AT 50 FOOT INTERVALS



MAP B. INDUSTRIAL SAND AND CONSTRUCTION SAND AND GRAVEL RESOURCES

INDUSTRIAL MINERAL RESOURCES OF THE ROLLA 1° X 2° QUADRANGLE, MISSOURI

By
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Missouri Geological Survey
1987

EXPLANATION FOR MAP A

Fault—Dashed where approximately located; bar and ball on downthrown side

Crushed stone resources—Stone resource categories, defined by use, are designated by letter, and if suitable for more than one category of use by a combination of letters. Known resources are identified by upper case letters and hypothetical resources are identified by lower case letters. A rock unit that is a known resource of high-purity dolomite, and a known resource of high-quality aggregate, and a known resource of commercial limestone and dolomite (for example, the Bonneterre Formation) is labeled DAC

- L **Known resources of high-purity limestone**
- D **Known resources of high-purity dolomite**
- d **Hypothetical resources of high-purity dolomite**
- G **Known resources of intrusive igneous rocks**
- R **Known resources of volcanic igneous rocks**
- A **Known resources of high-quality aggregate**
- a **Hypothetical resources of high-quality aggregate**
- C **Known resources of commercial limestone and dolomite**
- **Rock units and (or) areas with little or no commercial potential**

EXPLANATION FOR MAP B

Fault—Dashed where approximately located; bar and ball on downthrown side

Industrial sand and construction sand and gravel resources

- **Known resources of industrial sand**
- **Potential resources of industrial sand**
- **Hypothetical resources of industrial sand**
- ●●●●● **Alluvial construction sand and gravel resources**
- **Upland construction sand and gravel resources**

DISCUSSION

This map is part of a folio of maps of the Rolla 1° x 2° quadrangle, Missouri, prepared under the Conterminous United States Mineral Assessment Program. Other publications in this folio include U.S. Geological Survey Miscellaneous Field Studies Maps MF-1000-A and B, MF-1001-A and B, MF-1002-A through J, MF-1004-A through C, MF-1005-A and B, Miscellaneous Investigations Map I-1161, and Circular 869.

The industrial mineral resources of the Rolla 1° x 2° quadrangle are extensive and varied. Materials being produced at present are stone, and construction sand and gravel. Substantial resources of material potentially suitable for industrial sand are available; resources of clay and shale are extremely limited and, in most cases, of marginal quality. Products manufactured from these raw materials include lime, dolomitic lime, refractory dolomite products, construction aggregate, railroad ballast, dimension granite, and roofing granules.

CLAY AND SHALE

Clay and shale resources of the Rolla quadrangle are very limited and have little potential for significant economic development. Material present is of three different types: refractory clay, kaolin clay, and common shale.

Minor deposits of refractory clay have been worked in the extreme northwestern part of the quadrangle in Phelps and Crawford Counties. Flint and semi-flint clays are present in small filled-sink deposits, each containing on the average several thousand tons of marketable clay. The better flint clays are essentially pure kaolin and are suited for many high-temperature refractory products. In addition, clays of this type, after calcining, are used in the manufacture of alum. Many deposits contain significant amounts of iron, which limits their use for refractory products; however, these clays are used as additives in the manufacture of cement. Remaining resources are unknown and are thought to be small.

A very limited economic potential exists for kaolin clays in Bollinger County near Glen Allen. Known deposits are small and most appear to be preserved in filled-sink structures or within fault blocks in Ordovician bedrock. Deposits are impure and contain chert, quartz sand, and abundant iron stains. Deposits may vary both vertically and laterally within a few feet. The impurities and small size effectively limit any significant economic potential for these deposits.

CRUSHED STONE

Economic stone resources of the Rolla quadrangle are limestone, dolomite, sandstone, granite, and rhyolite (trap rock). Some rock units are suitable for use as all types of construction aggregate, others for aglime, and many for chemical and industrial use, while others have little or no economic potential. Bedrock over large areas in the southern part of the quadrangle is covered with 100 to nearly 400 feet of residuum.

Map A groups the mapped geologic units into use categories based on known or potential suitability for various uses. The use category for each unit was determined by present or past performance records of material from that unit, laboratory tests, and physical and (or) chemical similarity to other rock units with a history of use either within the quadrangle or elsewhere in southern Missouri. Table 1 gives approximate ranges for selected properties for rock units having extensive resources within the quadrangle. This information is highly generalized and individual sites must be evaluated on their own merit. For detailed information on the lithology and distribution of mapped rock units in the Rolla 1° x 2° quadrangle refer to Pratt and others (1985).

Stone resource categories developed for the Rolla quadrangle are the following: known resources of high-purity limestone, known resources of high-purity dolomite, hypothetical resources of high-purity dolomite, known resources of intrusive igneous rock (granite), known resources of volcanic igneous rock (rhyolite), known resources of high-quality aggregate, hypothetical resources of high-quality aggregate, known resources of commercial limestone and dolomite, and rock units with little or no commercial potential.

High-purity limestone for the purposes of this report is limestone that contains a minable section of stone with a minimum $CaCO_3$ content of 95 percent. These resources are restricted to the northeast corner of the quadrangle and are contained in two units, the Kimmswick and Salem Formations. (Sedimentary stratigraphic units referred to in this report are listed in table 1.) There is no present production of Kimmswick within the quadrangle; the Salem is quarried extensively in Ste. Genevieve County for the manufacture of lime and aggregate. Large tracts of land containing high-purity limestone resources are not present within the quadrangle.

High-purity dolomites are relatively widespread in the Rolla quadrangle. For the purposes of this report, dolomites with a minable section of stone containing over 40 percent $MgCO_3$ and with less than 5 percent noncarbonate are considered high-purity. Portions of the Bonneterre Formation and much of the Eminence Dolomite meet these requirements (table 2). The Bonneterre in the Bonne Terre-Fredericktown area is a potential source of high-quality stone for both chemical and aggregate use. Several aggregate quarries operate in this unit and one dolomitic lime plant is active near Bonne Terre. In many areas, particularly in the southern part of the quadrangle, the Eminence has become disaggregated into a loose carbonate sand, locally referred to as a "running lime." Extensive resources of dolomite from the Eminence are available in the western and southern parts of the quadrangle. Because of the thick overburden and disaggregation tendencies of the unit, careful evaluation of any proposed site is necessary.

Hypothetical high-purity dolomite resources include those formations that potentially contain a section of stone meeting the criteria for high-purity dolomite. Formations in this category include the Derby-Doerun and Potosi Dolomites, the Upper Cambrian stromatolite/mud facies (see Pratt and others, 1985), and the upper unit of the Gasconade Dolomite (table 2). Resources of these units are large and widespread.

Intrusive igneous rocks are present in the northeastern part of the quadrangle, in the Bismarck to Fredericktown area. Minor resources are present in the Des Arc area. They include fine-grained to slightly porphyritic to coarse-grained, red to gray granites. Most are quartz rich and contain abundant orthoclase. Present granite production (as was most past production) is for dimension stone. Southeast Missouri granites have some very limited potential for the production of feldspar for use in the glass, ceramic, and chemical filler industries. Serious drawbacks to their use is the high iron content of the feldspar and the difficulty in separating the feldspar from the country rock.

Volcanic rocks (rhyolite, trap rock) are common in Iron, southern Madison, and Shannon Counties. Past production has been for aggregate and dimension stone (curbing); present production is for aggregate, decorative stone, railroad ballast, and roofing granules. The use of this material for skid-resistant aggregate is increasing. Most production of rhyolite or trap rock for aggregate use prior to 1976 was from leftover waste rock from Precambrian-hosted iron mines such as Iron Mountain and Pilot Knob. Because this higher iron content results in a high specific gravity, some of the material was sold for use as high-density aggregate.

Known resources of high-quality aggregate are present almost exclusively in the eastern half of the quadrangle. High-quality aggregate is a somewhat arbitrary category and includes stone that meets the Missouri Highway and Transportation Department specifications as aggregate for portland cement, for concrete pavement, or as railroad ballast. Formations commonly meeting these specifications are the granites and trap rocks and the Bonneterre, Derby-Doerun, and Plattin Formations.

Hypothetical resources of high-quality aggregate are those that may contain a small section of stone meeting the specifications for uses outlined above. Some stone units are included in this category because of physical similarity to rock units utilized in other areas of southern Missouri for these purposes, or because of test data on samples from widely scattered localities. Principal formations included in this category are the Potosi and Gasconade Dolomites, Kimmswick Formation, and St. Louis Limestone.

Commercial limestones and dolomites include those carbonate rock units that have widespread commercial uses, such as aglime, asphalt stone, base stone, and other less stringent uses. Rock units considered in the commercial category are Bonneterre, Derby-Doerun, Potosi, Upper Cambrian stromatolite/mud facies ("white rock"), Eminence, Gasconade, Jefferson City, Cotter, Powell, Joachim, Plattin, Kimmswick, Salem, St. Louis, and Ste. Genevieve.

Numerous rock units have little or no commercial value. Perhaps the most common reason is the simple lack of generally desired chemical and (or) physical properties. Other reasons include limited distribution, lack of minable thickness, abrupt lateral and vertical variation in lithologic character, and occasionally lack of performance data or use record. Some areas shown on Map A have little economic potential because of thick residual overburden, the tendency of certain rock units to become disaggregated and form "running lime," or because of structural deformation which has made the stone resources difficult to mine, and may have altered physical or chemical properties.

DIMENSION STONE

The Rolla quadrangle has a long history of producing dimension stone although there is only limited present production.

Several carbonate rock units, principally the Kimmswick Formation, Little Saline Limestone, and Grand Tower Limestone, have been extensively quarried in the past for marble. In recent years only rough blocks were produced and were shipped outside the quadrangle for finishing. All production ceased in the early 1970s.

Three units, the Lamotte Sandstone, Roubidoux Formation, and Aux Vases Sandstone, have had past usage as dimension sandstone. Minor production of sandstone from the Roubidoux continues in the southern part of the quadrangle.

Production of granite for dimension purposes continues with two producers active in the northeast part of the quadrangle. Only rough blocks are produced and all material is shipped out of state for finishing, mostly for monuments.

With the vagaries of architectural demand and styling along with high costs, the potential for increased future dimension stone production is speculative. Should a market develop, ample resources are available. For the distribution of the formations mentioned refer to the geologic map by Pratt and others (1985).

INDUSTRIAL SAND

Industrial sand resources in the quadrangle are quite large, although there is no present production. Known high-quality resources are available in the St. Peter Sandstone, and large resources of potentially good quality material are available in the Lamotte Sandstone. Hypothetical resources may be available in the Roubidoux, Aux Vases, and Everton Formations. The locations of these resources are shown on map B. Representative size data are given in table 3, and representative chemical data are given in table 4.

The St. Peter Sandstone is a well-known source of industrial (silica) sand in the midcontinent, and production is reported from three sites in eastern Missouri. There is no production recorded within the Rolla quadrangle. The St. Peter is a very pure orthoquartzite; it is white when fresh, tan or light brown on weathered surfaces, and composed of well-rounded, fine- to medium-grained quartz sand. Most of the sand grains are -40 to +80 (U.S. Standard sieve) in size. The unit is somewhat friable, massive, and uniform in appearance, and occasionally crossbedded. Its maximum thickness approaches 100 feet. Exposures of the St. Peter are restricted to a narrow belt, 1/2 to 2 miles wide, in the northeast corner of the quadrangle. This belt is terminated on the south by the Ste. Genevieve fault system, which effectively shifts the St. Peter outcrop several miles to the east and outside the quadrangle.

The Lamotte Sandstone is the basal Cambrian unit in the Ozark region of Missouri and is a potential source of industrial sand. It rests directly on an irregular Precambrian surface; consequently, thickness varies greatly, from 0 to more than 400 feet.

Lamotte lithology varies considerably both vertically and with distance from the igneous knobs. At the base, arkosic sandstones and conglomerates predominate. Overlying these are thick sequences of orthoquartzite, and near the contact with the overlying Bonneterre the unit becomes dolomitic.

The orthoquartzites have the greatest economic potential and in many places make up 90 percent of the entire section. These units are often nearly white on fresh surfaces; weathered surfaces are commonly tan to light-brown. Sorting in the orthoquartzites varies from good to poor; however, most material is -30 to +140 (U.S. Standard) in size. Grain shape ranges from angular to well-rounded; most grains are rounded.

While the area of surface exposures is quite large, exposures of Lamotte showing a thick vertical section are not common. Available resources are extremely large, the best area probably being northeast of Farmington. Smaller resource areas are present in the Mine Lamotte—Knob Lick area and near Caledonia. Only rarely has the Lamotte been quarried as a dimension stone.

The Roubidoux Formation is a hypothetical source of industrial sand. It is a cherty dolomite containing several sandstone beds, commonly 10 to 15 feet thick but ranging to 40 feet or more. The sand is subangular to rounded and grain size varies from fine to coarse, with most material -20 to +140 (U.S. Standard) in size. Pebble-sized chert fragments, ripple marks, mud cracks, and other shallow-water sedimentary features are common. The unit is highly iron stained, and red clay along bedding planes is common.

Exposures of sandstone in the Roubidoux are common throughout the quadrangle; the best resources are in the west and southwest parts of the quadrangle. The variability in physical and chemical properties probably eliminates the unit for all but the lower specification industrial sand use.

Included as a hypothetical resource of industrial sand on Map B is the Everton Formation. This unit is composed of two lithologies, an upper dolomite and a lower sandstone. The formation totals about 100 feet in thickness, the sandstone representing 40 to 60 feet. The sandstone is very similar to the overlying St. Peter, although it is slightly finer grained. Because of its fine grain size, the presence of thin dolomite beds, and the nearness of high-quality resources in the St. Peter Sandstone, the Everton Formation is thought to have little economic potential.

Very minor resources of sandstone are present in the Aux Vases Formation south of Ste. Genevieve in the extreme eastern part of the quadrangle. Approximately 300 acres are underlain by this fine-grained, yellow-to-tan, argillaceous sandstone. It has been used for building stone but is too well cemented for industrial sand use. It is thought to have little economic potential other than for dimension stone.

CONSTRUCTION SAND AND GRAVEL

The Rolla quadrangle contains abundant resources of sand and gravel suitable for construction purposes (map B). Deposits are of two distinct types; the vast majority are alluvial, and minor upland deposits are present in the extreme southeast corner of the quadrangle.

In the alluvial deposits, chert gravel and quartz sand derived from the surrounding bedrock predominate. The chert gravel varies from dense, brown, extremely sound particles, to white, somewhat porous, weathered particles. The sand fraction is commonly quartz grains and minor chert. Some chert gravels react adversely with certain cements causing "pop outs" of the aggregate and deterioration of the concrete. This alkaline reactivity problem restricts the use of the gravel for certain aggregate uses. Alluvial gravels in streams draining the St. Francois Mountains contain substantial amounts of trap rock and granite and only minor amounts of sand.

Gradation of the alluvial material is variable and in many places ranges from boulders to fine silt. Organic material is a common deleterious substance. Occasionally "mud balls" and beds of tough clay are present and limit usage. The thickness of sand and gravel in the flood plain varies with the size of the stream. Typical thicknesses may range from a few feet in small tributaries to as much as 50 feet in the lower reaches of major streams such as the Meramec and Black Rivers. Overburden thickness ranges from a few feet to 15 feet or more in the larger streams.

Important resources of sand and gravel are present as inchannel and flood-plain deposits along the Meramec River and its larger tributaries, the Big Piney and Little Piney Rivers, Jacks Fork River, the Current River and its larger tributaries, the various forks of the Black River, and the Castor River.

Upland deposits are small and have a very limited distribution. Several have been worked near Leora in northwest Stoddard County. Other occurrences, small and mostly uneconomic, are present along the Ozark escarpment in Bollinger and Wayne Counties. These upland gravels are composed principally of dense brown cherts and minor amounts of white and black cherts. Size range is normally 1/2 to 2 inches. Sand is also present and is both coarse and angular. Red clay is a common contaminant and is present as beds and lenses and also intermixed with the sands and gravels. Other than for minor local use these upland deposits in the quadrangle have little potential.

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Table 1.—List of Paleozoic sedimentary stratigraphic units of the Rolla 1° x 2° quadrangle

Aux Vases Sandstone	(Upper Mississippian)
Ste. Genevieve Formation	(Upper Mississippian)
St. Louis Limestone	(Upper Mississippian)
Salem Formation	(Upper Mississippian)
Warsaw Formation	(Upper Mississippian)
Keokuk Limestone	(Lower Mississippian)
Burlington Limestone	(Lower Mississippian)
Fern Glen Formation	(Lower Mississippian)
Beauvais Sandstone	(Middle Devonian)
Grand Tower Limestone	(Middle Devonian)
Little Saline Limestone	(Lower Devonian)
Bailey Formation	(Lower Devonian)
Bainbridge Formation	(Silurian)
Orchard Creek(?) Formation	(Upper Ordovician)
Thebes Sandstone	(Upper Ordovician)
Cape Limestone of Sweet and others, 1975	(Upper Ordovician)
Kimmswick Formation	(Middle Ordovician)
Decorah Formation	(Middle Ordovician)
Plattin Formation	(Middle Ordovician)
Joachim Dolomite	(Middle Ordovician)
St. Peter Sandstone	(Middle Ordovician)
Everton Formation	(Middle Ordovician)
Smithville Formation	(Lower Ordovician)
Powell Dolomite	(Lower Ordovician)
Cotter Dolomite	(Lower Ordovician)
Jefferson City Dolomite	(Lower Ordovician)
Roubidoux Formation	(Lower Ordovician)
Gasconade Dolomite	(Lower Ordovician)
Eminence Dolomite	(Upper Cambrian)
Stromatolite/mud facies	(Upper Cambrian)
Potosi Dolomite	(Upper Cambrian)
Derby-Doerun Dolomite of Missouri Geological Survey, 1979	(Upper Cambrian)
Davis Formation	(Upper Cambrian)
Bonneterre Formation	(Upper Cambrian)
Lamotte Sandstone	(Upper Cambrian)

Table 2.—Generalized chemical and physical properties of formations having large available resources in the Rolla 1° x 2° quadrangle, Missouri

[Ratings indicate the potential for a major portion of the specified rock unit to meet [+], exceed [++], or fall short of [0] the requirements for each property]

Geologic unit	Chemical properties: $CaCO_3$ ≥95%	$MgCO_3$ ≥40%	SiO_2 ≤5%	Physical properties: Los Angeles abrasion ≤30%	Specific gravity ≥2.60	Absorption ≤1.5%	Soundness (visual)
Rhyolite (trap rock)	0	0	0	++	++	++	++
Granite	0	0	0	++	++	++	++
Bonneterre Formation	0	++	+	++	++	++	++
Derby-Doerun Dolomite	0	+	+	+	+	+	+
Potosi Dolomite	0	++	+	+	++	++	+
Stromatolite/mud facies "white rock"	0	+	+	0	0	0	0
Eminence Dolomite	0	++	++	0	+	+	0
Gasconade Dolomite	0	+	0	+	++	+	+
Roubidoux Formation	0	0	0	0	0	0	0
Jefferson City, Cotter, Powell, and Smithville Formations	0	0	0	0	+	0	+

Table 3.—Average sieve analyses of sandstone units that are sources of industrial sand in the Rolla 1° x 2° quadrangle, Missouri

[Values given in percentage by weight retained on each U.S. Standard Sieve]

Geologic unit (Number of samples)	10	16	20	30	40	50	60	80	100	140	200	Pan
Lamotte Sandstone (8)	0	0	0.2	1.0	8.5	21.3	12.5	17.5	8.9	19.6	7.2	3.6
Roubidoux Formation (12)	0	0	0	4.9	24.0	29.2	8.5	16.8	7.8	5.5	1.0	1.8
St. Peter Sandstone (9)	0	0	0	0	3.4	30.9	17.1	27.2	10.5	7.9	1.6	1.4

Table 4.—Chemical composition of sandstone units that are potential sources of industrial sand in the Rolla 1° x 2° quadrangle, Missouri

[LOI, loss on ignition; values given in percent]

Range and average	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	LOI
Lamotte Sandstone (8 samples)									
High	98.74	.82	.50	.02	.06	.05	.13	.19	.81
Low	96.26	.16	.13	.01	.04	.02	.06	.10	.27
Average	97.49	.39	.25	.02	.05	.03	.09	.12	.42
Roubidoux Formation (12 samples)									
High	98.79	.78	.59	.02	.22	.12	.33	.14	.94
Low	95.58	.09	.20	.01	.04	.02	.13	.12	.17
Average	97.23	.52	.29	.02	.07	.05	.21	.13	.52
St. Peter Sandstone (8 samples)									
High	99.48	.22	.23	.01	.39	.06	.13	.38	.44
Low	98.16	.05	.14	.01	.04	.02	.06	.12	.12
Average	98.99	.1	.18	.01	.11	.03	.1	.17	.21

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1987

For sale by Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225