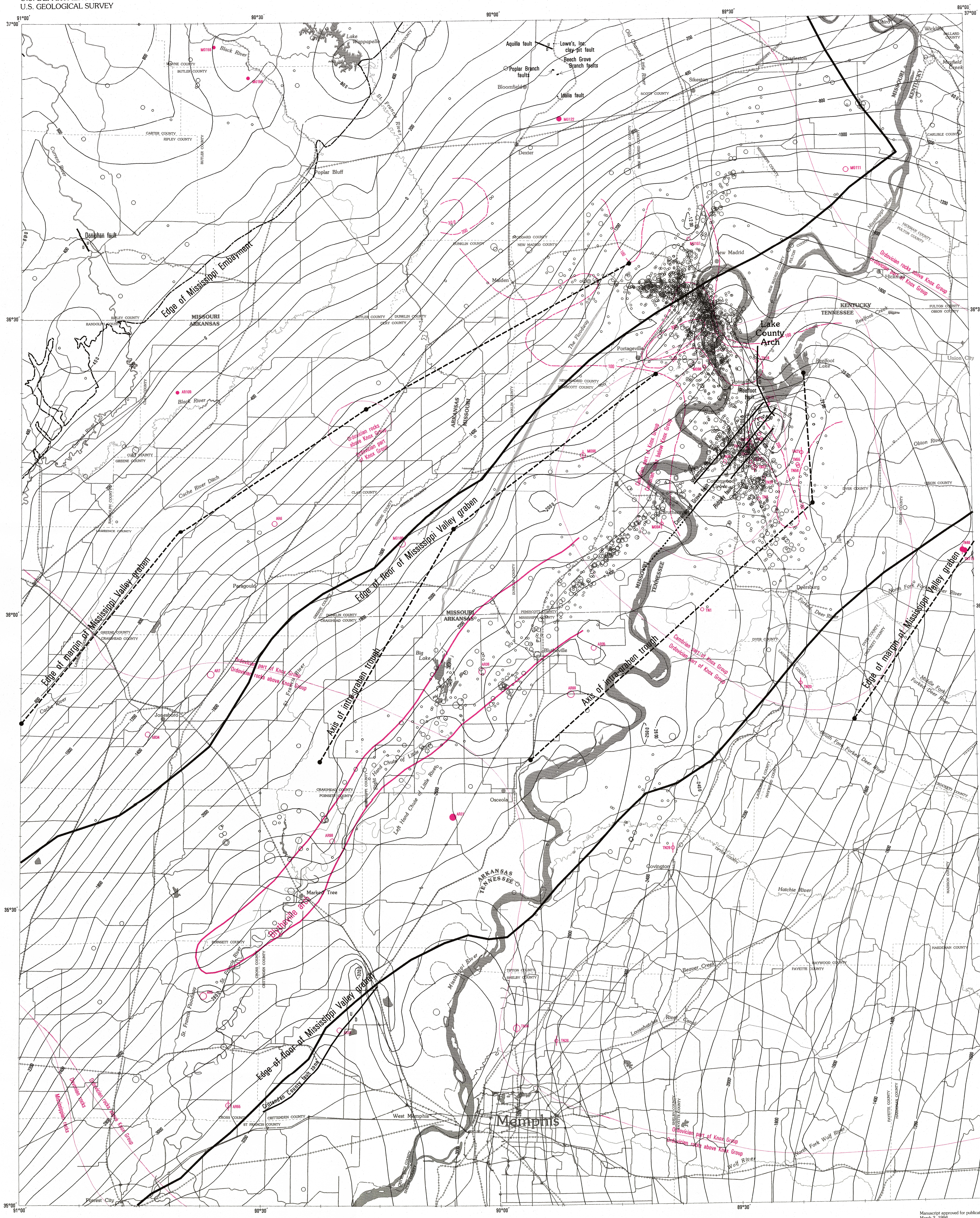
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-2264-D
SEISMOTECTONIC MAP FOLIO IN THE VICINITY OF NEW MADRID, MISSOURI



SCALE 1:250,000

5 0 5 10 15 20 25 30 KILOMETERS

5 0 5 10 15 20 25 30 MILES

Albers Equal-Area Conic Projection
Standard Parallels 29°30′ and 45°30′

MAP SHOWING STRUCTURE OF THE MISSISSIPPI VALLEY GRABEN IN THE VICINITY OF NEW MADRID, MISSOURI

By

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EXPLANATION

Geologic contact

Structure contours on unconformity atop Paleozoic rocks. Datum is sea level. Contour interval, 100 ft

Subcrop geologic contacts beneath Cretaceous-Paleozoic erosion surface

Faults--Dotted where inferred; U, upthrown side; D, downthrown side

Radon concentration in soil gas--Contour interval, 100 alpha track counts per unit area of detector

Structure inferred from seismic reflection data

Structure inferred from aeromagnetic data

Structure inferred from magnetotelluric data

Control point on structure inferred from magnetotelluric data

Selected wells--Circle diameter shows total depth from sea level, ornamentation shows whether well reached basement, penetrated igneous rocks, or both (Dart, 1992). Table 3 defines map codes

Depth less than 4,000 ft

Depth 4,000 to 8,000 ft

Depth exceeds 8,000 ft

Well reached basement

Well penetrated igneous rocks

Well reached basement and penetrated igneous rocks

Earthquake epicenters, scaled by earthquake magnitude

Less than 2.0

Between 2.0 and 2.9

Between 3.0 and 3.9

4.0 or greater

State boundary

County boundary

Selected city or town if not identified by road intersections

Limited access, primary, or secondary road

Railroad

Selected river, stream, or irrigation ditch

Wide river, selected lake or pond

INTRODUCTION

This is one of a series of five seismotectonic maps of the seismically active New Madrid area in southeast Missouri and adjacent parts of Arkansas, Kentucky, and Tennessee (table 1). We cannot legibly show all the seismotectonic data on a single map, therefore each of the five maps in this series groups a different type of related information. Rhea and others (1994) summarized the background and purpose of the seismotectonic map folio. The different types of data shown on this map are described in table 2.

Except for a few exposed faults, all structures shown on this map are in Paleozoic sedimentary rocks of the midcontinent or underlying metamorphic and igneous basement rocks of presumed Precambrian age (Dart, 1992; Muehlberger, 1992). Edge of Mississippi Embayment, as shown on the map, marks the contact between gently dipping, exposed Paleozoic rocks to the northwest (Anderson and others, 1979) and unconformably overlying, flat or gently dipping Mesozoic and Cenozoic strata of the embayment to the southeast.

LARGE STRUCTURES IN THE MISSISSIPPI VALLEY GRABEN

The structure contours show that the unconformable contact between the eroded top of the Paleozoic rocks and the overlying embayment strata forms a gentle syncline, which plunges southwest along the Mississippi River. Geologic maps of Missouri and adjacent states show pre-Quaternary strata dipping gently inward under Quaternary strata of the embayment, indicating that the unconformity was folded into a syncline, rather than eroded into a paleovalley. Northwest of the edge of the Mississippi Embayment, the erosional surface of the Paleozoic rocks is represented by smoothed topographic contours. Southeast of the embayment edge, the buried part of the erosional surface reaches its greatest structural complexity along a generally south plunging arch between New Madrid, Mo. and Dyersburg, Tenn. (Crone and Brockman, 1982). The structure contours show that the subsurface arch follows a sinuous trend about 60 km long, plunging southward near well MO107 near New Madrid, Mo., then eastward, then southward again past well TN16 and toward Reelfoot Lake, then southwestward, and finally southward and disappears between wells TN38, TN53, and TN3. The arch coincides approximately with the most seismically active part of the map area. The topographically high Lake County uplift (Russ, 1982) is the surface expression of the subsurface arch, which we will refer to as the Lake County arch to distinguish it from the uplift. The Lake County arch and the area of intense seismicity also coincide with unusually high concentrations of radon in soil gas (Steele and others, 1982) and with other geological and geophysical anomalies such as inferred faults and intrusive rocks (Chiu and others, 1992; Rhea and others, 1992; Rhea and Wheeler, 1994a). The complex shapes of the structure contours in this part of the map show that the Lake County arch has folded the Paleozoic-Mesozoic erosional contact and, therefore, the arch partly or wholly postdates the contact.

Subcrop contacts at six stratigraphic levels in the Paleozoic section outline the Pascola arch as a wide, gentle uplift that is elongated northwest-southeast (table 2). The subcrop contacts show the distribution of various Paleozoic stratigraphic units as they would appear if the overlying Mesozoic and Cenozoic strata of the embayment were removed. The Pascola arch is so wide that the map area includes only three of the subcrop contacts on the northeast limb of the arch and five on the southwest limb. The subcrop contacts at the two deepest stratigraphic levels outline a broad dome on the poorly located northwest-trending crest line of the arch. The dome coincides with the smaller Lake County arch and with the area of intense seismicity between New Madrid and Dyersburg. The Pascola arch is not labeled on the map because the broad arch underlies more than the entire map area. Although the arch is about 100 km wide from northeast to southwest (R.L. Dart, unpub. data, 1992), the crest line is too poorly located for us to label it on a map of this scale.

In contrast to the broad, northwest-trending Pascola arch, seismic-reflection profiles define the northeast-trending Blytheville arch as being narrower and shorter, with steeper limbs (Crone and others, 1985; Hamilton and McKeown, 1988; McKeown and others, 1990; McKeown and Diehl, 1994). Although both arches deformed the same Paleozoic units and predate the buried Paleozoic-Mesozoic erosional contact, the striking differences in size, limb steepness, and orientation lead us to conclude that the two arches were not formed in the same stress field or at the same time.

Crone and Brockman (1982) suggested that the Lake County arch formed together with the overlying Lake County uplift, which Chiu and others (1992) attribute to uplift of the hanging wall of a southwest-dipping, seismically active, reverse fault. The formation of the Blytheville arch has been attributed to various causes, including upwarping caused by felsic intrusions and diapirism (Crone and others, 1985; McKeown and others, 1990). The structurally highest area of the Pascola arch coincides roughly with the wide, northwest-trending Missouri gravity low of Guinness and others (1982), which Hildenbrand and Hendricks (1994) interpreted as a batholith (Rhea and Wheeler, 1994a). We speculate that the spatial coincidence between the highest area of the Pascola arch and the Missouri gravity low is evidence that the arch could have formed by isostatic uplift of a low-density mass of felsic rocks such as a batholith. Therefore, the Lake County, Blytheville, and Pascola arches may have formed at different times and by different mechanisms.

The overall shape of the Mississippi Valley graben is obvious in the geophysical data (fig. 1). The graben walls or margins slope inward as a series of successively downdropped fault blocks (Howe and Thompson, 1984; Hildenbrand, 1982; McKeown and others, 1990). The outer edges of the margins can be located approximately from modeling of the magnetotelluric data (Stanley and Rodriguez, 1992; B.D. Rodriguez and W.D. Stanley, written commun., 1992). The edges of the graben floor can be located approximately from interpretation of the aeromagnetic data (Hildenbrand and Hendricks, 1994). A northeast-trending axial high on the graben floor is inferred from magnetotelluric data (Stanley and Rodriguez, 1992; B.D. Rodriguez and W.D. Stanley, written commun., 1992). The axial high is partly coincident with the Blytheville arch. Two northeast-trending, intra-graben axial troughs flank the axial high, separating it from the bottoms of the inward sloping graben margins. The map shows the two margin tops, the two floor edges, and the two trough lines (see also Wheeler and Rhea, 1994a). The crest line of the axial high is too poorly defined to show at this scale (Stanley and Rodriguez, 1992; B.D. Rodriguez and W.D. Stanley, written commun., 1992). Rhea and Wheeler (1994a) show these margin tops, floor edges, and trough lines superimposed on contours of aeromagnetically estimated depth to the shallowest magnetic rock, whether basement or igneous rocks.

WELLS

Locations of 42 wells selected for their scientific value are shown on the map. These include all wells that penetrated to depths of at least 4,000 ft below sea level or penetrated igneous or basement rocks (Dart, 1992). The 12 wells that penetrated igneous rocks are in or close to the Mississippi Valley graben, with six of the 12 on or near the structurally highest part of the Pascola arch. The map also shows all wells that have provided or are likely to provide index fossils, cores, or fracture data (H.S. Swolfs, written communs., 1992, 1993; for example, Swolfs, 1992). Table 3 lists well owners and operators.

FAULTS

The locations of individual faults of the Mississippi Valley graben remain mostly unknown, although their existence and most likely orientations are well established. Consequently, we have been conservative in showing faults, preferring to exclude a real fault rather than include an inferred fault that does not exist. Paleozoic grabens elsewhere in eastern North America that are coeval with the Mississippi Valley graben have abundant faults of diverse lengths (Webb, 1980; Forsyth, 1981; Gower and others, 1986). Mesozoic grabens shown on state geologic maps from North Carolina to Massachusetts also have numerous faults of various lengths. In the Paleozoic and Mesozoic grabens of eastern North America the strikes of the faults scatter widely about preferred orientations that are roughly parallel to the grabens (R.L. Wheeler, unpub. data, 1992-1994). Many seismic-reflection profiles in the Mississippi Valley graben have been interpreted to show an abundance of faults (see reports cited by Rhea and Wheeler, 1994b). There is no question whether the rocks of the map area are faulted nor what orientations the faults are most likely to have, however the map shows only individual faults for which we have found citable evidence of both their existence and their locations (table 4).

Several faults shown in previous reports are omitted from this map. We omitted faults that Heyl and McKeown (1978) coded as inferred, possible, or hypothetical; all of their lineaments; and two faults classified as known or approximately located because we could find no citable evidence for their existence. The two latter faults were inferred to be near Sikeston, Mo., and in Carlisle and Hickman Counties, Ky.

We omitted a large fault that Bond and others (1971) inferred to strike west-northwest through Pemiscot County, Mo., near the center of the map area. The same fault was shown by Heyl and McKeown (1978), Schwalb (1982), and Leighton and others (1991). This fault was inferred from stratigraphic relations interpreted in four wells (Moore, 1965; Schwalb, 1982) and the four control points can be contoured without interpreting a fault (R.L. Dart, unpub. mapping, 1992); in addition, the fault was not seen on two seismic-reflection profiles that cross its inferred location (profiles S-8 and S-9 of Hamilton and Zoback, 1982).

We omitted the southwest-striking faults that Heyl and Brock (1961) and Heyl and McKeown (1978) showed as extending into the northeastern part of the map area from the Illinois-Kentucky fluorspar district. Evidence for the extensions is equivocal (Heyl and McKeown, 1978; Treworgy, 1981; Kolata and others, 1981) and existing geologic maps of parts of the Paducah 1° by 2° quadrangle, which borders the New Madrid map area on the north, do not show any faults extending into the map area (W.J. Nelson, oral communs., 1993, 1994).

We omitted six faults in and near the bluffs that border the Mississippi River flood plain in western Kentucky. Finch (1971a, b) and Olive (1976, 1980) mapped four faults 0.1-1.2 km long that Jibson and Keefer (1988) remapped as bounding some of the many landslides along the bluffs. Finch (1971a, b) inferred two longer, northeast-striking faults that Heyl and McKeown (1978) classified as lineaments.

We omitted numerous faults inferred in Wayne and Stoddard Counties, Mo., near the north edge of the map area. Although McCracken and McCracken (1965), McCracken (1971), and Anderson and others (1979) show the Greenville fault striking southwest into Wayne County, all three show it as an inferred fault in and near the map area. Stewart and others (1981) mapped numerous short, closely spaced faults striking northeast near the Beech Grove Branch and Poplar Branch faults. However, Thompson (1983) suggested that the short faults are at least partly slump features. We omitted one fault with 1 m of vertical separation in the Rock Knob gravel pit about 17 km west of the Aquilla fault because it is small and might be a prehistoric slump feature (Thompson, 1983). We omitted a northwest-striking fault that Stewart and others (1981) mapped 5 km southwest of the Beech Grove Branch fault because we found no other evidence for it. We omitted two small, unnamed faults exposed in the Porters Creek Clay of Paleocene age because Farrar (1935, p. 28) described them as examples of common small faults in the Porters Creek Clay. Their small size makes it unlikely that they are deeply penetrating tectonic faults (for example, Nyman, 1965).

We omitted a network of large, orthogonal faults that were mapped north of the map area, and which probably strike southeast and southwest into the northwestern part of the map area (Clendenin and others, 1989; Clendenin, Lowell, and Niewendorp, 1993; Clendenin, Middendorf, and others, 1993; Clendenin and Duane, 1990; Clendenin and Lowell, 1991). Some of these faults are exposed north of the map area in the St. Francois Mountains (McCracken, 1971; Anderson and others, 1979). Clendenin and coworkers used bore hole cores, mine observations, and geologic mapping to extend the fault system toward the map area. Numerous closely spaced bore holes provided the primary means of detecting and tracing faults between the St. Francois Mountains and the map area, however, in the map area there are few, widely spaced bore holes (Clendenin, Lowell, and Niewendorp, 1993). We agree with Clendenin and Lowell (1991) and Clendenin, Lowell, and Niewendorp (1993) that several of the faults probably strike southeast and southwest into the map area, and almost all faults that we show on the map strike northwest and northeast, parallel to the mapped and inferred faults of Clendenin and coworkers. However, the bore hole control shown by Clendenin, Lowell, and Niewendorp (1993) is too sparse south of lat 37° N. for us to show their faults at the scale of this map. The northwestern part of the map area contains no seismic-reflection lines in the public domain that might supplement the sparse bore hole control (Rhea and Wheeler, 1994b).

Recent and continuing geologic mapping 5-30 km north of the map area has characterized exposed faults with Quaternary slip (Harrison and Schultz, 1992; Nelson and Harrison, 1993; Palmer and Hoffman, 1993; Hoffman and others, 1994). Some of these faults strike toward the map area. Additional study of the Quaternary slip along these faults might illuminate modern deformation in the northern part of the map area.

Stoddard County, Mo., at the north edge of the map area, has more known, exposed faults than any other similarly sized part of the map area. These faults cut Cretaceous and Tertiary strata (Farrar, 1935; Farrar and McManamy, 1937; Grohskopf, 1955; Thompson, 1983), overlie the Bloomfield pluton, and are outside the areas of intense seismic activity (Rhea and Wheeler, 1994a; Rhea and others, 1994). The faults are exposed in the largest area of exposed Cretaceous and Tertiary strata in the map area (Farrar and McManamy, 1937; Anderson and others, 1979). There are two possible explanations for these spatial relations: (1) The Cretaceous and Tertiary strata may be densely faulted throughout most of the map area beneath masking Quaternary sediments. (2) Alternatively, the Bloomfield pluton was probably intruded before Cretaceous time (Hildenbrand and Hendricks, 1994), it may have been tectonically reactivated during or after Cretaceous or Tertiary time, but it is no longer active. Present evidence does not allow us to choose between the two alternative explanations.

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REFERENCES

Anderson, K.H., Dean, T.J., Hebrank, A.W., Miller, D.E., Robertson, C.E., Rueff, Ardel, Satterfield, I.R., Stout, L.N., Thacker, J.L., Thompson, T.L., Wells, J.S., Whitfield, J.W., Kisvarsanyi, E.B., Emerson, John, Pratt, W.P., and Thomson, K.C., 1979, Geologic map of Missouri: Missouri Geological Survey, 1 sheet, scale 1:500,000.

Bond, D.C., Atherton, Elwood, Bristol, H.M., Buschbach, T.C., Stevenson, S.L., Becker, L.E., Dawson, T.A., Fernalld, E.C., Schwalb, Howard, Wilson, E.N., Statler, A.T., Stearns, R.G., and Buehner, J.H., 1971, Possible future petroleum potential of region 9--Illinois basin, Cincinnati arch, and northern Mississippi embayment, in Cram, I.H., ed., Future petroleum provinces of the United States--Their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 1165-1218.

Chiu, J.M., Johnston, A.C., and Yang, Y.T., 1992, Imaging the active faults of the central New Madrid seismic zone using PANDA array data: Seismological Research Letters, v. 63, no. 3, p. 375-393.

Clendenin, C.W., and Duane, M.J., 1990, Focused fluid flow and Ozark Mississippi Valley-type deposits: Geology, v. 18, p. 116-119.

Clendenin, C.W., and Lowell, G.R., 1991, Aspects of the structural architecture of southeast Missouri resulting from Reelfoot rift extension, in Louis Unfer conference on the geology of the mid-Mississippi Valley--Extended abstracts: Missouri Division of Geology and Land Survey Special Publication 8, p. 18-21.

Clendenin, C.W., Lowell, G.R., and Niewendorp, C.A., 1993, Sequencing Reelfoot extension based on relations from southeast Missouri and interpretations of the interplay between offset preexisting zones of weakness: Tectonics, v. 12, p. 703-712.

Clendenin, C.W., Middendorf, M.A., Thompson, T.L., and Whitfield, J.W., 1993, Structural style of the Eureka fault system, eastern Missouri: Geological Society of America Abstracts with Programs, v. 25, no. 3, p. 13.

Clendenin, C.W., Niewendorp, C.A., and Lowell, G.R., 1989, Reinterpretation of faulting in southeast Missouri: Geology, v. 17, p. 217-220.

Crone, A.J., 1992, Structural relations and earthquake hazards of the Crittenden County fault zone, northeastern Arkansas: Seismological Research Letters, v. 63, no. 3, p. 249-262.

Crone, A.J., and Brockman, S.R., 1982, Configuration and deformation of the Paleozoic bedrock surface in the New Madrid seismic zone, in McKeown, F.A., and Pakiser, L.C., eds., Investigations of the New Madrid, Missouri, earthquake region: U.S. Geological Survey Professional Paper 1236, p. 115-135.

Crone, A.J., Harding, S.T., Russ, D.P., and Shedlock, K.M., 1986, Seismic-reflection profiles of the New Madrid seismic zone--Data along the Mississippi River near Caruthersville, Missouri: U.S. Geological Survey Miscellaneous Field Studies Map MF-1863, 4 sheets, various scales.

Crone, A.J., McKeown, F.A., Harding, S.T., Hamilton, R.M., Russ, D.P., and Zoback, M.D., 1985, Structure of the New Madrid seismic source zone in southeastern Missouri and northeastern Arkansas: Geology, v. 13, p. 547-550.

Dart, R.L., 1992, Catalog of pre-Cretaceous geologic drill-hole data from the upper Mississippi embayment--A revision and update of Open-File Report 90-260: U.S. Geological Survey Open-File Report 92-685, 253 p.

Farrar, Willard, 1935, The geology and bleaching clays of southeast Missouri, part I: Missouri Geological Survey and Water Resources, 58th biennial report of the State Geologist, Appendix I, p. 1-35, 1 folded plate, scale approximately 1:250,000.

Farrar, Willard, and McManamy, Lyle, 1937, The geology of Stoddard County, Missouri: Missouri Geological Survey and Water Resources, 59th biennial report of the State Geologist, Appendix VI, 92 p., 3 folded plates, various scales.

Finch, W.I., 1971a, Geologic map of part of the Bondurant quadrangle, Fulton County, Kentucky and New Madrid and Mississippi Counties, Missouri: U.S. Geological Survey Geologic Quadrangle Map GQ-944, 1 sheet, scale 1:24,000.

_____1971b, Geologic map of part of the Hickman quadrangle, Fulton County, Kentucky and Mississippi County, Missouri: U.S. Geological Survey Geologic Quadrangle Map GQ-874, 1 sheet, scale 1:24,000.

Forsyth, D.A., 1981, Characteristics of the western Quebec seismic zone: Canadian Journal of Earth Sciences, v. 18, p. 103-119.

Gower, C.F., Erdmer, Philippe, and Wardle, R.J., 1986, The Double Mer Formation and the Lake Melville rift system, eastern Labrador: Canadian Journal of Earth Sciences, v. 23, p. 359-368.

Grohskopf, J.G., 1955, Subsurface geology of the Mississippi embayment of southeast Missouri: Missouri Division of Geological Survey and Water Resources Report 37, Second Series, 133 p., 9 folded plates, scale about 1:400,000.

Guinness, E.A., Arvidson, R.E., Strebeck, J.W., Schulz, K.J., Davies, G.F., and Leff, C.E., 1982, Identification of a Precambrian rift through Missouri by digital image processing of geophysical and geological data: Journal of Geophysical Research, v. 87, p. 8529-8545.

Hamilton, R.M., and McKeown, F.A., 1988, Structure of the Blytheville arch in the New Madrid seismic zone: Seismological Research Letters, v. 59, no. 4, p. 117-121.

Hamilton, R.M., and Zoback, M.D., 1982, Tectonic features of the New Madrid seismic zone from seismic-reflection profiles, in McKeown, F.A., and Pakiser, L.C., eds., Investigations of the New Madrid, Missouri, earthquake region: U.S. Geological Survey Professional Paper 1236, p. 55-82.

Harrison, R.W., and Schultz, A.P., 1992, Faulting at Thebes Gap, Mo.-Ill.: Implications for New Madrid tectonism: Geological Society of America Abstracts with Programs, v. 24, no. 7, p. A191.

Heyl, A.V., Jr., and Brock, M.R., 1961, Structural framework of the Illinois-Kentucky mining district and its relation to mineral deposits: U.S. Geological Survey Professional Paper 424-D, p. D3-D6.

Heyl, A.V., and McKeown, F.A., 1978, Preliminary seismotectonic map of the central Mississippi Valley and environs: U.S. Geological Survey Miscellaneous Field Studies Map MF-1011, 2 sheets, scale 1:500,000.

Hildenbrand, T.G., 1982, Model of the southeastern margin of the Mississippi Valley graben near Memphis, Tennessee, from interpretation of truck-magnetometer data: Geology, v. 10, p. 476-480.

Hildenbrand, T.G., and Hendricks, J.D., 1994, Geophysical setting of the Reelfoot rift and relations between rift structures and the New Madrid seismic zone, Chap. E of Shedlock, K.M., and Johnston, A.C., eds., Investigations of the New Madrid seismic zone: U.S. Geological Survey Professional Paper 1538-E, in press.

Hoffman, David, Palmer, J.R., Harrison, R.W., Odum, J.K., Stephenson, W.J., and Williams, R.A., 1994, Faulting associated with the southeastern escarpment of the Benton Hills, Scott County, Missouri: Geological Society of America Abstracts with Programs, v. 26, no. 1, p. 8.

Howe, J.R., and Thompson, T.L., 1984, Tectonics, sedimentation, and hydrocarbon potential of the Reelfoot rift: Oil and Gas Journal, v. 82, Nov. 12, 1984, p. 179-190.

Jibson, R.W., and Keefer, D.K., 1988, Landslides triggered by earthquakes in the central Mississippi Valley, Tennessee and Kentucky: U.S. Geological Survey Professional Paper 1336-C, 24 p., 1 folded plate, scale 1:62,500.

Kolata, D.R., Treworgy, J.D., and Masters, J.M., 1981, Structural framework of the Mississippi embayment of southern Illinois: Illinois State Geological Survey Circular 516, 38 p.

Leighton, M.W., Kolata, D.R., Oltz, D.F., and Eidel, J.J., eds., 1991, Interior cratonic basins: American Association of Petroleum Geologists Memoir 51, 819 p.

Luzietti, E.A., Kanter, L.R., Schweig, E.S., Shedlock, K.M., and VanArsdale, R.B., 1992, Shallow deformation along the Crittenden County fault zone near the southeastern boundary of the Reelfoot rift, northeast Arkansas: Seismological Research Letters, v. 63, no. 3, p. 263-275.

_____1994, Shallow deformation along the Crittenden County fault zone near the southeast margin of the Reelfoot rift, northeastern Arkansas, Chap. J of Shedlock, K.M., and Johnston, A.C., eds., Investigations of the New Madrid seismic zone: U.S. Geological Survey Professional Paper 1538-J, in press.

McCracken, Earl, and McCracken, M.H., 1965, Subsurface maps of the Lower Ordovician (Canadian Series) of Missouri: Rolla, Missouri, Missouri Division of Geological Survey and Water Resources, 6 folded sheets, scale 1:1,000,000.

McCracken, M.H., 1971, Structural features of Missouri: Missouri Geological Survey and Water Resources Report of Investigations 49, 99 p., 1 folded plate, scale 1:500,000.

McKeown, F.A., and Diehl, S.F., 1994, Evidence of contemporary and ancient excess fluid pressure in the New Madrid seismic zone of the Reelfoot rift, central United States, Chap. N of Shedlock, K.M., and Johnston, A.C., eds., Investigations of the New Madrid seismic zone: U.S. Geological Survey Professional Paper 1538-N, in press.

McKeown, F.A., Hamilton, R.M., Diehl, S.F., and Glick, E.E., 1990, Diapiric origin of the Blytheville and Pascola arches in the Reelfoot rift, east-central United States--Relation to New Madrid seismicity: Geology, v. 18, p. 1158-1162.

Moore, G.K., 1965, Geology and hydrology of the Claiborne Group in western Tennessee: U.S. Geological Survey Water-Supply Paper 1809-F, 44 p., 8 folded plates, various scales.

Muehlberger, W.L., compiler, 1992, Tectonic map of North America, southeast sheet: Tulsa, Oklahoma, American Association of Petroleum Geologists, scale 1:5,000,000.

Nelson, W.J., and Harrison, R.W., 1993, Post-Cretaceous faulting at head of Mississippi embayment: Geological Society of America Abstracts with Programs, v. 25, no. 3, p. 69-70.

Nicholas, D.P., Schweig, E.S., Kanter, L.R., Odum, J.K., Stephenson, W.J., Shedlock, K.M., VanArsdale, R.B., 1992, New shallow seismic reflection survey across the Crittenden County fault zone in the New Madrid seismic zone [abs.]: EOS, Transactions of the American Geophysical Union, v. 73, no. 43 (Supplement), p. 390.

Nyman, D.J., 1965, Origin of clastic dikes in the Porters Creek Clay at Pinson, Tennessee: Journal of the Tennessee Academy of Science, v. 40, p. 143-147.

Olive, W.W., 1976, Geologic map of parts of the Arlington and Wickliffe SW quadrangles, Carlisle and Hickman Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1329, 1 sheet, scale 1:24,000.

_____1980, Geologic maps of the Jackson Purchase region, Kentucky: U.S. Geological Survey Miscellaneous Investigations Series Map I-1217, 1 sheet, scales 1:250,000 and 1:500,000, 11 p. pamphlet.

Palmer, J.R., and Hoffman, David, 1993, Possible late Quaternary faulting in the Benton Hills, southeastern Missouri: Geological Society of America Abstracts with Programs, v. 25, no. 3, p. 72.

Rhea, Susan, and Wheeler, R.L., 1994a, Map showing large structures interpreted from geophysical data in the vicinity of New Madrid, Missouri: U.S. Geological Survey Miscellaneous Field Studies Map MF-2264-B, scale 1:250,000.

_____1994b, Map showing locations of geophysical survey and modeling lines in the vicinity of New Madrid, Missouri: U.S. Geological Survey Miscellaneous Field Studies Map MF-2264-C, scale 1:250,000.

Rhea, Susan, Wheeler, R.L., and Tarr, A.C., 1992, Work sheets for seismotectonic map of the New Madrid 2°x2° area [abs.]: Seismological Research Letters, v. 63, no. 4, p. 612.

_____1994, Map showing seismicity and sand blows in the vicinity of New Madrid, Missouri: U.S. Geological Survey Miscellaneous Field Studies Map MF-2264-A, scale 1:250,000.

Russ, D.P., 1982, Style and significance of surface deformation in the vicinity of New Madrid, Missouri, in McKeown, F.A., and Pakiser, L.C., eds., Investigations of the New Madrid, Missouri, earthquake region: U.S. Geological Survey Professional Paper 1236, p. 95-114.

Schwalb, H.R., 1982, Paleozoic geology of the New Madrid area: U.S. Nuclear Regulatory Commission Report NUREG/CR-2909, 61 p.

Sexton, J.L., 1988, Seismic reflection expression of reactivated structures in the New Madrid rift complex: Seismological Research Letters, v. 59, no. 4, p. 141-150.

Sexton, J.L., and Jones, P.B., 1986, Evidence for recurrent faulting in the New Madrid seismic zone from Mini-Sosie high-resolution reflection data: Geophysics, v. 51, p. 1760-1788.

_____1988, Mini-Sosie high-resolution reflection survey of the Cottonwood Grove fault in northwestern Tennessee: Bulletin of the Seismological Society of America, v. 78, p. 838-854.

Shedlock, K.M., and Harding, S.T., 1982, Mississippi River seismic survey: Geophysical Research Letters, v. 9, p. 1275-1278.

Stanley, W.D., and Rodriguez, B.D., 1992, Structure of the Reelfoot rift as interpreted from 2-D magnetotelluric models: Seismological Research Letters, v. 63, no. 3, p. 223-232.

Steele, S.R., Hood, W.C., and Sexton, J.L., 1982, Radon emanation in the New Madrid seismic zone, in McKeown, F.A., and Pakiser, L.C., eds., Investigations of the New Madrid, Missouri, earthquake region: U.S. Geological Survey Professional Paper 1236, p. 191-201.

Stewart, Dan, McManomy, Lyle, and Amos, Dewey, 1981, Geology of the Advance, Bell City, Bloomfield, Clines Island, Essex, and Dexter quadrangles, Mo.: Missouri Division of Geology and Land Survey Open-File Map OFM-81-52-G1, 1 sheet, scale 1:62,500.

Swolfs, H.S., 1992, Structural features in the Dow Chemical No. 1 B.L. Garrigan well, Mississippi County, Arkansas, and their paleotectonic implications: Seismological Research Letters, v. 63, no. 3, p. 243-247.

Thompson, T.L., 1983, Structural geology of southeastern Missouri, in Buschbach, T.C., preparer, New Madrid seismotectonic study--Summary of activities from 1977 through 1981: U.S. Nuclear Regulatory Commission Report NUREG/CR-3173, p. 115-136.

Treworgy, J.D., 1981, Structural features in Illinois--A compendium: Illinois State Geological Survey Circular 519, 22 p., 1 folded plate, scale approximately 1:700,000.

Webb, E.J., 1980, Cambrian sedimentation and structural evolution of the Rome trough in Kentucky: University of Cincinnati, Ph.D. dissertation, 116 p.

Wheeler, R.L., and Rhea, Susan, 1994, Map showing surficial and hydrologic features in the vicinity of New Madrid, Missouri: U.S. Geological Survey Miscellaneous Field Studies Map MF-2264-E, scale 1:250,000.

Zoback, M.D., 1979, Recurrent faulting in the vicinity of Reelfoot Lake, northwestern Tennessee: Geological Society of America Bulletin, v. 90, p. 1019-1024.

Zoback, M.D., Hamilton, R.M., Crone, A.J., Russ, D.P., McKeown, F.A., and Brockman, S.R., 1980, Recurrent intraplate tectonism in the New Madrid seismic zone: Science, v. 209, p. 971-976.

Table 3. *Well names in the vicinity of New Madrid, Mo. (from Dart, 1992)*

Map code	Operator/Owner
AR5	Houston Oil and Minerals/No. 1 Singer
AR6	Quintin Little/No. 1 H. Griffith
AR7	Quintin Little/No. 1 Little
AR18	M.E. Davis/No. 1 DeMange
AR31	Dow Chemical Co./L. Wilson and Co. No. 1
AR34	Tenn-Ark Inc./No. 1 R.M. Martin and others
AR35	Benedum Trees Oil Co./No. 1 C.W. Mack
AR36	Dow Chemical Co./B.L. Garrigan No. 1
AR55	Manning and Martin Inc./No. 1 Park-Gieseck
AR98	Harrison Interests Ltd./No. 1 Portis-Potter
AR99	Amoco Petroleum Co./No. 1 B.P. Haynes
AR109	Pursley and others/No. 1 Cox
MO94	O.W. Killiam/K.M. Pattinson
MO96	Strake Petroleum Co./T.P. Russell No. 1
MO98	Dept. of Interior/E. Russell NMTW 1-X
MO107	Lilbourn Oil Co./S.L. Hunter No. 1
MO111	Mammoth Production Co./Big Oak Tree No. 1
MO122	M.H. Marr/C. Barnett No. 1
MO158	Exxon Minerals/No. KN-1
MO159	Kerr McGee/No. W-4
MO160	Amoco/No. 1 Spence Trust
TN1	Henderson Oil Co./No. 1 J. Fields
TN3	Henderson Oil Co./J.E. Rice (Broadmoor) No. 1
TN11	Corley, Geiselman and Benz/No. 1 J.E. Vaughan
TN12	Frazier and Benz/No. 1-B S. Hays
TN13	Henderson Oil Co./A.E. Markham No. 1
TN14	Henderson Oil Co./No. 1-A.L. Morris
TN16	Reelfoot Dome Oil Co./No. 1 K. Wright
TN20	R. Gear/No. 1 Dyer Bros.
TN21	Henderson Oil Co./No. 1 F.B. Carroll
TN26	Lion Oil Co./No. 1 L. Bateman
TN28	Pure Oil Co./No. 1 R.R. McGregor
TN32	Benz Oil Co./No. 1 Marritt Estate
TN33	I.T. Johnson Oil Co./No. 1 S.J. Bradshaw
TN36	Appalachian Oil and Gas/No. 1 Dr. B.F. Mitchell
TN38	Maralo Inc./No. 1 Keiser
TN39	Maralo Inc./No. 1 Fuqua Estate
TN48	Big Chief Drilling Co./No. 1 H.H. Taylor
TN53	Benz Oil Corp./N. Cherry No. 1
TN55	Benz Oil Corp./A. Yates No. 1
TN56	Benz Oil Corp./B. Stover No. 1
TN113	Gulf Oil Co./Taylor No. 1

Table 1. *Maps in the U.S. Geological Survey seismotectonic folio of the New Madrid, Missouri, area*

Map	Theme: features shown	Reference
MF-2264-A	Seismicity: earthquake epicenters, focal mechanisms, seismic velocities, instrument locations, and aspects of liquefaction	Rhea and others (1994)
MF-2264-B	Crustal structure: epicenters; large structures inferred from gravity, aeromagnetic, seismic reflection, seismic refraction, and magnetotelluric data	Rhea and Wheeler (1994a)
MF-2264-C	Geophysical surveys: epicenters; lines of gravity, aeromagnetic, magnetotelluric, seismic reflection, and seismic refraction surveys and models	Rhea and Wheeler (1994b)
MF-2264-D	Bedrock geology: epicenters; geologic and subcrop contacts; structure contours; radon concentrations; selected wells; selected faults; and arches, troughs, and faulted boundaries of the Mississippi Valley graben	This map
MF-2264-E	Surficial and hydrologic features: epicenters; aspects of liquefaction; trench sites; earthquake-induced landslides; courses of the Mississippi River since 1765; fluvial and hydrologic anomalies; selected topographic features; Bootheel lineament; and geodetic monuments	Wheeler and Rhea (1994)

Table 2. *Structural features shown on this map of the New Madrid, Mo., area*

Mapped feature	Methods, locational uncertainty, and sources[1]
Structure of eroded top surface of Paleozoic rocks	R.L. Dart is preparing a map of contoured subsurface elevations of the top of the Paleozoic rocks as determined by others from well and seismic reflection data. Contour uncertainty varies with stratigraphic interpretations of well logs and reflection data, data spacing, and the contouring algorithm. Dart (1992) catalogued the well interpretations. The contact between soft, low velocity, clastic strata of the Mississippi Embayment and underlying, hard, high velocity, mostly carbonate rocks of the Paleozoic section is likely to be identified reliably from well logs, samples, or a clearly imaged seismic reflector. Dart's map shows well spacing and describes tests of the contouring algorithm.
Radon concentrations	Steele and others (1982) sampled soil gas monthly at sites about 8 km apart on a roughly rectangular grid, measured radon concentrations, and mapped and contoured the concentrations averaged over 13 months.
Pascola arch	R.L. Dart is preparing a subcrop map showing contacts between Paleozoic stratigraphic units that were drilled and identified immediately beneath the embayment strata. Dart's map area includes this one but is about three times as large. Locational uncertainty of the subcrop contacts varies, depending on well spacing and accuracy of stratigraphic identifications from well samples and logs. Dart's map shows well spacings and Dart (1992) summarizes the stratigraphic identifications.
Selected wells	See text for methods. Dart (1992) catalogued lithologic identifications of drilled igneous rocks and metamorphic or igneous basement from many sources. Well locations are recorded according to the U.S. Public Land Survey grid to the nearest mile to sixteenth of a mile (about 1.6 km to 100 m), with most recorded to the nearest eighth of a mile (about 200 m).
Selected faults	See text for methods. Locational uncertainty varies with sources from which we digitized the fault locations (table 4).

[1] Rhea and others (1994) describe the edge of the Mississippi embayment and earthquake epicenters. Rhea and Wheeler (1994a) summarize the Blytheville arch and the structure of the Mississippi Valley graben as inferred from aeromagnetic and magnetotelluric data.

Table 4. *Faults shown on this map of the New Madrid, Mo., area*

Fault name (north to south)	References, notes
Lowe's, Inc. clay pit fault	Known from a temporary exposure in a clay pit wall and from logs of closely spaced drill holes to strike northwest with the northeast side down (Thompson, 1983). However, control provided by the exposure and logged holes spans only about 40 m along the strike of the fault, so we show only the pit location.
Aquilla fault	Inferred from well data in area of loess cover (Farrar and McManamy, 1937).
Beech Grove Branch faults	Known from field mapping and logs of closely spaced, shallow drill holes to strike northwest. Stewart and others (1981) inferred that one fault extends more than 8 km, with other, shorter faults parallel to it. The control provided by the logged wells and outcrops spans only 110 m of this inferred extent (Grohskopf, 1955; Thompson, 1983). We show only the locality of the logged wells and outcrops.
Poplar Branch faults	Faults and folds exposed along 0.8 km of stream bed (Grohskopf, 1955).
Idalia fault	Faults exposed at the same locality are reported to strike in two different directions (Farrar and McManamy, 1937; Grohskopf, 1955; McCracken, 1971), so we show only the locality.
Doniphan fault	Exposed: Anderson and others (1979) showed a fault striking northwest, whereas McCracken (1971) showed one striking west. The northwest-striking fault is exposed and a smaller exposed fault parallels it nearby, but the west-striking fault is expressed only as a zone of broken rock (A.W. Rueff, oral commun., 1993). We show only the larger, northwest-striking fault of Anderson and others (1979).
Reelfoot fault	Interpreted from seismic reflection profiles (Zoback, 1979; Zoback and others, 1980; Sexton and Jones, 1986; Sexton, 1988).
Unnamed fault west of Cottonwood Grove fault	Interpreted from seismic reflection profiles (Zoback and others, 1980; Hamilton and Zoback, 1982).
Cottonwood Grove fault	Interpreted from seismic reflection profiles (Zoback and others, 1980; Hamilton and Zoback, 1982; Shedlock and Harding, 1982; Crone and others, 1986; Sexton, 1988; Sexton and Jones, 1988).
Ridgely fault	Interpreted from seismic reflection profiles (Zoback, 1979, Zoback and others, 1980; Hamilton and Zoback, 1982).
Crittenden County fault zone	Interpreted from well logs and seismic reflection profiles (Crone, 1992; Luzietti and others, 1992, 1994; Nicholas and others, 1992).

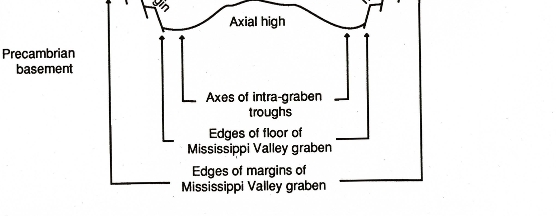

Figure 1. Unscaled cross section of Mississippi Valley graben, showing some structures discussed in text. Section is generalized, so it corresponds to no specific profile line on map.

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