Illinois Geologic Quadrangle Map
IGQ Joppa-G

Geology of Joppa Quadrangle

Massac County, Illinois

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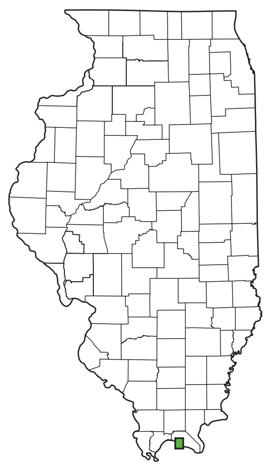
2008



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Introduction

The Joppa Quadrangle contains three major types of geologic materials. Oldest and at greatest depth is the bedrock, which dates from the Mississippian Period (about 330 to 350 million years before present). The Mississippian bedrock is dominantly limestone that was deposited in a warm, shallow sea that covered much of North America at that time. Bedrock is not exposed in the Joppa Quadrangle, but it is at the surface in nearby areas to the north, east, and west, and many wells within the quadrangle penetrate limestone. Data from these wells have been used to construct the Mississippian bedrock geologic map included here (fig. 1). Figure 1 shows the formation at the bedrock surface and indicates the topography of the bedrock surface by means of contour lines.

Overlying the bedrock are deposits of weakly lithified clay, silt, sand, and gravel that range in age from late Cretaceous through early Tertiary (about 60 to 80 million years ago). At that time, the Gulf of Mexico extended northward into southern Illinois, forming the Mississippi Embayment. The Cretaceous and lower Tertiary sediments, which comprise the Post Creek, McNairy, Clayton, and Porters Creek Formations, accumulated mainly in shallow, near-shore settings, such as deltas, bays, and tidal flats. Only the McNairy Formation (Cretaceous) is widely distributed in the map area. It underlies the rolling hills that separate the lowlands of the Ohio River to the south from those of the Cache Valley to the north.

The youngest geologic materials in the quadrangle date from the late Tertiary and Quaternary Periods and are less than 10 million years old. The Mounds Gravel, the reddish brown chert gravel that is quarried for road-surfacing material, caps many hills in the quadrangle and also is found at lower elevation in wells near the Ohio River. This gravel apparently was laid down by large rivers during the late Tertiary and early Quaternary Periods, before the advent of continental glaciers in Illinois. Although glaciers never reached as far south as Massac County, their influence is recorded in many deposits of the Pleistocene Epoch (early Quaternary). These deposits include the Metropolis Formation (fluvial silt, sand, and gravel found near the Ohio River); the Henry Formation (fluvial sand) and Equality Formation (lacustrine silt and clay) in the Cache Valley; and the Loveland, Roxana, and Peoria Silts (wind-blown silt known as loess). The youngest geologic unit in the area is the Cahokia Formation, which consists of stream and river sediments deposited in the postglacial Holocene Epoch (the last 10,000 years). Loess units are not shown on the large geologic map in order to depict the underlying materials clearly.

A geologic map (Finch 1967) covering the Kentucky portion of the Joppa Quadrangle is available from the Kentucky Geological Survey in Lexington.

Structural Geology

The limestone bedrock and younger sediments in the Joppa Quadrangle originally were laid down in more or less horizontal layers. As a result of earth movements through geologic time, these strata are locally tilted, folded, and broken and offset along faults.

Generally, the bedrock strata of western Massac County are tilted gently toward the northeast. This tilt reflects regional upwarping of a structure called the Pascola Arch, centered in the "bootheel" of Missouri, coupled with downwarping of the Illinois Basin, centered in Wayne County in southeastern Illinois. These gradual earth movements took place between the Permian and Jurassic Periods, approximately 150 to 290 million years ago. As a result, wells drilled near the northeastern corner of the Joppa Quadrangle encounter younger bedrock formations than do wells drilled near the Ohio River. The approximate distribution of bedrock formations is illustrated on the bedrock geology map (fig. 1).

A second round of regional earth movements beginning in the Cretaceous Period produced the Mississippi Embayment. The embayment was an elongate trough open to the Gulf of Mexico, and it is now a northward extension of the Gulf Coastal Plain. The axis of the embayment lay close to the present position of the Mississippi River, and its northern end borders the Shawnee Hills just north of the map area. Cretaceous and early Tertiary marine and near-shore sediments were deposited within the Embayment. The bedrock geologic map (fig. 1) shows that the upper surface of bedrock generally becomes deeper toward the south. The southward deepening of bedrock reflects greater southward subsidence of the Mississippi Embayment.

Several fault zones cross the Joppa Quadrangle. These faults are part of the Fluorspar Area Fault Complex, an intricate array of fractures that affect a large area of southernmost Illinois and western Kentucky. These faults have undergone repeated periods of activity (Kolata and Nelson 1991, Weibel et al. 1993, Potter et al. 1995). They may have originated during an episode of crustal rifting in the Cambrian Period, some 500 to 550 million years ago. Widespread fault movements took place during the Pennsylvanian and Permian Periods, some 250 to 325 million years ago, and possibly also during the Jurassic Period, 150 to 205 million years ago. Renewed movements occurred after the end of the Cretaceous period (65 million years ago), displacing the bedrock surface along with the Cretaceous McNairy Formation. Some faults in the Joppa Quadrangle were active during the Pleistocene, yet we have found no evidence that any have moved within the last 75,000 years (Nelson et al. 1997, 1999).

Lusk Creek Fault Zone

The Lusk Creek Fault Zone, in the western part of the map area, is the westernmost major fault zone in the Fluorspar Area Fault Complex. This fault zone continues more than 30

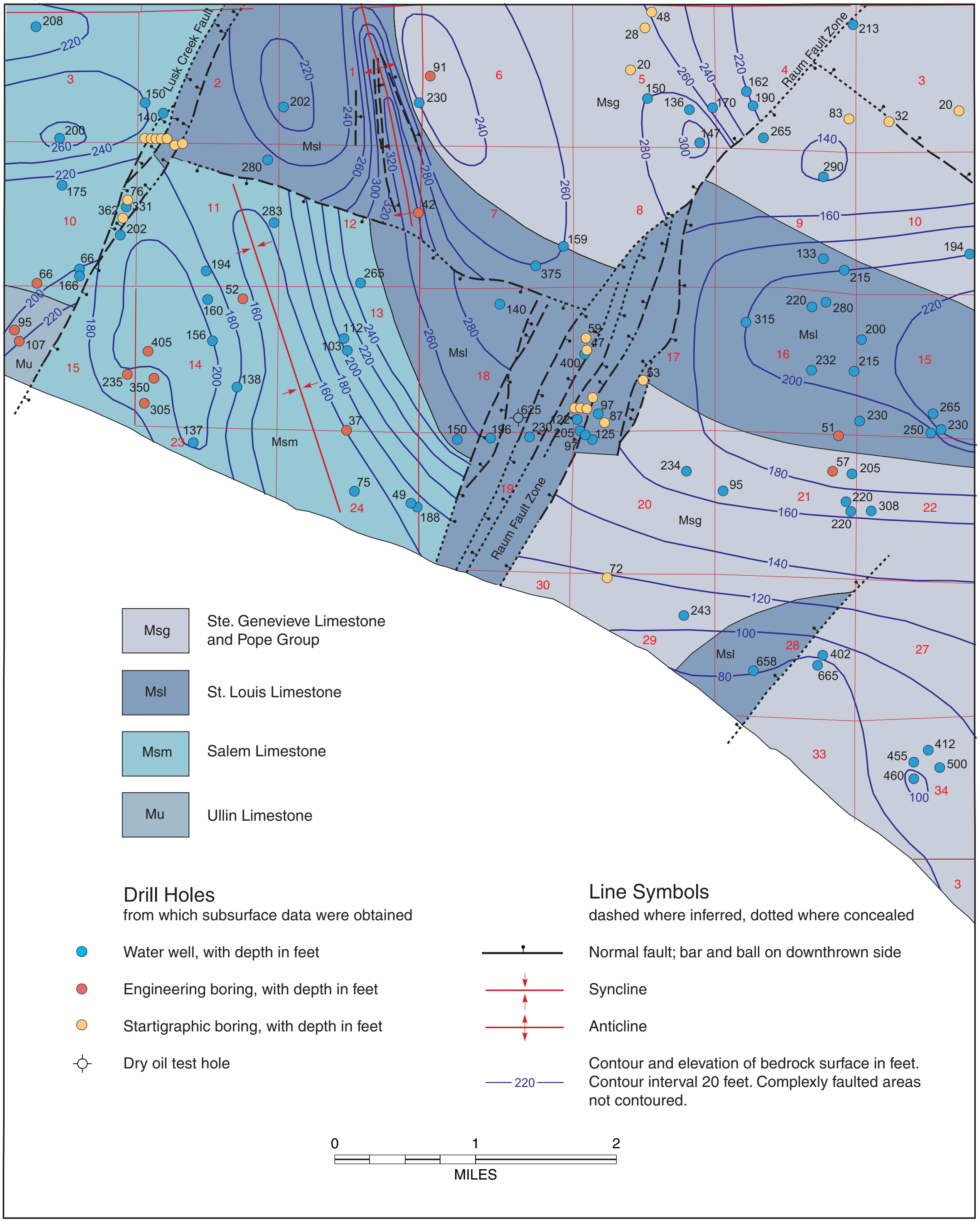

Figure 1 Bedrock geology of Joppa Quadrangle. Scale 1:48,000.

miles northeast of Joppa into Pope County, where it merges with the east-west trending Rough Creek-Shawneetown Fault System. The Lusk Creek is a complicated fracture system that has undergone several episodes of movement. In most places, the net result of these movements displaced bedrock down to the southeast.

Within the Joppa Quadrangle, the Lusk Creek Fault Zone is less than ¼ mile wide and trends about N35°E. The zone is mapped on the basis of borehole data and a seismic reflection profile (fig. 2) north of Maple Grove School. No faults are visible at the surface, although in places, subtle linear ridges and valleys appear to mark its trace. The range of hills in the central part of Sec. 2, T15S, R3E and the small stream in the western part of Sec. 15 both are roughly parallel with the fault zone.

Borehole data indicate that Mississippian limestone formations are downthrown on the southeast side of the Lusk Creek Fault Zone. A test hole at the Missouri Portland Cement plant, on the Ohio River just beyond the western border of the quadrangle, encountered the Ullin Limestone at the bedrock surface, whereas several boreholes at the Electric Energy, Inc. power plant found the younger Salem Limestone at the bedrock surface. The indicated displacement of roughly 100 feet is much smaller than that mapped northeast of the Joppa Quadrangle (Devera 1991, Weibel et al. 1993, Devera and Nelson 1998).

Maple Grove Site

Detailed studies near Maple Grove School, 2 miles northwest of Joppa, indicate repeated movements of the Lusk Creek Fault Zone as recently as Pleistocene time. An east-west seismic reflection profile 3,300 feet long was run ½ mile north of Maple Grove School (fig. 2). The more or less horizontal lines on the profile are "reflectors" that represent layering in Mississippian bedrock and overlying McNairy Formation. Offsets of reflectors are interpreted to be faults that displace both the bedrock and the McNairy. In fact, the fault pattern depicted on the seismic profile is too intricate to portray at the map scale of 1:24,000. We drilled seven test holes on the Jimmy Rodgers farm in Sec. 2, T15S, R3E to try to verify the faults shown on the seismic line. A cross section of the fault zone (fig. 3) is based on interpretation of the seismic line and drill-hole records. Core samples from several of the holes showed layering of the McNairy Formation dipping at 20° to 40°, which suggests nearby faults. The overlying Mounds Gravel does not appear to be faulted here. Possible faulting of Mounds Gravel in the hills northeast of the Rodgers farm is suggested by the gravel lying at lower elevation here than on hills east and west of the fault zone. Also, a thin deposit thought to be Metropolis Formation was encountered below loess in two test holes, JR3 and JR4 (fig. 3). Whether the Metropolis is faulted here could not be determined, but any displacement would be small.

The log (not shown) of a water well at Maple Grove School showed an abnormally great depth to bedrock, suggesting

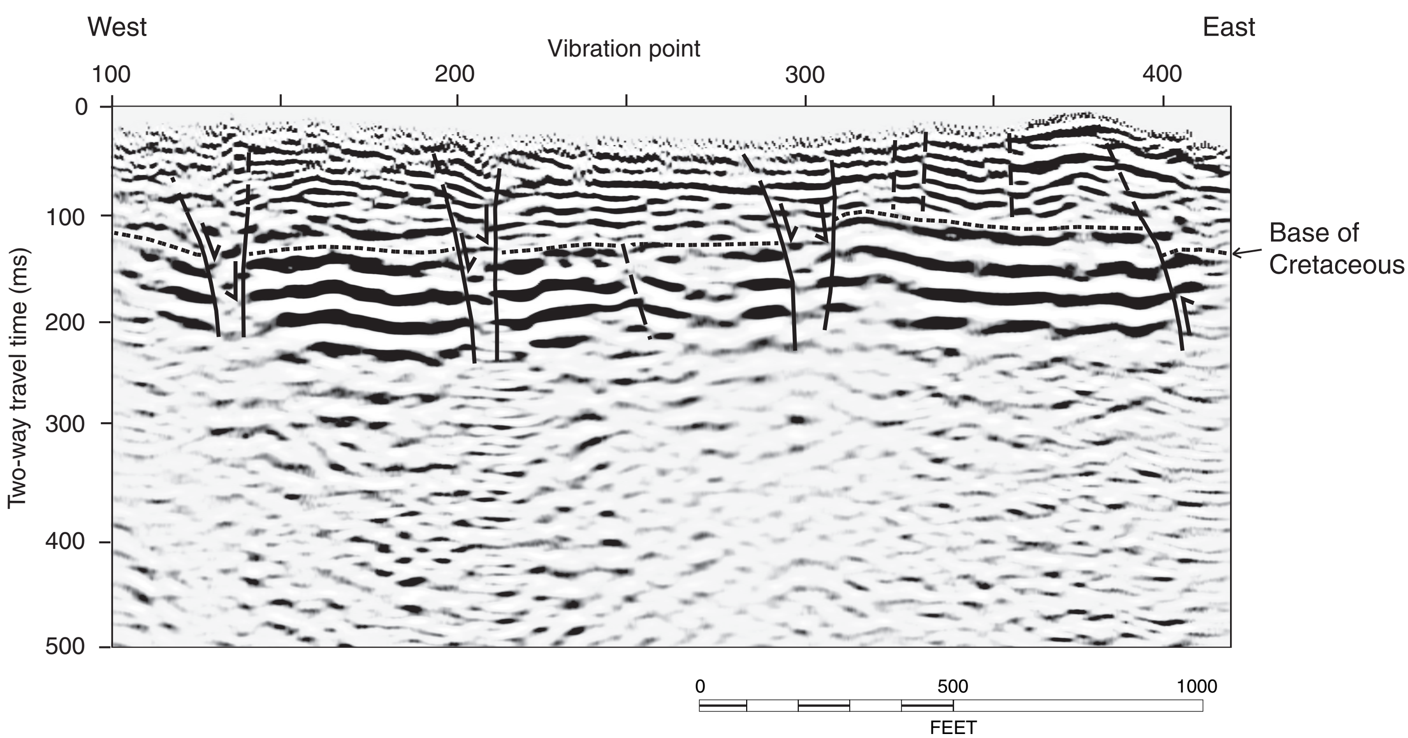

Figure 2 Migrated seismic profile showing interpreted faults from the Maple Grove School site. Vibration points are 10 feet apart; the line of section is shown on map sheet 1 of the geologic map.

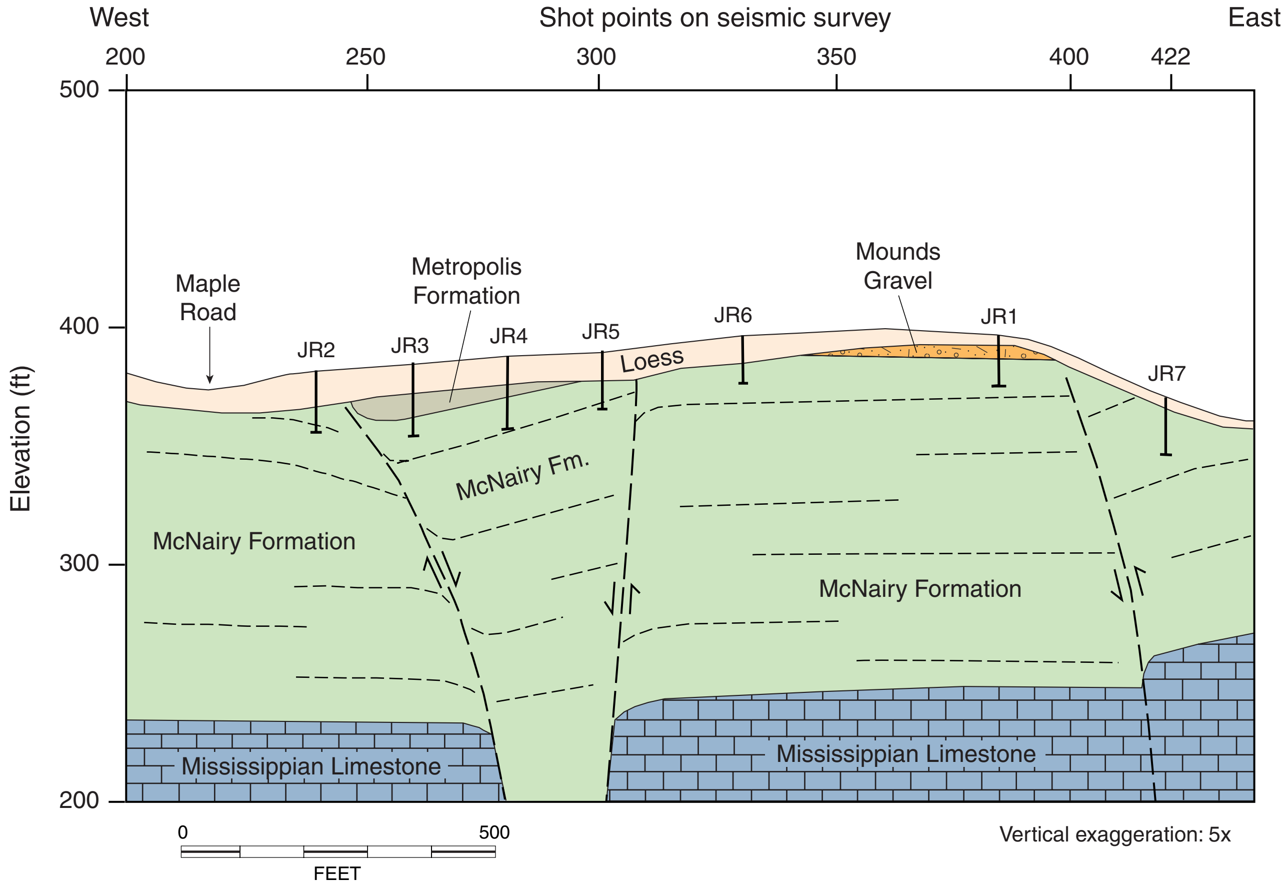

Figure 3 Cross section of Lusk Creek Fault Zone on the Jimmy Rodgers farm, north of Maple Grove School in Sec. 2, T15S, R3E. This section is based on the eastern half of the seismic profile (fig. 2) plus information from shallow drilling. Dashed lines within the McNairy Formation represent bedding or lamination.

a narrow graben (downfaulted block). The ISGS drilled two test holes at the school in an attempt to verify faulting. First a small rig was used to drill ISGS No. 1 Maple Grove School, which reached a depth of 76 feet without reaching the McNairy Formation. Deformed sediments that did not match known formations of the area confirmed the presence of a structural anomaly. A larger rig was then brought in to drill a second hole, ISGS No. 2 Maple Grove School, which was cored continuously to a depth of 362 feet. The following strata were penetrated:

0 to 20 feet	**Loess**, silt; incomplete sample recovery.
20 to 48.5 feet	**Metropolis Formation**, mottled silt and sand with chert pebbles, gravel at base.
48.5 to 109.7 feet	**Unidentified sand**, very fine to medium, scattered quartz and chert granules, mostly loose, laminations dip 30°.
109.7 to 127.0 feet	**Unidentified gravel**, gray chert gravel with quartz sand matrix.
127.0 to 320.0 feet	**McNairy Formation**, dominantly fine sand, slightly micaceous, massive to laminated.
320.0 to 359.0 feet	**Post Creek Formation**, gray chert gravel in sand and clay matrix.
359.0 to 362.0 feet	**Salem Limestone**, crinoid-bryozoan packstone with chert lenses.

The No. 2 Maple Grove borehole confirms presence of a deep graben. The top of bedrock (Salem Limestone) is 200 feet deeper in No. 2 Maple Grove than in other wells in the area (fig. 1). Moreover, the succession of strata above the McNairy in No. 2 Maple Grove is unlike that found in any other drill hole in the area. The Post Creek and McNairy Formations appear as usual, but the gravel at 109.7 to 127 feet and sand at 48.5 to 109.7 feet do not match any other unit found in southern Illinois. The unidentified sand contains small, polished gray to black chert granules, similar to those typical of the Eocene Jackson and Claiborne Formations in nearby areas of western Kentucky (Olive 1974, 1980). The gravel at 109 to 127 feet does not resemble any known formation from the surrounding region. The unidentified sand and gravel could be as old as Cretaceous or as young as early Quaternary. The Metropolis Formation in No. 2 Maple Grove occurs slightly below its expected elevation, but may not be faulted. Joints and small faults (less than 1 foot of throw) were observed in the Metropolis Formation along the south-flowing stream west of Maple Grove School (western part of Sec. 10, T15S, R3E). The Holocene-age Cahokia Formation (less than 12,000 years old) is not disturbed (fig. 3).

Overall the evidence implies that the Lusk Creek Fault Zone underwent a pre-Cretaceous displacement of about 100 feet down to the southeast, offsetting Mississippian limestone. Post-Cretaceous tectonic activity produced narrow grabens that dropped as much as 200 feet. Small movements may have taken place as recently as the Pleistocene.

Raum Fault Zone

The Raum Fault Zone parallels the Lusk Creek to the east and, like the latter, has been traced more than 30 miles along strike into northern Pope County. Along most of its length, the northwest side of the Raum Fault Zone is downthrown, but at least two episodes of movement have taken place (Weibel et al. 1993). In the Joppa Quadrangle, the top of Mississippian bedrock (and base of McNairy Formation) is displaced 75 to 150 feet down to the southeast (fig. 1). Because the base of the McNairy is offset, this movement can be no older than late Cretaceous (about 65 to 75 million years ago).

Near the former village of Choat, the Raum Fault Zone widens into an intricate zone of horsts and grabens nearly 1 mile wide. Within this complicated area, a combination of outcrop data, water-well records, cored test holes, and a seismic reflection profile indicate that faults were active as recently as the Pleistocene.

The large geologic map shows many faults displacing the Mounds Gravel near Choat. The faults appear to trend northeast to north-northeast and to outline narrow horsts and grabens. They were mapped largely on the basis of abrupt elevation changes of the base of the Mounds (Mounds-McNairy contact) among adjacent outcrops and wells. Also, in several places, bedding of the McNairy and Mounds was found to be dipping, suggesting nearby faults. However, the only place where a fault actually was seen in outcrop is at the Metropolis landfill, and the exposure was not good. Most faults mapped in the Choat area are inferential, and some are questionable. It is likely that some elevation changes of the Mounds Gravel in this area reflect non-tectonic features, such as infilled channels, landsliding, or soil creep. Some well records may be erroneous, and inferred offsets of the Mounds may be nonexistent. Nevertheless, the overall evidence for faulting in this area is strong.

At the Metropolis landfill site, a poorly exposed fault displaced the McNairy Formation, but not the Mounds Gravel. Northeast of this outcrop, the Mounds Gravel seems to be downthrown into a graben that is bounded by hidden faults. Bright orange sand is exposed in a borrow pit at the northwest corner of the landfill. The bedding of this sand dips 30° to 40° southeast, a strong indicator of tectonic deformation. Drilling at this site showed that typical Mounds Gravel underlies the orange sand; the sand itself is considered to be part of the Mounds. Overlying the orange sand along the edge of the borrow pit are three Pleistocene loess units: the Loveland Silt (Illinoian) and the Roxana and Peoria Silts (Wisconsinan). The layering of the loess is horizontal, truncating the tilted bedding of the sand beneath. This relationship indicates that the Mounds sand and gravel were tilted and downdropped before deposition of the Loveland and younger silts. Thus, the movements took place between late Tertiary and Illinoian time.

The ISGS No. 1 Metropolis Landfill test hole, drilled in the borrow pit, encountered an unexpected formation below the Mounds Gravel. The core samples from 30 to 45 feet are dark gray to green sandy clay, rich in glauconite, and show burrowed structure (Paleocene Clayton Formation). Below the Clayton Formation is cored micaceous clay and sand representing the McNairy Formation. The Clayton Formation is absent in nearly all of Massac County, having been eroded before the Mounds Gravel was deposited. Its presence in a graben at the landfill is evidence that the graben sank during Tertiary time, before deposition of the Mounds, and sank again after the Mounds was deposited.

Another place where faults are evident is along Crim and Mt. Mission Roads in Secs. 17 and 18, T15S, R4E. A high-resolution seismic reflection profile run along these roads (not reproduced here; line of section is on the large geologic map) showed several sets of offset reflectors that probably represent faults displacing Mississippian bedrock and the McNairy Formation. The mapped pattern of faults that cross Crim and Mt. Mission Roads is largely based on the seismic data. Although the strike trends of the faults cannot be determined from a single seismic line, other geologic data indicate that the faults probably strike northeast, as shown on the map.

Three boreholes on the north side of Crim Road just west of the Burlington Northern Santa Fe Railway indicate a graben or downfaulted block containing strata as young as Mounds Gravel. A water well drilled for Melferd Krueger, Jr. reached a depth of 400 feet without encountering bedrock. Given the surface elevation of 380 feet, the top of bedrock is at least 20 feet below sea level at the well site, in contrast to bedrock elevations of 173 to 290 feet above sea level outside of the fault zone. To verify the log of the water well, the ISGS drilled two continuously cored test holes nearby (No. 1 and No. 3 M. Krueger, Jr.). These holes demonstrated that the Mounds Gravel is 80 to 100 feet lower in elevation here than on adjacent farms, providing strong support for the graben hypothesis. Moreover, the No. 3 Krueger borehole encountered Porters Creek Clay and Clayton Formation (both Paleocene) directly beneath Mounds Gravel and overlying the McNairy Formation. As in the No. 1 Metropolis Landfill borehole, the presence of Paleocene units here is evidence of faulting both before and after deposition of the Mounds.

Another graben underlies the junction of Mt. Mission and Staton Ridge Roads, SE¼ NE¼ SW¼, Sec. 17, T15S, R4E. The seismic profile shows reflectors apparently downdropped into a narrow graben here. A test hole (ISGS No. 2 Melferd Krueger) adjacent to the road junction penetrated 53 feet of the Metropolis Formation without reaching the base of the unit. Such a thick deposit of Metropolis is out of place this far from the Ohio River and suggests that the graben was active during the Pleistocene while the Metropolis was being deposited.

Finally, small faults that displace the Metropolis Formation were observed along a linear ravine about 2,000 feet east of the center of Sec. 19, T15S, R4E. The ravine is directly in line with a large fault mapped through the landfill and shown on the seismic profile, to the northeast. The Cahokia Formation (Holocene alluvium), which overlies the faulted Metropolis Formation, truncates the faults and is horizontal and unfractured.

In summary, the Raum Fault Zone comprises a swarm of fractures, most of which strike northeast to east-northeast and outline narrow upthrown and downthrown blocks. These faults were definitely active during the Tertiary Period, both before and after the Mounds Gravel was deposited or during its deposition. The youngest unit offset is the Pleistocene Metropolis Formation. Because the Loveland Silt and younger sediments are not deformed, the faults apparently have not moved since the end of Illinoian time, about 130,000 years ago.

Kelley Structure

A new railroad cut at Kelley switch (not shown on the topographic base map), in the eastern part of Sec. 1, T15S, R3E, revealed a graben in which Mounds Gravel has been dropped at least 100 feet below its normal elevation. Additional studies carried out to define this structure included test probing and digging, excavating the entire northern side of the railroad cut, and running two seismic reflection profiles south of the railroad cut. The northern seismic profile (fig. 4) is reproduced here. An interpretive cross section (fig. 5) is based on the seismic profile and the excavation.

Digging showed the graben to be about 200 feet wide and bordered by steeply dipping faults. The McNairy Formation, horizontal away from the graben, is dragged sharply downward along both margins. The downthrown Mounds Gravel is folded into a syncline, dipping as steeply as 50° along the

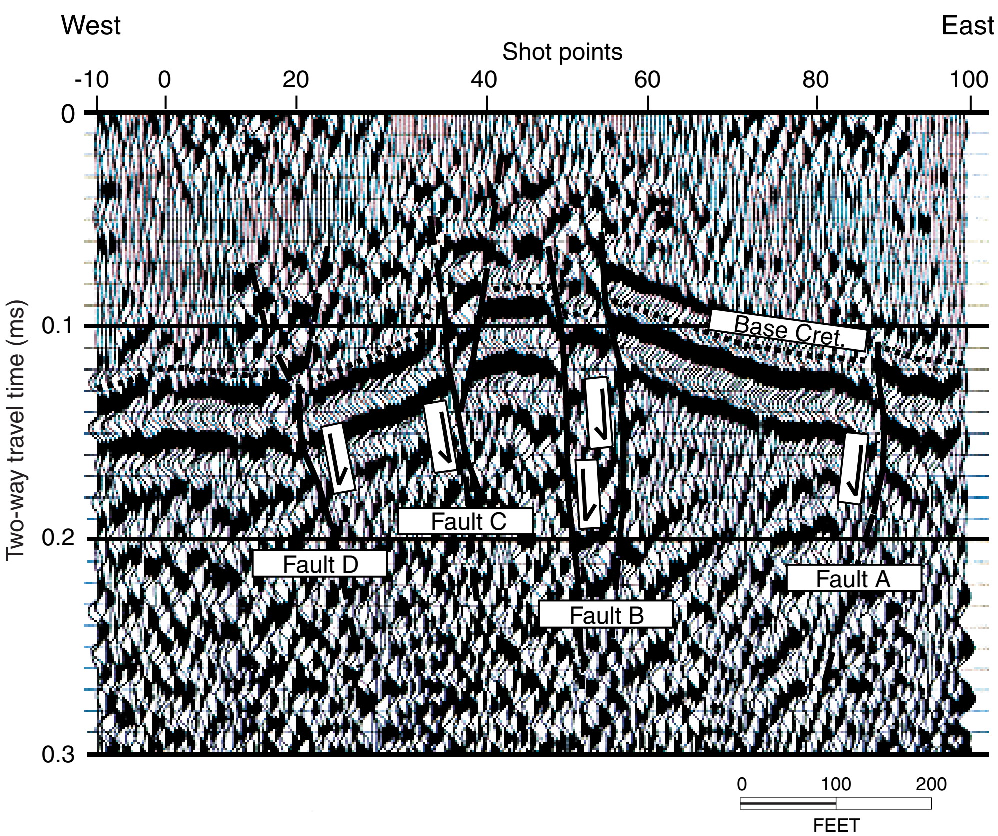

Figure 4 Interpreted seismic profile, Kelley North. Shot points are 10 feet apart.

bounding faults. Within the larger graben, a smaller half-graben contains a tilted block of strongly mottled, yellowish orange silty sand and gravel. This unit resembles the Metropolis Formation, which is foreign to this part of the Joppa Quadrangle. Overlying the Metropolis-like unit is about 2 feet of Loveland Silt, confined to the half-graben. The overlying Roxana and Peoria Silts sag and thicken slightly into the larger graben, but no faults offset them.

The structure revealed by trenching indicates fault movements took place during the Pleistocene, as recently as the Sangamon interglacial episode (75,000 to 130,000 years ago). The graben may have continued to sag gently, without fault displacements, through the Wisconsin glacial episode. However, the present topography at Kelley is a hill, nearly circular in map view; no linearity is evident.

The seismic reflection profile (fig. 4) shows a faulted anticline at depth beneath the graben at the surface. An interpretive cross section (fig. 5) highlights the contrast between shallow and deep structure. The most plausible explanation is that the Kelley structure underwent at least two episodes of movement. The earlier episode was likely compressional, forming an anticline and breaking its crest. The resulting configuration is a "positive flower structure," commonly attributed to strike-slip fault movement with a compressional component. A second episode of movement during the Quaternary involved extension, which caused the crest of the anticline to collapse and produced the graben.

Perhaps the most striking aspect of the Kelley structure is that, without the railroad cut, the structure would not have been detected. Before railroad construction, thick loess totally concealed it. Many similar structures perhaps lie buried beneath surficial deposits in southern Illinois.

Other Faults

A fault having pre-Cretaceous displacement down to the west is likely to be present between the Frank Hepp, Jr. No. 1A and No. 2 AEP Service boreholes in Sec. 28, T15S, R4E. The No. 1A boring penetrated about 55 feet of St. Louis Limestone, 250 feet of Salem Limestone, and the upper 70 feet of the Ullin Limestone. The No. 2 boring, about ½ mile east of No. 1A, encountered only 79 feet of Salem overlying 135 feet of Ullin and the upper 168 feet of the Fort Payne Formation. The upper surface of limestone is at nearly the same elevation in the two wells, but Mississippian formation contacts are about 300 feet lower in elevation in No. 1A. The strike trend of the fault cannot be determined; it is drawn striking northeast because this is the prevalent trend of faults in the area.

A cored test hole, ISGS No. 2 Buldtman, at 1,250' SL, 1,400' WL, Sec. 3, T15S, R3E, encountered McNairy Formation with layers dipping 30° to 45° at a depth of 21 to 32 feet (bottom of hole). An oriented core indicated that the layering dips northeast. The test hole was drilled at the tip of a narrow, linear northwest-trending ridge. The combination of topography and inclined lamination suggests a post-Cretaceous fault striking northwest and having the northeast side

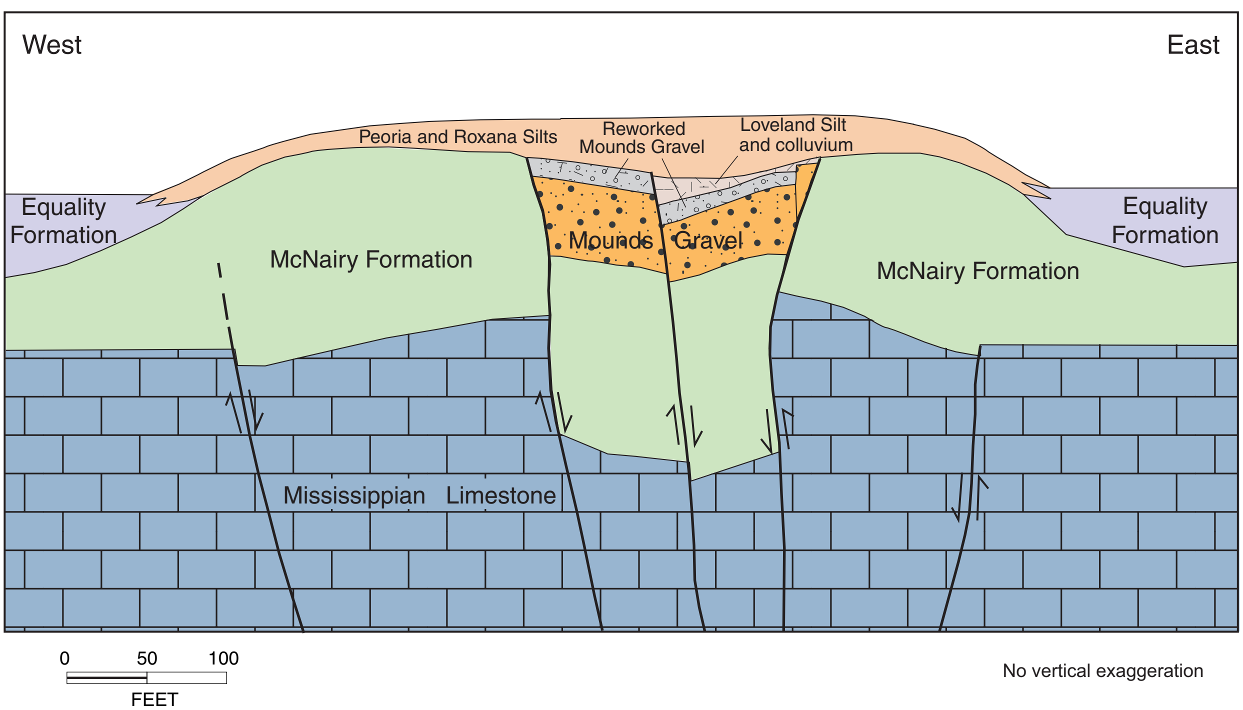

Figure 5 Interpretive cross section of Kelley structure, looking north. Apparently, an early episode of arching and reverse faulting (compressional) was followed by extension and graben formation during the Pleistocene.

downthrown. Water-well records indicate that the displacement of this fault (if it exists) is small.

A fault that trends west-northwest has been inferred to link the Lusk Creek and Raum Fault Zones about 2 miles north of Joppa and south of the Kelley structure. Scattered outcrop and water-well data suggest that the Mounds Gravel is displaced down to the south. The best indication of a fault was found in small gravel pits near the Cumberland Church in SE¼, Sec. 7, T15S, R4E. Just west of the church, the Mounds-McNairy contact was observed dipping 17° east at an elevation of 410 to 420 feet. At the top of the ridge 500 feet north of that point, the same contact is horizontal and at an elevation of 460 feet. A similar displacement of 40 to 50 feet down to the south is inferred from Mounds Gravel outcrops and a well log in Secs. 11 and 12, T15S, R3E. The elevation of the top of Mississippian bedrock is higher north of the western part of the inferred fault, but lower north of the eastern fault. Small ridges and valleys align with the suspected fault in subtle fashion. The poor quality of supporting data render existence of this fault questionable.

Field notes (ISGS) taken by H.B. Willman and dated April 14, 1948, suggest a fault displacing the Metropolis Formation in the southeastern part of the map area. The locality is described as "badlands" west of the Chicago and Eastern Illinois (now Burlington Northern Santa Fe), near the center of the SW¼, Sec. 27, T15S, R4E. Willman described a section comprising about 14 feet of loess overlying 11 feet of sandy silt containing scattered pebbles and abundant burrows lined with iron oxide. Willman states, "Hundreds [of burrows] are present. They end sharply along a line crossing the badlands northeast-southwest [and] densely cover a surface 30'×100'". We visited the area indicated, and found it densely vegetated and containing only a few small exposures of loess overlying Metropolis Formation.

Earthquake Hazard

The discussion of faults raises the issue of earthquake risk in the Joppa area. Mapping indicates that some faults in the Joppa Quadrangle were active as recently as the Pleistocene, but none has moved within the last 75,000 years. Only four small earthquakes, having Modified Mercalli Intensity of V or smaller, are on record in Massac County. Although southern Illinois (south of latitude 39° N) has a greater frequency of tremors than the rest of the state, only a few of these events have caused even minor damage to man-made structures (Heigold and Larson 1990).

Of greater concern is the New Madrid Seismic Zone, centered about 60 miles southwest of the map area. The earthquakes that occurred here during the winter of 1811–1812 were among the most powerful experienced in North America since European settlement. Street and Nuttli (1984) compiled maps showing Modified Mercalli Intensity of VI and VII for localities near Joppa during these earthquakes. However, a less severe earthquake closer to Joppa could produce greater damage. An earthquake near Charleston, Missouri, on October 31, 1895, had an estimated Richter magnitude of 6.5. Hopper and Algermissen (1980) estimated that this quake registered Modified Mercalli Intensity VIII at Paducah, Kentucky, based on reports such as ". . . at 5:10 o'clock this morning a severe shock of earthquake was felt all over town. Houses swayed to and fro, a number of chimneys fell, and several walls were cracked." Hopper (1985) estimated that an earthquake of magnitude 7.6 near the northern end of the New Madrid Seismic Zone could produce Modified Mercalli Intensity as high as IX in the Joppa area.

For reference, a Modified Mercalli Intensity of VII produces negligible damage to well-built structures, but can do considerable damage to poorly built or badly designed buildings, particularly masonry. In an earthquake of Modified Mercalli Intensity IX, even structures especially built to withstand earthquakes may be shifted off their foundations, and buildings of poor construction may collapse (Iacopi 1971, p. 35).

Another important consideration in predicting earthquake hazard is the nature of the ground. Ground motion and resulting damage are least on bedrock and greatest on weak substrates, such as alluvium and artificial fill. The Joppa Quadrangle contains no areas where bedrock is near the surface. A map by Bauer et al. (1999) indicates that in areas underlain by the McNairy, Mounds, and Metropolis Formations, earthquake ground motion may be amplified by 1.5 to 2.4 times. Higher ground motion and possible liquefaction of soil may take place in the Cache Valley and close to the Ohio River, where the Equality, Henry, and Cahokia Formations form the substrate (Bauer et al. 1999).

Groundwater

The boundary between high and low Mounds Gravel marked on the geologic map is significant in terms of groundwater. North of this boundary, the high Mounds Gravel is confined to small areas on hilltops, and is not a source of water. Domestic wells in the northern area thus are completed in aquifers older than the Mounds. Some wells are finished in sands of the McNairy Formation at depths of 50 to 150 feet. Other wells are completed in materials that drillers log as "chert," "gravel," or "novaculite." This material probably represents either the Post Creek Formation or chert rubble derived from weathering of limestone bedrock. Still other wells in the northern area produce water from the limestone bedrock itself. Because drillers provided no details on the geology and samples are not available, the nature of limestone aquifers in the northern area is not known, nor is information available on water quality from the northern area.

The approximate depth to bedrock at any point on the Joppa Quadrangle may be determined by subtracting the elevation of the top of bedrock shown on figure 1 from the surface elevation.

The low Mounds Gravel in the southern part of the map area is an aquifer and supplies many domestic wells. The gravel ranges from 10 to 45 feet thick and lies 50 to 75 feet below the surface in this area. In most cases it is capable of yielding water at 10 to 30 gallons per minute (gpm) through a 6-inch well casing. The Mounds is capable of supplying substantial amounts of water, as illustrated by a well yielding 500 gpm through 16-inch casing at the Missouri Portland Cement plant. No information has been published on water quality from Mounds Gravel in Illinois, but in the adjacent area of Kentucky, water from the Mounds tends to be hard (120–300 ppm of dissolved solids), but has lower iron content than water from other sources (Hansen 1966, Lambert 1967, Davis et al. 1973).

Large industrial water wells at the Electric Energy, Inc. generating station, the Cook Coal Terminal, and the Allied Signal plant are completed in Mississippian limestone. In nearly all of these wells, drillers reported encountering broken zones, crevices, and caverns in the limestone. Sand-filled caverns as large as 12 feet are recorded, and the well samples contain large amounts of sand and gravel mixed with limestone cuttings. Water outputs from such openings can be substantial. Among three wells at the Cook Coal Terminal, well No. 1 encountered a 5-foot cavern that initially yielded 4,000 gpm of water and provided sustained capacity of 2,000 gpm. The nearby No. 2 well established 1,850 gpm from voids and crevices in limestone. Less than one-half mile away, No. 1A encountered fractured and cavernous zones in the limestone also, but water flowed at less than 25 gpm, and the well was plugged and abandoned.

No data are available on the dimensions and orientation of water-bearing crevices in limestone. However, many crevices probably are tectonic fractures that dip vertically or nearly so and run northeast-southwest, parallel with the large mapped faults in the quadrangle. We therefore recommend that the best sites for large-capacity wells are along or close to mapped faults, and at locations northeast or southwest of established producing wells.

Mineral Resources

Sand and Gravel

Numerous small gravel pits have operated in the Mounds Gravel in the Joppa Quadrangle and elsewhere in the Mississippi Embayment area of Illinois. Gravel from these pits is used chiefly for surfacing secondary roads, driveways, and lanes. Currently, most pits are operated on a part-time basis by farmers on their own land. Larger gravel pits, such as the one near the center of the N½, Sec. 12, T15S, R3E were operated by the county highway department to obtain material for surfacing secondary roads. These pits provided a natural mixture of gravel, sand, and clay, which makes a good water-bound macadam pavement.

At the time of mapping, a dredge in the Ohio River east of Metropolis was actively recovering and screening sand for commercial use.

Clay

The Paducah Pottery Company operated clay pits near the railroad in SE¼, Sec. 7, T15S, R4E from the 1910s through the 1940s. The clay deposit that was mined was 10 to 16 feet thick and overlain by about 10 feet of loess with a thin gravel deposit at the base. The clay reportedly was silty and is part of the McNairy Formation. Use of the clay is not reported, but Lamar (1948) published analytical results and suggested that the clay is suitable for making face brick, terra cotta, and stoneware.

Clay in the McNairy Formation occurs in lenticular beds and is interbedded with silt, sand, and ironstone. No information is available on the location of McNairy clay deposits that might be suitable for commercial use today. Drilling and testing would be required to develop such a deposit. The prevalence of faulting in the Joppa Quadrangle adds uncertainty to clay exploration.

Oil and Gas

Only one test hole for oil and gas is on record in the Illinois portion of the Joppa Quadrangle. The C.L. Owens No. 1 Sommers hole was drilled in 1970 to a total depth of 633 feet in Mississippian limestone, probably the Salem Limestone. No shows of oil or gas were reported, and the hole was plugged and abandoned. A sample study by the senior author is the only log on file for this hole.

Four oil test holes were drilled in 1985 and 1986 in the Kentucky portion of the quadrangle. These four wells are clustered near the Brewer Cemetery, about 2½ miles south of Joppa. Wireline logs for these holes are on file at the Kentucky Geological Survey's field office in Henderson. All four wells reached Middle Devonian limestone; the deepest, the McCracken Exploration No. 2 Gibbs, reached a total depth of 3,260 feet in the Upper Ordovician Maquoketa Shale. There are questionable reports of oil shows in two of these wells at depths of 2,610 to 2,660 feet. The reported shows are within the Lower Devonian to Upper Silurian Bailey Limestone, a unit that has produced negligible amounts of oil and gas in the Illinois Basin. All four holes were plugged and abandoned.

The nearest producing oil wells are located more than 30 miles north of the Joppa Quadrangle in Williamson County, Illinois. The outlook for hydrocarbon production in the Joppa Quadrangle is not promising. The chief oil-producing formations of Illinois are the Upper Mississippian Pope Group and Ste. Genevieve Limestone, which are absent or at the bedrock surface here. Devonian and deeper production is possible, but untested except in the Kentucky wells. The extensive faulting, accompanied by many wide open crevices and cavities in the bedrock, suggests that any hydrocarbons once present may have escaped to the surface.

Acknowledgments

This map could not have been produced without the cooperation of numerous individuals. Beth Clanahan, Mayor of Metropolis; Rollo Burnett, Melferd Krueger, Sr. and Melferd Krueger, Jr., Jimmy Rodgers, Arnold Snell, Ralph Reed, Superintendent of School District 38, and Barry Ancell, Principal of Maple Grove School. Robert L. Powers and William L. Carter, P.E. of Electric Energy, Inc., facilitated trenching studies at the Kelley site. Lane Erectors, Inc. of Harrisburg provided a backhoe and operator at no cost for the trenching at Kelley. Wayne Simmons of Simmons Engineering in West Paducah, Kentucky, provided blueprints and borehole data from the Kelley site. Many people, too numerous to mention, allowed us access to their land for mapping and helped us verify the locations of wells on their property. The map benefitted from critical reviews by David A. Grimley, Joseph A. Devera, Robert A. Bauer, and Dennis R. Kolata.

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