GEOLOGY OF PULASKI QUADRANGLE
PULASKI COUNTY, ILLINOIS

Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief

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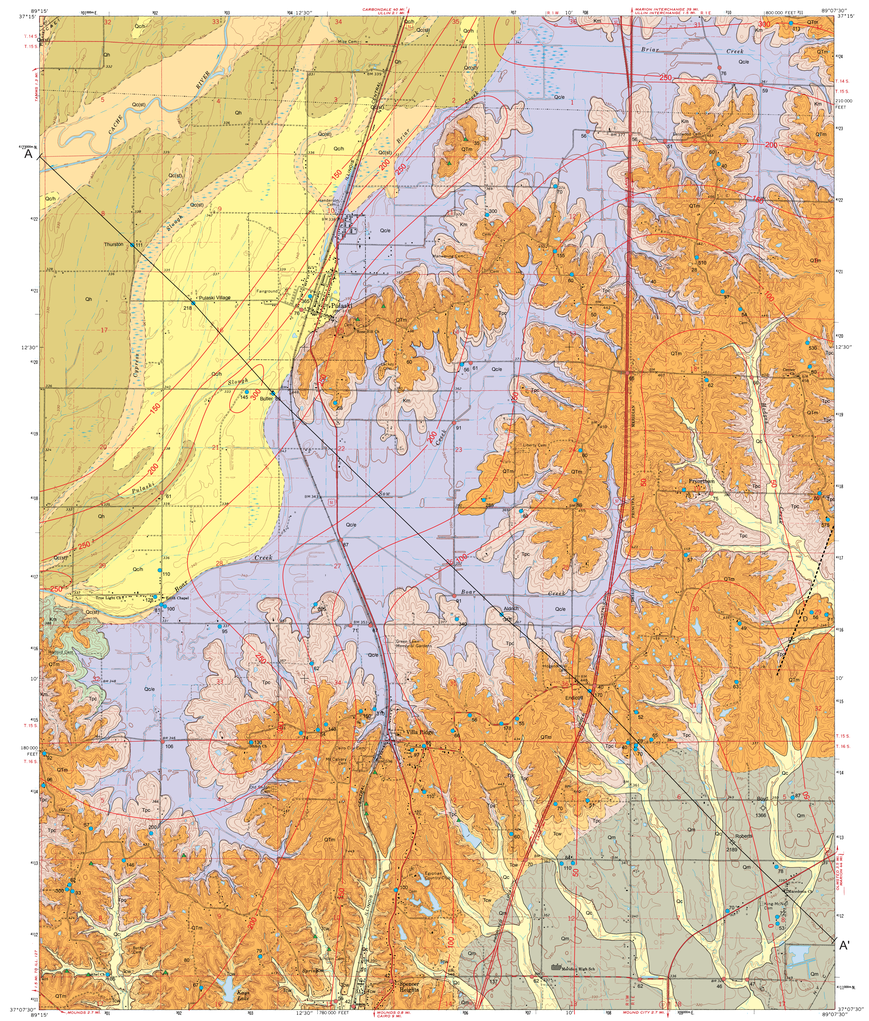
2004

Illinois Preliminary Geologic Map
IPGM Pulaski-G



Base map compiled by Illinois State Geological Survey from digital data provided by the United States Geological Survey. Topography and photogrammetric methods from aerial photographs taken 1965. Field checked 1967.

North American Datum of 1983 (NAD 83)
Projection: transverse Mercator
10,000-foot ticks: Illinois State Plane coordinate system, west zone (transverse Mercator)
1,000-meter ticks: Universal Transverse Mercator grid, zone 16

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SCALE 1:24 000

1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER

BASE MAP CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Released by the authority of the State of Illinois: 2004

Geology based on fieldwork by W.J. Nelson and L. Williams.

Digital cartography by W. J. Nelson, Illinois State Geological Survey.

This Illinois Preliminary Geologic Map (IPGM) is a lightly edited product, subject to less scientific and cartographic review than our Illinois Geological Quadrangle (IGQ) series. It will not necessarily correspond to the format of IGQ series maps, or to those of other IPGM series maps. Whether or when this map will be upgraded depends on the resources and priorities of the ISGS.

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ADJOINING QUADRANGLES
1 Mill Creek
2 Dongola
3 Cypress
4 Olive Br.
5 Olmsted
6 Cache
7 Cairo
8 Barlow

APPROXIMATE MEAN DECLINATION, 2003

Primary highway, hard surface
Secondary highway, hard surface
Light duty road, hard or improved surface
Unimproved road
Interstate Route
U.S. Route
State Route

EXPLANATION

Loess, which mantles all uplands in the Pulaski Quadrangle, is not mapped

- Qc — Cahokia Fm
- Qc(st) — Cahokia - silty clay facies
- Qch — Cahokia Fm over Henry Fm where Cahokia is 5 feet or thicker
- Qc/e — Cahokia Fm over Equality Fm
- Qh — Henry Fm where Cahokia is thinner than 5 feet
- Qm — Metropolis Fm
- QTm — Mounds Gravel
- Tcw — Wilcox Fm
- Tpc — Porters Creek Clay and Clayton Fm
- Km — McNairy Fm (Km) includes Owl Creek and Post Creek Fms, where present

Cross Section Only

- Pt — ? Pearl Fm
- Dna — New Albany Shale
- Dsl — St. Laurent and Grand Tower Fms
- Dt — Tamms Gp

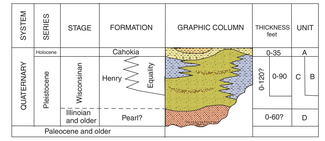
LINE SYMBOLS Dashed where inferred or approximately located, dotted where concealed

- **Contact** (accurately located)
- **Contact** (approximately located)
- **Fault,** U indicates upthrown, D indicates downthrown side.
- **Structure contour** drawn on top of Paleozoic bedrock; contour interval 50 feet.

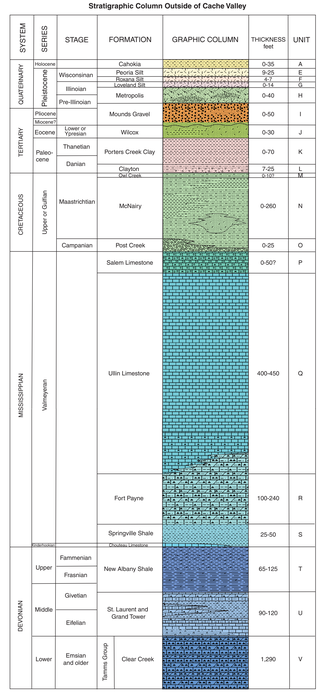
OTHER SYMBOLS

- **Outcrop** observed during mapping or described by previous geologist
- **Drill holes from which subsurface data were obtained.** Number indicates depth in feet.
- 185 — Water well
- 65 — Engineering borehole
- 70 — ISGS stratigraphic test hole
- Roberts / 2189 — Dry petroleum test with lease name and total depth in feet
- Water (ponds, streams)

Stratigraphic Column for Cache Valley



Stratigraphic Column Outside of Cache Valley



A. **Cahokia Formation** Silt, clay, sand, and gravel. Information on this unit comes largely from logs of Illinois Department of Transportation (IDOT) bridge borings. As described therein, the dominant material is silt loam, clay loam, and clay that is mottled gray and brown and is soft and moist, not stiff. The water content is generally between 25% and 40%, while the unconfined compressive strength (Qu) is less than 1.0 ton per square foot. Graham (1985) stated that the Cahokia has a lower clay content (less than 20%) than the Equality Formation (25 to 40%). Within the Cache Valley, the Cahokia ranges up to at least 25 feet thick and contains little sand and gravel.

The silty clay facies (map unit Qc(st)) underlies swampy, abandoned channels and sloughs in the Cache Valley and is silty clay that is rich in rotten vegetation and logs. This unit, called "wetland facies" in the adjacent Dongola Quadrangle (Nelson et al., 1999a), was mapped where the soil maps of Parks and Fehrenbacher (1968) indicate clay and silty clay soils. The usual soil types include the Karnak clay, the Cape and Karnak silty clay, and the Petrolia and Piopolis silty clay loams. This facies occurs in abandoned channels that represent the final course of a large river in the Cache Valley, and along smaller and more recent streams that meander across the valley floor.

Where it overlies the Equality Formation in lowlands adjacent to the Cache Valley, the Cahokia Formation is 4 to 10 feet thick, but can be difficult to distinguish from the Equality. Along streams that drain uplands in the map area, the Cahokia contains abundant chert gravel derived from the Mounds Gravel and sand derived from the Wilcox and McNairy Formations. The maximum known thickness, 35 feet, is indicated by bridge borings along the drainage west of Spencer Heights near the southern edge of the quadrangle. The lower contact may be either sharp or gradational.

B. **Equality Formation** Silt, clay, minor sand and gravel. Silt and clay are medium to dark gray, olive-gray, and bluish-gray, although orange and brown mottling is common in the upper part of the unit. Logs of IDOT bridge borings indicate unconfined compressive strength (Qu) ranging from 0.4 to 4.2 tons per square foot, but typically 1.0 to 2.0 tpsf. The blow count is normally less than 10 per foot, and the water content varies from 15% to 40% but most samples fall in the range of 20% to 30%. Some very stiff clay in the lower part of the Equality yields blow counts as high as 30 per foot and Qu of 2.0 to 4.2 tpsf. Clay and silt of the Equality may be massive to thinly laminated. Thirty feet of "varved clay" was logged in the lower Equality in a bridge boring at Boar Creek in Sec. 26, T15S, R1W. Fragments of wood, plant matter, and thin layers of peat occur locally. Lenses of sand and gravel become common in the lower part, particularly at the base of the Equality adjacent to uplands. The basal gravel is described as white to reddish orange, fine to coarse, and having a clay binder. Some of this gravel may represent units older than typical Equality Formation, but samples are not available.

The Equality Formation underlies valleys tributary to the Cache Valley and ranges up to at least 90 feet thick. Within the eastern part of the main Cache Valley, the Equality interfingers with part of the Henry Formation. This formation is interpreted as fluvial-overbank and lacustrine sediments of Wisconsinan age. Where the Equality rests on units older than the Henry, the lower contact is unconformable.

C. **Henry Formation** Sand and gravel, minor clay and silt. Sand is light yellowish to brownish gray, very fine to very coarse, and composed mainly of quartz with a small portion of chert and other lithic grains. Gravel is composed of granules and small (mostly less than ½ inch) pebbles that are subrounded to well-rounded and composed of quartz, chert, and a variety of igneous, metamorphic and sedimentary rocks. In general, the Henry becomes finer grained upward, and it intergrades laterally with clay and silt of the Equality Formation. Data on the Henry in the Pulaski Quadrangle are sparse. There are no outcrops and only two sets of well samples, which are of poor quality. Much better information is available in the adjacent Dongola Quadrangle (Nelson et al., 1999a). The lower contact probably is erosional.

Henry Formation (map unit Qh) is shown in ridged portions of the Cache Valley, where the soil maps of Parks and Fehrenbacher (1968) indicate soils that contain sand within 5 feet of the surface. Typical soils are the Alvin sandy loam, the Ginat silt loam, the Weinbach silt loam, and the Scotoville silt loam. The thin surficial silt is assumed to be Cahokia Formation, overlying sands of the Henry. The few available water-well records show thick intervals of sand and gravel in the shallow subsurface. The linear to gently arcuate ridges and swales of the southwestern part of the map area represent sandy point-bar and longitudinal bars that formed when a large river occupied the Cache Valley. Such bar forms are found the length of the Cache Valley, and closely resemble modern sand bars of the lower Ohio River.

Cahokia and Henry Formations (map unit Qch) is shown in areas where the land is level to gently rolling, without well-marked ridges and swales; and where the soil survey (Parks and Fehrenbacher, 1968) and water wells indicate surficial silt thicker than 5 feet overlying sand and gravel at greater depth.

D. **Pearl Formation** Sand and gravel. Given the lack of detailed well records, the Pearl Formation has not been positively identified in the Pulaski Quadrangle, but it is present in the adjacent Dongola Quadrangle to the north (Nelson et al., 1999a). In that quadrangle the Pearl underlies the Henry Formation in the deeper part of the Cache Valley. The Pearl consists of sand and gravel similar to that of the Henry, but coarser, including pebbles as large as 3 inches in diameter. The Pearl is interpreted as fluvial channel deposits of the ancestral Ohio River dating to the Illinoian Age.

E. **Peoria Silt** Silt is mottled yellowish-gray, yellowish-brown, and gray; it is massive to blocky and has low clay content. Iron and manganese oxides occur as pellets, small nodules, and joint-fillings. The modern soil is developed in the Peoria. This unit is interpreted as loess, or silt that was blown out of the Cache and Mississippi Valleys during the late Wisconsinan Age, and deposited as a blanket across uplands. The contact to the underlying Roxana Silt is gradational and difficult to determine in many places.

F. **Roxana Silt** Silt is medium brown to reddish-brown, more uniform in color than the Peoria. The Roxana is massive to blocky, generally having higher clay content than the Peoria, retaining moisture better and having plastic texture in fresh drill samples. Pellets of iron and manganese oxides are common. The Farmdale Geosol, a buried soil, is developed in the Roxana in places and can be recognized on the basis of features such as root traces, clay coatings on fractures, and strong blocky structure. The Roxana is loess, or silt deposited by the wind during the middle Wisconsinan Age. Where it rests directly on pre-Pleistocene units, the lower part of the Roxana commonly contains scattered sand grains and pebbles. Where it rests on the Loveland Silt, the Roxana has a gradational lower contact.

G. **Loveland Silt** Silt is strongly mottled in yellowish, reddish, and orange-brown, and has massive to angular blocky structure. Brown clay linings on fractures (clay skins) are common. The Loveland typically is sandy and contains scattered granules and small pebbles, increasing toward the base. The Sangamon Geosol, a thick and strongly developed ancient soil, is developed in the Loveland and may extend into underlying units. The Loveland is loess, or silt deposited by the wind during the late Illinoian Age. It is a lenticular or patchy unit, missing in many places. The lower contact may be sharp or gradational.

H. **Metropolis Formation** Silt, sand, and gravel. Silty sand and sandy silt are strongly mottled in gray, brown, yellow, and orange. Gravel, found mostly near the base of the unit, is composed of rounded to well-rounded, dull gray chert and quartz pebbles derived from the Mounds Gravel. The pebbles have largely lost the glossy brown patina that characterizes the Mounds. The Metropolis does not crop out in the Pulaski Quadrangle; it was mapped on the basis of topography and sparse information from boreholes. In IDOT bridge borings, the Metropolis is logged mostly as silty clay loam having unconfined compressive strength (Qu) of 0.5 to 2.0 tons per square foot, and a water content of 20% to 35%. These values do not differ greatly from those of loess, so identifying Metropolis on these logs is difficult. This unit is interpreted as alluvial sediment deposited by the ancestral Tennessee River during early to middle Pleistocene (Illinoian and older) time (Nelson et al., 1999b). The contact to the underlying Mounds Gravel seems to be gradational.

I. **Mounds Gravel** Gravel, sand, and clay. Gravel is reddish-orange to brown and composed chiefly of subrounded to well-rounded chert pebbles that range up to 4 inches across. Small quartz pebbles are a minor constituent. The chert pebbles bear a characteristic glossy brown or bronze-colored patina of iron oxide. The gravel is crudely layered and has a matrix of sand. At the base are scattered cobbles and small boulders of sandstone, chert, and other sedimentary rocks; the basal part of the gravel commonly is cemented by iron oxide. Sand in the Mounds is reddish-orange to brown, fine to very coarse, and composed mostly of quartz, with a minor component of chert. Where the Mounds is thick, the upper part is mostly sand that tends to become coarser downward and grade into gravel. Gray to orange, sandy, stiff clay lenses or interbeds occur locally and are less than 1 foot thick. Throughout the hilly upland areas of the map area, the Mounds is overlain by loess (not mapped) and overlies older units with an erosional contact that lies at 360 to 420 feet above sea level. In the southeast corner of the quadrangle, the Mounds underlies the Metropolis Formation and its base is at elevations of 250 to 300 feet (as shown by well records). The Mounds is interpreted as the deposits of large braided rivers that apparently were ancestral to the modern Tennessee River (Potter, 1955; Nelson et al., 1999b).

J. **Wilcox Formation** Sand, silt, and clay. Sand is light gray to yellow, red, and brown; fine to coarse, and contains granules of quartz and gray to black chert. The sand is predominantly quartz, commonly has iron oxide cement and contains little or no mica. Silt and clay are gray, pink, yellow, red, and brown; partly sandy, and massive. Clay of the Wilcox has much higher compressive strength and is more difficult to penetrate in drilling than any Quaternary clay of the map area. The Wilcox may represent shallow marine to marginal-marine sediments deposited at the northern end of the Mississippi Embayment, which was an arm of the Gulf of Mexico during the Eocene Epoch. The lower contact probably is sharp.

K. **Porters Creek Clay** Clay is dark gray, olive-gray, and brownish-gray, very stiff, massive to weakly laminated, and breaks with a conchoidal fracture. Water-well drillers commonly log it as "soapstone" or "shale". In IDOT bridge borings, the Porters Creek is logged as very stiff dark gray clay having unconfined compressive strength of 2.0 to 5.0 tons per square foot and requiring 20 to 40 blows per foot to penetrate. The clay is finely silty and micaceous, becoming sandy near the base. The lowermost part may be calcareous, and contains siderite crystals and glauconitic grains. Sample logs noted microscopic marine fossils, such as foraminifera and radiolarians. The Porters Creek is well known from the adjoining Olmsted Quadrangle to the east, where it has been mined for many decades and used to make absorbent clay products. This formation represents marine clays deposited when the Mississippi Embayment, an arm of the Gulf of Mexico, reached southern Illinois during the Paleocene Epoch. The lower contact is gradational.

L. **Clayton Formation** Sand and clay. Clayey sand and sandy clay generally are dark gray, dark olive-gray, or dark greenish-gray. The sand is fine to medium-grained and composed of quartz along with abundant (10% to 50%) dark green glauconite. The clay tends to be olive-gray. Clay and sand are intermixed; the sediment was thoroughly burrowed by small animals. Sample logs report biotite flakes, siderite rhombs, limonite pebbles, and marine microfossils such as foraminifera and radiolarians. White to black, rounded chert pebbles as large as 3 inches may occur in the lower part. The Clayton is interpreted as a transgressive, shallow-marine deposit of the Mississippi Embayment during early Paleocene time. Well records indicate that the Clayton may rest directly on Devonian bedrock near the southwestern corner of the map area. This bedrock high was a likely source of the chert pebbles. The lower contact is sharp and believed to be unconformable.

M. **Owl Creek Formation** Sand and clay. Sand and sandy clay are strongly mottled in greenish gray to brownish orange. The sand is very fine to fine-grained, mostly quartz with abundant mica and some glauconite, but much less glauconite than is found in the Clayton. The sediment is laminated to some degree, but burrowing disrupts the layering. No fossils are reported. The Owl Creek is known from one ISGS core in the Pulaski Quadrangle and from outcrops in adjacent quadrangles. This unit is interpreted as shallow marine to marginal marine sediment of the Mississippi Embayment, an arm of the Gulf of Mexico near the end of the Cretaceous Period. The lower contact is gradational.

N. **McNairy Formation** Sand, silt, and clay. The sand is white to light gray in the subsurface, weathering bright yellow, orange, and red near the surface. It is mostly very fine to fine-grained; some medium sand occurs in the lower part of the unit. Quartz is the dominant mineral, but mica is very conspicuous and distinguishes the McNairy from other units. Much of the sand is thinly layered and contains pin-stripe laminations of gray to black, micaceous clay and silt. The McNairy also contains thicker intervals of clay and silt that are mostly medium to dark gray, very micaceous, and laminated with light gray sand. Some sample logs report presence of pyrite, siderite, and lignitic material. Light brown to brick-red greasy clay was logged in samples from the Vick # 1 Boyd oil-test hole in Sec. 5, T16S, R1E. The McNairy may be absent near the southwest corner of the map area, which apparently was a bedrock island during late Cretaceous time. Its maximum known thickness in the Pulaski Quadrangle is 260 feet in the aforementioned Vick #1 Boyd well. The McNairy is interpreted to represent deltaic and marginal-marine sediments near the northern end of the Mississippi Embayment. The lower contact may be gradational to the Post Creek Formation, or erosional on Paleozoic bedrock.

O. **Post Creek Formation** Gravel. Presence of this unit in the Pulaski Quadrangle is poorly documented from water-well drillers' logs and a few sample logs that are not of the best quality. In other areas of southern Illinois the Post Creek is mostly gravel, composed of subangular to rounded, white to gray, dull and opaque chert pebbles in a matrix of pritty clay and sand. Well drillers generally do not distinguish the water-worn gravel of the Post Creek from the underlying residual, angular chert and clay deposits derived from weathering and alteration of the Paleozoic bedrock. Sediment now known as Post Creek previously was called the Tuscaloosa Formation, but the Post Creek is different in age and rock type from the typical Tuscaloosa of the Gulf Coastal Plain (Harrison et al., 1997).

P. **Salem Limestone** Limestone is medium to dark gray, fossiliferous, and contains oolites and chert nodules. No wells having samples penetrate the Salem within the map area; the Salem is projected from the neighboring Dongola Quadrangle (Nelson et al., 1999a).

Q. **Ullin Limestone** Limestone is light to medium gray, composed largely of fragments of echinoderms and fenestrate bryozoans. The lower part is somewhat darker and more cherty, grading into the underlying unit. No wells having samples penetrate the Ullin within the map area; the Ullin is projected from the neighboring Dongola Quadrangle (Nelson et al., 1999a).

R. **Fort Payne Formation** Siliceous limestone and chert. Limestone is dark colored, micritic to very fine-grained, siliceous and very cherty. Cores and well cuttings from the adjacent Olmsted Quadrangle indicate the Fort Payne is largely leached of carbonate minerals and silicified, producing a chert-bearing dark brown to olive-gray material that resembles siltstone.

S. **Springville Shale** and **Chouteau Limestone** Shale and siltstone. The Springville is green-gray, siliceous and pyritic, glauconitic siltstone and silty shale that becomes coarser upward. The Springville is not clearly differentiated from silicified Fort Payne rocks on sample logs. The Chouteau, recorded in one sample log, is 6 feet of light brown, micritic, silty and argillaceous dolomite.

T. **New Albany Shale** The upper part of the New Albany Shale is silty, pyritic shale that is mottled dark gray and olive to greenish-gray. The lower part of the New Albany is dark brown to black and thinly fissile, also partly silty and pyritic. Some of the shale is dolomitic or slightly calcareous. A thin, pyritic sandstone (Sylamore) may occur at the base.

U. **St. Laurent** and **Grand Tower Formations** Chert, limestone, shale, sandstone. Information on these units in the map area is meager. In Alexander and southern Union Counties, northwest of the Pulaski Quadrangle, the St. Laurent is composed of cherty, argillaceous to silty, fossiliferous limestone and dolomite interbedded with calcareous or dolomitic shale and siltstone. The underlying Grand Tower is white to gray limestone that is purer than the St. Laurent but commonly sandy, finely to coarsely granular or crystalline, and fossiliferous. A unit of white to gray quartz sandstone and very sandy limestone, the Dutch Creek Sandstone Member, occurs at the base of the Grand Tower (Nelson et al., 1995). Sample logs of wells in and near the Pulaski Quadrangle suggest that carbonate rocks in the St. Laurent and Grand Tower have been largely dissolved and replaced by silica.

V. **Tamms Group** Chert, cherty limestone. Well records in and near the map area show this interval to consist largely of chert that is white to gray and yellowish-gray and opaque to slightly translucent. The chert contains casts of dolomite crystals, sponge spicules, and scattered glauconite grains. The lower part of the interval includes cherty limestone and dolomite that is light to medium gray and brownish-gray and quite argillaceous and silty. This interval includes the Clear Creek Formation (youngest), Backbone Limestone, Grassy Knob Chert, and Bailey Formation, but these formations cannot be differentiated in most well logs. The Clear Creek Formation, containing characteristic fossils, crops out along Boar Creek less than ½ mile west of the map area (J.A. Devera, ISGS, personal communication, 1999). In outcrops north of the map area, the Tamms Group is composed of cherty carbonate rocks that have been silicified extensively, apparently as a result of hydrothermal activity (Berg and Masters, 1994; Nelson et al., 1995). A well less than 1 mile east of the map area shows the Tamms Group to be 1,290 feet thick. The group is largely of Lower Devonian age, although the lower part of the Bailey may be Silurian.

NOT SHOWN ON COLUMN

Moccasin Springs Formation is approximately 170 to 225 feet thick and consists of very silty and argillaceous limestone to calcareous shale and siltstone, variegated in greenish gray to reddish brown. Foraminifera (microscopic marine fossils) were observed in one sample set. Age of this formation is Upper Silurian (Cayugan and Niagaran).

St. Clair Formation is 20 to 25 feet of limestone that is white to buff, with orange and salmon-pink mottling. Bright orange and red fossil fragments or "spots" are diagnostic of the St. Clair. Foraminifera identified as Ammodiscus are reported in this unit, which is Middle Silurian (lower Niagaran) age.

Sexton Creek Formation is 45 to 65 feet thick and consists of light gray to light brown limestone that is "sublithographic" to medium-grained, and contains abundant light gray semi-opaque chert. The limestone also is somewhat shaly and may contain the green mineral glauconite. Age of the Sexton Creek is Lower Silurian (Alexandrian).

Maquoketa Shale is 185 to 210 feet thick and is mostly silty shale and siltstone that is pyritic and partly calcareous. Most of the Maquoketa is dark gray and dark brown to nearly black, but some green shale occurs in the mid-upper portion. The Thebes Sandstone Member, less that 15 feet thick, is very fine-grained sandstone that occurs 50 to 90 feet below the top of the Maquoketa. Phosphate pellets occur at the base of the Maquoketa. This unit is of Upper Ordovician (Cincinnatian) age.

Kimmswick (Trenton) **Limestone** is 134 to 155 feet thick and white to light gray, occasionally showing a pink cast. The limestone is mostly medium to coarse-grained and crystalline, containing a little chert. In some wells this unit is partly altered to light gray, finely granular dolomite. Age of the unit is Upper Ordovician (Mohawkian) age.

Decorah Formation is probably 10 to 20 feet thick and identified as brown, mostly fine-grained limestone that is shaly and fossiliferous. It is Upper Ordovician (Mohawkian) age.

Plattin Limestone may be 600 to 830 feet thick, depending on how the lower contact is picked. The limestone is mottled buff to dark brown and most of it is extremely fine-grained, often logged as "lithographic" or "sublithographic". Chert is present but not abundant, as are partings or thin layers of shale. The Plattin is of Upper Ordovician (Mohawkian) age.

Joachim and **Dutchtown Formations** together are logged as being 305 to 490 feet thick, but loggers differ on where to place the contact to the Plattin. The Joachim and Dutchtown are mostly dolomitic, light to dark gray and very fine-grained to granular in texture. Some of the dolomite is sandy, and a little chert is present. These units also contain limestone similar to that of the Plattin. Age of these formations is Middle-Upper Ordovician (Whiterockian-Mohawkian).

St. Peter Sandstone is a distinctive unit approximately 125 to 140 feet thick. It is nearly pure sandstone that is white to yellowish-gray and yellowish-orange, and fine- to coarse-grained. Although not mentioned in the sample logs, the sand of the St. Peter is typically composed of well-rounded quartz grains that have frosted surfaces. This formation is Middle Ordovician (Whiterockian) age.

Knox Group The deepest penetration was about 511 feet into the Knox Group in the Cache Oil Co. #1 Moses oil-test hole, located in Sec. 17, T16S, R1W in the Cairo Quadrangle (less than one mile south of the Pulaski Quadrangle). The Knox is almost entirely dolomite, gray to yellowish brown in color and containing variable amounts of silt, sand, and chert. The texture varies from microgranular to coarsely sucrosic. The Everton Formation, at the top of the Knox Group, is characterized by very sandy dolomite that includes interbeds of sandstone similar to the St. Peter.

Sandstone at the bottom of the Moses well is tentatively identified as the Roubidoux Sandstone as exposed on the Ozark Dome in Missouri. The Roubidoux through Everton succession is Lower-Middle Ordovician (Ibexian-Whiterockian) age.