BEDROCK GEOLOGIC MAP

Waterloo Quadrangle, Monroe County, Illinois

Department of Natural Resources
George H. Ryan, Governor
ILLINOIS STATE GEOLOGICAL SURVEY
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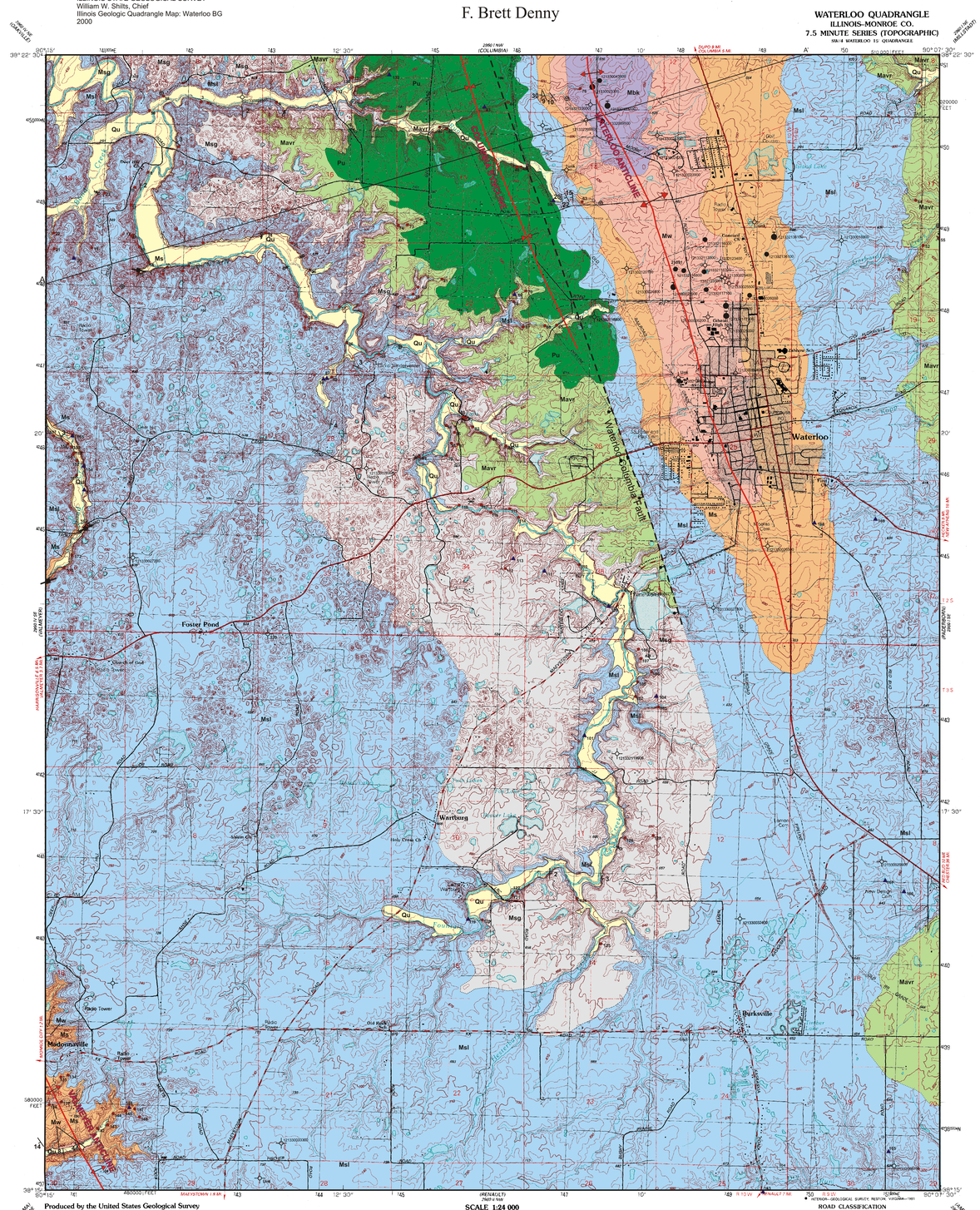
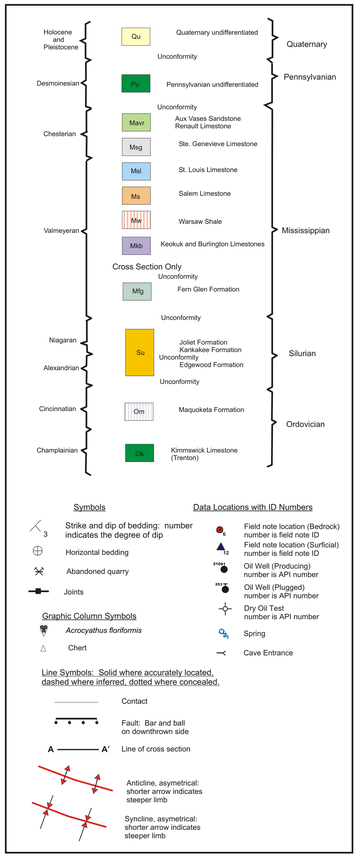
Illinois Geologic Quadrangle Map: Waterloo BG
2000

F. Brett Denny





Symbols

- Strike and dip of bedding: number indicates the degree of dip
- Horizontal bedding
- Abandoned quarry
- Joints

Data Locations with ID Numbers

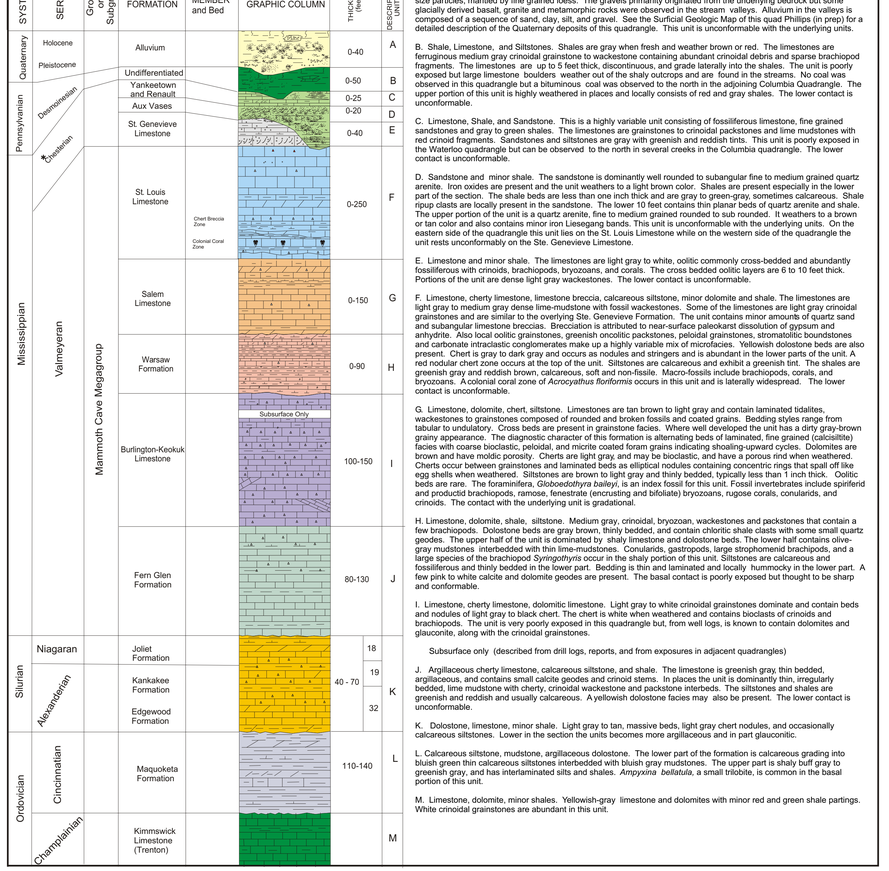
- Field note location (Bedrock) number is field note ID
- Field note location (Surficial) number is field note ID
- Oil Well (Producing) number is API number
- Oil Well (Plugged) number is API number
- Dry Oil Test number is API number
- Spring
- Cave Entrance

Graphic Column Symbols

- *Acrocyathus floriformis*
- Chert

Line Symbols: Solid where accurately located, dashed where inferred, dotted where concealed.

- Contact
- Fault: Bar and ball on downthrown side
- A — A′ Line of cross section
- Anticline, asymetrical: shorter arrow indicates steeper limb
- Syncline, asymetrical: shorter arrow indicates steeper limb



* Chesterian Boundary based on Maples and Water (1987)

A. Clay, Silt, Sand, Gravel. The upland sediments are mainly a diamicton composed of clay, silt, sand, gravel and cobble size particles, mantled by fine grained loess. The gravels primarily originated from the underlying bedrock but some glacially derived basalt, granite and metamorphic rocks were observed in the stream valleys. Alluvium in the valleys is composed of a sequence of sand, clay, silt, and gravel. See the Surficial Geologic Map of this quad Phillips (in prep) for a detailed description of the Quaternary deposits of this quadrangle. This unit is unconformable with the underlying units.

B. Shale, Limestone, and Siltstones. Shales are gray when fresh and weather brown or red. The limestones are ferruginous medium gray crinoidal grainstone to wackestone containing abundant crinoidal debris and sparse brachiopod fragments. The limestones are up to 5 feet thick, discontinuous, and grade laterally into the shales. The unit is poorly exposed but large limestone boulders weather out of the shaly outcrops and are found in the streams. No coal was observed in this quadrangle but a bituminous coal was observed to the north in the adjoining Columbia Quadrangle. The upper portion of this unit is highly weathered in places and locally consists of red and gray shales. The lower contact is unconformable.

C. Limestone, Shale, and Sandstone. This is a highly variable unit consisting of fossiliferous limestone, fine grained sandstones and gray to green shales. The limestones are grainstones to crinoidal packstones and lime mudstones with red crinoid fragments. Sandstones and siltstones are gray with greenish and reddish tints. This unit is poorly exposed in the Waterloo quadrangle but can be observed to the north in several creeks in the Columbia quadrangle. The lower contact is unconformable.

D. Sandstone and minor shale. The sandstone is dominantly well rounded to subangular fine to medium grained quartz arenite. Iron oxides are present and the unit weathers to a light brown color. Shales are present especially in the lower part of the section. The shale beds are less than one inch thick and are gray to green-gray, sometimes calcareous. Shale ripup clasts are locally present in the sandstone. The lower 10 feet contains thin planar beds of quartz arenite and shale. The upper portion of the unit is a quartz arenite, fine to medium grained rounded to sub rounded. It weathers to a brown or tan color and also contains minor iron Liesegang bands. This unit is unconformable with the underlying units. On the eastern side of the quadrangle this unit lies on the St. Louis Limestone while on the western side of the quadrangle the unit rests unconformably on the Ste. Genevieve Limestone.

E. Limestone and minor shale. The limestones are light gray to white, oolitic commonly cross-bedded and abundantly fossiliferous with crinoids, brachiopods, bryozoans, and corals. The cross bedded oolitic layers are 6 to 10 feet thick. Portions of the unit are dense light gray wackestones. The lower contact is unconformable.

F. Limestone, cherty limestone, limestone breccia, calcareous siltstone, minor dolomite and shale. The limestones are light gray to medium gray dense lime-mudstone with fossil wackestones. Some of the limestones are light gray crinoidal grainstones and are similar to the overlying Ste. Genevieve Formation. The unit contains minor amounts of quartz sand and subangular limestone breccias. Brecciation is attributed to near-surface paleokarst dissolution of gypsum and anhydrite. Also local oolitic grainstones, greenish oncolitic packstones, peloidal grainstones, stromatolitic boundstones and carbonate intraclastic conglomerates make up a highly variable mix of microfacies. Yellowish dolostone beds are also present. Chert is gray to dark gray and occurs as nodules and stringers and is abundant in the lower parts of the unit. A red nodular chert zone occurs at the top of the unit. Siltstones are calcareous and exhibit a greenish tint. The shales are greenish gray and reddish brown, calcareous, soft and non-fissile. Macro-fossils include brachiopods, corals, and bryozoans. A colonial coral zone of *Acrocyathus floriformis* occurs in this unit and is laterally widespread. The lower contact is unconformable.

G. Limestone, dolomite, chert, siltstone. Limestones are tan brown to light gray and contain laminated tidalites, wackestones to grainstones composed of rounded and broken fossils and coated grains. Bedding styles range from tabular to undulatory. Cross beds are present in grainstone facies. Where well developed the unit has a dirty gray-brown grainy appearance. The diagnostic character of this formation is alternating beds of laminated, fine grained (calcisiltite) facies with coarse bioclastic, peloidal, and micrite coated foram grains indicating shoaling-upward cycles. Dolomites are brown and have moldic porosity. Cherts are light gray, and may be bioclastic, and have a porous rind when weathered. Cherts occur between grainstones and laminated beds as elliptical nodules containing concentric rings that spall off like egg shells when weathered. Siltstones are brown to light gray and thinly bedded, typically less than 1 inch thick. Oolitic beds are rare. The foraminifera, *Globoendothyra baileyi*, is an index fossil for this unit. Fossil invertebrates include spiriferid and productid brachiopods, ramose, fenestrate (encrusting and bifoliate) bryozoans, rugose corals, conulariids, and crinoids. The contact with the underlying unit is gradational.

H. Limestone, dolomite, shale, siltstone. Medium gray, crinoidal, bryozoan, wackestones and packstones that contain a few brachiopods. Dolostone beds are gray brown, thinly bedded, and contain chloritic shale clasts with some small quartz geodes. The upper half of the unit is dominated by shaly limestone and dolostone beds. The lower half contains olive-gray mudstones interbedded with thin lime-mudstones. Conulariids, gastropods, large strophomenid brachiopods, and a large species of the brachiopod *Syringothyris* occur in the shaly portion of this unit. Siltstones are calcareous and fossiliferous and thinly bedded in the lower part. Bedding is thin and laminated and locally hummocky in the lower part. A few pink to white calcite and dolomite geodes are present. The basal contact is poorly exposed but thought to be sharp and conformable.

I. Limestone, cherty limestone, dolomitic limestone. Light gray to white crinoidal grainstones dominate and contain beds and nodules of light gray to black chert. The chert is white when weathered and contains bioclasts of crinoids and brachiopods. The unit is very poorly exposed in this quadrangle but, from well logs, is known to contain dolomites and glauconite, along with the crinoidal grainstones.

Subsurface only (described from drill logs, reports, and from exposures in adjacent quadrangles)

J. Argillaceous cherty limestone, calcareous siltstone, and shale. The limestone is greenish gray, thin bedded, argillaceous, and contains small calcite geodes and crinoid stems. In places the unit is dominantly thin, irregularly bedded, lime mudstone with cherty, crinoidal wackestone and packstone interbeds. The siltstones and shales are greenish and reddish and usually calcareous. A yellowish dolostone facies may also be present. The lower contact is unconformable.

K. Dolostone, limestone, minor shale. Light gray to tan, massive beds, light gray chert nodules, and occasionally calcareous siltstones. Lower in the section the units becomes more argillaceous and in part glauconitic.

L. Calcareous siltstone, mudstone, argillaceous dolostone. The lower part of the formation is calcareous grading into bluish green thin calcareous siltstones interbedded with bluish gray mudstones. The upper part is shaly buff gray to greenish gray, and has interlaminated silts and shales. *Ampyxina bellatula*, a small trilobite, is common in the basal portion of this unit.

M. Limestone, dolomite, minor shales. Yellowish-gray limestone and dolomites with minor red and green shale partings. White crinoidal grainstones are abundant in this unit.

Introduction

The Waterloo Quadrangle is located in Monroe County southeast of St. Louis Missouri. The bedrock exposed in the quadrangle is Mississippian age (Valmeyeran and Chesterian Series) and Pennsylvanian (Desmoinesian Series). The Pennsylvanian units occur in the Columbia Syncline in the north-central portion of the map. The southern end of the syncline is mapped just west of Waterloo and extends to the north-northwest into the adjoining Columbia quadrangle. The Pennsylvanian is poorly exposed and much of the unit is described from drill records and outcrops in the Columbia Quadrangle. It is nearly horizontal and does not appear to be offset by the Waterloo anticlinal structure and produces an angular unconformity with the underlying units. The Chesterian units in descending order are the Renault Limestone, Aux Vase Sandstone and the Ste. Genevieve Limestone. The Valmeyeran units in the quadrangle are in descending order, St. Louis Limestone, Salem Limestone, Warsaw Shale, Keokuk Limestone, and the Burlington Limestone. Due to the lithologic similarities of the Burlington Limestone and Keokuk Limestone, they have been combined into one unit for this report. The Aux Vase and Renault have also been combined into one unit on the map due to lack of exposures and small combined thickness.

Stratigraphy

Valmeyeran Series

The Burlington Limestone is coarse-grained cherty limestone. The unit is dominated by crinoidal packstone to grainstones in the lower part and is interbedded limestone and very thin shles in the upper part. Fresh exposures are white to light gray and the unit weathers to a darker gray. The cherts are usually light gray but when weathered are white to yellow with orange iron oxides. The cherts are nodular and may coalesce along bedding planes to form beds up to one foot thick. In general, the Burlington becomes more argillaceous and thinner bedded upward and grades almost imperceptible into the Keokuk Limestone. The contact is completely gradational. The Burlington Limestone was deposited in an intermittently high-energy, shallow, warm environment. Abundant disarticulated crinoids mixed with sponge spicules and bryozoan debris is evidence of transportation of this assemblage from lower energy habitats. Cross bedded bioclasts in some layers of the Burlington supports a high-energy, shoaling, depositional setting. Subsequent diagenesis mobilized the biogenic silica from some of the sponge spicules to form nodules and stringers of chert. The unit is very cherty and in places the chert makes up a significant portion of the limestone.

The Keokuk Limestone is nearly identical in lithologic character to the Burlington. It is cherty at the base and becomes more argillaceous upward. The cherts are gray and may be slightly darker than that of the Burlington. The contact with the overlying Warsaw is probably gradational.

The Warsaw Formation is dominantly limestone and shale in the lower part and carbonates in the upper part. The limestones can be quite fossiliferous and may contain large bryozoan fronds of *Archimedes* sp. This unit was formerly called the Archimedes Limestone in early reports (Willman, et.al., 1975). Shales are in part soft, blue gray, and laminated. Limestones are light brown to gray grainstones to wackestones and are dolomitic in places. The upper part of the Warsaw is thicker bedded and fossiliferous with crinoids, brachiopods, and bryozoans being the most common. The upper unit is dominated by pelloidal limestones and dolomites which are inter-bedded with thin shale partings. Some of the thicker beds are dolomitic, while others are fairly pure limestones. Bedding in the lower part is thin typically less than one foot and undulatory. The Warsaw Formation was deposited in moderate to low energy conditions with periods of high energy influx. Carbonate production was periodically cut off by the transportation of siliciclastics into these quiet water environments. Frond-like fenestrate bryozoans dominate the muddy, silty, quiet water niches. However, echinoderms were also common in inter-shoal areas and higher-energy transportation of pelmatozoans occurred in this formation much like that of the Burlington.

The Salem Limestone is dominantly a tan-brown to gray limestone and dolomitic limestone (grainstones) with occasional shale partings. The beds range from several inches to a few feet thick. Texturally, the unit is dominated by small fossil fragments composed of disarticulated echinoderms and fenestrate bryozoans that are abraded into a fossil hash. Cross beds are common. Chert is white to light gray, banded, and nodular. Lasemi and Norby (1999) described the contact with the overlying units to be unconformable and resembles a paleo-karstic surface. This karstic surface seems to be persistent in the Metro-East St. Louis area., but in areas south of Waterloo the contact is difficlut to determine and may be gradational.

The St. Louis Limestone is dominantly a micritic fine grained light to medium gray lime mudstone with occasional thin greenish-gray shale layers. Benches of wackestones to packstones, microcrystalline dolomite, brecciated limestone, oolitic limestone are present in the unit. The shales are greenish and usually less than two feet thick. In the subsurface in parts of the Illinois basin thin layers of gypsum and anhydrite occur in this unit. Saxbyand Lamar (1957) attributed the conspicuous limestone breccias to near surface solution collapse of the gypsum and recystalization of calcite between limestone clasts. The St. Louis may be divided into an upper and lower unit. Lasemi and Norby (1999) described the lower St. Louis as a near shore restricted marine facies consisting of pelleted and fenestral lime mudstone, algal limestone, collapsed breccia beds, and microcrystalline dolomite. The upper St. Louis is characterized by bioclastic wackestones to packstone, lime mudstone, and peloidal grainstones which are interpreted as a return to normal open marine conditions. There is a significant break in the conodont fauna which occurs just above a bryozoan rich cherty limestone bed named the Lost River Chert zone (Lasemi and Norby, 1999). The contact with the overlying Ste. Genevieve Formation is placed just above this chert zone. The contact with the overlying unit is unconformable.

Chesterian Series

The Ste. Genevieve Limestone is composed of light gray to medium gray oolitic limestone, lime mudstone, dolomitic limestone, and shaly to sandy limestone with minor amounts of chert. Texturally it is similar to the underlying St. Louis and separation of the units is sometimes difficult. The Ste. Genevieve was formerly placed in the Valmeyeran Series, but we now place this unit in the Chesterian based on the work of Maples and Water (1987). The unit is probably less than 40 feet thick and contains some layers of fine to very fine calcareous sandstone . The Ste Genevieve commonly contains a higher percentage of cross bedded oolitic limestones than the underlying St. Louis. Since the contact with the St. Louis Formation is difficult to determine, the contact drawn on the accompanying geologic map in many places is approximated. The contact with the overlying unit is unconformable.

The Aux Vases Sandstone is composed of fine to medium grained quartz arenite with occasional green shale or siltstone. The sandstone may contain occasional rip up clasts of the green shale. The sandstone is light gray or greenish gray and in places may be calcareous and contain ripple marks, burrows, and polygonal dessication cracks. It is unconformable with the overlying unit. The lower part of the unit is thin bedded fine grained sandstone with thin shale partings. The upper part of the unit is composed of fine to medium grained cross bedded sandstone that down cuts into the underlying planar beds. The Aux Vase was formerly placed in the Valmeyeran Series, but now we place this unit in the Chesterian based on the work of Maples and Water, 1987. The Aux Vases lies unconformably on the Ste. Genevieve Limestone west of Waterloo and on the St. Louis Limestone east of Waterloo.

The Renault and Yankeetown Formations are variable and may be composed of sandstone, shale, and relatively pure limestone which may be oolitic in places. This unit is unconformable with the overlying units. The top of this unit is highly weathered in places and is difficult to separate from the overlying Pennsylvanian units.

Desmoinesian Series

Pennsylvanian age rocks occur in the Columbia Syncline. These rocks are fine grained sandstone, Limestone, and shale. Coals are exposed just to the north in the Columbia quadrangle but were not observed in the Waterloo Quadrangle. The limestones are medium gray and fernginous wackestones to grainstones. Shales are red, green, and gray. The unit is poorly exposed and is unconformable with the overlying units.

Pleistocene and Holocene Series

The Pleistocene units are not differentiated on this bedrock map. For detailed information concerning these units see the Surficial Geology of the Waterloo quadrangle (Phillips, in prep).

Structural Geology

The Waterloo Anticline is an asymmetrical structure that trends approximately N20°W to N25°W and the Chesterian and older units have dips over 40° on the northwest side and gentle 2° to 4° on the northeast side. To the north in the Columbia Quadrangle, where the structure is better exposed, Chesterian units can be observed dipping to the west up to 50° overlain by horizontal Pennsylvanian units. The structure is called the Waterloo Anticline near Waterloo, Illinois and the Dupo Anticline in the vicinity of Dupo, Illinois. In the Waterloo Quadrangle, the structure apparently plunges to the south and the feature can't be traced much south of Waterloo. Silurian and Devonian units thin over the structure (Tikrity, 1968) which indicates that the structure may have been active during Silurian and early Devonian. At the extreme southern edge of the Columbia Quadrangle the Chesterian Series Aux Vases Sandstone dips about 22° to the west and Pennsylvanian units are horizontal over the Chesterian units producing an angular unconformity. Therefore, a second major tectonic event occurred in late Mississippian to early Pennsylvanian.

The Columbia Syncline is an asymmetrical feature that separates the Waterloo-Dupo Anticline from the Valmeyer Anticline to the south and west. The Columbia Syncline parallels the Waterloo-Dupo structure and has a steep limb on the east side with dips up to 45° and a broad gentle west limb. Chesterian and older rocks are observed to be affected but the Pennsylvanian units appear to lie horizontally above, forming an angular unconformity.

A fault between the Columbia Syncline and the Waterloo–Dupo Anticline has been proposed by several workers (Lamar and Swartz, 1922, Weller and Weller, 1939). Most previous workers suggested the fault is present in the Precambrian basement rocks with the overlying sedimentary rocks being draped over this basement fault. The main question is how far up the sedimentary succession has the fault zone propagated. Mapping in the area has found no evidence that the Pennsylvanian units are affected by the fault and Desmoinesian Series units lie unconformably on steeply dipping Chesterian and older units. A fault, here named the Columbia-Waterloo Fault, is mapped trending N20°W beneath the Pennsylvanian units. It is mapped as displacing Chesterian and Valmeyeran units and the displacement is probably less than 50 feet at the surface. Evidence for this fault was found in two oil wells (#000277; 3S-T2S-R10W) and (#000278; 36-T2S-R10W). The western well was reported to contain 50 feet of Aux Vases and Ridenhower sediments while the eastern well encountered the St. Louis Limestone in the uppermost portion of the hole. The two holes are about 2000 feet apart. The outcrops in the area, where observed, were nearly horizontal, which would imply that a small fault is present as mapped. The Columbia-Waterloo Fault is mapped as a normal fault with the west side being down-dropped. The true relationship may be high angle reverse at depth in the Precambrian basement units with the east side being up-thrown. Field evidence for this fault is sparse primarily due to the Pennsylvanian cover, which is apparently unaffected. Therefore, the fault was active during late Mississippian or early Pennsylvanian, prior to the deposition of the Desmoinesian Age sediments.

The Valmeyer Anticline (Weller and Weller 1939) was observed at the southwestern edge of the map. At this location the lower Salem and upper Warsaw outcrop in the bed of a small east west trending creek. Just west of the Waterloo Quadrangle in the Valmeyer Quadrangle a dip of 14° was observed on the lower part of the Salem Limestone. This structure appears to be asymmetrical, having a fairly steep southwest limb and gentle 2° to 3° dips on the northeast limb. It is very similar in nature to the Waterloo-Dupo Anticline but the dips are not as steep and the trend is more westerly. The trend of the Valmeyer is approximately N45°W.

Mineral Resources

Oil

Oil was discovered while drilling a water well in the 1920's in the Waterloo Quadrangle. Mapping conducted by the Illinois State Geological Survey located an anticline which is called the Waterloo Anticline. Over 405,000 barrels of oil have been produced from this structure all from the Ordovician Kimmswick Limestone (Nelson, 1995). The field was abandoned in 1930, revived in 1939 and converted to gas storage in 1951 (Schwalb, 1968). Initial production of the wells was 75 to 125 barrels per day quickly decreasing to 25 to 50 barrels per day. The top of the producing zone is about 250 feet mean sea level and the oil-water contact at about 200 feet (Schwalb, 1968). Structure contours on the top of the Kimmswick in the Waterloo area reveals at least 300 feet of closure (Bristol and Bushbach, 1973). Although the field has been explored fairly extensively, there are a few locations which may contain additional oil that have not been tapped (SE1/4 of 14-T2S.R10W).

No oil has been found associated with the Valmeyer Anticline in the Waterloo Quadrangle.

Aggregates

Two abandoned quarries were located in the St. Louis Limestone while mapping the quadrangle. The Ste. Genevieve Limestone, St. Louis Limestone and the Salem Limestones are good quality limestones suitable for aggregate and construction and may be a potential resource for fine grind and high calcium limestone. No quarry is currently active in the quadrangle.

Small quantities of sand and gravel may be present in the flood plain of the Fountain Creek at the northwestern edge of the quadrangle.

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Topography by photogrammetric methods from aerial photographs taken 1986. Field checked 1989. Map edited 1991

Projection and 10,000-foot grid ticks: Illinois coordinate system, west zone (transverse Mercator)
1000-meter Universal Transverse Mercator grid, zone 15
1927 North American Datum
To place on the predicted North American Datum 1983, move the projection lines 2 meters south and 9 meters east as shown by dashed corner ticks
Gray tint indicates area in which only landmark buildings are shown

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

UTM GRID AND 1991 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

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Acknowledgments

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