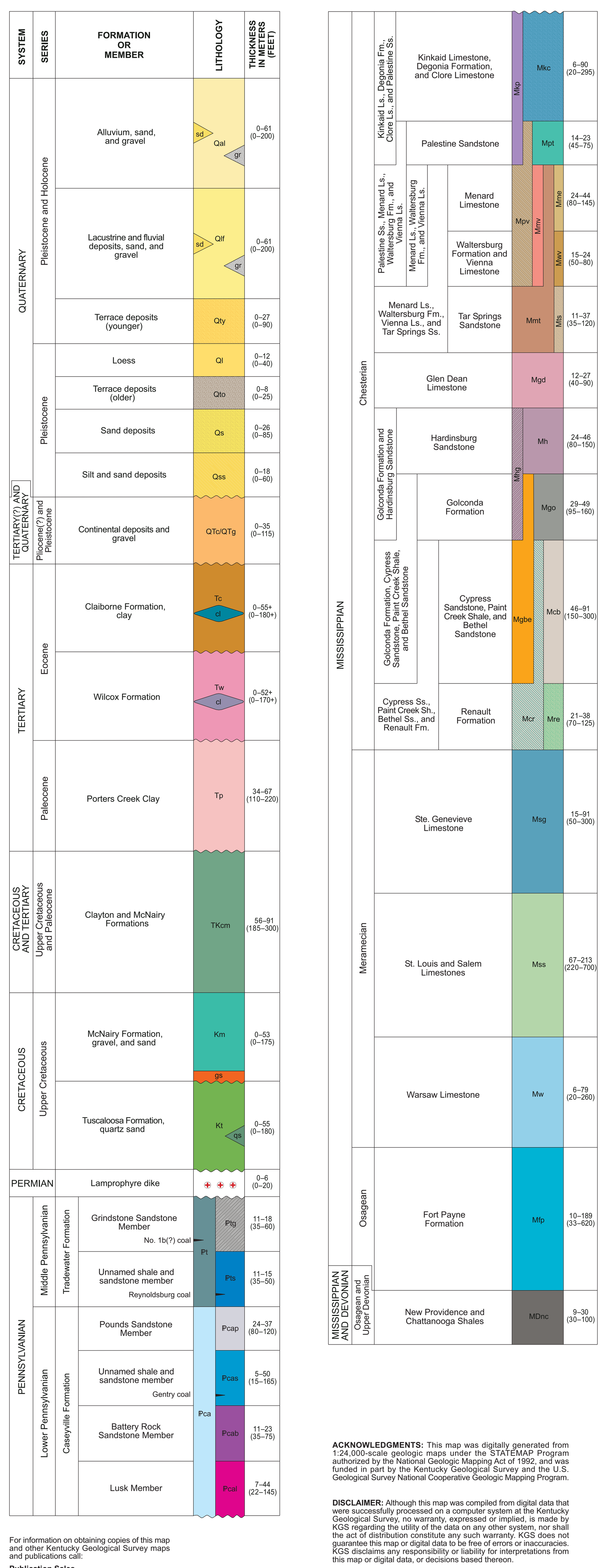
KGS **KENTUCKY GEOLOGICAL SURVEY**
James C. Cobb, State Geologist and Director
UNIVERSITY OF KENTUCKY, LEXINGTON

GEOLOGIC MAP 14
Series XII, 2007



DESCRIPTION OF MAPPED UNITS

Qal ALLUVIUM—Silt, sand, clay, and gravel, intermixed and interlayered. Silt, variably sandy and clayey, argillaceous, micaceous, calcareous, carbonaceous, sparsely glauconitic, locally pebbly with small rounded chert and quartz grains and heavy minerals; thin- to thick-bedded. Sand, fine- to coarse-grained, angular to well-rounded, poorly to well-sorted grains of quartz, chert, and minor amounts of heavy minerals; generally silty and clayey, and contains scattered pebbles of chert and quartz; micaceous, carbonaceous, and rarely calcareous; generally poorly bedded and locally crossbedded, and occurs as thin layers and lenses. Clay, usually sandy, silty, and locally contains quartz and chert pebbles, micaceous, calcareous, and carbonaceous; occurs as thin lenses, and is locally well laminated. Gravel, subangular to subrounded pebbles, and cobbles of chert, quartz, quartzite, sandstone, and metamorphic and igneous rocks (derived from glacial deposits to the north) in a matrix of sandy clay, silty sand, and sandy silt; occurs as lenses that are generally unconsolidated, but weakly cemented in part by iron oxides.

sd **gr**

Qlf LACUSTRINE AND FLUVIAL DEPOSITS—Silt, clay, sand, and gravel, intermixed and interlayered. Silt, sandy and clayey, contains small quantities of angular to spherical, fine to medium sand, coal particles, and chert and quartz pebbles; argillaceous, micaceous, fossiliferous, locally calcareous, and locally lignitic. Clay, silty, locally interlaminated with sand and commonly contains sparse fine quartz; micaceous, slightly calcareous, lignitic, and sparsely fossiliferous. Lacustrine silt and clay are distinguished from alluvial silt and clay by a well-developed B horizon in their soil profiles. Sand, silty, clayey, and pebbly, consists of moderately to well-sorted, angular to well-rounded, fine- to medium-grained quartz and chert; micaceous, contains dark minerals and particles of bituminous coal in various amounts. Gravel, chiefly subangular to subrounded chert pebbles and cobbles with subrounded to rounded quartz pebbles; common in an argillaceous, sandy, silty matrix; poorly sorted and unconsolidated.

Qty TERRACE DEPOSITS (YOUNGER)—Clay, silt, and sand.

Ql LOESS—Silt, variably clayey and sandy near base; contains small amounts of clay and very fine to very coarse, angular to rounded quartz, chert, and very sparse heavy minerals; argillaceous, micaceous, locally calcareous, and unfossiliferous; unstratified and generally structureless except for modern soil horizons. Forms blanket-like deposits of fairly uniform thickness atop ridges and hills, and is probably of eolian origin. Basal contact is usually sharp and variably irregular, but locally gradational; appears to intergrade with alluvial silt.

Qto TERRACE DEPOSITS (OLDER)—Clay, silt, and sand; has a lower proportion of clay and silt than younger terrace deposits.

Qs SAND DEPOSITS—Sand, fine- to medium-grained, subangular to subrounded, well-sorted, predominantly quartz with minor amounts of chert and dark heavy minerals; silty and clayey in part; unconsolidated, but locally bedded and crossbedded; mantles irregular surface of deposition, and locally intertongues with loess.

Qss SILT AND SAND DEPOSITS—Silt, sand, and very sparse gravel. Silt, variably clayey and sandy, fine- to medium-grained quartz, and chert; micaceous and slightly calcareous. Sand, variably silty and clayey, poorly to well-sorted, fine- to medium-grained quartz and chert; locally micaceous; occurs as thin, poorly defined beds. Silt and sand deposits locally contain sparse granules and pebbles of chert that occur as thin stringers.

QTc/QTg CONTINENTAL DEPOSITS AND GRAVEL—Gravel, sand, silt, and clay, intermixed, locally micaceous. Gravel, poorly sorted, subangular to well-rounded chert pebbles and cobbles, with well-rounded ellipsoidal quartz and quartzite pebbles in a poorly sorted matrix of quartz and chert sand, silt, and clay; locally, clay balls and fragments of clay occur in lower few feet of gravel; generally noncalcareous, but clayey silt matrix is calcareous in part; thin- to massive- and crudely bedded; locally crossbedded. Gravel is unconsolidated to fairly well consolidated, and locally well-cemented near the base of the unit with iron oxide. Sand, very fine to coarse-grained, angular to well-rounded, poorly to well-sorted quartz and chert; poorly to well sorted; commonly silty and clayey; contains sparse to moderately abundant chert and quartz pebbles in some localities; noncalcareous; occurs as discontinuous lenses and interbedded with gravel; locally well cemented with ferruginous material. Silt, commonly sandy and clayey; moderately to well-sorted, locally contains small chert and quartz pebbles; noncalcareous; poorly to well-bedded and locally thinly laminated. Clay, sandy, silty; occurs as lenses in gravel. The base of the unit is generally sharp.

Tc CLAIBORNE FORMATION—Sand, silt, and clay. Sand, silty and clayey, fine- to medium-grained, commonly very coarse and granular near contact with underlying unit, well to poorly sorted, angular to subrounded quartz, chert, opaque minerals, and rare small fragments of rod-like kaolinite crystals; crossbedded at places; local indurated zones cemented by iron oxide or secondary silica near lower contact; disseminated angular to subrounded clay pebbles and cobbles at some horizons, and lenses of clay breccia and clay gravel in sand near base of unit. Silt, sandy and clayey, laminated, thin- to massive-bedded; commonly interbedded with sand and clay; locally micaceous. Clay, variably sandy and silty, kaolinitic, carbonaceous, and rarely lignitic; thin- to thick-bedded; occurs in laminae, thin beds, and beds and lenses several feet thick, commonly interbedded with silt and sand. Marked erosional unconformity at base.

cl CLAIBORNE FORMATION–CLAY LENSES—Clay, variably sandy and silty, kaolinitic, carbonaceous, and rarely lignitic; thin- to thick-bedded.

Tw WILCOX FORMATION—Sand, clay, and silt. Sand, silty and clayey, very fine- to very coarse-grained, well- to poorly sorted, angular to well-rounded quartz, chert, and sparse heavy minerals; also contains angular to well-rounded grains, pebbles, and boulders of silty clay derived from nearby slightly older clay bodies; thin- to thick-bedded, locally crossbedded, and cemented by iron oxide or secondary silica to form indurated layers; commonly argillaceous, locally micaceous and carbonaceous. A distinctive lithology in this unit is a "sawdust sand," which occurs as discontinuous lenses and is composed of quartz, clay, and chert grains, and sparse to moderately abundant kaolinite crystals. Clay, silty and sandy, massive to thin-bedded; carbonaceous, rarely lignitic, pyritic, and micaceous; occurs as lenses interbedded with sand and silt. Silt, clayey and sandy, commonly thinly laminated and thin- to thick-bedded, and intergrades with clay; micaceous and carbonaceous.

cl WILCOX FORMATION–CLAY LENSES—Clay, silty and sandy, massive to thin-bedded; carbonaceous, rarely lignitic, pyritic, and micaceous; occurs as lenses interbedded with sand and silt.

Tp PORTERS CREEK CLAY—Clay and sand. Clay, sandy and silty, micaceous, glauconitic in lower part of unit, sparse iron-sulfide nodules and grains, and carbonized and pyritized wood; consists of quartz and clay minerals (calcium, montmorillonite, illite, kaolinite, clinoptilolite, and gypsum). Sand, clayey, very fine- to medium-grained, quartz, sparse dark minerals, and rare fragments of lignitized plant material; micaceous, glauconitic in lower part of unit, argillaceous; occurs as thin beds in lower part and is dominant in upper part. Clastic dikes occur locally.

TKcm CLAYTON AND McNAIRY FORMATIONS (UNDIFFERENTIATED)—The Clayton and McNairy Formations are combined for mapping purposes because of the general concealment of the contact and because of lithologic similarities of the formations. The Clayton Formation is poorly to moderately consolidated, poorly exposed, and consists of sand, clay, and silt. The disconformity at the base of the Clayton Formation is widespread in the Mississippi Embayment. The McNairy Formation is poorly to moderately consolidated and poorly exposed, and consists of sand, clay, and gravel. An erosional unconformity occurs at the base of the McNairy Formation. Clastic dikes occur locally.

CLAYTON FORMATION— Sand, clay, and silt, interbedded. Sand, variably clayey and silty, very fine- to medium-grained, well-sorted quartz and dark heavy minerals; micaceous, glauconitic, and carbonaceous; locally, tightly cemented by ferruginous material. Clay, silty and sandy, contains blebs of fine angular micaceous quartz sand; lignitic and glauconitic; thinly laminated to thin-bedded and occurs as lenses. Silt, clayey, well-sorted, very fine-grained, with quartz and dark heavy minerals; micaceous and locally carbonaceous.

Km McNAIRY FORMATION—Sand and clay, interbedded. Sand, silty and clayey, fine- to medium-grained, well-sorted, with quartz and sparse dark heavy minerals; contains irregular patches of chert pebbles and granules near base, and clay blebs and streaks; locally micaceous; thin- to thick-bedded and locally well-cemented with iron oxide. Clay, variably silty, micaceous; occurs as laminae, seams, thin layers, lenses, and irregular masses.

gs McNAIRY FORMATION–GRAVEL AND SAND LENSES—Gravel, angular to subrounded chert pebbles and cobbles; matrix consists of of medium- to coarse-grained quartz and tripolitic chert sand, locally cemented with iron oxide; thick- to medium-bedded. Sand, medium-grained, quartz and tripolitic chert; argillaceous; thin- to thick-bedded, locally cemented with iron oxide; small lenses and thin interbeds of clay occur locally.

Kt TUSCALOOSA FORMATION—Gravel, subangular to well-rounded, poorly sorted, pebbles, cobbles, and rare boulders of chert; chert sand, silt, and clay present as interstitial matrix in varying amounts; chert commonly tripolitic; bedding rare or crudely crossbedded, and locally cemented with iron oxide or silica; local thin lenses of chert sand and clayey silt.

qs TUSCALOOSA FORMATION–SAND LENS—Sandstone, fine- to coarse-grained, subangular to subrounded quartz grains; friable to very hard.

+ + LAMPROPHYRE—Igneous dike material, dark green, finely to moderately crystalline, consisting of clinopyroxene, olivene, biotite, phlogopite, serpentine, peroskvite, ilmenite, and magnetite. Many dikes are steeply dipping, and have been hydrothermally altered to a light green rock containing abundant calcite, chlorite, and leucoxene. These dikes weather very rapidly to a greenish-brown soil horizon. Magnetic anomalies may suggest larger bodies at depth near Coefield Creek.

Pt TRADEWATER FORMATION—Sandstone, shale, and coal. Sandstone, fine- to medium- grained; micaceous with an argillaceous matrix; trough and planar crossbedded; contains disseminated iron oxide and iron-oxide concretions. Shale, sandy, some papery and brittle, commonly interbedded with sandstone beds. Coal is vitreous to dull and rarely exposed.

Ptg TRADEWATER FORMATION–GRINDSTAFF SANDSTONE MEMBER—Sandstone, fine- to medium-grained, micaceous; crossbedding common; lower few feet commonly contains flattened clay pebbles.

Pts TRADEWATER FORMATION–UNNAMED SHALE AND SANDSTONE MEMBER—Siltstone, sandstone, and shale, micaecous. Siltstone, thin-bedded, some beds separated by shale laminae; thin beds of shale present near top. Sandstone, fine- to medium-grained, thin-bedded, and crossbedded. Shale, thin-bedded, contains a few thin interbeds of micaceous siltstone near top; local lenses of freshwater limestone near middle of unit.

REYNOLDSBURG COAL BED—-Coal bed is 5 to 8 ft above base, shaly in part; thin-bedded, micaceous siltstone at bottom of unit.

Pca CASEYVILLE FORMATION—Siltstone, sandstone, and shale; interbedded and in part lenticular. Siltstone, thin-bedded, micaceous, locally argillaceous; locally contains thin interbeds of silty shale. Sandstone, quartzose, micaceous, fine- to coarse-grained, thin-to thick-bedded, locally crossbedded; graded bedded and ripple-marked; subrounded to rounded chert and quartz granules and pebbles locally abundant and generally concentrated in lower parts of beds. Beds locally contain clay pellets, interstitial clay, and coal near the base; ferruginous concretions locally abundant; plant casts and molds locally present. Shale, variably silty or sandy; locally carbonaceous and contains small siderite nodules.

Pcap CASEYVILLE FORMATION–POUNDS SANDSTONE MEMBER—Sandstone, medium- to coarse-grained, rarely fine-grained, medium- to thin-bedded; crossbedding and graded bedding common; quartz granules and pebbles locally abundant, generally concentrated in lower part of beds, especially along crossbeds; some coarser-grained beds have hematite or limonite cement or both.

Pcas CASEYVILLE FORMATION–UNNAMED SHALE AND SANDSTONE MEMBER—Sandstone, siltstone, and shale. Sandstone, fine- to coarse-grained, thin- to thick-bedded, crossbedded; quartz granules and pebbles locally abundant. Unit locally contains shale and thin shaly coal bed. Siltstone, micaceous, thin-bedded and lenticular. Shale, variably silty, locally carbonaceous.

GENTRY COAL BED—Coal, shaly top and bottom, discontinuous, locally underlain by silty underclay.

Pcab CASEYVILLE FORMATION–BATTERY ROCK SANDSTONE MEMBER—Sandstone, medium- to coarse-grained, medium- to thick-bedded; crossbedding and graded bedding common; quartz granules and pebbles locally abundant, generally concentrated in lower part of beds, especially crossbeds; some coarser-grained beds have hematite and limonite cement; clay pebbles and hematite or limonite concretions.

Pcal CASEYVILLE FORMATION–LUSK MEMBER—Siltstone and interbedded shale and sandstone. Siltstone, fine-grained, thin-bedded, micaceous; plant casts locally abundant. Sandstone, medium- to fine-grained, thin- to medium-bedded; thicker beds generally crossbedded; limonite concretions locally abundant; locally, some beds coarse-grained and contain quartz granules and pebbles; locally contains thin interbeds of silty shale. Shale, silty and carbonaceous. Conglomerate, medium-bedded; contains abundant limonite concretions; lower third of unit contains abundant angular chert pebbles in medium- to coarse-grained quartz sandstone matrix; upper two-thirds of unit consists of abundant rounded quartz pebbles and sparse angular chert pebbles in medium- to coarse-grained quartz and feldspar sandstone matrix.

KINKAID LIMESTONE—Limestone, shale, sandstone, and siltstone, interbedded. Limestone, thin- to thick-bedded; micrograined limestone and coarsely to moderately crystalline calcarenite, locally argillaceous or sandy, fossiliferous, dolomitic, and containing local chert nodules and shale partings. Shale, variably silty and sandy, calcareous, fossiliferous, and containing siderite concretions. Sandstone, fine-grained, well-sorted, locally calcareous and argillaceous; contains abundant shale partings and clay pebbles; irregular bedding planes and locally crossbedded. Siltstone, thin- to medium-bedded; argillaceous and locally very fine-grained sandstone.

DEGONIA FORMATION—Siltstone, shale, sandstone, and chert, interbedded. Siltstone, micaceous and locally calcareous, thin- to medium-bedded, locally grades into fine-grained sandstone, and overlies thick-bedded chert; dolomitic and siliceous. Shale, variably silty and sandy, and slightly calcareous near base of unit. Sandstone, fine-grained, medium- to thick-bedded, and argillaceous. Chert, medium- to thick-bedded; bedding planes undulate and are ripple-marked.

CLORE LIMESTONE—Limestone, shale, sandstone, and siltstone, interbedded. Limestone, dense to finely crystalline, thin- to medium-bedded, some beds dolomitic, many beds argillaceous, scattered chert nodules, some beds very fossiliferous. Thin beds of sandy and silty shale and dolomitic limestone in upper part of unit. Shale, silty, commonly calcareous, fossiliferous, locally pyritic; interbeds of limestone common. Sandstone, fine-grained, medium-bedded, slightly calcareous and micaceous; crossbedding common. Siltstone, shaly, thin-bedded; calcareous cement.

Mkc DEGONIA FORMATION, KINKAID LIMESTONE, AND CLORE LIMESTONE, UNDIFFERENTIATED

Mpt PALESTINE SANDSTONE—Sandstone, shale, and siltstone. Sandstone, variably silty and shaly, fine-grained, medium- to thick-bedded, few thin beds, thinly crossbedded, ripple marks common, scattered clay pellets; micaeous, slightly calcareous. Shale, variable silty and sandy; scattered siltstone lenses and beds common, and scattered lenses of fine-grained sandstone; slightly calcareous, carbonaceous. Siltstone, variably shaly and sandy, thin-bedded, beds commonly lenticular, bedding planes commonly irregular.

Mkp KINKAID LIMESTONE, DEGONIA FORMATION, CLORE LIMESTONE, AND PALESTINE SANDSTONE, UNDIFFERENTIATED

Mme MENARD LIMESTONE—Limestone and shale, interbedded. Limestone, variably silty or sandy, dense to finely crystalline, thin- to thick-bedded; few dolomitic beds, locally siliceous, argillaceous, fossiliferous; chert nodules and beds. Shale, variably silty, fissile, commonly calcareous, fossiliferous; contains interbedded dolomite and limestone.

WALTERSBURG FORMATION—Sandstone, shale, and siltstone, interbedded. Sandstone, fine-grained, thin- to thick-bedded, some beds separated by thin shale laminae; crossbedded. Shale, variably sandy and silty, fissile, calcareous, fossiliferous; contains siderite nodules. Siltstone, thin- to medium bedded, even-bedded; argillaceous; contains abundant interstitial chlorite, noncalcareous.

VIENNA LIMESTONE—Limestone, shale, and chert; interbedded. Limestone, dense to finely crystalline, shaly, locally siliceous and dolomitic, fossiliferous; scattered chert nodules, lenses, and beds. Shale, fissile, fossiliferous, calcareous; occurs as interbeds and laminae. Chert, as lenses and beds interlayered with limestone.

Mwv WALTERSBURG FORMATION AND VIENNA LIMESTONE, UNDIFFERENTIATED

Mmv MENARD LIMESTONE, WALTERSBURG FORMATION, AND VIENNA LIMESTONE, UNDIFFERENTIATED

Mpv PALESTINE SANDSTONE, MENARD LIMESTONE, WALTERSBURG FORMATION, AND VIENNA LIMESTONE, UNDIFFERENTIATED

Mts TAR SPRINGS SANDSTONE—Sandstone, shale, and siltstone, interbedded. Sandstone, generally quartzose, locally argillaceous, fine-grained, thin- to thick-bedded, ripple-marked and crossbedded; some lenticular beds; many shaly partings; locally carbonaceous; contains a few flattened clay pebbles; fossiliferous. Shale, fissile, silty, slightly calcareous, carbonaceous, fossiliferous; contains laminae and thin beds of sandstone and siltstone, and locally includes nodules and layers of siderite. Siltstone, thin-bedded, micaceous, slightly carbonaceous; some lenticular beds.

Mmt MENARD LIMESTONE, WALTERSBURG FORMATION, VIENNA LIMESTONE, AND TAR SPRINGS SANDSTONE, UNDIFFERENTIATED

Mgd GLEN DEAN LIMESTONE—Limestone, shale, and sandstone. Limestone, fine- to coarse-grained, medium- to thick-bedded, rarely thin-bedded; thicker beds commonly separated by thin shaly partings, and a few thin beds of sandstone; fossiliferous, argillaceous, locally siliceous, slightly dolomitic. Shale, commonly calcareous; present as thin interbeds and laminae. Sandstone, fine-grained, slightly calcareous; some disseminated pyrite.

Mh HARDINSBURG SANDSTONE—Sandstone, shale, siltstone, and coal, interbedded. Sandstone, quartzose, silty, variably micaceous, locally calcareous, fine-grained, thin- to thick-bedded; ripple marks and crossbedding common; few clay pellets; shaly partings and laminae; some interstitial dolomite cement. Shale, silty and sandy, locally carbonaceous; shaly coal underlain by underclay; abundant plant impressions; thin laminae of shale common in sandstone and siltstone. Siltstone, shaly, thin-bedded, even-bedded, micaceous, argillaceous, rarely carbonaceous. Coal bed near base of unit; underclay with scattered carbonaceous material is overlain by shaly coal with abundant leaf impressions.

Mgo GOLCONDA FORMATION—Limestone, shale, siltstone, and sandstone, partly interbedded. Limestone, variably shaly, sandy, silty, and dolomitic, moderately to coarsely crystalline; thin- to thick-bedded, thinner beds commonly laminated and argillaceous, fossiliferous; slightly oolitic; commonly crossbedded, and locally ripple-marked. Shale, fissile, sandy, and silty, locally calcareous, fossiliferous; siderite nodules present; contains lenses of finely crystalline limestone. Siltstone, shaly, thin-bedded, calcareous, micaceous, argillaceous; locally ripple-marked. Sandstone, quartzose, fine-grained, argillaceous, calcareous, locally carbonaceous; minor interbedded shale; crossbedded.

Mhg HARDINSBURG SANDSTONE AND GOLCONDA FORMATION, UNDIFFERENTIATED

CYPRESS SANDSTONE—Sandstone, shale, siltstone, and coal. Sandstone, fine-grained, partly medium-grained near base; thin- to thick-bedded, thinner beds commonly micaceous; ripple marks and crossbeds common; some beds contain clay pellets; locally calcareous; few shaly partings. Shale, silty, calcareous, locally carbonaceous; contains scattered pyrite and plant fragments; contains clay pebbles and abundant coaly material. Siltstone, thin-bedded, micaceous, argillaceous. Coal, shaly, discontinuous, occurs locally at or near base of unit.

PAINT CREEK SHALE—Shale, sandstone, limestone, and siltstone. Shale, silty and sandy, locally calcareous; contains thin, lenticular, discontinuous interbeds of sandstone. Sandstone, fine-grained, thin- to medium-bedded; ripple marks and crossbeds; some beds lenticular and separated by thin shale laminae, some beds slightly calcareous; brachiopod casts common. Limestone, sandy, silty, and argillaceous, finely to moderately crystalline, fossiliferous. Siltstone, thin-bedded, some irregularly bedded or lenticular; locally calcareous.

BETHEL SANDSTONE—Sandstone, quartzose, fine- to medium-grained, some scattered coarse grains, thin- to thick-bedded; fairly well cemented, locally brecciated and silicified; ripple marks and crossbeds common; plant impressions and carbonaceous fragments; locally contains calcareous fossil fragments; few shaly partings.

Mgbe GOLCONDA FORMATION, CYPRESS SANDSTONE, PAINT CREEK SHALE, AND BETHEL SANDSTONE, UNDIFFERENTIATED

Mcb CYPRESS SANDSTONE, PAINT CREEK SHALE, AND BETHEL SANDSTONE, UNDIFFERENTIATED

Mre RENAULT FORMATION—Limestone and interbedded shale. Limestone, variably silty and sandy, finely to coarsely crystalline, thin- to thick-bedded, thinner beds commonly argillaceous; few beds slightly dolomitic; few thin interbeds of calcareous shale; locally cherty; oolitic, fossiliferous; conglomeratic near base. Shale, silty, calcareous, fossiliferous; occurs as thin interbeds.

Mcr CYPRESS SANDSTONE, PAINT CREEK SHALE, BETHEL SANDSTONE, AND RENAULT FORMATION, UNDIFFERENTIATED

Msg STE. GENEVIEVE LIMESTONE—Limestone, sandstone, shale, and siltstone, interbedded. Limestone, variably sandy and slightly argillaceous, finely to coarsely crystalline; some beds are dolomitic; some beds shaly, medium- to thick-bedded; crossbedded, fossiliferous, oolitic, cherty. Sandstone, fine-grained, thin- to thick-bedded; calcareous cement; commonly crossbedded, locally ripple-marked; commonly interbedded or associated with silty calcareous shale. Shale, variably sandy and silty, calcareous; occurs as thin interbeds. Siltstone, medium-bedded, calcareous, discontinuous.

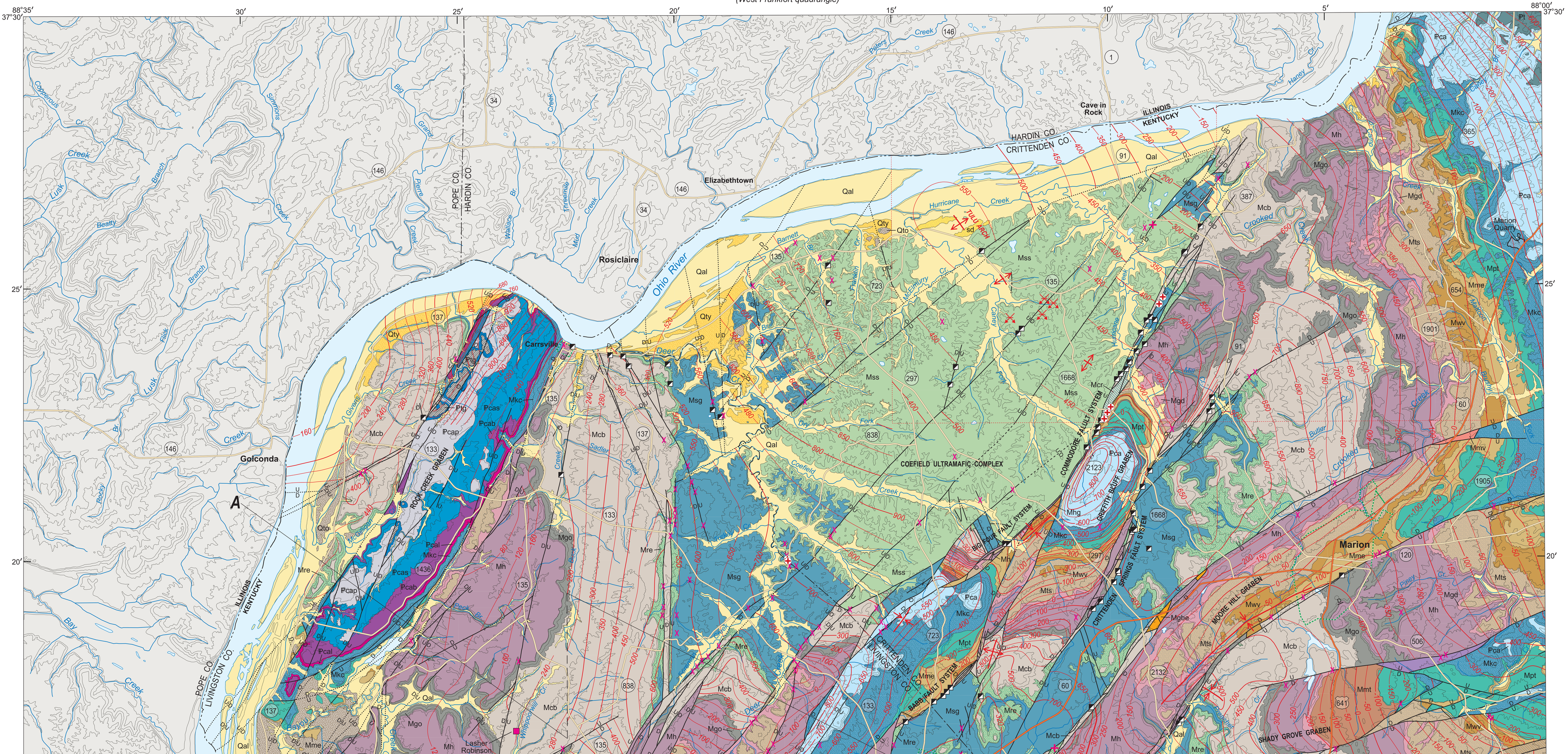
Mss ST. LOUIS AND SALEM LIMESTONES, UNDIFFERENTIATED—Limestone and chert. Limestone, argillaceous, partly silty; fine- to coarse-grained, medium- to thick-bedded; interbedded thin shaly beds; dolomitic; petroliferous odor; oolitic, cherty, fossiliferous. Chert occurs as sparse to common spheroids, discoids, irregular knobby bodies, and discontinuous layers; some shows wavy laminations.

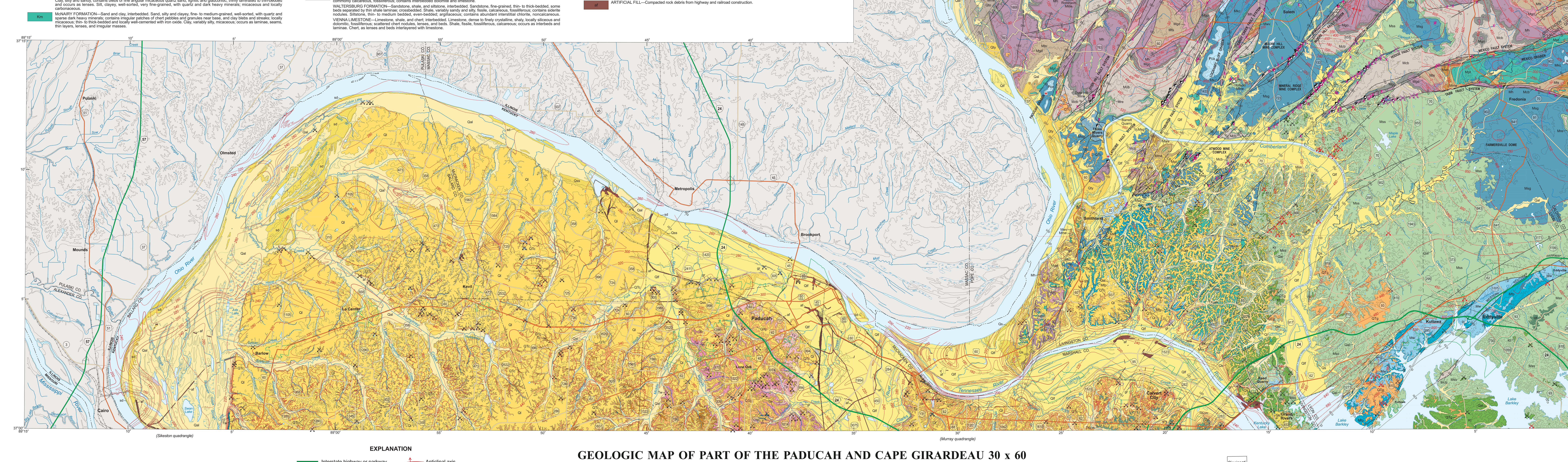
Mw WARSAW LIMESTONE—Limestone and chert, interbedded. Limestone, fine- to coarse-grained, medium- to thick-bedded, fossiliferous, rarely oolitic; argillaceous; some beds separated by thin shale laminae; chert nodules common; crossbedded. Chert occurs as nodules, irregular beds, and discontinuous layers in finer-grained limestone.

Mfp FORT PAYNE FORMATION—Limestone and chert, interlayered. Limestone, variably silty and clayey, micrograined to fine-grained, siliceous, argillaceous, locally shaly, fossiliferous. Chert present in beds and lenticular masses.

MDnc NEW PROVIDENCE AND CHATTANOOGA SHALES, UNDIFFERENTIATED—Shale, clayey with minor silt; carbonaceous, pyritic.

af ARTIFICIAL FILL—Compacted rock debris from highway and railroad construction.





EXPLANATION

- Interstate highway or parkway
- U.S. highway
- State highway
- State boundary
- County boundary
- City boundary
- Railroad
- Contact
- Concealed contact
- Normal fault (U, upthrown side; D, downthrown side)
- Concealed fault
- Structure contour, feet (200)
- Anticlinal axis
- Synclinal axis
- Datum horizon boundary
- Active pit; gravel, sand, or clay
- Abandoned pit; gravel, sand, or clay
- Abandoned iron ore pit
- Abandoned fluorite mine
- Abandoned fluorite shaft
- Zinc shaft
- Mineral prospect, fluorite and sphalerite
- Mineral vein
- Mantos deposit

GEOLOGIC MAP OF PART OF THE PADUCAH AND CAPE GIRARDEAU 30 x 60 MINUTE QUADRANGLES, WESTERN KENTUCKY

Steven L. Martin, Warren H. Anderson, and Thomas N. Sparks

Cartography by Terry D. Hounshell

1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 KILOMETERS
1 0 1 2 3 4 5 6 7 8 9 10 MILES
1000 0 5000 10 000 15 000 METERS
5000 0 10 000 20 000 30 000 40 000 50 000 FEET

SCALE 1:100 000

universal transverse Mercator projection, zone 16: 1927 North American datum

TOPOGRAPHIC CONTOUR INTERVAL 10 METERS

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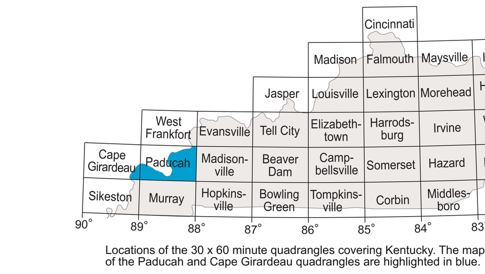
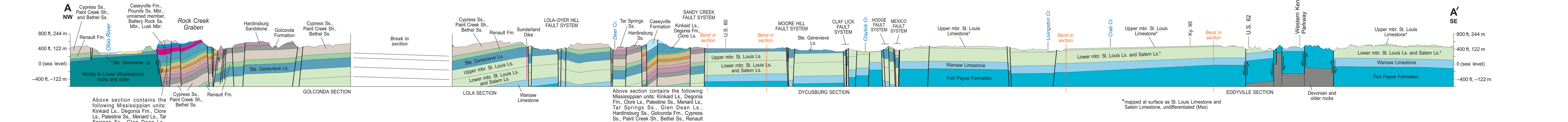


Locations of the 30 x 60 minute quadrangles covering Kentucky. The mapped parts of the Paducah and Cape Girardeau quadrangles are highlighted in blue.



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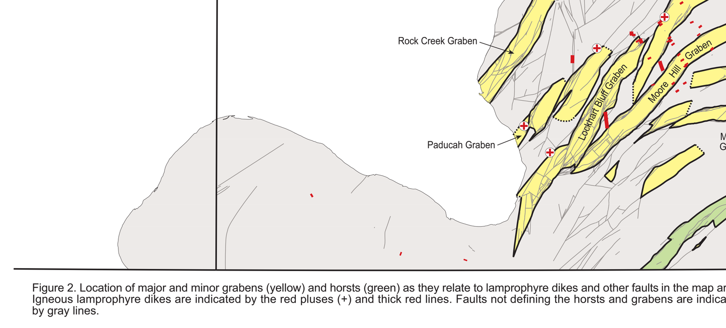

Figure 2. Location of major and minor grabens (yellow) and horsts (green) as they relate to lamprophyre dikes and other faults in the map area. Igneous lamprophyre dikes are indicated by the red pluses (+) and thick red lines. Faults not defining the horsts and grabens are indicated by gray lines.

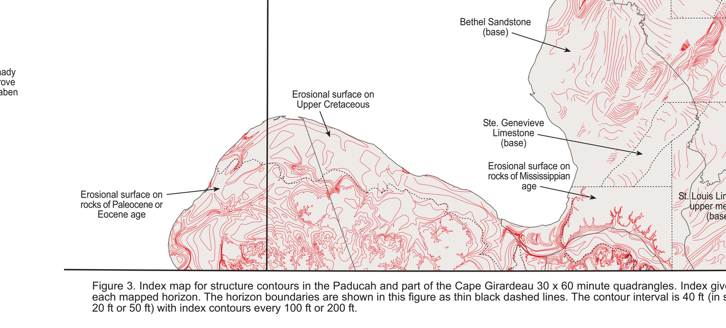

Figure 3. Index map for structure contours in the Paducah and part of the Cape Girardeau 30 x 60 minute quadrangles. Index gives names of each mapped horizon. The horizon boundaries are shown in this figure as thin black dashed lines. The contour interval is 40 ft (in some places 20 ft or 50 ft) with index contours every 100 ft or 200 ft.

INTRODUCTION

The geology of parts of the Paducah and Cape Girardeau 30 x 60 minute quadrangles was digitally compiled, mostly from U.S. Geological Survey 7.5-minute quadrangle maps (GQ's), as cited in the references. The 7.5-minute quadrangles that make up part of the Paducah and Cape Girardeau 30 x 60 minute quadrangles are shown in the index map (Fig. 1). The original GQ's are products of a cooperative mapping project between the U.S. Geological Survey and the Kentucky Geological Survey from 1960 to 1978. The conversion into digital format has been another USGS-KGS cooperative program funded through the National Cooperative Geologic Mapping Program (STATEMAP). Several regional geologic investigations (Finch and others, 1964; Olive, 1966, 1980; Olive and Finch, 1969; Ervin and McGinnis, 1975; Anderson and others, 1982; Trace and Amos, 1984; Goldhaber and Eidel, 1992; Hayes and Anderson, 1992; Plumlee and others, 1995; Heck and others, 2006) have been published since the original geologic quadrangle maps were completed. Of particular importance is the report of the Conterminous United States Mineral Assessment Program (Eidel and Goldhaber, 1992), which discusses tectonics, structure, stratigraphy, mineralization, geochemistry, geochronology, and diagenesis of the Western Kentucky Fluorspar District.

The data files resulting from the digitization of the GQ's are part of a comprehensive relational and spatial data set being released as Digitally Vectorized Geologic Quadrangles (DVGQ's) (Anderson and others, 1999) by the Kentucky Geological Survey. All of the DVGQ's for the Kentucky parts of the Paducah and Cape Girardeau 30 x 60 minute quadrangles are available on CD-ROM, and others throughout the state will be released in the near future. Users of the DVGQ data can prepare custom geologic maps by overlaying data using their own GIS or CAD software. KGS also provides an Internet map server where users can create simple maps without purchasing DVGQ's (kgsmap.uky.edu/website/KGSGeology/). KGS is also developing a comprehensive database of mineral information for the Western Kentucky Fluorspar District and other mineral districts in the state.

PROCEDURE

The 7.5-minute quadrangle maps were digitally compiled using a semi-automated data-capture technique to convert hard-copy geologic maps into digital format. Compiling 7.5-minute maps into a 30 x 60 minute map required the resolution of significant problems, such as (1) correlating geologic formations across quadrangle boundaries, (2) determining the boundary of Quaternary lacustrine and fluvial deposits associated with Lake Paducah, a late Pleistocene glacial lake (Finch and others, 1964; Olive, 1966), and (3) resolving discrepancies in other Quaternary alluvial boundaries and inferred contacts. The metadata portion of each DVGQ file provides detailed sources of data and information about the conversion process. Formation codes were assigned using the American Association of Petroleum Geologists' standard stratigraphic code (Cohee, 1967), which was modified by the Kentucky Geological Survey for state-specific use. Formations and formation boundaries were not mapped consistently on each of the 7.5-minute quadrangles as they were compiled by various authors between 1960 and 1978. Resolution of the differences between quadrangles was necessary for topological analysis in a geographic information system environment, and was resolved by adhering to geologic, cartographic, and GIS standards.

This map is a compilation of existing maps, and no additional field work was attempted. When there were problems in stratigraphic correlation between quadrangles, the best current data available were used to resolve differences.

GEOLOGIC SETTING

The Paducah and Cape Girardeau 30 x 60 minute quadrangles lie in the geologic provinces known as the Mississippi Embayment and the Illinois Basin. The Kentucky portion of the Mississippi Embayment is commonly referred to as the Jackson Purchase Region. The area that occurs along this part of the Illinois Basin in western Kentucky is referred to as the Western Kentucky Fluorspar District, and is part of the Kentucky-Illinois Fluorspar District. These structural provinces, apparently initiated before the mid-Paleozoic, are broad, shallow, crustal warps generally measuring 200 or more miles across and with only a mile or two of structural relief (McDowell, 1986).

The Jackson Purchase Region contains marine and nonmarine sediments that range in age from Cretaceous to Holocene. The Western Kentucky Fluorspar District in this region contains Devonian to Pennsylvanian sedimentary rocks, intrusive igneous rocks of Permian age, and Holocene alluvial sediments. During the Pleistocene glaciation, glacial dams formed along the ancestral Ohio River and produced a large glacial lake called Lake Paducah (Finch and others, 1964; Olive, 1966). The large lake deposited a layer of lacustrine sediments along the Ohio River from Metropolis, Ill., to Smithland, Ky.

The Western Kentucky Fluorspar District is located along the intersection of two major fault systems: the northeast-trending New Madrid Fault System and the east-trending Rough Creek Fault System. The principal structural features in the district are the Tolu Arch (a dominant anticline in northern Crittenden County) and a series of elongate, northeast-trending, complexly faulted horsts and grabens crosscut by northwest-trending igneous dikes and sills (Fig. 2). Paleozoic rocks underlying sediments in the southwestern part of the map area are extremely faulted, similar to the northeast-trending faults exposed in the northeastern part of the area. The district is also seismically active, and is located near the New Madrid Seismic Zone.

Detailed information about the geology, stratigraphy, structure, mineralization, and ore deposits of the fluorspar district are available in Klepser (1954), Thurston and Hardin (1954), Trace (1954a, b), Hardin (1955), Williams and Duncan (1955), Hardin and Trace (1959), Trace (1962), Hutcheson (1974), Anderson and others (1982), Trace and Amos (1984), Baxter and others (1992), Goldhaber and Eidel (1992), and Plumlee and others (1995).

Stratigraphy

The stratigraphy of the Jackson Purchase Region of the Mississippi Embayment and the Western Kentucky Fluorspar District of the Mississippian Plateau is discussed in Olive (1980), Trace and Amos (1984), and Martin (2004). Post-Paleozoic strata consist of clastic continental and marine sediments, ranging from Late Cretaceous to Quaternary in age along the Mississippi Embayment. Along the Mississippian Plateau, sedimentary rocks are Devonian to Pennsylvanian in age, with some Cretaceous sediments, Tertiary(?) gravel, and overlying Holocene alluvium.

Quaternary sediments in the map area consist of alluvial deposits, lacustrine and fluvial deposits, and loess. Alluvial deposits are incised into Mississippian–Tertiary sediments. The alluvial deposits represent recent sedimentation along stream valleys, glacial outwash, and reworking of the glacial outwash. Lacustrine and fluvial deposits near Paducah were deposited in a lake during the Pleistocene Epoch (Finch and others, 1964; Olive, 1966). The formation of lakes along the Ohio River during the Pleistocene was in response to advancing glaciers that diverted the ancestral Ohio River (Walker, 1957). Pleistocene loess deposits cover most Tertiary units in the Jackson Purchase Region.

Tertiary sediments in the map area consist of Pliocene(?) and Pleistocene gravel deposits unconformably overlying Eocene sands of the Claiborne and Wilcox Formations and the Porters Creek Clay of Paleocene age. The overlying gravel deposits are flat-lying, in contrast to the regionally dipping older sediments of the Mississippi Embayment.

Late Cretaceous sediments consist of the McNairy and Tuscaloosa Formations. The Tertiary Clayton Formation is hard to distinguish from the McNairy Formation, so they were mapped together during mapping of the 7.5-minute quadrangles. The Late Cretaceous deposits are incomplete because of erosion and nondeposition.

Pennsylvanian rocks occur in some of the grabens near the eastern margin of the map area. These rocks consist of the Middle Pennsylvanian Tradewater Formation and associated members, and the Lower Pennsylvanian Caseyville Formation and associated members. These sedimentary rocks consist of alternating sequences of sandstone and shale.

Mississippian rocks comprise most of the map units along the Mississippian Plateau and consist of interbedded limestone, shale, siltstone, and sandstone. The oldest map unit exposed in the area is the Mississippian-Devonian New Providence and Chattanooga Shales. These units are exposed near Kuttawa, near the Cumberland River, and are brought to the surface by a horst.

Igneous rocks occur as mafic dikes and sills at the surface and as plutons in the deep subsurface. These mafic alkalic intrusive dikes are abundant, and have been associated with sphalerite mineralization in the Western Kentucky Fluorspar District. Most of these dikes occur in a north–northwest-trending belt 6 to 8 mi wide and strike approximately north 20 to 30° west. Radioisotopic study indicates that the dikes are Early Permian in age (Trace and Amos, 1984).

Structure and Seismic Risk

The Mississippi Embayment is a broad, south-plunging syncline whose axis approximately coincides with the Mississippi River. Paleozoic rocks in the Jackson Purchase Region dip north from the Pascola Arch toward the Illinois Basin, except locally, where apparent reversal of dips may be caused by faulting (Schwalb, 1969). Upper Cretaceous and Tertiary formations, except for the Tuscaloosa Formation and the continental deposits, strike parallel to the margin of the embayment, whereas the dip is uniformly toward the embayment axis. As interpreted from structure-contour maps by Davis and others (1973), the tops of the McNairy Formation and the Porters Creek Clay dip west 30 to 35 ft/mi, whereas the top of the Wilcox Formation dips west about 23 ft/mi. Numerous mostly northeast-trending, high-angle normal faults displace Paleozoic rocks along the eastern border of the Jackson Purchase Region, but only a few of them offset post-Paleozoic strata (Heyl and others, 1965; Olive, 1980).

The current form of the Mississippi Embayment in Kentucky was established in latest Cretaceous time, after subsidence and erosion of the Pascola Arch to the south, according to Olive (1980). Schwalb (1969) concluded, however, that the basin might have developed much earlier. He identified a Cambrian-Ordovician basin of sedimentation, the Reelfoot Basin. The center of deposition of the Reelfoot Basin moved north into the Jackson Purchase Region in Late Ordovician time, and a thick section of sediments accumulated. This sedimentary basin was later uplifted, forming the Pascola Arch; pre-Late Cretaceous erosion exposed Cambrian beds at the center of the arch. Later downwarping submerged the Pascola Arch and allowed the accumulation of Late Cretaceous and Cenozoic sediments in the present trough of the Mississippi Embayment. Other interpretations concerning the formation of the embayment are by Cressman (1973), Ervin and McGinnis (1975), Austin and Keller (1982), and McKeown (1982). Cressman's (1973) interpretation was that regional facies relationships of the Lexington Limestone of central Kentucky and adjacent states implied the presence of an ancestral Mississippi Embayment. Ervin and McGinnis (1975) suggested, based on geophysical data, that the present embayment stems from the late Mesozoic, reactivation of the failed arm (the Reelfoot Rift) of a late Precambrian triple junction. A recent seismic study of the crustal structure of the embayment by Austin and Keller (1982) supports the model proposed by Ervin and McGinnis (1975). Recent geophysical, geological, and seismological studies of the Reelfoot Basin, which underlies the Jackson Purchase Region, and extends southwest into Missouri, Arkansas, and Tennessee, suggest that the basin is a fault-bounded rift zone that is responsible for the relatively high level of modern seismic activity in the New Madrid earthquake region (McKeown, 1982), which includes much of western Kentucky.

The Western Kentucky Fluorspar District is located along the southern boundary of the Illinois Basin at the intersection of the Reelfoot Rift and its east-trending extension into Kentucky, the Rough Creek Graben. This area consists of a series of complex, steeply dipping, northeast-trending normal faults that divide the area into elongate northeast-trending grabens and horsts (Trace and Amos, 1984). To the east, these faults trend more easterly, and many terminate within the western part of the western Kentucky coal basin (Trace and Amos, 1984). Some well-defined grabens in the area include the Mexico, Moore Hill, Griffith Bluff, Lockhart Bluff, and Rock Creek Grabens. Many cross faults occur between the grabens and horsts in the area. Most of these faults strike north to northwest, and are occupied at places by mafic dikes (Trace and Amos, 1984). In general, stratigraphic displacement of the bounding faults that define the grabens ranges from a few feet to a few hundred feet, and as much as 3,000 ft in the southeastern corner of the Smithland 7.5-minute quadrangle and the adjacent corner of the Burna 7.5-minute quadrangle (Amos, 1967, 1974). The major displacement along all faults probably was completed by middle Cretaceous time, although some movement continued through the Cretaceous and Tertiary to the present (Rhoades and Mistler, 1941; Heyl and Brock, 1961; McGinnis, 1963; Ross, 1963; Amos, 1967; York and Oliver, 1976).

The internal structure of the grabens is different from that of the horsts (Trace and Amos, 1984). In the grabens, most of the dips are inward as a result of tilt and associated drag folding parallel to the bounding faults (Trace and Amos, 1984). Within the horst blocks, beds commonly retain their regional northeastern dip toward the western Kentucky coal basin. The differences in the structure of the graben and horst blocks suggest that the actual block movement was confined to the grabens.

Another prominent structural feature in the fluorspar district is the Tolu Arch. The Tolu Arch is located near Tolu, Ky., along the Ohio River, and extends southeast for at least 6 mi, where it is transected by the younger Griffith Bluff Graben, and possibly farther southeast by the Moore Hill Graben (Trace and Amos, 1984). To the south, along the arch's strike, dip reversal of beds near Dycusburg along the Cumberland River provides evidence for possible extension of the arch (Trace and Amos, 1984). Farther south, Cretaceous and Tertiary sediments conceal evidence for possible extension of the arch (Trace and Amos, 1984). Schwalb (1969) interpreted the southwestern limb of the Tolu Arch to extend into central Livingston County.

The northeast-trending New Madrid Rift System is a Precambrian failed rift zone (Ervin and McGinnis, 1975) that developed along a preexisting shear zone and merges into the east-trending Rough Creek Fault System north of the map area. The New Madrid Rift System is composed of a series of en echelon basement grabens, formed during incipient rifting. Three basement faults or fault zones near the fluorspar district can be inferred from magnetic studies (Lidiak and Zietz, 1976; Johnson and others, 1978). Two of the inferred basement faults trend west-northwest and are not expressed at the surface, with the possible exception of the easternmost fault zone, which may be a part of the Tabb Fault System (Trace and Amos, 1984). The inferred east-trending basement fault is expressed at the surface by several east-trending surface faults (Trace and Palmer, 1971). Seismotectonic maps by Hildenbrand and others (1977) and Heyl and McKeown (1978) show the boundaries of the New Madrid Rift Zone aligned with and encompassing the entire Illinois-Kentucky Fluorspar District. These maps suggest that the dominant northeast-trending faults of the fluorspar district are the surface expression of the New Madrid Fault System. Many near-surface normal faults occur near rift junctions in the subsurface, which are hosts for mineralization in the Western Kentucky Fluorspar District and the site of igneous intrusions such as dikes and plutons.

Magnetic anomalies have been identified in the New Madrid Rift System and reflect buried basement plutons (Trace and Amos, 1984). The Hicks Dome intrusive in Illinois and the Coefield Ultramafic Complex in Kentucky are two of these magnetic highs. Hicks Dome is a major geologic structure in the district and influenced the geology and mineralization history of western Kentucky.

The potential for a major seismic event is great, as indicated by the frequency and magnitude of earthquakes in the area. Seismic activity in this area is recorded by the Kentucky Seismic and Strong-Motion Network (www.uky.edu/KGS/geologichazards/equake3.htm). Several of the largest earthquakes in the central United States occurred near New Madrid, Mo., in 1811-1812 (McKeown, 1982; Street and Nuttli, 1990). Tertiary and younger sediments in the Jackson Purchase Region contain clastic dikes, which are suggestive of seismically induced liquefaction features.

ECONOMIC GEOLOGY

The major economic resources of the area are fluorite and associated minerals, limestone, sand, gravel, and clay. Fluorite and associated minerals, including sphalerite, galena, and barite, are associated with the Western Kentucky Fluorspar District. The district is part of the Kentucky-Illinois Fluorspar District, which was the largest producer of fluorite in the United States during World War II and has produced millions of tons of fluorite. Limestone and coal are quarried and mined along the Mississippian Plateau, and sand, gravel, and clay deposits are available in the Jackson Purchase Region and the Mississippian Plateau. Oil and gas exploration has occurred in the area. Iron-ore mining and processing was also an important industry during the last half of the 19th century.

Classification of Mineral Deposits in the Fluorspar District

There are three classes of mineral deposits in the fluorspar district. The first is Mississippi Valley-type deposits (MVT), as described by Ohle (1980), which are very narrow, vein-mineral deposits that extend vertically and horizontally for hundreds of feet and are composed of fluorite, sphalerite, calcite, barite, and galena. The second type is stratabound or bedded deposits, also classified as MVT's and containing fluorite; these deposits occur mainly in the Joy and Carrsville areas, and bedded sphalerite may occur in other areas of the district. The third type of deposit is an igneous intrusive carbonatite similar to Hicks Dome located in Hardin County, Ill. (Mariano, 1989).

Fluorite is the dominant mineral in the district; barite, sphalerite, and galena have been produced in smaller quantities. Some sphalerite mineralization is associated with mafic dikes at the Hutson Mine along the Sandy Creek Fault System; and smithsonite, a zinc oxide, occurs at the Old Jim Mine near the Crittenden Springs Fault System. Other major fault systems with associated fluorite are the Dyer Hill, Levias–Crittenden Springs, Commodore, Moore Hill, Claylick, and Tabb. Many museum-quality specimens of fluorite and calcite have been obtained from the mines in the district and are some of the best in the world. Secondary minerals such as smithsonite, cerrusite, celestite, hemimorphite, greenokite, and pyromorphite also occur here (Anderson, 1994).

The vein and stratabound deposits were formed during the Permian by upward-migrating, fluorine-rich hydrothermal fluids that flowed along the fault planes of the northern New Madrid Fault System (Trace and Amos, 1984). Vein deposits occur mostly along northeast-trending faults; a few veins are along northwest- and north-trending fissures or faults that at places contain mafic dikes. A typical vein is lenticular, pinches and swells erratically, is a mixture of fluorite and variable quantities of calcite, and occurs in Mississippian carbonate rocks (Trace and Amos, 1984). The width of most veins is 3 to 10 ft, and mined ore shoots commonly range from 200 to 400 ft in length and from 100 to 200 ft in height (Trace and Amos, 1984; Baxter and others, 1992). The veins pinch and swell for several hundred feet, and have been mined to a depth of 800 ft (Trace and Amos, 1984).

Bedded, or manto, deposits occur along the Rock Creek Graben and are associated with the Renault Formation and the upper part of the Ste. Genevieve Limestone (Trace and Amos, 1984). These deposits are generally 50 to 200 ft wide and 5 to 20 ft thick (Trace and Amos, 1984; Baxter and others, 1992). Lengths range from 200 ft to 2 mi, and ore averages 20 to 35 percent fluorite (Trace and Amos, 1984; Baxter and others, 1992).

The Coefield Ultramafic Complex was discovered by Billiton Minerals in the early 1980's. It is characterized by a large magnetic anomaly and has been identified as both a lamprophyre and kimberlite ultramafic intrusive (Anderson, 1992). Numerous companies have examined the area for diamond potential, but no diamonds have been found. This intrusive is probably a southern extension of Hicks Dome, and is located in northern Crittenden County. Another magnetic anomaly is south of Coefield near Maple Lake in southern Crittenden County. These ultramafic and carbonatite complexes are characterized by brecciated alkalic igneous bodies that suggest the possibility of magma upwelling and subsequent withdrawal, resultant arching, and later fracturing due to collapse (Trace and Amos, 1984; Plumlee and others, 1995).

Origin of Fluorspar Deposits

The vein and bedded deposits were formed by a release of fluorine-rich fluids from deep-seated alkalic intrusive rocks. These magmatic fluids intersected with hydrothermal basinal fluids rich in base metals such as sphalerite, galena, and barite. The interaction of these fluids generated an acidic hydrothermal fluid and resulted in the fluorite deposits (Plumlee and others, 1995). Paragenetic studies by Hayes and Anderson (1992) suggest that these magmatic/hydrothermal fluids were part of a regional system of mineralization that correlates with the Central Tennessee Zinc District and the Central Kentucky Mineral District.

Fluorspar Mineral Production

Since mining began in 1873, the Western Kentucky Fluorspar District has produced about 3.23 million tons of fluorspar, 70,000 tons of zinc concentrate, 12,000 tons of lead concentrate, and 100,000 tons of barite concentrate (Anderson and others, 1982). Some trace elements such as silver, copper, cadmium, and gallium have also been recovered. Thirty percent of the fluorspar came from the Tabb Fault System, a major curvilinear fault in southern Crittenden and western Caldwell Counties (Trace and Amos, 1984). Most of the mining recovered the surficial residual deposits accumulated above the vein and ore deposits in the shallow subsurface; however, there is still a substantial reserve in deeper deposits.

Other Resources

Mississippian limestone is currently being quarried in the eastern part of the map area along the Mississippian Plateau. Limestone is used for aggregate, riprap, road metal, rough building stone, agricultural lime, cement, and chemical purposes. Currently, there are three large mining operations in the area: Marion Quarry in Marion, Three Rivers Quarry in Smithland, and the Reed Quarry in Gilbertsville. The Reed Quarry is one of the largest crushed stone quarries in the United States and is the leading producer of stone in Kentucky.

Coal has been mined in the northeastern part of the map area from the Gentry coal bed of the Caseyville Formation and from the Reynoldsburg and No. 1b coal beds of the Tradewater Formation. The Gentry coal is 18 in. to a reported 30 in. thick. The Reynoldsburg coal is reported to be 18 in. thick and of lesser quality than the Gentry coal. The No. 1b coal ranges in thickness from 0 to 57 in., and averaged 42 in. where it has been mined.

Sand and gravel are mined throughout the area. River dredges recover sand from the Ohio and Tennessee Rivers, and large quantities of high-silica sand, which has many economic uses, are obtained from most stratigraphic units. Deposits have been prospected in Marshall, McCracken, and Calloway Counties. Gravel is intermittently mined for road metal, fill, concrete aggregate, and railroad ballast. Gravel has been dredged from the Ohio and Tennessee Rivers, and quarried from alluvium, continental deposits, and the Tuscaloosa Formation. Gravel of the continental deposits is obtained from many quarries throughout the Jackson Purchase Region, and is used principally for base construction of paved highways and as road metal on secondary roads (Olive, 1980). The largest and most accessible sources of gravel are in the eastern part of the region where the deposits are thickest and the overlying loess is less than 15 ft thick (Olive, 1980). Chert gravel from the Tuscaloosa Formation occurs in areas bordering Kentucky Lake and Lake Barkley.

Clay bodies of possible economic value occur in the Claiborne Formation, Wilcox Formation, Porters Creek Clay, and McNairy Formation. The clays associated with the Claiborne and Wilcox Formations are kaolinitic, and include ball, wad, sagger, and bonding clays; they have uses for ceramics, low-duty refractories, and pottery (Olive and Finch, 1969). Because of high shrinkage, the Porters Creek Clay is generally unsuited for ceramic products; however, it is a potential source of fuller's earth-type clay (Olive, 1980). Thin clay beds of possible economic value occur in the McNairy Formation, and may be suitable for the manufacture of structural products, whiteware, and low-heat-duty refractories (Olive, 1980).

Several oil and gas wells have been drilled in the area. None have yielded any commercial hydrocarbons, but shows of oil and gas and evidence of bitumen have been detected in some wells and cores. The M.D. Davis No. 1 well, east of Tolu, was one of the deepest wells in the area. A show of gas was found in the Chattanooga Shale (McCann, 1956).

Some iron-ore deposits were mined and smelted in furnaces in Caldwell and Lyon Counties in the early 1900's, but are currently uneconomic. Grayish-red iron oxide is scattered as local deposits of cement in the Quaternary and Tertiary(?) gravel, the McNairy Formation, and the Tuscaloosa Formation.

ENGINEERING GEOLOGY

Geologic map units in the Jackson Purchase Region of the Paducah and Cape Girardeau quadrangles can be reclassified as geotechnical map units based on engineering properties as well as lithology (Finch, 1968; Nichols, 1968; Martin 2001). Sediments and rocks in this area can be classified as unconsolidated, poorly to moderately consolidated, or consolidated. The Quaternary surficial deposits such as silt, sand, and gravel are unconsolidated, whereas Tertiary and Cretaceous sediments such as bedded and interbedded clays, silts, sands, and gravels are poorly to moderately consolidated. The Paleozoic rocks exposed along Kentucky Lake and occurring in the subsurface to the west below the post-Paleozoic sediments are considered consolidated bedrock. The probable behavior of these geotechnical map units when disturbed by engineering and construction practices, in response to natural phenomena such as erosion, flooding, and earthquakes, or the effects of this behavior on existing structures are discussed by Finch (1968) and Nichols (1968).

The fluorspar district of the Paducah and Cape Girardeau quadrangles is underlain by Mississippian carbonate rocks, which are prone to form karst features. Several caves are located in the northeastern part of the map area (George, 1985; Mylroie and Dyas, 1985). This area is also an abandoned mining district with numerous abandoned mine shafts, adits, and drifts; therefore, geologic maps and old mine maps should be consulted before any construction or development.

Beck and others (2004a–e, 2005) discussed the land-use potential for the Kentucky counties shown on this map. They compared rock-unit types with respect to construction practices, transportation issues, recreational areas, and utility locations. They also delineated urban areas, watersheds, and wetlands, and showed the locations of quarries and water wells.

The area bordering the Mississippi River is currently tectonically active and is the site of frequent seismic events, most of which have epicenters along or near the embayment axis (Fuller, 1912; McKeown, 1978; Moneymaker, 1954, 1955, 1957, 1958; Stauder and others, 1976). The epicenter of the New Madrid earthquakes of 1811–1812, believed to be among the most violent earthquakes that have taken place in North America, was adjacent to the westernmost border of the Jackson Purchase Region. Amplification of earthquake ground motion, liquefaction, and earthquake-induced landslides by near-surface geologic conditions have been recognized as major causes of damage in areas underlain by deep, unconsolidated, saturated sediments. Clastic dikes occur throughout this part of the Jackson Purchase Region, and represent areas of prior liquefaction.

HYDROGEOLOGY

Surface water is extensive in the map area. The Ohio River, Kentucky Lake, and Lake Barkley are the most significant bodies of surface water in the area. The large dams at the lakes in the southeastern part of the map area serve to make the rivers navigable, allow for flood control, and allow recreation. Groundwater occurs in aquifers associated with Paleozoic rocks; Cretaceous sediments; sands within Eocene strata and Pliocene(?) and Pleistocene gravel; and recent alluvium. Detailed discussions of the hydrogeology of the area are found in Davis and others (1973) and Carey and Stickney (2002, 2004a–d, 2005).

Aquifers within rocks of Paleozoic age contain a rubble zone at the top of the bedrock, and fissures and fractures deeper within bedrock that yield large amounts of groundwater (Davis and others, 1973). Groundwater in the northeastern part of the map area is also from karst aquifers occurring in underground caves and conduits. Most wells in the area are relatively shallow and produce from fractures and alluvial material (Carey and Stickney, 2004a–c, 2005). Since the area is complexly faulted, many of these water conduits may occur along faults and fractures. In the Paleozoic bedrock areas, groundwater occurs in aquifers of Pennsylvanian and Mississippian age. Pennsylvanian formations yield enough water for domestic supply in lowland areas bordering streams, and are inadequate in uplands areas (Carey and Stickney 2004a–c, 2005). The most common Paleozoic bedrock exposed in the area is Mississippian limestone. The Mississippian System can be divided into the Chesterian and Meramecian Series. Aquifers in Chesterian formations have small yields to wells and springs near exposed bedrock areas (Carey and Stickney, 2004a–c, 2005). Lowland areas are usually adequate for domestic use, whereas upland areas are usually inadequate. Meramecian aquifers occur mostly in limestone and form karst areas. Low flow ranges from 10 to 1,500 gal/min and maximum flow ranges from 100 to 100,000 gal/min (Carey and Stickney, 2004a–c, 2005). The largest yields of groundwater from these aquifers are near streams in solution channels. In karst areas, yields of 50 gal/min allow for domestic use. In nonkarst areas, yields are much lower and are inadequate for domestic supply (Carey and Stickney, 2004a–c, 2005).

Cretaceous sediments such as the Tuscaloosa Formation consist of rounded chert gravel with a tripolitic matrix, and have a low permeability and low yields; however, the McNairy Formation consists mainly of sand and makes an excellent aquifer with large yields (Davis and others, 1973). The Tuscaloosa Formation yields approximately 100 gal/day (yields increase to 5 gal/min near Kentucky Lake and Lake Barkley), with water hardness from 26 to 57 ppm and dissolved solids from 50 to 76 ppm (Carey and Stickney, 2004a–d, 2005). The McNairy Formation can yield as much as 830 gal/min with water hardness from 13 to 182 ppm and dissolved solids from 62 to 275 ppm (Carey and Stickney, 2004a, c, d).

Eocene sediments are the Porters Creek Clay, Wilcox Formation, and Claiborne Formation. The Porters Creek Clay is an aquitard and is a hydrologic base for groundwater movement in the overlaying Eocene sand beds and a barrier from upward movement of water from the underlying McNairy Formation (Davis and others, 1973). The Wilcox Formation consists of beds at the base and higher up in the formation, and yields sufficient water for domestic wells (Davis and others, 1973). The Claiborne Formation consists of thick sand beds that are potentially the most productive and important aquifers in the area (Davis and others, 1973). Wells can yield as much as 1,700 gal/min with water hardness of 7 to 212 ppm and dissolved solids from 28 to 431 ppm (Carey and Stickney, 2002, 2004c, d).

The Pliocene(?) and Pleistocene continental deposits consist of gravel. The saturation thickness of gravel is commonly less than 10 ft, and the area is a large zone of perched water throughout its extent, and supplies domestic water wells (Davis and others, 1973). Most wells yield less than 10 gal/min, with water hardness of 8 to 724 ppm and dissolved solids from 43 to 782 ppm (Carey and Stickney, 2002, 2004a–d).

Alluvium occurs along major and minor tributaries. Alluvium is thick along the Ohio, Tennessee, and Cumberland Rivers and contains large supplies of groundwater for domestic and industrial use (Davis and others, 1973; Carey and Stickney, 2002, 2004a, d, 2005). Generally, most wells yield more than 500 gal/day, with water hardness of 12 to 664 ppm, and dissolved solids from 53 to 1,220 ppm. Thinner, fine-grained alluvium occurs along smaller tributaries to the major rivers, and yields practically no water to wells (Carey and Stickney, 2002, 2004a–d, 2005).

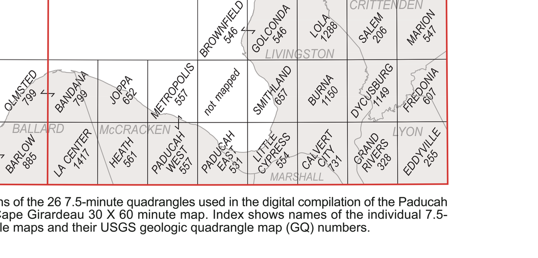

Figure 1. Locations of the 26 7.5-minute quadrangles used in the digital compilation of the Paducah and part of the Cape Girardeau 30 X 60 minute map. Index shows names of the individual 7.5-minute quadrangle maps and their USGS geologic quadrangle map (GQ) numbers.

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