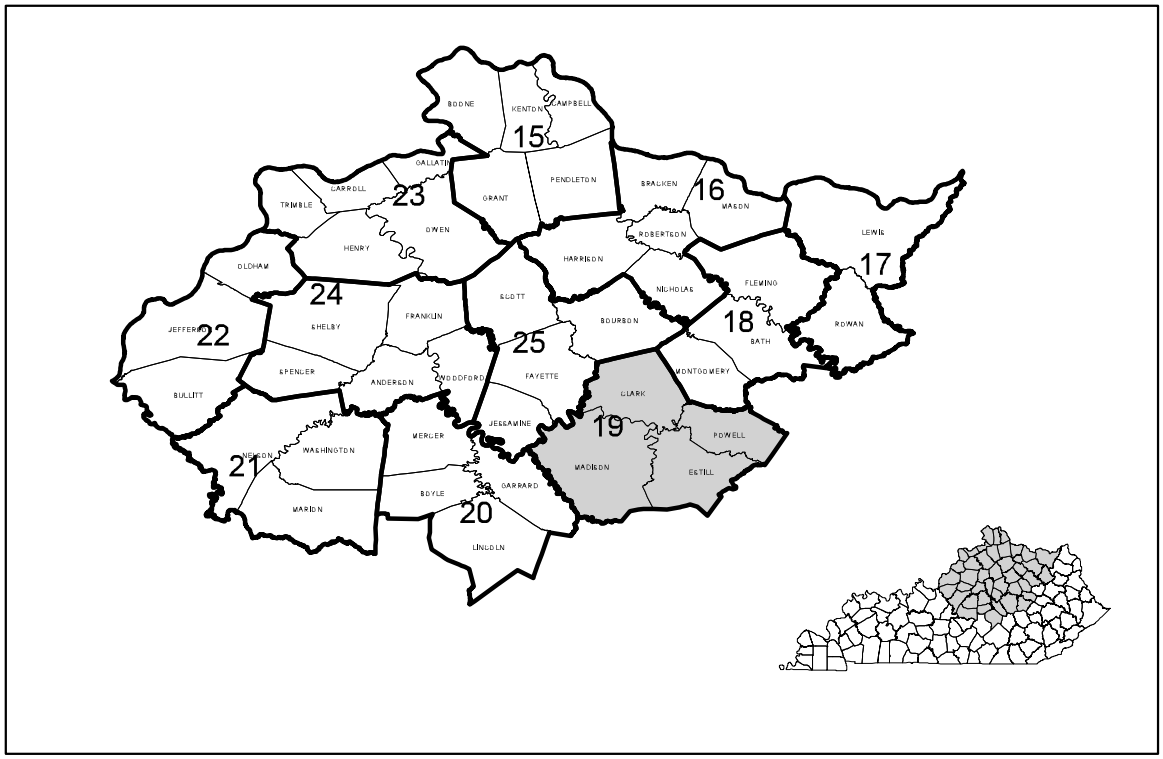
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE COMMONWEALTH OF KENTUCKY
AND THE KENTUCKY GEOLOGICAL SURVEY
UNIVERSITY OF KENTUCKY

AVAILABILITY OF GROUND WATER IN CLARK, ESTILL, MADISON, AND POWELL COUNTIES, KENTUCKY

By
F.R. Hall and W.N. Palmquist, Jr.

HYDROLOGIC INVESTIGATIONS
ATLAS HA-19



INDEX MAP OF THE BLUE GRASS REGION, KENTUCKY, SHOWING COUNTY GROUPS AND AREA OF THIS ATLAS

This is 1 of 11 atlases (HA-15 to HA-25) showing geology and availability of ground water in the Blue Grass region, Kentucky U.S. Geological Survey Water-Supply Paper 1533 contains a text description and illustrations providing further information on the occurrence and quality of ground water in the Blue Grass region.

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HYDROLOGIC INVESTIGATIONS
ATLAS HA-19 (SHEET 1 OF 3)

EXPLANATION

CARBONIFEROUS TERTIARY OR QUATERNARY

Pliocene or Pleistocene
- QTi — Irvine formation

- P — Pennsylvanian rocks (Lee formation)
- M — Mississippian rocks
- D — Devonian rocks
- S — Silurian rocks

ORDOVICIAN

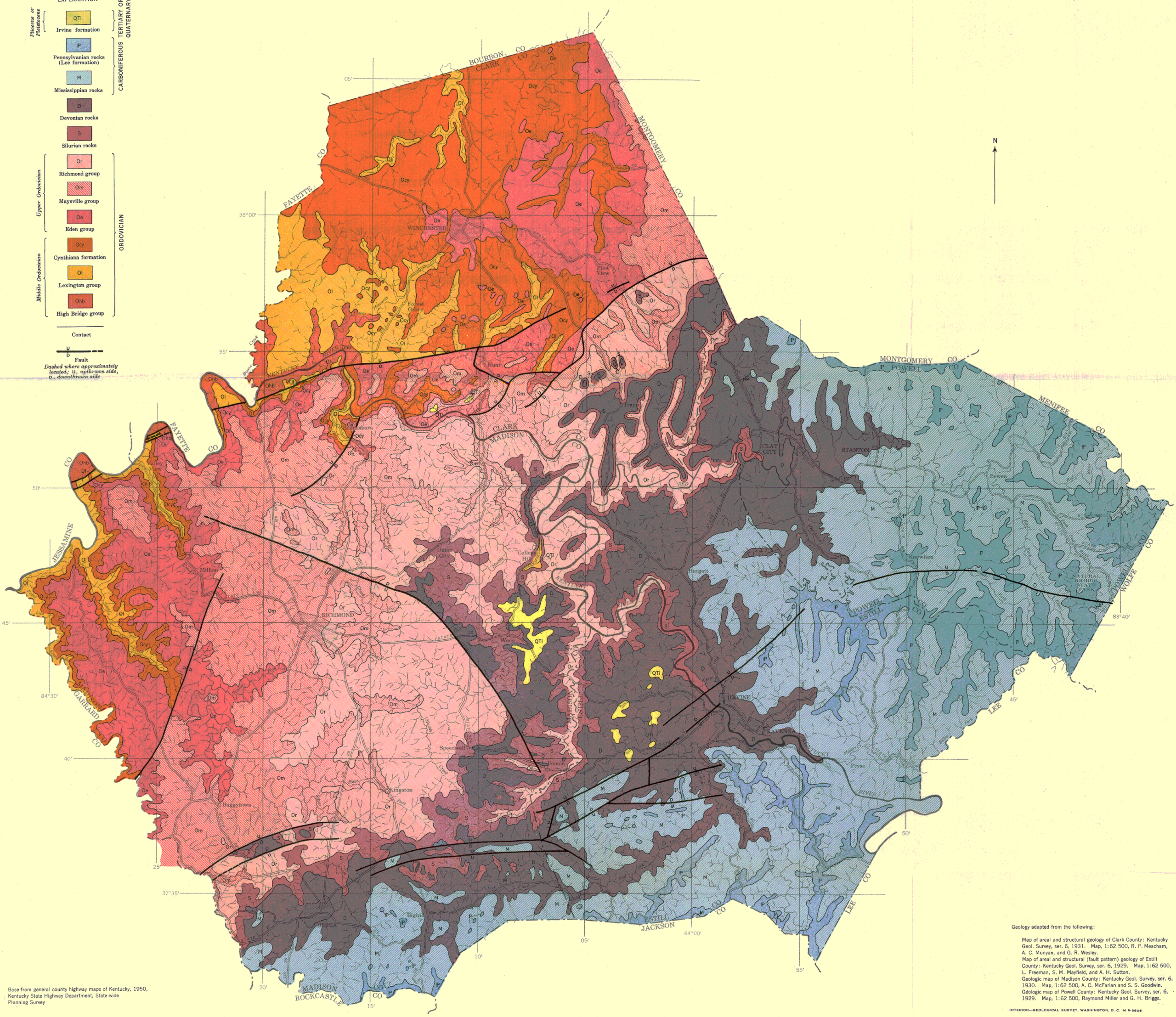
Upper Ordovician
- Or — Richmond group
- Om — Maysville group
- Oe — Eden group

Middle Ordovician
- Ocy — Cynthiana formation
- Ol — Lexington group
- Ohb — High Bridge group

Contact

U / D — Fault
Dashed where approximately located; U, upthrown side, D, downthrown side

N



Base from general county highway maps of Kentucky, 1950, Kentucky State Highway Department, State-wide Planning Survey

Geology adapted from the following:

Map of areal and structural geology of Clark County: Kentucky Geol. Survey, ser. 6, 1931. Map, 1:62 500, R. P. Meacham, A. C. Munyan, and G. R. Wesley.
Map of areal and structural (fault pattern) geology of Estill County: Kentucky Geol. Survey, ser. 6, 1929. Map, 1:62 500, L. Freeman, S. M. Mayfield, and A. H. Sutton.
Geologic map of Madison County: Kentucky Geol. Survey, ser. 6, 1930. Map, 1:62 500, A. C. McFarlan and S. S. Goodwin.
Geologic map of Powell County: Kentucky Geol. Survey, ser. 6, 1929. Map, 1:62 500, Raymond Miller and G. H. Briggs.

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GEOLOGIC MAP OF CLARK, ESTILL, MADISON, AND POWELL COUNTIES, KENTUCKY (COUNTY GROUP 19)

Scale 1:125 000

1 0 1 2 3 4 5 6 7 8 9 10 Miles

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HYDROLOGIC INVESTIGATIONS
ATLAS HA-19 (SHEET 2 OF 3)

EXPLANATION

Well

Spring
No objectionable quantities of salt or hydrogen sulfide in water

Sulfurous water[1]
Contains hydrogen sulfide in noticeable amounts

Salty water
Contains sodium chloride in amounts readily detected by tasting

Salty and sulfurous[1] water
Contains both sodium chloride and hydrogen sulfide in readily detectable amounts

D-H / 30 — Well
M-2 — Spring

Aquifer

- Qal Alluvium (Quaternary)
- Qti Irvine(?) formation (Quaternary and Tertiary)
- M Mississippian rocks
- D Devonian rocks
- S Silurian rocks
- Or Richmond group (Ordovician)
- Om Maysville group (Ordovician)
- Oe Eden group (Ordovician)
- Ocy Cynthiana formation (Ordovician)
- Ol Lexington group (Ordovician)
- Ohb High Bridge group (Ordovician)

Yield

- 2 Figure above line indicates yield, in gallons per minute, where known
- P Reported adequate for power-pump installation
- H Reported adequate for hand-pump installation
- N No pump, or reported inadequate supply

Depth

30 *Figure below line indicates depth of well, in feet*

[1] Much of the sulfurous (hydrogen sulfide-bearing) water is satisfactory for domestic use, as the hydrogen sulfide escapes as a gas upon exposure of the water to the air

EXPLANATION

Area 2
Most drilled wells in this area will produce enough water for a domestic supply with a power pump and and pressure system (more than 500 gallons a day) at depths of less than 100 feet. Some wells produce as much as 50 gallons per minute from alluvium or thick limestone along large streams. Water is hard or very hard and may contain salt or hydrogen sulfide, especially at depths greater than 100 feet

Area 3
Most drilled wells in this area will produce enough water for a domestic supply with a hand pump (100 to 500 gallons a day) at depths of less than 100 feet. Some wells will produce more than 500 gallons a day except during dry weather. Water is hard or very hard and may contain salt or hydrogen sulfide, especially at depths greater than 100 feet

Area 4
Most drilled wells in this area will not produce enough water for a dependable domestic supply (100 gallons a day). Wells along drainage lines may produce enough water for a domestic supply except during dry weather. Water is hard and may contain salt or hydrogen sulfide at depths greater than 100 feet

AVAILABILITY OF GROUND WATER IN CLARK, ESTILL, MADISON, AND POWELL COUNTIES, KENTUCKY (COUNTY GROUP 19)

Scale 1:125 000

1 0 1 2 3 4 5 6 7 8 9 10 Miles

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HYDROLOGIC INVESTIGATIONS
ATLAS HA-19 (SHEET 2 OF 3)

SYSTEM	SERIES	GROUP	FORMATION	THICKNESS, IN FEET	SECTION	LITHOLOGY	TOPOGRAPHY	HYDROLOGY
QUATERNARY	PLEISTOCENE AND RECENT		ALLUVIUM	0-40		Clay, silt, and fine sand in thin discontinuous deposits along large streams. Thicker along Red River in Powell County, where it includes some coarse sand and gravel.	Flood plains and small terraces of large streams and tributaries.	Yields more than 500 gpd (gallons per day) in Red River valley, Powell County. Elsewhere is too thin and fine grained to yield much water. Water may be soft or hard and may contain iron in objectionable quantities.
			IRVINE FORMATION	0-30		Discontinuous deposits of crossbedded fine- to medium-grained sand containing clay lenses. Well-rounded pebbles scattered throughout sand.	Upland and hilltops having no distinct surface expression.	Yields 100 to 500 gpd to wells in thick deposits; yields water to small springs. Water is soft.
TERTIARY OR QUATERNARY	PLIOCENE OR PLEISTOCENE		LEE FORMATION	320		Massive crossbedded medium-grained to coarse sandstone and sandy shale in upper part, and some coal seams. Discontinuous channel fill of coarse crossbedded sandstone and conglomerate in lower part; lower part not present in some places.	Tops of steep-sided ridges and knobs, steep bluffs and cliffs; broad, flat ridgetops in eastern part of area. Some channels have been cut through the Pennington shale into limestone units of Late Mississippian age.	Yields 100 to 500 gpd to drilled wells on broad ridges; yields almost no water to wells on narrow ridges or hilltops; yields water to small springs. Water is soft.
PENNSYLVANIAN			PENNINGTON SHALE	0-30		Soft green to gray shale and some interbedded sandstone and limestone; in Madison County only.	Too thin and limited in extent to have distinct surface expression.	Yields almost no water. Impermeable shale may hold water in overlying sandstone and conglomerate.
CARBONIFEROUS	UPPER MISSISSIPPIAN		UNDIFFERENTIATED LIMESTONE	170-227		Soft green marly shale overlain by dark blue-gray thick-bedded coarse-grained limestone with shaly partings in upper part. Remainder in descending order, light-colored thick-bedded oolitic limestone, medium to thick-bedded limestone, medium-thick-bedded fine-grained cherty limestone, and yellow impure limestone.	Tops of steep-sided ridges and knobs; prominent bluffs in sides of ridges and knobs that the capped by rocks of Pennsylvanian age.	Yields 100 to 500 gpd to drilled wells in the few places where it occurs below stream level; yields water to many springs, particularly at the heads of streams. Springs have large winter and small summer flows. Water is hard.
	LOWER MISSISSIPPIAN	BORDEN[1]	MULDRAUGH FORMATION[1]	35-50		Argillaceous limestone with shaly partings above and clayey shale below, in southern Madison County; argillaceous limestone with shale partings in upper part, and gritty siltstone and glauconitic silt in lower part, elsewhere.	Dissected upper slopes and tops of some knobs. Limestone beds project as ledges in ravines and hillsides. Erodes easily, undermining overlying limestone. beds and causing them to fall in large blocks.	Yields 100 to 500 gpd to wells in valley bottoms; may yield more than 500 gpd to drilled wells in broad valley bottoms from fractured sandy rocks near streams, but almost no water to wells on hills; yields water to small springs. Water from wells drilled below stream level may contain salt and sulfate. Water from dug wells and springs is soft and has a low dissolved-solids content. Because it is soft and silty, the New Providence is well suited to construction of dug wells.
			FLOYDS KNOB FORMATION[1]	1-1½		Silt; cherty, shaly, or calcareous siltstone; silty shale or silty limestone, containing glauconitic streaks or specks.	Ledges between shale slopes above and below.	
			BRODHEAD FORMATION[2]	125-285		Massive siltstone with silty or argillaceous shale that locally contains large calcium and iron carbonate concretions, quartz geodes, and thin crinoidal limestone lenses in Estill, southern Madison, and Powell Counties; evenly bedded siltstone with shale partings in central and northeastern Powell County.	Main part of Mississippian escarpment and many knobs. Shale forms dissected slopes, massive siltstone forms cliffs, and limestone forms ledges on shale slopes.	
			NEW *PROVIDENCE* FORMATION[1]	125-275		Silty or clay shale with thin beds of siltstone or dense limestone in Madison and Estill Counties; contains large iron and calcium carbonate concretions, and, at base, phosphatic nodules and thin ferruginous siltstone layers. Argillaceous shale in upper part, and silty shale with beds of siltstone one-half foot thick in lower part, in Powell County.	Dissected lower slopes of knobs, and broad, flat valleys.	
DEVONIAN	UPPER DEVONIAN		OHIO SHALE	75-170±		Black highly fissile bituminous shale with local green shale layers. Shale contains clay, grains of quartz, pyrite, and other minerals, and organic material.	Broad, flat valleys and flat upland surfaces; steep, dissected hillsides and bluffs along streams.	Yields 100 to 500 gpd to drilled wells in valley bottoms and on upland; yields water to small springs. Water may be soft or highly mineralized. Salt, hydrogen sulfide, and iron are the usual objectionable constituents.
	MIDDLE DEVONIAN		BOYLE LIMESTONE[3]	0-25		Medium- to coarse-grained massive dolomitic limestone with much chert and silicified coral.	Prominent ledges along hillsides.	Yields little water to wells; yields water to many small perennial springs. Water is hard.
SILURIAN		CRAB ORCHARD[4]		55-100		Thin- to medium-bedded greenish-gray lumpy shale and thin limestone or dolomitic beds. Shale contains epsom salt and selenite (clear gypsum) crystals.	Steep, dissected hillsides and broad, flat valley bottoms; erodes readily below more resistant overlying limestone, forming notches and recesses.	Yields almost no water to wells or springs; may yield small amounts of water to wells in valley bottoms. Water is highly mineralized.
			BRASSFIELD LIMESTONE	4-23		Massive dolomitic limestone with crinoidal layers.	Discontinuous ledges along hillsides.	Yields water to small springs. Water is hard.
ORDOVICIAN	UPPER ORDOVICIAN	RICHMOND	LIBERTY AND WHITEWATER FORMATIONS UNDIFFERENTIATED	65±-82		Shale in upper part; interbedded dolomitic limestone and shale in lower part. Limestone may be cavernous owing to leaching of fossils.	Dissected upland areas, with slopes moderately steep where underlain by shale, and moderately undulating to gently rolling where underlain by limestone. Steep and cliffy slopes along large streams, littered with limestone slabs left as shale beds weather and wash away.	Yields 100 to 500 gpd to drilled wells in broad valleys and along streams in upland; yields almost no water to drilled wells on hillsides or ridgetops; yields water to small springs. Water is hard and in valley bottoms may contain salt or hydrogen sulfide. Shale limits amount of water that has access to thick limestone beds, and therefore restricts number of openings in these beds enlarged by solution. As a result, the limestone beds yield little water.
			WAYNESVILLE LIMESTONE	55±-75		Interbedded fine-grained argillaceous limestone and shale.		
			ARNHEIM FORMATION	25-48±		Rubbly argillaceous limestone, dolomitic in places, in upper part; shale and some limestone in lower part.		
		MAYSVILLE	MC MILLAN FORMATION	115-125±		Limestone and a little shale in upper part; interbedded shale and argillaceous limestone in lower part. Siliceous beds at the base weather to platy chert.	Gently to moderately rolling upland away from major streams, moderately dissected where shale is predominant. Dissected, steep slopes along large streams. Thick limestone beds stand out as ledges on steep hillsides and bluffs along streams; where present on upland, they underlie broad, flat valleys that may have small sinkholes and some underground drainage. Lower part of the Maysville group caps broad, rather flat ridges between steep-sided valleys cut into the underlying Eden group.	Yield 100 to 500 gpd to drilled wells in broad valley bottoms and along streams in upland, but almost no water to wells on hillsides or ridgetops; yield water to small springs. Water is hard and in valley bottoms may contain salt or hydrogen sulfide. Where thick limestone beds with little shale occur below stream level in valley bottoms or on upland, they may have undergone solutional enlargement of fractures and bedding-plane openings. Wells drilled into these limestone beds may produce more than 500 gpd. These thick beds also yield water to some large springs. The fine-grained well-cemented sandstone and siltstone of the Garrard yields almost no water to wells. Water is hard.
			FAIRVIEW FORMATION	115-125±		Rubbly limestone and some interbedded shale; sandy shale and limestone at base.		
			UNNAMED STONE-SAND MEMBER					
		?	GARRARD SANDSTONE	65-90±		Fine-grained sandstone or siltstone with calcareous cement; grades into sandy limestone and shale above and below.		
		EDEN		65±-75		Bluish-gray lumpy calcareous shale and some thin beds of limestone; thick limestone beds toward the base.	Narrow, steep-sided ridges with narrow valleys between.	Yields 100 to 500 gpd to drilled wells in valley bottoms; yields water to small springs. Water is hard and in valley bottoms may contain salt or hydrogen sulfide.
	MIDDLE ORDOVICIAN		CYNTHIANA FORMATION	70-125		Thin- to thick-bedded fine- to coarse-grained argillaceous limestone, in places crossbedded, rubbly, or bouldery, with drab-brown or bluish gray shale. Upper part is more shaly than lower part.	Gently to moderately rolling upland with sinkholes; poorly developed underground drainage where shaly, and well-developed underground drainage where there is little shale; underlies broad, flat valleys extending into the Eden shale belt.	Yields more than 500 gpd to wells in broad valley bottoms; yields 100 to 500 gpd to drilled wells in narrow valley bottoms and along streams in upland; yields water to springs, particularly those in the Woodburn limestone member. Water is hard and below stream level may contain salt or hydrogen sulfide.
			WOODBURN LIMESTONE MEMBER	30±-35		Fine- to coarse-grained gray crystalline phosphatic limestone.		
			BRANNON LIMESTONE MEMBER	10-15±		Fine-grained siliceous limestone, bouldery in places; weathers to fine chert residuum.		
		LEXINGTON		40±		Medium- to coarse-grained blue-gray crystalline limestone in beds several inches to more than 1 foot thick, with shale partings.	Gently rolling to moderately dissected upland with sinkholes and well-developed underground drainage. Limestone beds crop out in discontinuous bands on valley sides in dissected parts along Kentucky River and major tributaries.	Yields more than 500 gpd to wells in broad valley bottoms; yields 100 to 500 gpd to drilled wells in narrow valley bottoms and along streams in upland; yields water to many small and moderate-sized springs. Water is hard and below stream level may contain salt or hydrogen sulfide. The Benson limestone is less shaly and generally yields more water than the rest of the Lexington group.
			BENSON LIMESTONE	75-100±		Fine-grained crystalline siliceous limestone and some interbedded shale.		
			JESSAMINE LIMESTONE					
			LOGANA FORMATION	30±-35		Crystalline limestone with shale partings.		
			CURDSVILLE LIMESTONE	18-26		Crystalline cherty limestone with bentonite bed at the base in many places.		
		HIGH BRIDGE	TYRONE LIMESTONE	90-100±		Pure, very dense and extremely fine-grained, almost lithographic, limestone in medium-thick beds with scattered inclusions of coarsely crystalline calcite; weathers chalky white with dark calcite grains standing in relief (Birdseye limestone).	Bottoms and walls of Kentucky River gorge and larger tributaries. Faulting restricts extensions of the High bridge group up tributary valleys in Madison County. The High bridge reaches nearly to the upland in bottoms of several tributary valleys in Clark County. Massive limestone beds form steep walls or cliffs along large streams. Bedrock terraces have been cut into the High bridge along the Kentucky River. May be small sinkholes and some underground drainage on the terraces and in broader valley bottoms.	Yields more than 500 gpd to drilled wells along the Kentucky River and large tributaries; yields water to springs on hillsides and in steep walls along streams. Water is hard. Bentonite beds in the Tyrone limestone hinder downward movement of water and, except where the bentonite has been breached or removed by erosion, the High bridge group yields little water.
			OREGON LIMESTONE	20-30		Granular, finely crystalline gray to cream-colored magnesian limestone in medium-thick beds.		
			CAMP NELSON LIMESTONE	300		Massive limestone characterized by an intergrowth of limestone similar to the Oregon and Tyrone; composed of irregular patches of gray-buff finely crystalline magnesian limestone in a matrix of dense dove-gray limestone with scattered small calcite crystals; weathers to honeycombed surfaces with less soluble magnesian limestone in relief.		

[1] As used by Stockdale (1939). [2] Of Stockdale (1939). [3] Of Foerste (1906) as used by Savage (1930). [4] As used by Foerste (1935)

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GENERALIZED COLUMNAR SECTION AND WATER-BEARING CHARACTER OF THE ROCKS IN CLARK, ESTILL, MADISON, AND POWELL COUNTIES, KENTUCKY (COUNTY GROUP 19)

By
F. R. Hall and W. N. Palmquist, Jr.

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