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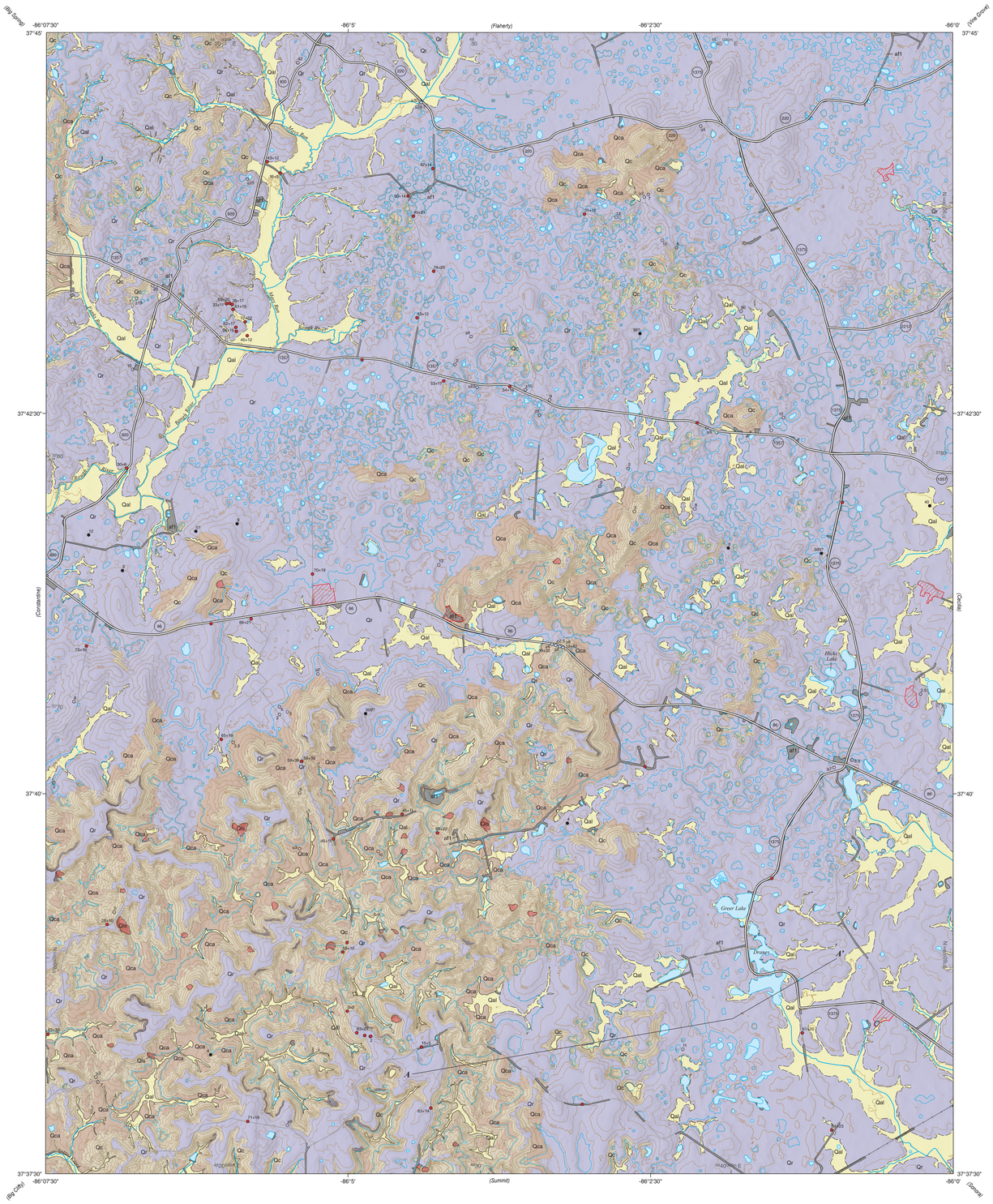


SURFICIAL GEOLOGIC MAP OF THE HOWE VALLEY 7.5-MINUTE QUADRANGLE, CENTRAL KENTUCKY

Antonia E. Bottoms, Maxwell L. Hammond III, Matthew A. Massey, Emily Morris, and Michele McHugh

Topographic lines and hillshading derived from KYAPED 5-Foot Digital Elevation Model and USGS 3DEP 1/3 arc-second digital elevation model.

Highways, roads, and railroads from Kentucky Transportation Cabinet.

Hydrography from National Hydrography Dataset High Resolution.

Digital data collected in Kentucky Single Zone State Plane Coordinate System. Lambert conformal projection, North American 1983 datum.

Topographic contours and hillshading may not be current within areas of artificial fill.

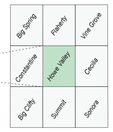
APPROXIMATE MEAN DECLINATION, 2021

CONTOUR INTERVAL 20 FEET

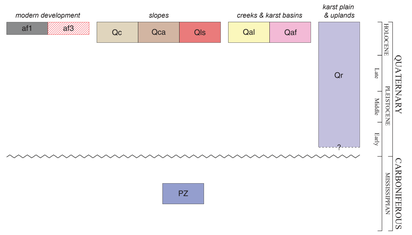
SCALE 1:24,000

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

MAP LOCATION



Correlation of Map Units



Description of Map Units

af1 — **Artificial fill, engineered (modern)**
Engineered fill that includes compacted material used for major road embankments, roadway interchanges, dams, levees, and major urban development where original topography has been significantly modified.

af3 — **Artificial fill, other (modern)**
Areas associated with the development of densely populated neighborhoods and urban areas where original surficial geologic deposits have been significantly disturbed. Displayed as overlay.

Qc — **Colluvium, undifferentiated (Holocene)**
Sand, silt, and clay, strong brown (7.5YR 5/8) to yellowish brown (10YR 5/6), poorly sorted. Sediments derived from lithologic material(s) upslope (Qr), and commonly include variably sized fragments of local bedrock that include limestone, sandstone, and shale (PZ). Mapped on slopes of knobs and ridges greater than 12° mostly in the southwestern corner of the quadrangle, but also present in karst basins, sinkholes, and valleys across the Pennyroyal region. Thickness consistent on slopes up to 10 ft, but highly variable because of karst development in underlying limestones, reaching up to at least 20 ft. Upper contact with parent material interpreted as gradational. Does not display well-developed soil horizons. Partially correlative with "slumped sandstone and shale" of Kepferle (1963) and Vertrees silty clay loam (46 percent area), Vertrees silt loam (10 percent area), Riney loam (9 percent area), Cumberland silt loam (6 percent area), and minor proportions of other soil series (Arms and others, 1979).

Qca — **Colluvium, accumulation zone (Holocene)**
Silt, clay, sand, and gravel, poorly sorted. Mostly quartz with variable proportions of muscovite, feldspar, biotite, goethite, and clay minerals. Accumulations of sediments derived from lithologic material(s) upslope (Qc) at base of slopes, characterized by wedge-shaped landforms with slopes less than 12°; commonly consist of variably sized fragments of local bedrock that include limestone, sandstone, and shale (PZ). Thicknesses up to 10 ft, commonly decreasing toward lower contacts. Upper contact interpreted as gradational; lower contact interpreted to interfinger with base lithology. Soil horizons commonly developed. Partially correlative with Caneyville-Rock outcrop complex (23 percent area), Cumberland silt loam (17 percent area), Vertrees silty clay loam (7 percent area), Ramsey-Steinsburg-Allegheny complex (7 percent area), Wellston silt loam (6 percent area), and minor proportions of other soil series (Arms and others, 1979).

Qls — **Landslide deposit (Holocene)**
Clay, silt, sand, gravel, and variably sized fragments of local bedrock, very poorly sorted. Derived from local lithologic material (Qc and PZ). Landslide deposits characterized by head and lateral scarps; commonly exhibits hummocky terrain. Contacts mapped as sharp along scarps.

Qal — **Alluvium, small creek floodplain (Holocene)**
Silt, sand, clay, and gravel, dark yellowish brown (10YR 5/4) to yellowish brown (10YR 5/6), poorly sorted. Mostly muscovite and subangular to subrounded quartz. Locally derived sediments in small creeks, streams, and tributaries up to 30 ft thick, and in karst basins and sinks of variable extent (many areas too small to depict at this map scale) and thickness (up to at least 40 ft). Contacts are commonly sharp but locally interfingered with Qc and Qr. Partially correlative with Qal of Kepferle (1963) and Vertrees silt loam (11 percent area), Hagerstown silt loam (8 percent), Cumberland silt loam (8 percent), Allegheny-Lenberg-Caneyville complex (7 percent area), Bedford silt loam (7 percent area), and minor proportions of other soil series (Arms and others, 1979).

Qaf — **Alluvial fan (Holocene)**
Sediment is locally derived from surficial and bedrock lithologic material. Thickness decreases toward lower contacts. Lobe-shaped landforms located at mouths of small tributaries along upper section of Funks Run. Contacts are sharp, but locally gradational with upper and lateral Qc and Qca. Partially correlative with Qal of Kepferle (1963) and Frondorf-Lenberg silt loam (91 percent area) and Newark silt loam (9 percent area) (Arms and others, 1979).

Qr — **Residuum (Early Pleistocene?–Holocene)**
Silt, sand, and clay, mostly dark red (2.5YR 3/6) to dark yellowish brown (10YR 4/6) in the Pennyroyal and strong brown (7.5YR 4/6) to yellowish brown (10YR 5/8) in the Dripping Springs Escarpment and Mammoth Cave Plateau, poorly to moderately sorted. Mostly subangular to subrounded quartz with illite and variable proportions of feldspar, biotite, calcite, and other clay minerals. Loess is commonly incorporated into Qr throughout the quadrangle. Mapped on low-relief areas with slopes less than 12° in the sinkhole plain and in uplands of knobs, hills, and ridges. Karst development in sinkhole plain is pervasive and thickness is highly variable and up to at least 90 ft; thickness of upland Qr is more consistent and up to 10 ft. Mapped extent of Qr includes localized areas of Qal and Qc that are too small to be depicted at this map scale. Partially correlative with "slumped sandstone and shale" of Kepferle (1963) and Lawrence silt loam (28 percent area), Pembroke silt loam (10 percent area), Bedford silt loam (7 percent area), and minor proportions of other soil series (Arms and others, 1979).

Pz — **Bedrock (Mississippian)**
Predominantly the Big Clifty Sandstone Member of the Golconda Formation, but also includes older limestones, sandstones, and shales. The Big Clifty Sandstone Member is associated with cliff-forming exposures near the peaks of ridgetops and knobs. Artificial exposures of bedrock may occur along highways, railroads, and areas of excavation and development, but often weather quickly to colluvium.

Explanation of Map Symbols

- State highway
- Local road
- Topographic contour
- Small stream or creek
- River or large stream or creek
- Water body; pond or lake
- Contact
- Contact, approximate
- Gradational contact
- Gradational contact, approximate
- 86+11 — Sample (Kentucky Geological Survey); numbers indicate silt + clay percentages
- 56+37 / 20 — Drillhole data (Kentucky Transportation Cabinet); numbers indicate silt + clay percentages (top) and depth to bedrock in feet (bottom)
- 9 — Drillhole data (KGS water well database); number indicates depth to bedrock in feet
- 17 — Drillhole data (KGS oil and gas well database); number indicates depth to bedrock in feet
- Photograph location
- Sinkhole

Geologic Summary

The Howe Valley 7.5-minute quadrangle is located in the Pennyroyal, part of the Mississippian Sinkhole Plain physiographic province (McFarlan, 1943), west of Elizabethtown in Hardin County. Topography is mostly characterized by a low-relief karst plain that has been modestly incised by the headwaters of the Rough River (lowest elevation in the quadrangle at almost 600 ft) and its tributaries. The quadrangle is also characterized by steep knobs, hills, and ridges of the Dripping Springs Escarpment, with the highest elevation at more than 1,000 ft at Blueball Hill in the northeastern corner. Kepferle (1963) mapped the bedrock geology of the quadrangle, which was later digitized by Crawford (2002). Upper Mississippian bedrock is exposed throughout the quadrangle and dips gently to the southwest. The oldest unit mapped in the quadrangle is the St. Louis Limestone, which is exposed throughout the northeastern half of the quadrangle. The Ste. Genevieve Limestone overlies the St. Louis and is exposed along the northern boundary of the quadrangle. Younger rocks are confined to the knobs and ridges of the Dripping Springs Escarpment, including the Paoli Limestone, Beaver Bend Limestone, Mooretown Formation, Sample Sandstone, Reelsville Limestone, Golconda Formation (Beech Creek Limestone, Big Clifty Sandstone, and Haney Limestone Members), and Hardinsburg Sandstone; the Big Clifty and Hardinsburg Sandstones cap most of the high ridges and knobs. A series of northeast-trending faults, which are splays from the Rough Creek Fault System, cut bedrock in the northwestern corner and southern boundary of the quadrangle.

Methods

This map was generated using new field mapping, sample analysis, LiDAR elevation data (5-ft average horizontal spacing) and derivative maps, aerial imagery, and data compiled from water-well logs, oil and gas records, Kentucky Transportation Cabinet geotechnical reports, and landslide inventory mapping from Crawford (2014). Sinkholes in Hardin County were identified using the random forests algorithm by Zhu and Pierskalla (2016). The extent of colluvium was determined using image classification analysis to detect areas exceeding slope stability (determined at approximately 12° by field and geotechnical evidence). Samples were described by Munsell color and petrography. Grain-size analysis was performed on sediment fractions of less than 2 mm with a laser particle analyzer; results were interpreted using methods discussed in Folk (1966) and grain size is reported using the modified Wentworth scale. Samples representative of major map units were analyzed by X-ray fluorescence and X-ray diffraction for bulk chemistry and mineralogy, respectively. Previously published reports by Kepferle (1963) and Arms and others (1979) were also used for interpretation. The complete digital dataset for this map was published in Massey and others (2021).

Surficial Geology

The lithologic units described here reflect deposits of natural processes operating as an integrated, dynamic, geomorphic system (Newell, 1978). The primary mechanisms of sediment transport and deposition in this area are flowing water (fluvial processes), wind (eolian processes), and gravity/mass movement (colluvial processes). Residual soils are interpreted to have accumulated as a result of in-situ chemical weathering of underlying bedrock, soil production, erosion, and integration with transported sediments. All these processes can be complexly interrelated.

The low-relief sinkhole plains of the Pennyroyal in the northeastern half of the Howe Valley quadrangle are characterized by dense clusters of sinkholes, and mapped as residuum (Qr) and water-dominated alluvial deposits (Qal). Qr immediately overlies bedrock (PZ), although its thickness in the sinkhole plain is highly variable because of extensive karstification in the underlying limestones. Petrography and grain-size analysis reveal an abundance of medium- to fine-silt–size, subangular to subrounded quartz grains (Figs. 2B, 3). The dominant mode of silt-size quartz suggests a significant component of loess throughout the area, also noted by Kepferle (1963). The variable proportions of silt, sand, and clay suggest multiple sediment sources and degrees of pedogenesis for Qr, which we interpret as in-situ weathering of carbonate bedrock and integration with windblown and clastic (formerly overlying bedrock) sediments. Merino and Banerjee (2008) and Driese and others (2011) reached similar conclusions in their studies of similar geologic settings. Munsell hue of Qr samples appears to be correlated with physiographic setting (Fig. 3), as samples collected in the Pennyroyal tend to have more reddish hues (2.5YR to 10YR) compared to samples collected in the Dripping Springs Escarpment and Mammoth Cave Plateau that have more brown and yellowish hues (7.5YR to 10YR). This suggests that limestone bedrock parent material plays a role in the distinctive reddish color of terra rossa in the area.

Alluvial sediments are divided between two distinct geomorphic settings: fluvial (Rough River headwaters and its tributaries) and karst basins (sinkholes, sinking streams, karst valleys). Rough River, Mays Run, and their tributaries have the most extensively mapped deposits of Qal. The average sample of Qal in the Howe Valley quadrangle is characterized by high proportions of sand relative to other lithologies (Fig. 2A). Alluvial fan deposits (Qaf) are not common in the Howe Valley quadrangle, but have been mapped in a small tributary in the northeastern corner (Funks Run), and interpreted as water-dominated debris-flow deposits. Karst-basin alluvial deposits have formed from surface-water runoff and deposition in karst depressions; this variety of Qal is often mixed with Qr and Qc, and common throughout the quadrangle, though mostly below the scale of this map (Fig. 2).

Slope deposits are mostly gravity controlled and are also developed in two distinct settings in the Howe Valley quadrangle: knobs, hills, and ridges, including the Dripping Springs Escarpment, that extend above the sinkhole plain (Qc, Qca, and Qls), and the sinkhole plain itself (Qc). Knobs, hills, and ridges are concentrated in the southwestern corner of the quadrangle, but are also scattered throughout. Qr in the uplands is similar to that found in the sinkhole plain, except the uplands thickness is more consistent, reaching depths up to 10 ft; exposures of bedrock (PZ) are commonly located between the contacts of overlying Qr and underlying Qc. The steepest slopes (greater than 12°) are interpreted as actively moving deposits of colluvium (Qc) and characterized by sediments formerly located upslope (Qr in the uplands) and fragments of local bedrock. Landslides (Qls) are common in steep slopes of Qc in the Howe Valley quadrangle. Accumulations of Qc at the base of slopes (Qca) are stable, older, and display a higher degree of pedogenesis (Fig. 1A). Colluvial deposits are also common across the sinkhole plain, where fragments of bedrock (limestone, shale, and formerly overlying sandstone and siltstone) are often mixed with Qal and Qr in the bottoms of sinkholes and karst depressions; these areas are below the scale of this map.

Disclaimer

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Acknowledgments

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Figure 1. (A) Qca in the Mammoth Cave Plateau and Dripping Springs Escarpment. Notice mix of sediment, bedrock fragments, and bedrock outcrop (PZ). (B) Qr in the knobs of the Dripping Springs Escarpment.

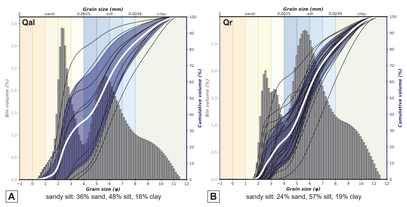

Figure 2. Grain-size distributions of mean (A) Qal (n=9) and (B) Qr (n=32) samples collected in the Howe Valley quadrangle. Both lithologies are similar, which may be due to heterogeneity of mapped Qr and sub-map-scale alluvium in sinkholes. White curve=mean cumulative frequency; black curves=cumulative frequency of individual samples; blue polygon=one standard deviation above and below cumulative frequency; gray bars=mean volume per bin.

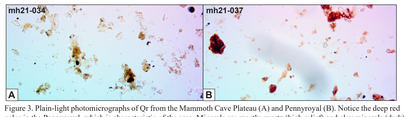
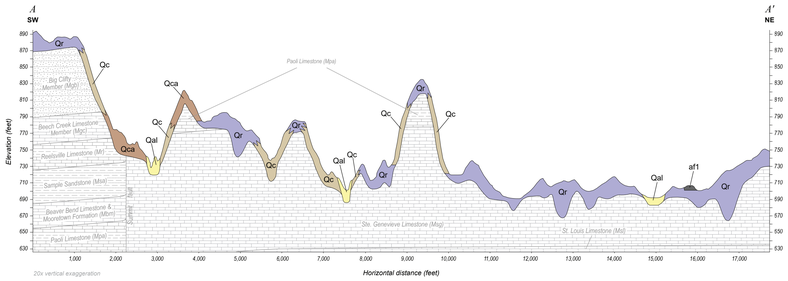
Figure 3. Plain-light photomicrographs of Qr from the Mammoth Cave Plateau (A) and Pennyroyal (B). Notice the deep red color in the Pennyroyal, which is characteristic of the area. Minerals are mostly quartz (high relief) and clay minerals (dark).