ACKNOWLEDGMENTS: This map was digitally generated from 1:24,000-

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DESCRIPTION OF MAPPED UNITS ALLUVIUM—Unconsolidated sand, silt, clay, and gravel. Unit coalesces with colluvium along valley sides, and the contact is usually approximate. Locally may include artificial fill but primarily consists of floodplain deposits. TERRACE DEPOSITS—Sand, gravel, and silt, Sand, frequently unconsolidated, locally well-rounded, fine- to medium-grained. Crossbedded with some crossbeds bonded by clay or limonite. Local gravel consists of pebbles of chert and quartzite, weathered fragments of sandstone and ironstone; found at base of some deposits. Deposits range from 22 to 70 m (72–230 ft) above present drainage levels.

MONONGAHELA FORMATION AND UPPER PART OF CONEMAUGH FORMATION, UNDIVIDED—Sandstone, siltstone, shale, underclay, and limestone. Sandstone is very fine- to coarse-grained and frequently silty and friable. Siltstone is sometimes calcareous. Shale is clavey to silty and varies in color from red, maroon, gray, or yellowish gray Underclay is locally at the base of the formation. Locally limestone is black with some ostracods. Mapped with underlying upper part of Conemaugh Formation as far as the Ames Limestone Member of the Conemaugh (or equivalent unit).

ONEMAUGH FORMATION—Siltstone, shale, sandstone, limestone, coal, and clay. iltstone is medium- to coarse-grained and generally calcareous. Locally the siltstone nas small ironstone concretions or siderite nodules: sometimes ironstone cemented and may be bioturbated. The lower part has occasional calcareous nodules with marine fossils: occasional plant roots and impressions occur. Shale is sandy to clayey and frequently calcareous, rarely carbonaceous; sometimes interbedded with limestone. Locally contains small limestone, siderite, and pyrite nodules. Some plant fragments are in the upper parts of units; invertebrate fossils and brackish or freshwater bivalves appear. Lower shales may be multicolored—gray, yellow, red, purple, olive, and brown. Sandstone is very fine- to coarse-grained and may be silty or calcareous. Frequently quartzose, micaceous, or feldspathic with a white clay matrix locally, and silica cemented. Quartz pebbles scattered or appear as conglomerate locally. Sandstone varies from thin- to thick-bedded, is occasionally crossbedded, trough crossbedded, slabby bedded, or ripple bedded. It has limonite nodules or a limonitic cap on some layers. The limestone is moderately granular to microcrystalline, locally porcelaneous, and may be silty to clayey: occasionally argillaceous to sandy locally, sometimes cherty. It has sparse to abundant fossils, including brachiopods, ostracodes, crinoid fragments, bivalves (pelecypods), and bryozoans; nonfossiliferous limestones may be of freshwater origin. It may be weathered, porous, or pitted. Coal is banded, sometimes impure, and has calcite in some fractures. Underclay is often carbonaceous, silty, and plastic.

PRINCESS FORMATION—Sandstone, siltstone, shale, coal, limestone, ironstone, underclay, and flint clay. Sandstone is very fine- to coarse-grained, infrequently silty, thinto thick-bedded, sometimes ripple laminated, trough crossbedded, or crossbedded, often representing channel deposits. It is largely quartz, feldspathic, very micaceous, and silica cemented, rarely calcareous; local limonite concretions, local pebbles, and rarely has plant debris. Siltstone sometimes has calcareous lenses, locally carbonaceous, is commonly ripple laminated and locally may contain burrows, plant roots, marine fossils, or siderite nodules. It is often silicified, interbedded with sandstone and shale, and sometimes multicolored. Shale is clayey to silty, frequently carbonaceous, sometimes canneloid. It is often linked and graded with coal beds and has frequent siderite and limonite concretions and ironstone lenses. Shales vary in thickness and may locally contain silicified wood and plant fragments. Limestone is microcrystalline to coarsely crystalline and frequently occurs as lenses or thin beds. Locally it is concretionary, micritic sometimes argillaceous or cherty, may be porcelaneous; some local beds probably of freshwater origin; rarely fossiliferous but locally has leaf impressions; Spirorbis, brachiopods, gastropods, bivalves (pelecypods), and ostracodes present. Coal, which is frequently discontinuous, is generally banded and varies from hard vitric to shaly soft bands. It often grades with carbonaceous shales or has shale partings; sometimes canneloid coal overlies other coal. Ironstone is sandy to silty, locally calcareous, sometimes sandy; generally micaceous limonite or ferruginous sandstone. Underclay is silty, hard to soft, semiplastic to plastic, often contains plant roots and Stigmaria rootlets, and underlies most coal beds. The underclay sometimes is iron-stained and rarely contains gypsum Flint clavs, which occur as black to dark brownish gray marker beds, appear above and beneath the Princess No. 6 coal bed, and are up to 1 m thick. They can be massive. have conchoidal fractures, are often iron-stained. Locally they may be lenticular. Princess No. 9 coal bed or the Upper Freeport coal bed is considered the top of the formation Contact is approximate because of uncertainty of Princess Formation coal correlation in some areas. The top of the Princess No. 3 (Mudseam/Peach Orchard) coal bed is used for approximate base of the formation. Chesnut (1992) placed the base of the formation at the base of the Stoney Fork Member (not mapped in this area), slightly

above the Princess No. 3 coal bed FOUR CORNERS FORMATION—Shale, sandstone, siltstone, coal, underclay, and limestone. Shale is locally carbonaceous, silty to sandy, and is locally hard, platy, and calcareous. It varies from fossiliferous to sparsely fossiliferous. Sandstone is very fineto medium-grained and mostly quartz with few feldspar, mica, and rock fragments. It varies from planar- and ripple-bedded to trough crossbedded and massive; locally fossiliferous, containing crinoid plates and brachiopods. Siltstone is shaly to sandy, contains plant roots and siderite nodules. Underclay is silty, plastic, and often contains plant roots. Limestone varies from very fossiliferous to sparsely fossiliferous and varies from unlaminated to laminated. The base of this formation coincides with the base of the

HYDEN FORMATION—Sandstone, siltstone, shale, coal, underclay, flint clay, and limestone. Sandstone is very fine- to coarse-grained, silty, thin- to thick-bedded, ripple laminated in upper part of bodies, trough crossbedded in lower parts. It is very micaceous, ranges from low in quartz and feldspar to abundant quartz; generally silica cemented but locally calcite cemented and locally bioturbated. Siltstone is ripple-laminated, locally bioturbated, contains siderite nodules. Shale is locally clavey to silty and carbonaceous. contains ironstone concretions, is thin bedded; locally very fissile and sparsely fossiliferous and may have large argillaceous limestone concretions. Coal is usually thin and sporadi often grades to carbonaceous shale, contains shale partings, and locally may be canneloid in upper parts. Underclay is silty and ranges from soft and plastic to hard. Limestone is micritic, sparsely fossiliferous, and has ellipsoidal concretions. Base of Hyden is placed at the top of the Van Lear coal bed in this quadrangle. Chesnut (1992) placed the base of the formation at the base of the Kendrick Shale Member (not mapped). The Kendrick Shale Member occurs 6 to 28 m (20–92 ft) above the Van Lear.

OUR CORNERS AND HYDEN FORMATIONS. UNDIVIDED—Both units as described above but combined where the Magoffin Member was thinner or not mapped. This ombined unit was only mapped in the Blaine and Mazie 7.5-minute quadrangles. PIKEVILLE FORMATION—Sandstone, siltstone, shale, coal, and underclay. Sandstone is very fine- to medium-grained, crossbedded to even bedded, and sometimes has carbonaceous laminae. The grains are generally angular, mostly quartz, with feldspar. mica, siderite grains and nodules, clay galls, and coals spars. The matrix is silt- to claysize quartz and clay, and the cement is commonly calcite, siderite, or limonite, Siltstone is frequently interbedded with shale and sandstone, contains siderite, and is laminated. Shale is frequently interbedded with siltstone and sandstone, contains siderite, and is laminated; occasionally ripple laminated and burrowed. Underclay is silty, plastic, and locally contains plant roots and ironstone nodules. The base of this formation is placed at the top of the Corbin Sandstone Member of the Grundy Formation, Chesnut (199 placed the base of the Pikeville at the base of the Betsie Shale Member of the Pikeville Formation (not mapped in this area), which occurs slightly above the top of the Corbin Sandstone Member. Unit as mapped may contain parts of the Grundy Formation.

MIDDLE PART OF BREATHITT GROUP (Four Corners, Hyden, and Pikeville Formations, undivided)—Sandstone, siltstone, shale, coal, limestone, ironstone, and underclay. andstone is very fine- to medium-grained, commonly crossbedded, occasionally ripple bedded and wavy bedded, and thin- to thick-bedded. Locally it is partly to highly calcareous, sometimes ferruginous, locally contains mica and chlorite flakes, sparse glauconite and feldspar grains, and rarely phosphatic pellets. Locally has a slight to moderate clay matrix, frequent brachiopod and crinoid fragments: locally Stigmaria rootlets are abundant, as are sand-filled worm burrows. Siltstone is partly calcareous. Shale is partly calcareous. locally carbonaceous, locally fossiliferous with some leaf prints, plant fossils, and Lingula. and contains some siderite nodules. Coal is banded with occasional flint-clay partings and is discontinuous. Limestone is finely crystalline, contains bivalves (pelecypods similar to the *Lima* genus, and sometimes appears as nonfossiliferous concretions Ironstone is locally fossiliferous. Clay is plastic to semiplastic, locally semiflint clay, with local siderite concretions. Mapped where correlative coals were not present.

GRUNDY FORMATION—Shale, siltstone, sandstone, coal, underclay, and ironstone. Shale is interbedded with siltstone and may be carbonaceous with local nodular siderite eds. Siltstone often contains rootlets. abundant burrows. and occasional *Zoophycus* trace fossils. It is locally nonbedded argillaceous with lenses of finely to moderately ystalline limestone and dolomite. Sandstone is generally thin deposits, ripple marked, and moderately micaceous; Stigmaria roots and rootlets are common. Coals are iscontinuous, banded, and unnamed. Underclay is beneath or near coals. The Olive Hill Clay Bed, in the Oldtown 7.5-minute quadrangle, is a discontinuous flint clay, semiflint, and plastic in many places, up to 3 m (10 ft) thick, and generally overlies the Slade Formation or Borden Formation. Ironstone concretions occur throughout the formation. Formation intertongues with locally mapped, unnamed, thin-bedded sandstone and

ORBIN SANDSTONE MEMBER OF THE GRUNDY FORMATION—Prominent cliffning, channel-fill sandstone. Sandstone is very fine- to very coarse-grained, with local quartz pebbles; often nonbedded, locally wavy bedded or massive, but generally crossbedded. It varies from mostly micaceous, quartzose to nonmicaceous, slightly to highly ferruginous, locally feldspathic, usually silica cemented, and locally cemented by

SLADE FORMATION—Limestone and dolomite. Limestone is finely to moderately crystalline or oolitic limestone, locally occurs as finely crystalline, dolomitic limestone beds containing some shale. Some beds locally cherty: many oolites are fossil fragments or foraminifera. Dolomite, finely crystalline and silty. Mapped as undivided unit and includes the St. Louis Limestone Member of the Newman Limestone, which was revised formally to Burnside Member of the Slade Formation (Dever and Moody, 2002) in the

ORDEN FORMATION—Siltstone, shale, and claystone. Siltstone is interbedded with ninor shale and claystone, contains occasional lenses of finely to moderately crystalline estone and dolomite; common Zoophycus trace fossils present.

KIMBERLITE INTRUSIONS—A diatreme (volcanic neck) of kimberlite occurs within the Willard 7.5-minute guadrangle. Th kimberlite is derived from near the base of the crust and is partly mafic. It contains olivine and phlogopite phenocrysts, garnet, ilmenite, pyroxene, calcite, serpentine, and svenitic to granitic rock fragments. The kimberlite is nonresistant to weathering, producing exposures of yellow ground ontaining abundant ilmenite and pyrope. Pp1, unweathered peridotite (kimberlite) Pp2 Pp2, yellow ground saprolite (oxidized and

Pp3 Pp3, areas of soil containing crystals of Inset map ilmenite and garnet, and foreign rock scale 1:50,000

EXPLANATION

NOTE: cross section is diagrammatic

Middle part of Breathitt Group

Ohio Shale

Devonian and older rocks

vertical exaggeration 8x

→ 800 Structure contour, feet Interstate highway U.S. highway ----- Datum horizon boundary Coal State highway Inferred coal — -- State boundary Concealed coal —-—- County boundary ----- City boundary Strip mine Abandoned stone quarry or mine Normal fault (U, upthrown side;

D, downthrown side) Abandoned iron ore mine Active pit; sand and gravel Concealed fault ★ Abandoned clay pit ____ Contact X Prospect or outcrop; clay Concealed contact Inferred contact

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GEOLOGIC MAP OF THE KENTUCKY PART OF THE HUNTINGTON

30 x 60 MINUTE QUADRANGLE, NORTHEASTERN KENTUCKY

Carl Petersen, Thomas N. Sparks, and Douglas C. Curl

000 0 5000 10 000 15 (

SCALE 1:100 000

universal transverse Mercator projection, zone 17: 1927 North American datum

TOPOGRAPHIC CONTOUR INTERVAL 50 METERS

Princess Formation

Middle part of Breathitt Group

Borden Formation

Ohio Shale

Middle part of Breathitt Group

Lower part of Breathitt Group

Borden Formation

The geology of the Huntington 30 x 60 minute quadrangle was marine deposition, turbiditic clastic sediments, expressed as fan 40 ft below ground surface; operations remain above the highest digitally compiled mostly from U.S. Geological Survey 7.5-minute complexes, are indicated by interpretation of reflection seismic coal. The clay shale is used in the manufacture of brick in an geologic quadrangle maps (GQ's), as cited in the references. The data (Drahovzal, 1994a, b). GO's are products of a cooperative mapping project between the Post-Cambrian growth faulting of decreased magnitude, com-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 for Ordovician through Pennsylvanian units (Dever, 1999). regional geologic studies on mapping and stratigraphy (Chesnut 992; Dever, 1999) have resulted in changes in stratigraphic nomenclature and correlation. These changes are shown on this map, and were necessary for compilation of regional maps and ered in 1885 by Crandall (1886), are exposed in an area of about underlies the Princess No. 6 coal, but in others it is separated

rangle are shown in the index map (Fig. 1). part of a comprehensive relational and spatial data set, being released as Digitally Vectorized Geologic Quadrangles (DVGQ's) by the Kentucky Geological Survey (Anderson and others, 1999). These DVGQ's are available on CD-ROM, and can be purchased via the Internet. Users of the DVGQ data can prepare custom others, 1967; Bolivar, 1982). geologic maps by overlaying data using their own GIS or CAD Most of the material within the diatreme (volcanic pipe) consists software. KGS has also developed an Internet map server where

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) resolving nonuniform structure-contour datums or intervals, and (3) resolving discrepancies in Quaternary alluvium boundaries and inferred contacts. The metadata file provides detailed information about the conversion process. ormation 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 the same way on each of the 7.5-minute maps, since they were compiled by various authors between 1960 and 1978. Resolution of the differences between quadrangles was necessary for efficient topological analysis in a GIS environment. In addition, numerous small members mapped on individual 7.5-minute quadrangle maps are too small to be displayed on a 30 x 60 minute quadrangle map. These problems were resolved by adhering to the geologic, cartographic, and GIS standards appropriate for the scale of the map. This map is a compilation of existing maps, and no additional

field work took place. When there were problems in stratigraphic correlation between quadrangles, the best current data available were used to resolve these differences. GEOLOGIC SETTING AND STRUCTURAL GEOLOGY

The geology of the Huntington 30 x 60 minute quadrangle consists of gently to steeply dipping sedimentary rocks of Mississippian through Late Pennsylvanian age and unconsolidated sediments of Tertiary and Quaternary age. These rocks occur in the Eastern Kentucky Coal Field along the western limb of the central Appalachian Basin. The dominant rock types for the mapped area are interbedded sandstone, siltstone, shale, coal. and limestone for the Mississippian and Pennsylvanian units; and terrace and alluvial deposits for the Tertiary and Quaternary strata. The Tertiary and Quaternary sediments are mainly unconsolidated 2001). Diamonds have not been found, nor has there been any for use in glass making, a local industry in adjacent West Virginia. or semiconsolidated, and contain clay, silt, sand, and gravel commercial production of other minerals. deposits, some of which may be locally cemented. The map area is on the western border of the Appalachian

Basin and is underlain by the Rome Trough. Immediately west is the eastern flank of the Cincinnati Arch, described by Dever (1999) as a broad anticlinal structure that extends northeast from central Fennessee through central Kentucky and toward Cincinnati. Ohio. The arch was a positive structural feature as early as Silurian time and increasingly influenced sedimentation during the Middle and Late Silurian. It gradually limited westward movement of terrigenous-detrital sediment and formed a barrier to open marine circulation (Freeman, 1951; Currie, 1981). Progressive onlap of the arch by Devonian black shale sequences, and their thinning toward the axis, indicate that the arch was a positive, but submerged, feature during the Late Devonian (Dillman, 1980; Ettensohn and others 1988) During the Missis oblan, the arch was alternately submergent and emergent (Sable and Dever, 1990). Influence of the arch during the Pennsylvanian is indicated by the westward thinning of Pennsylvanian strata in the Appalachian Basin of eastern Kentucky (Chesnut, 1991).

The Appalachian Basin in the mapped area is represented at the surface by Pennsylvanian strata, but elsewhere within the basin and into the subsurface it contains sedimentary rocks from Precambrian to Early Permian age. The Upper and Middle Pennsylvanian strata of the Huntington quadrangle contain numerous coal seams that characterize this area, the Eastern Kentucky Coal Field. The general configuration of the basin is shown by the structure contours of the near-surface horizons compiled fror the geologic quadrangle maps (Fig. 2). The stratigraphic and structural framework of the Carboniferous (Mississippian and nnsylvanian) rocks in the basin is presented in Chesnut (1992). One of his four dip sections traverses the Huntington quadrangle. Regional subsurface geologic cross sections of the Mississippia System in eastern Kentucky were compiled from well data and geophysical logs by Harris and Sparks (2000). Two of their 10

ip sections originate in this map area. The Rome Trough is a linear asymmetric Precambrian graber that dominates the basement surface configuration in eastern Kentucky. It was first noted by Thomas (1960), and described by Woodward (1961), who recognized the abrupt southeastward thickening of the Cambrian sediments. The Rome Trough extends eastward across the state from the Grenville Front in central Kentucky and is part of a larger Cambrian feature that extends northeastward across West Virginia and Pennsylvania into southern New York (Hickman, 2004: Hickman and others, 2006), The trough represents a late Precambrian to Cambrian continental rift zone that mainly formed contemporaneously with Cambrian lapetan rifting (mid-ocean-ridge spreading) (Ammerman and Keller, 1979: Thomas, 1991). It lies entirely on the Grenville allochthon (movir block), which was emplaced about 990 to 880 Ma as the result of continent-continent collision (Drahovzal and Noger, 1995). Its geometry consists of an elevated north-bounding shoulder that steps down across a series of down-to-the-south normal faults and a lower south-bounding shoulder (south of the Huntington quadrangle) that deepens into the graben across down-to-thenorth faults. The structural relief on the top of the Precambrian Grenville basement rocks is greater than 13.000 ft measured from the northern boundary of the trough to the deepest central part (immediately south of this quadrangle). In overall structure, the

graben generally deepens to the east, ranging from about -5.000 to –8,000 ft along the Grenville Front to more than –17,000 ft at the Kentucky–West Virginia boundary (Hickman and others, 2006). The major fault systems associated with the Rome Trough of eastern Kentucky are east-northeast-oriented normal faults, the Kentucky River Fault System on the northern boundary, the Irvine-Paint Creek Fault System within the interior, and the Rockcastle River Fault System along its southern border (Shumaker, 1987; Hamilton-Smith, 1988). The Paint Creek Uplift, a north-south surface structure in parts of Elliott, Lawrence, Morgan, Johnson, Magoffin, and Floyd Counties, is likely related to an underlying, north-south basement structure or series of structures Drahovzal and Noger, 1995). The shallow mapped faults in the southern part of the map area, the Little Sandy Fault and the Walbridge Fault, are lateral surface expressions of the Kentucky River and Irvine–Paint Creek Fault Systems, respectively. Large variations in thickness of the Cambrian strata in the Rome Trough suggest that penecontemporaneous faulting was a controlling factor in sediment distribution. North of the Kentucky River Fault System, Cambrian rocks range from 300 to 600 ft in thickness. South of this boundary fault, they abruptly increase from 1,000 to 2,000 ft, and up to 10,000 ft farther south into the

trough (Drahovzal and Noger, 1995). These graben-fill sediments are predominantly marine deposits whose lithologies suggest deposition in conditions ranging from as a blue-gray clay shale, is extracted at a rate of 1,000 tons/week tidal-flat to relatively deep marine waters. In addition to conventional from a surface-mining operation. The depth of the mine is 30 to

Locations of the 30 x 60 minute quadrangles covering Kentucky. The Kentucky part

of the Huntington quadrangle is highlighted in blue.

— Pennington Formation

pared to that of the Cambrian, occurred intermittently along bounding and interior faults, resulting in the thickening of Paleozoic

PETROLOGY OF PERIDOTITE (KIMBERLITE) INTRUSIVES for stratigraphic continuity between quadrangles. The 7.5-minute 1 mi² near the southwest corner of the Willard 7.5-minute quad- from the coal by several feet of sandstone, siltstone, or impure quadrangles that make up the Huntington 30 x 60 minute quad-rangle, eastern Elliott County (Brown, 1977). The rock is a clay Because the iron content of the clay increases with increased nonresistant, dark greenish black peridotite (kimberlite), has no distance from the surface of the outcrop, the clay was strip-mined The data files resulting from the digitization of the GQ's are particular topographic expression, and is commonly disintegrated only to a penetration distance of about 120 ft. to a yellow-ground saprolite at depths of 10 to 40 ft (Crandall, 1910). Initial petrography of the peridotite was described by Diller Coa

an interactive Geologic Map Information Service euhedral, olivine phenocrysts; pleochroic phlogopite phenocrysts (kgs.uky.edu/kgsmap/KGSGeology) (Weisenfluh and others, (biotite mica), some showing kink banding; pyropic garnet, com- 3, the Van Lear, and the Hazard (Keystone Coal Industry Manual, monly surrounded by a rim of kelyphite; magnesian ilmenite; ultrabasic xenoliths of garnet, pyroxene, and phlogopite; finegrained groundmass of calcite, serpentine, and accessories; and syenitic to granitic rock fragments (Hunt and others, 1971). Zartman and others (1967, p. 861) obtained a concordant Early Permian age of 269 million years from K-Ar and Rb-Sr dating of xenocrystic biotite from two samples from one of the intrusive masses. A ground magnetic survey was performed on an area of approximately 2 mi² in which earlier geologic mapping had indicated three separate intrusive loci. Preliminary modeling indicates the presence of both dike-like and pipe-like forms and the presence of two anomalies where no kimberlite had previously been reported. Remnant magnetization directions for a kimberlite breccia, and a massive kimberlite from this survey, suggest the kimberlite

bodies may be of different ages (Calandra, 1985). Geothermometry analyses performed on the kimberlite xenoliths yield formation temperatures of 818, 880, and 890°C (Moecher and Prater, 1994). A geobarometry analysis yielded a formation pressure of 14.6 kbars, approximately 50 km (31 mi) depth. This Ston pressure is typical of lower to subcrustal basaltic xenoliths. Seismic velocity models in this area show the crust-to-mantle boundary at approximately 45 km (28 mi) depth, indicating the xenolith was derived from near the base of the crust. This implies that the Appalachian Basin subcrust is partly mafic and that the protolith may have been derived by magmatic underplating of basalt during rifting associated with formation of the Rome Trough in the Late

The kimberlite has been explored intensely for diamonds and, search for diamonds began shortly after Crandall's discovery of currently active. the intrusives when a shaft 72 ft deep was sunk on the southeasternmost body (Brown, 1977). In 1907 the Kentucky Kimberlite Sand and Gravel of Henderson County, Ky. In the 1980's Cominco American Ltd.

Petroleum, natural gas, flint clay, underclay, and coal are the principal economic mineral resources of the Huntington quadrangle. Other mineral resources are limestone, which was exploited in for fill material; and iron mined in the 19th century. The locations of industrial mineral resources, including limestone and sand operations, were mapped and described by Anderson and Dever (2001) and Broyles and Malone (2010).

Approximately 2,400 wells have been reported drilled in the productive for hydrocarbons; over 300 were dry and abandoned, and most of the remainder were miscellaneous service, injection, The productive wells have been grouped into 50 named fields or pools. Only six were considered large (i.e., containing more than 60 wells), and are summarized below.

 Ashland Pool-northeast corner; over 300 wells, most producing gas gas from Devonian Ohio black shale. Depths range from 1,300 to 3,000 ft. Cordell Pool-south-central area (Adams and Blaine 7.5minute quadrangles), extending south into Williamson 30 x 60 minute quadrangle; approximately 80 productive wells in the Huntington quadrangle, most producing gas from the Lower Mississippian Berea Sandstone. Depths from

• Fallsburg Pool-lower east-central part; about 60 productive wells, most producing oil from the Berea Sandstone. Depths Keaton-Mazie—southeast corner, extending into Williamson 30 x 60 minute quadrangle. Combined waterflood pool contains over 300 productive wells in the Huntington quadrangle. Produces oil from the Mississippian Borden Formation Weir sands (in drillers' terminology). Depths

 Martha-southeast corner (Mazie 7.5-minute quadrangle). northeast of Keaton-Mazie pool. Waterflood pool contains over 300 productive wells, most producing oil from the Weir sands. Depths from 700 to 1,200 ft.

Naples—north-central region (Argillite 7.5-minute quadrangle); about 60 productive wells producing both oil and gas. s primarily from Ohio Shale and Berea Sandstone. Ohio Shale wells range in depth from 1,400 to 1,700 ft. Oil and gas wells in the Berea range in depth from 900 to 2,000 ft. Petroleum and natural gas production for the Huntington area by county is summarized below in Table 1. **Table 1.** Cumulative oil (million barrels) and gas production (billion

cubic feet) by county (1919–2009). 24.318

32.858

Source: Kentucky Geological Survey oil and gas production database, kgs.uky.edu/kgsmap/OGProdPlot/OGProduction.asp

The economic clays and shales in the Huntington quadrangle are associated with the Princess Nos. 6 and 7 coal beds. The properties of five clay and shale samples from the area have been evaluated (Floyd and Kendall, 1955; McGrain and Kendall, 1957, 1972). The sites were near Louisa, Lawrence County; southwest of Ashland, Boyd County; and near the Boyd-Greenup County line. All five samples were deemed suitable for the production of commercial products ranging from interior and exterior decorative also caused some localized increases in sulfate and metal conface brick to drainage and structural tile. One industrial clay excavation pit and one brick production facility are currently operational in this area. They are located near Princess, 9 mi southwest of Ashland near the Ashland-

Boltsfork 7.5-minute quadrangle border. The material, described

adjacent plant that uses a tunnel kiln operation (Danzel Ayers, Plant Manager, Sipple Brick Co., Ashland, Ky., oral communication,

Another important mining area (no longer operational) is near sediments on the downthrown sides. Thickening has been reported Hitchins (4 mi south of Grayson) in the west-central part of the map area. The beds here are collectively referred to as the Hitchins clav bed. This name is applied to the entire clavev interval between the Princess No. 6 coal and the "limestone ore" (the Vanport Three intrusive masses of an Early Permian kimberlite, discov-

(1886, 1887). Deep-seated faulting of unknown orientation is The Huntington quadrangle lies mostly within the Princess thought to be responsible for its emplacement (Zartman and District of the Eastern Kentucky Coal Field (Brant, 1983), with a ninor portion (eastern Elliott County) within the Licking River District (Brant and others 1983) The total original coal resource of relatively unaltered sedimentary rock fragments derived from for the five counties that are included in whole or in part of this users can prepare similar maps without purchasing DVGQ's via the vent wall of Paleozoic rocks and mixed with rounded to map area was 3,678 million short tons (MT). Of this amount, 2,400 MT was attributed to six coal beds: the Princess Nos. 7, 6, 5, and

2003). Coal production by county is shown in Table 2 below. Table 2. Cumulative coal production (million short tons) by county

and mining method (1824–2008).

Source: Kentucky Geological Survey coal production database, kgs.uky.edu/kgsweb/DataSearching/Coal/Production/prodsearch.

asp [accessed 4/14/10].

6.232

15.743 19.626 54.794 90.162

Sandstone from the middle part of the Breathitt Group (correlative with the Pikeville, Hyden, and Four Corners Formations) in the outheastern area has been used locally in the building of schoolhouses, bridges, culverts, chimneys, and house foundations. In the northwestern corner, the Upper Mississippian Newman Limestone (Slade Formation) was guarried on North Fork and near Tygarts Creek for use as flux in charcoal-iron furnaces. Largescale mining of the Slade Formation by underground methods was investigated in 1964 near Coalton in the north-central part to a lesser extent, for other potentially valuable minerals. The of the Huntington quadrangle; no other quarrying operations are

Diamond Mining Co. was established in Catlettsburg (Creason, Foundry sand has been mined from weathered sandstones of 1950). Between 1965 and 1970, additional trenches were dug the middle part of the Breathitt Group, from high terrace deposits, and a washing operation was carried out in colluvium near the and from Ohio River alluvium in the northeastern corner of the south end of the southeasternmost body by Kentanna Minerals, Huntington quadrangle (Richardson, 1927, p. 17–21). Small quantities of sand for local foundry use were extracted intermittently evaluated the deposit as a potential source of diamonds (personal from the high terrace deposits in the eastern part of Ashland. communication, W.H. Anderson, Kentucky Geological Survey, Sand in this area may contain too much iron and other impurities Sand and gravel for masonry materials are currently dredged from two facilities in eastern Lawrence County: 2 mi north of Louisa along the Big Sandy River, and near Clifford along the Tug Fork in the southeast corner of the quadrangle (Broyles and

During the 19th century, iron ore was mined from the ironstone deposits and smelted in local charcoal blast furnaces (Whittington and Ferm, 1967). The ironstone occurs as ferruginous sandstone and bedded, lenticular, and concretionary deposits of siderite with admixed sand, silt, clay, and micaceous impurities (Moore, 1876: Crandall, 1877; Phalen, 1908, 1912). The chief ores mined were the "main block ore" between the Princess Nos. 3 and 5 coal map area for oil and gas exploration, about 1,750 of which were beds, "limestone ores" associated with the Vanport Limestone ft above the Princess No. 7 coal bed (Brown, 1977) Iron ore was also mined in the 19th century from the Rough and Ready ore of Moore (1876) on Bolts Fork in the Fallsburg and Prichard 7.5-minute quadrangles (Sharps, 1967). The ore occurs as a 2-foot limonite bed above the Ames Limestone Member of the Conemaugh formation.

> The availability of groundwater in the Huntington quadrangle was discussed in detail by Carey and Stickney (2004, 2005a-d). Most of the wells in valley bottoms are adequate for domestic supply; however, the volume of groundwater available becomes progressively less on hillsides and ridgetops. High-volume wells nore than 100 gal/min) are found in the Ohio River alluvium. The alluvium along the Big Sandy River can also provide adequate water for domestic use, but often contains large amounts of iron. The alluvium yields more than 500 gal/day for nearly all wells Irilled along the Ohio River and is reported to yield as much as 360 gal/min for large industrial wells. The alluvium of valley tributaries to the Ohio River yields more than 100 gal/day for most wells. Wells drilled and screened in the alluvium of the Big Sandy River, and its Tug and Levisa Forks, will typically yield as much

The Conemaugh Formation, the upper part of the Breathitt Group (correlative with the Princess Formation), and the middle part of the Breathitt Group typically yield more than 500 gal/day to most wells in valley bottoms and smaller quantities on hillsides and ridgetops. Yields are slightly lower in the west-central part of the quadrangle (Carter County). The most common aquifers are sandstone and shale, but coal seams supply water to a few wells. Near-vertical joints and openings along bedding plains yield most

The yields in the Grundy Formation (containing the Corbin andstone) exceed 500 gal/day in the majority of wells drilled in valley bottoms and smaller quantities on hillsides and ridgetops. Sandstone is by far the principal aquifer, followed by shale and, to a much lesser extent, coal seams. Near-vertical joints and openings along bedding plains yield most of the water to wells. Perched and semiperched water tables are common.

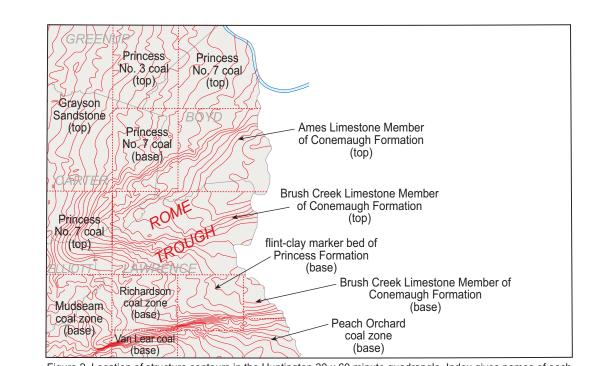
The Slade Formation (Newman Limestone) yields more than 500 gal/day to over half of the wells drilled in valley bottoms and to many wells drilled on hillslopes. It yields little water where overlain by Pennsylvanian rocks, but may yield more than 50 gal/min to wells that penetrate large solution cavities (the most ommon aquifer). Sandstone and shale may yield water to wells that intersect fractures. Springs are common, particularly at the head of streams. Discharge from some springs, near stream level, may approach 100 gal/min, but they have large seasonal fluctu-

alley bottoms. It may yield more than 500 gal/day to drilled wells broad valley bottoms from fractured sandy rocks near streams, but yields almost no water to wells on hills. Groundwater obtained from most drilled wells contains noticeable amounts of iron, and is hard to extremely hard, except for wells drilled into river alluvium, which produce moderately hard water. Other naturally occurring contaminants that may be present in objectionable amounts are sulfate, salt (sodium chloride), and magnesium. In some locations abandoned oil and gas wells have been responsible for contaminating shallow freshwater aguifers with saline water from deeper formations. Surface mining has centrations in the groundwater. Saline water is frequently encountered at depths of less than 100 ft below the level of the principal valley bottoms. The elevation of the fresh-saline water interface in the Huntington quadrangle ranges from 440 to 700 ft above

The Borden Formation yields 100 to 500 gal/day to wells in

Figure 1. Locations of the 16 guadrangles used in the digital compilation of the Kentucky portions of the Huntington 30 x 60 minute guadrangle map. Index shows names of the individual 7.5-minute quadrangle maps and their USGS geologic quadrangle map (GQ) numbers.

mean sea level (Hopkins, 1966).



ure 2. Location of structure contours in the Huntington 30 x 60 minute quadrangle. Index gives names of each napped datum horizon. The horizon boundaries are shown on the geologic map as thin red dashed lines. Contour

interval is 40 ft with index contours at every 200 ft.

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