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Topical Report

GEOMORPHOLOGY OF PORTIONS OF WESTERN KENTUCKY AND ADJACENT AREAS

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Abstract:

The geomorphology of portions of western Kentucky and adjacent areas in Indiana, Illinois and Tennessee is presented as a background for interpreters evaluating the present land surface using remotely sensed imagery. Eight physiographic units were analyzed and are briefly discussed with reference to topography and surface deposits. Great diversity was found to be characteristic of the region, the result of different structural influences and geomorphic processes. The lancscape bears the marks of fluvial, glacial, eolian, lacustrine and karstic environments, so a regional geomorphic history was compiled from the literature as an aid to understanding the land surface. Three smaller zones in Kentucky were analyzed in greater detail regarding topography and geomorphic development because of their potential importance in subsurface exploration.

Key Words: Eastern Shales
Geomorphology
Kentucky Geomorphology
Kentucky Geology

PREFACE

This report was prepared under two investigations for the Morgantown Energy Technical Center, Department of Energy, as part of the Eastern Gas Shales Project (contracts DE-AC21-79-MC11687 and DE-AC21-81MC16463). The test site area for this work is centered on the Moorman Syncline in Western Kentucky, the area covered by Landsat frame path 23/row34. Remote sensing and subsequent surface geophysical investigations were undertaken in this area. The principal investigator was Philip L. Jackson of the Geological Sciences Department of the University of Michigan.

The subject matter and quality of this work of Ronald Dilamarter merit a separate report for exposure to the geologic community. This report not only provides a background for studies in this area concerned with the Eastern Gas Shales Project, but for other geologic studies as well.

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INTRODUCTION

This report provides a geomorphological background of the study area to aid interpreters in evaluating imagery of the present land surface. The report thus complements investigations of the subsurface geology.

Variety in landforms and deposits characterizes the study area. The diversity is the product of several geomorphic processes and agents working over long periods of time under different structural influences and changing climates. Fluvial, glacial, eolian, lacustrine and karstic environments have left their mark on the landscape.

The report is primarily an overview of past geomorphic developments which have led to the variety in the surface configuration and deposits of the present terrain. A geomorphic history and description of the larger study area is presented first followed by brief dicussions of three small subareas (Figure 1).

PHYSIOGRAPHIC SETTING

Most of the study area lies within the Interior Low Plateaus Province. West of the Tennessee River is a portion of the Coastal Plain, and at the northwest a small glaciated area is in the Central Lowlands (Thornbury, 1965).

The lithologic and structural pattern of Mississippian and Pennsylvanian rock strata has yielded grossly concentric rings of cuestaform topography at the south and east. Within this general framework extensive flat bottomlands separate hilly uplands, with some upland areas also exhibiting low relief. A simplified physiographic diagram is shown in Figure 2. Physiographic subdivisions of the study area (Figure 3) are described briefly in the following subsections.

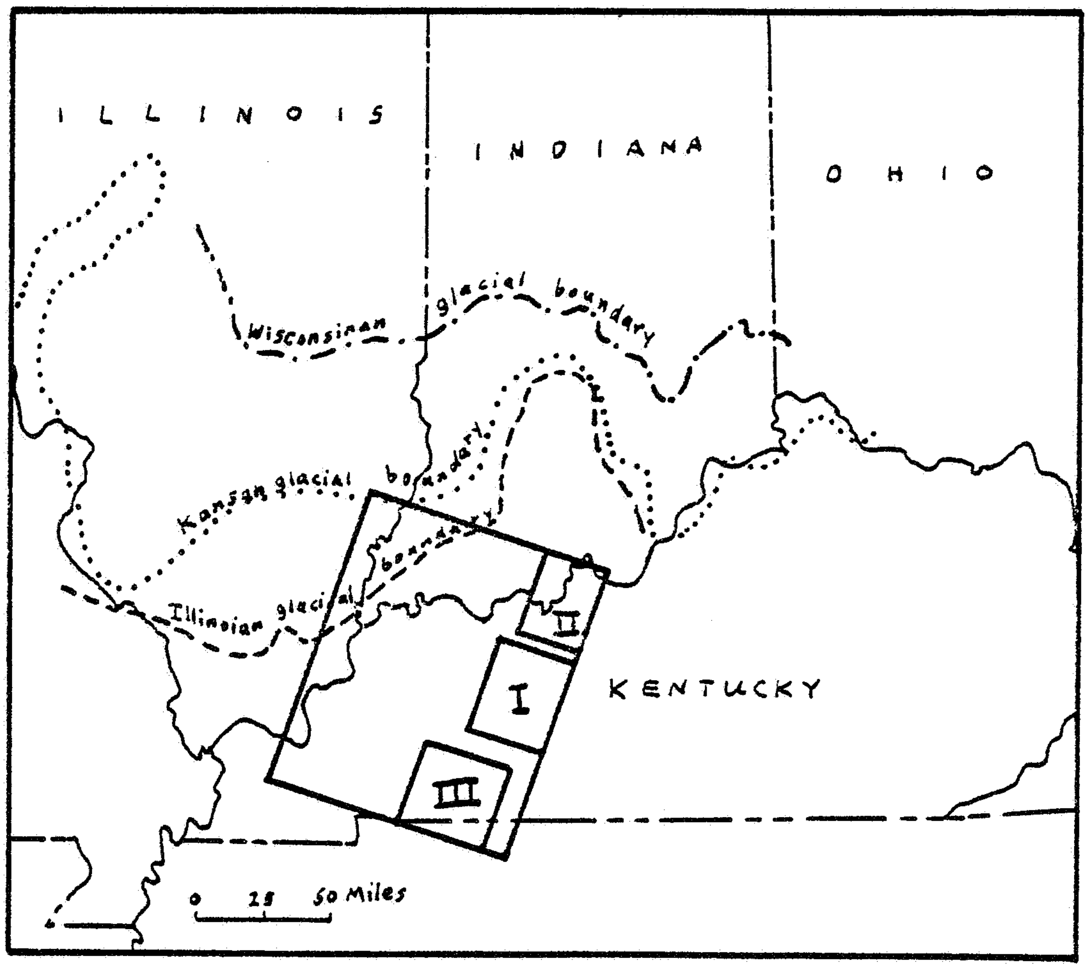


Figure 1. APPROXIMATE POSITION OF LANDSAT FRAME, PATH 23/ROW 24, WESTERN KENTUCKY AND ADJACENT STATES

(Roman numerals indicate 3 subareas specified for more detailed attention.)

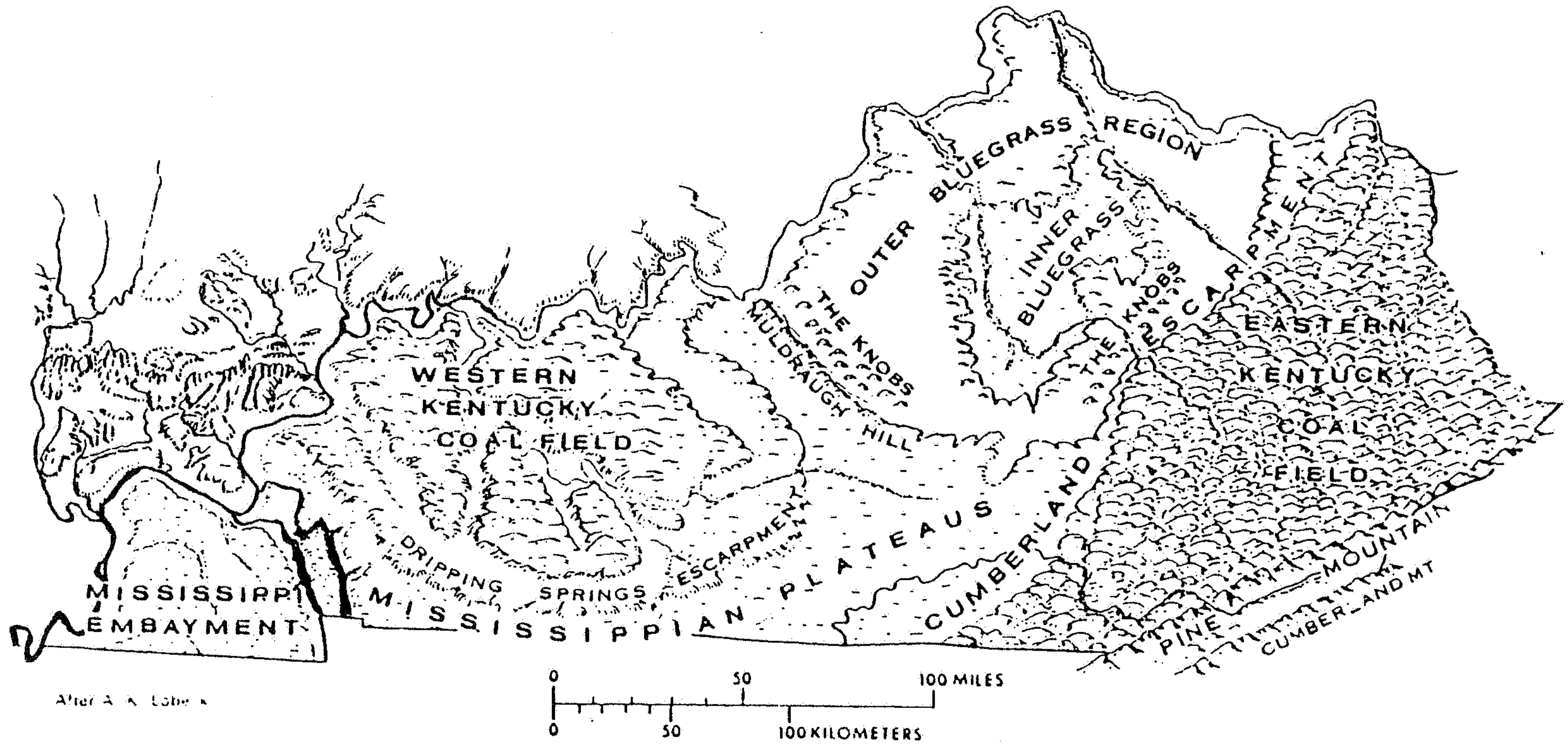


Figure 2. PHYSIOGRAPHIC DIAGRAM OF KENTUCKY AND AREAS OF INDIANA AND ILLINOIS INCLUDED IN STUDY AREA. KENTUCKY PORTION FROM KENTUCKY GEOLOGICAL SURVEY MAP.

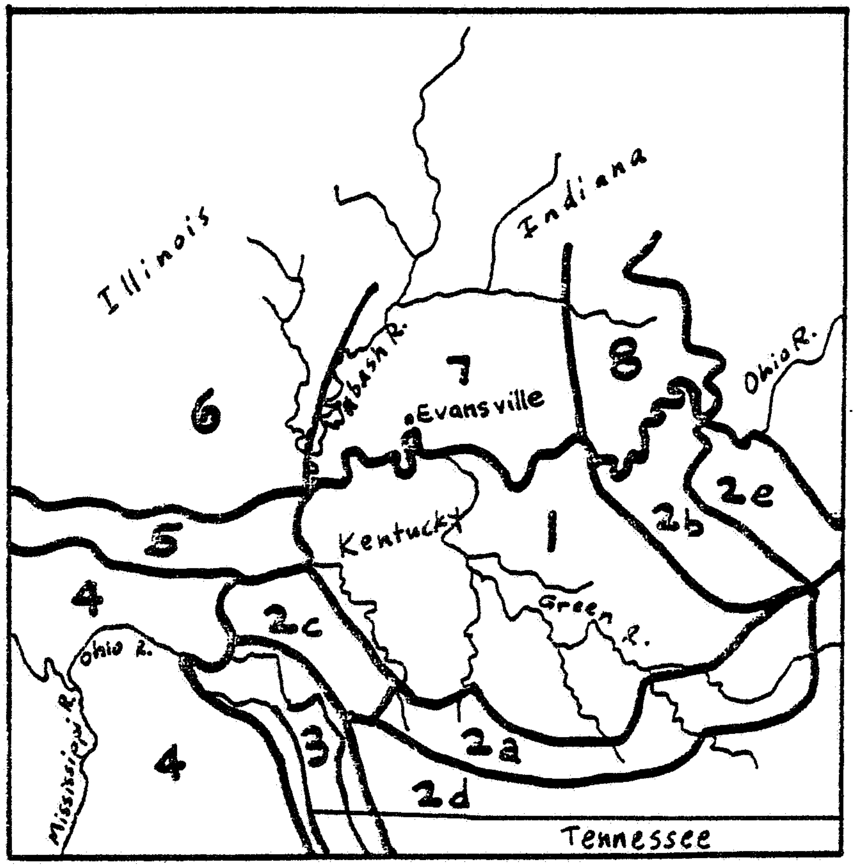


Figure 3. OUTLINE OF STUDY AREA PHYSIOGRAPHIC REGIONS

1. Western Kentucky Coal Field
2. Mississippian Plateaus
    - 2a. Southern Clifty Area
    - 2b. Northern Clifty Area
    - 2c. Marion Area
    - 2d. Pennyroyal Plain
    - 2e. Elizabethtown Area
3. Land Between the Lakes
4. Coastal Plain (Jackson Purchase in Kentucky)
5. Shawnee Hills
6. Mount Vernon Hill Country
7. Wabash Lowland
8. Crawford Upland

WESTERN KENTUCKY COAL FIELD

This physiographic region is the heart of the study area. Underlain by Pennsylvanian sandstones, shales, conglomerates, coal measures, and some limestone beds, the area consists of gently rolling to hilly uplands dissected by streams (Burroughs, 1924). The region's outer periphery, to the south and east, comprises the most rugged topography. Here streams have dissected the strata to form the ragged and discontinuous "Pottsville escarpment", or cuesta hills with local relief of 200 to 300 feet. Toward the northwest, elevations decrease, deeply alluviated stream valleys broaden dramatically, and upland ridges narrow and become isolated. The alluviated bottoms constitute approximately one quarter of the area of the Western Coal Field (McFarlan, 1943).

In very general terms the strata dip westward, but the Moorman Syncline, local folds and the Rough River Fault Zone provide much structural and topographic variation. The northern boundary is the Ohio River, which flows past high bluffs at the northeast, and lower hills and a broad floodplain downstream to the west. The major stream draining the interior of the coal field is the Green River and its larger tributaries, Rough River and Pond River. The western end of the area is drained by the Tradewater River (locally pronounced "Tredwater"), a tributary of the Ohio.

MISSISSIPPIAN PLATEAUS IN KENTUCKY

Beyond the outer boundary of the Western Coal Field in Kentucky is a semicircular zone, part of the Mississippian Plateaus. Cropping out from beneath the Pennsylvanian margin are Chesterian sandstones and limestones that form dissected plateau areas. Their outer margin is the Dripping Springs (or Chester) Escarpment. Along various portions of its extent, it ranges from a prominent scarp to a hilly zone with many outlying hills. Relief of 100 to 200 feet and more separates the surface of the Chester cuesta from a lower plateau formed on older Mississippian rocks (Meramec and Osage series).

In the southern part of the study area the Chester Plateau is part of the Southern Clifty Area and in the northeast it comprises part of the Northern Clifty Area (Sauer, 1927). In Western Kentucky the Dripping Springs Escarpment and both plateau surfaces are lost in a maze of faults (Thornbury, 1965) in an area Sauer (1927) called the Marion Area, the zone between the Tradewater, Ohio, and Cumberland Rivers.

The plateau south of the Dripping Springs Escarpment in the study area is part of the Pennyroyal* Plain (Sauer, 1927). The karstified plain, extending into Tennessee as part of the Highland Rim, has low relief, generally measured in tens of feet, except in areas of deep sinkholes and residual knobs near the escarpment. Numerous shallow sinkholes and subterranean streams are characteristic of the area. Some surface streams help drain this part of the Pennyroyal Plain, joining the Red River and the Little River, south- and west-flowing tributaries of the Cumberland.

The Pennyroyal Plain has a stratigraphic and topographic equivalent in the vicinity of the northeast part of the study area. It is the Elizabethtown Area (Sauer, 1927), a karst plain having extensions westward through the Dripping Springs Escarpment into the Northern Clifty area.

LAND BETWEEN THE LAKES

A dissected upland separates Kentucky Lake (Tennessee River) and Lake Barkley (Cumberland River). This area, which has Cretaceous exposures, and a narrow zone to the east and west, is an area of transition between the Mississippian Plateaus and the Coastal Plain (McFarlan, 1943).

*Also termed "pennyrile".

COASTAL PLAIN

West of Kentucky Lake is the head of the Mississippi Embayment, known as the Jackson Purchase in Kentucky, with plains and low hill topography broken by several prominent valley systems (Davis, 1923). The Coastal Plain extends northward across the Ohio River into Illinois as far as the southern edge of the Shawnee Hills, where eroded Cretaceous and Tertiary sediments overlap Paleozoic rocks (Leighton, Ekblaw, and Horberg, 1948).

SHAWNEE HILLS

In Illinois, north of the Coastal Plain, is a complex dissected upland, underlain by Mississippian and Pennsylvanian strata of varied lithology which dip toward the Illinois Basin. Faulting and folding have added structural complexity to the rugged hill land (Leighton, Ekblaw, and Horberg, 1948; Thornbury, 1965).

MOUNT VERNON HILL COUNTRY

Located north of the Shawnee Hills in Illinois is the Mount Vernon hill country, a portion of which is in the study area, bounded on the east by the Wabash River. The area is a surface of low relief formed on Pennsylvanian strata and thinly mantled with glacial till and loess (Leighton, Ekblaw and Horberg, 1948).

WABASH LOWLAND

East of the Wabash River, north of the Ohio, is the Wabash Lowland (Malott, 1922). It is a broad plains area of low relief with some hills north and east of Evansville, Indiana. The bedrock is Pennsylvanian, a northward extension of the Western Kentucky coal field strata. Lacustrine deposits, outwash sands, loess, and dunes are present within various parts of the Wabash Lowland.

CRAWFORD UPLAND

Located east of the Wabash Lowland is the Crawford Upland, the greatly dissected dipslope of the Chester cuesta. The upland is an extension into Indiana of that part of the Kentucky Mississippian Plateaus called the Northern Clifty Area by Sauer (1927).

Outside the study area to the east is the outer margin of the Crawford Upland, the Chester Escarpment, which trends southward into Kentucky as the Dripping Springs Escarpment. In the Crawford Upland sandstones and shales overlie limestones which, still farther east, crop out to form the karstified Mitchell Plain, the Indiana equivalent of Kentucky's Elizabethtown Area.

GEOMORPHIC HISTORY

Reconstruction of the geomorphic history of the study area, especially as compiled from older literature sources, reflects early models of long-term landscape evolution. Such models may not be correct in all their assumptions, but nevertheless permit a reasonably satisfactory account of the origin and development of terrain and deposits.

MESOZOIC ERA

Within the Interior Low Plateaus province evidence is lacking to point to a clear sequence of geomorphic events during the long interval between Pennsylvanian and later Tertiary times. It is generally believed that subaerial erosion and deposition have dominated the region since the end of late Paleozoic sedimentation. Cretaceous sediments, essentially nonmarine, outcrop in the land between the lakes. Westward toward the Mississippi River they are overlain by younger nonmarine deposits (McFarlan, 1943). By the end of the Mesozoic Era, ancestral versions of major modern rivers drained toward the head of the Mississippi Embayment. Gross patterns of today's landscape were being developed, although they were to be modified by later events.

TERTIARY PERIOD

Regional crustal stability in the Interior Low Plateaus is thought to have permitted the formation of at least one widespread surface of low relief during the Tertiary Period. Known as the Lexington Plain (Campbell, 1989, cited by Thornbury, 1965) in the northern part of the province, and the Highland Rim (Hayes, 1899, cited by Thornbury, 1965) in the southern area, the erosion surface has been correlated with uplands in Indiana (Malott, 1922) and possibly with old surface relics in the Shawnee Hills of Southern Illinois (Fenneman, 1938; Horberg, 1950). Extensive in some portions of the Interior Low Plateaus, the erosion surface has been greatly dissected where streams have been very active on weaker rocks. The ancient surface is inferred in some portions only by the presence of scattered accordant summits. Regional elevations range from more than 1000 feet in the Bluegrass Region in Central Kentucky to about 560 feet in Henderson County in Western Kentucky (Thornbury, 1965).

The age of the erosion surface ("peneplain") had been assigned by several early investigators to various portions of the Tertiary, but a widely accepted present view is that the plain was formed during the Miocene or early Pliocene Epoch (Thornbury, 1965). The surface may be correlative with the Harrisburg surface of the Appalachians, and other erosion surfaces recognized in the eastern United States (Table 1).

Closely associated with the development and subsequent modification of the Lexington/Highland Rim surface are the "Lafayette Gravels" (Malott, 1922). Known also by other local and regional names,

Table 1. CORRELATION CHART OF LATE CENOZOIC EROSION SURFACES IN EASTERN UNITED STATES

	AGE TO BASE (M.Y.)	INTERIOR LOW PLATEAUS	APPALACHIANS	INTERIOR HIGHLANDS	CENTRAL LOWLANDS
Pleistocene	2	Deep Stage	Valley Cycle	Valley Cycle Post-Osage Strath	Deep Stage Havanna Strath
Pliocene	7	Parker	Somerville	Osage Strath	Central Illinois
Miocene	26	Lexington/ Highland Rim	Harrisburg	Hot Springs/ Ozark	Lancaster/ Calhoun

Adapted from Melhorn and Edgar, in Melhorn and Flemal, 1975, p. 250.

the gravels consist primarily of insoluble residue such as chert, quartz and quartzite pebbles, and cobbles. They are known to include geodes, geodized fossils, sand, silt, and clay, and are commonly stained and cemented by iron and manganese oxides (Thornbury, 1965). The distinctive "bronzed" cherty gravels are called the "Luce Gravels" in Owensboro, Kentucky (L. L. Ray, 1965). Long controversial, the gravels are generally thought to be derived from Tertiary weathering, primarily of Mississippian and Pennsylvanian rocks. As a weathering residue they were probably widespread on the Lexington/Highland Rim erosion surface.

Streams flowing across the erosion surface apparently were rejuvenated by late Tertiary uplift, and dissection created many deep gorges. Intermittent stability, however, is thought to have alternated with uplift. It is likely that karstification of soluble rocks, including cavern formation, proceeded where favorable conditions existed. During stable times broad bottomlands were created by lateral stream migration. The old bottomland remnants are straths assigned to the Parker subcycle (Table 1). Much of the residual regolith was stripped from the Lexington Plain and concentrated in the developing bottomlands. Thick deposits of the Lafayette Gravels in Western Kentucky are thought to be fluvial in origin (Theis, 1922, cited in Ray, 1965; Malott, 1922; Leverett, 1929; Potter, 1955), and rest on stream-cut bedrock benches. Potter (1955) concluded that the gravels near the head of the Mississippi Embayment are remnants of coalescing alluvial fans deposited by the ancestors of the region's major streams--the Tennessee, Cumberland, Ohio and Mississippi Rivers.

Following the time of Parker Strath formation, possibly in the Quaternary Period, further uplift and stream downcutting occurred regionally. Major rivers deepened their valleys on the order of 200 feet or more, in a phase called the Deep Stage (Ver Steeg, 1926). In some parts of the Interior Low Plateaus there is evidence to suggest that valley deepening was interrupted for a time, when valley broadening occurred. Extensive lowlands were formed in weak strata, for example, the Scottsburg Lowland of Indiana (Malott, 1922). This surface may correlate with the early Pleistocene Havanna Strath of Southern Illinois (Thornbury, 1965). In the lower Ohio River region, a bedrock bench buried by younger deposits was noted by Ray (1965) in the Owensboro, Kentucky, area, and by Theis in 1922 (cited by Ray, 1965) at Henderson, Kentucky.

By the time glaciation was approaching, the ancestral Ohio, Wabash, Green, Cumberland, Tennessee, and Mississippi Rivers had separated upland remnants of the weathered Tertiary plain. Lafayette gravel-capped rock benches flanked the deep inner valleys in places where conditions were conducive to their preservation. Although major streams today remain relatively close to their early positions, some reaches have changed location by many miles. The lower ends of the Ohio, Cumberland, and Tennessee Rivers, for instance, now have different courses. The Ohio River formerly crossed Southern Illinois through the Cache Lowland; possible causes of relatively recent channel abandonment in relation to the Tennessee and Cumberland Rivers are reviewed in Thornbury (1965). Lesser tributary streams are thought to have exploited weak rocks and fault zones as late Tertiary dissection proceeded. Numerous cases of stream diversion ("piracy") are noted for tributaries of the Tradewater and lower Green Rivers in Webster County, Kentucky (Glenn, 1922).

The age of deep valley cutting may be best assigned to the Plio-Pleistocene time transition. Deep channels were later filled with deposits that included thick sequences of glacial outwash. Valley incision was thus pre-glacial, but not necessarily pre-Quaternary, as global criteria for the world's Plio-Pleistocene time boundary need not depend upon arrival of continental glaciers at a particular region. Regardless of age assignment, deep valleys were characteristic of major drainage lines of the study area just prior to midwestern glaciation.

QUATERNARY PERIOD (PLEISTOCENE AND HOLOCENE EPOCHS)

1. Nebraskan Stage. The extent of the Nebraskan glacier is unknown and no deposits assignable to the Nebraskan Stage are known in Indiana (Wayne and Zumberge, 1965). It has been postulated that Nebraskan ice contributed valley train fills in the deep valley of the Ohio (Ray, 1965). To the north and east, Nebraskan ice may have been responsible for the diversion of parts of the ancient Teays River system into the Ohio Basin (Ray, 1965). The ancient Ohio River previously was a much smaller system. Different views of its extent and evolution are summarized by Thornbury (1965). In the study area the river's course was generally not far from its present location, except for the abandoned Cache Lowland. At Owensboro, Kentucky, for example, a bedrock contour map (Ray, 1965) shows most of the ancient course within a mile or two of the present channel.

2. Kansan Stage. Although Kansan drift is mapped in portions of southwestern Indiana and southern Illinois (Flint et al., 1959), its occurrence is outside the study area a few miles to the north. Some further valley deepening may have occurred during the Kansan Stage, but a major net effect in the study area was probably alluviation. Kansan outwash is thought to have contributed to the lowest fills that now occupy the deep, buried bottoms of the preglacial valleys (Wayne and Zumberge, 1965). Additionally some loess deposition may have occurred (Ray, 1965).

3. Illinoian Stage. An early substage of the Illinoian resulted in till deposition in portions of the study area. North of the Shawnee Hills in Illinois, and in extreme southwestern Indiana, Illinoian till is mapped (Flint et al., 1959). The ice blocked westward flowing streams in Indiana, creating extensive ponding and glaciolacustrine

sedimentation (Thornbury, 1936; Wayne and Zumberge, 1965). Most of the lake plains were later subject to flooding and sedimentation from Wisconsinan meltwater draining into the area from ice in central Indiana. In Kentucky, tributaries to the Ohio River, such as Green River, perhaps were ponded because of aggradation of the Ohio channel, although the major ponding seems to be attributable to the Wisconsinan Stage. Loess deposits referable to the Illinoian (Loveland Loess) have been noted along the banks of the Ohio River (Leighton and Willman, 1950; Ray, 1957).

4. Wisconsinan Stage. The study area was not glaciated during Wisconsinan time, but was affected by glacial outwash and loess deposition. The Ohio River aggraded its deep bedrock bed, creating levee-like dams at the mouths of tributaries such as Green River in Kentucky and the Wabash along the Indiana-Illinois boundary (Thornbury, 1965). Various flat bottomlands in Southern Indiana, Illinois, and Western Kentucky (Figure 4) were long ago identified as old lake plains formed in ponded backwaters of tributaries whose mouths were dammed by outwash in the Wabash and Ohio Rivers (Shaw, 1915, cited by Thornbury, 1965). Projecting above the deeply alluviated valley systems in Indiana and Kentucky are partially buried bedrock hills called "island hills" by Shaw, and "hills of circumalluviation" by Fidlar (1948, cited by Thornbury, 1965). The lacustrine deposits are mainly heavy, blocky clays or silts. The direct cause of alluviation is thought to be mostly glaciofluvial action, but other possible contributing factors, including regional depression, are reviewed by Thornbury (1965).

Wisconsinan loess mantles most of the study area landscape, and is thickest near riverine sources, thinning away from bottomlands. Windblown silt and reworked colluvium derived from it ranges generally from one to ten meters in thickness (Ray, 1965; Willman and Frye, 1970). The loess mantle in places is composed of two units of Wisconsinan age, one of Illinoian, and in places possibly Kansan (Ray, 1965).

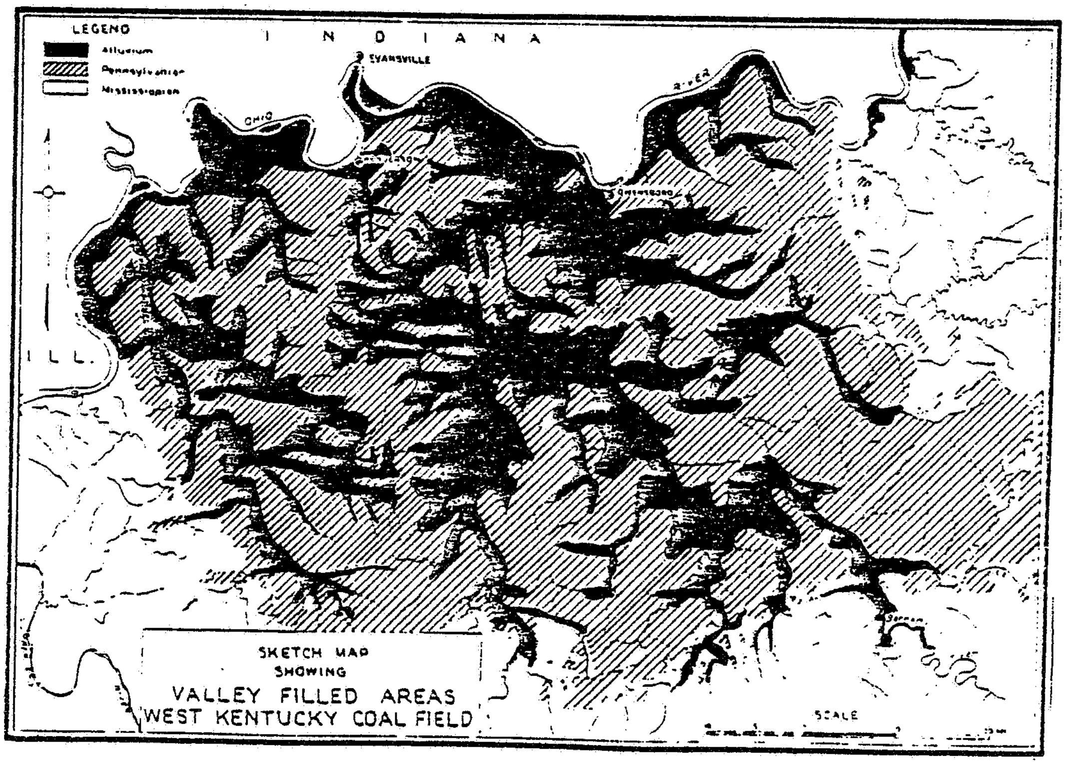


Figure 4. ALLUVIATED AREAS IN THE WESTERN KENTUCKY COAL FIELD

(Adapted from Jillson, 1928, p 44)

5. <u>Post-Glacial</u>. Since deglaciation of the upper Midwest about 11,000 years B.P., the study area has been subject to erosional processes operating under Holocene climatic conditions more or less similar to those of the present. Major streams have reworked the upper levels of their thick fills, degrading their beds only slightly (Ray, 1965). Climatic fluctuations and land use changes accompanying dam construction, mining, agriculture, and urban settlement of the region have contributed to surface modifications that are relatively minor in the context of the topographic texture of the entire study area.

GEOMORPHOLOGY OF THREE SPECIFIC ZONES

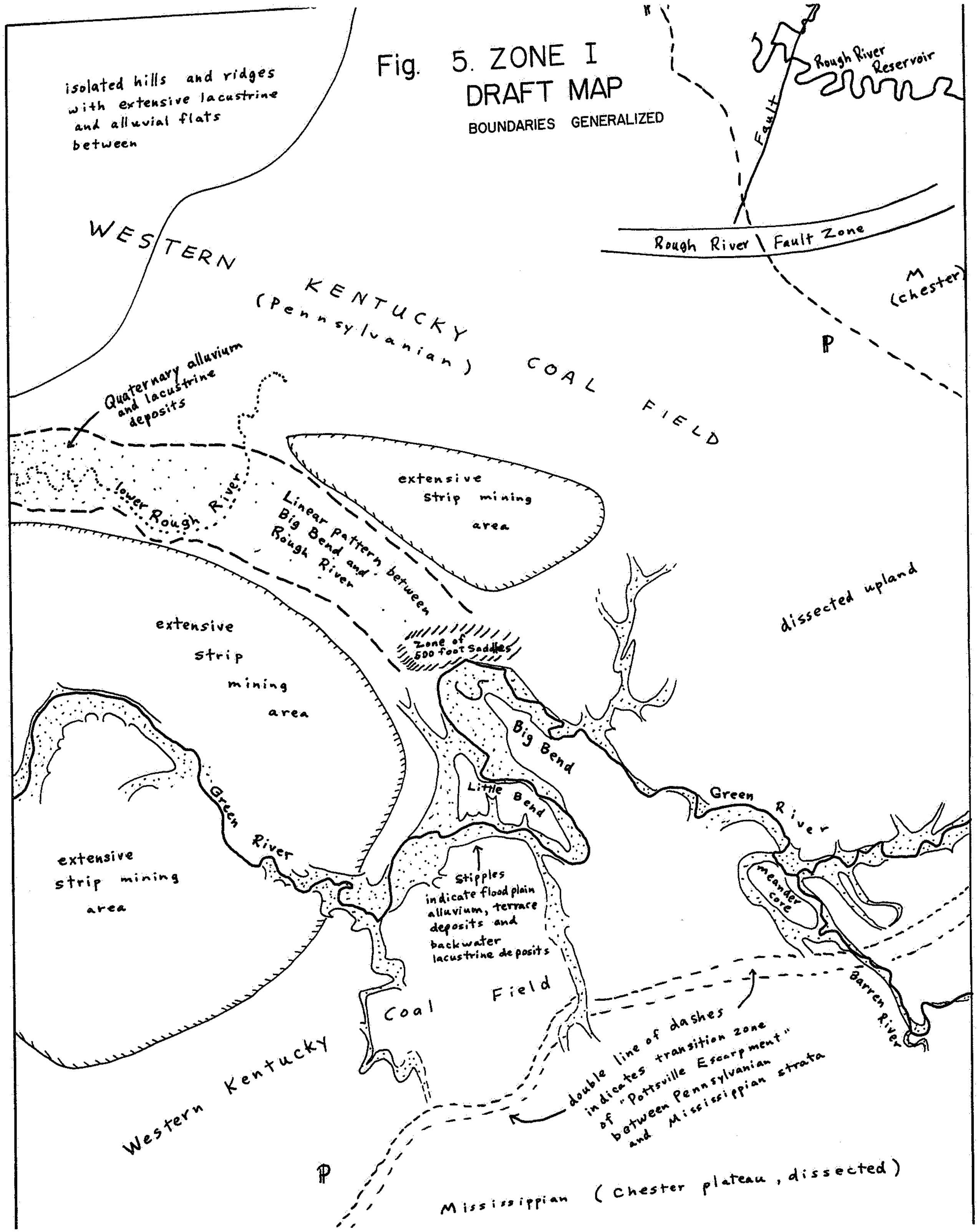
Within the wider study area, three smaller zones were specified for further discussion. Zones I, II, and III are in the eastern sector of the study area (Figure 1) and are at or near the updip end of the Pennsylvanian strata of the Western Kentucky Coal Field. Zone I is mostly within the Coal Field; Zone II is centered on the Chesterian Mississippian Plateau strata; and Zone III is almost entirely in the Chesterian (north) and older Mississippian (south) plateau area.

ZONE I

Except for the northeast and southeast corners where Mississippian rocks crop out, this zone (Figure 5) is within the Western Kentucky Coal Field of Pennsylvanian strata. Evidence of strip mining abounds in Zone I. Border areas of the Coal Field are generally rugged, in places having 200 and 300 feet of local relief, but westward toward the interior 150 feet or less is common (McGrain and Curren, 1978). Some of the ridges created by heavy stream dissection are relatively broad and level, but most are narrow and irregular in shape. Smaller tributary valleys tend to be V-shaped, but larger streams have entrenched steep-walled gorges with flat bottomlands. Extensive low, poorly drained flats are present in the western part of Zone I, the result of thick valley

Fig. 5. ZONE I DRAFT MAP

BOUNDARIES GENERALIZED



fills. The level of Pleistocene ponding and lacustrine and alluvial sedimentation was approximately to the elevation of the modern floodplain. In various other parts of the Coal Field the maximum thickness of valley sediments approaches 200 feet (Jillson, 1928), although in Zone I the fills are thinner. They are part of deposits up to about 420 feet in elevation made in what has been called Green Lake by Shaw (1911, cited by Leverett, 1929).

Prominent faulting in the north (Rough Creek Fault Zone) has affected the topography by accenting differential weathering and erosion. To the south, the Green River fault system follows a trend more or less parallel to the Rough Creek Zone. Between the two fault zones is the Green River, master stream of the Coal Field.

Green River follows a rather sinuous route in a generally northwestward direction. In the central part of Zone I, however, the Green River doubles back to the southeast at Cromwell before resuming its path to the Ohio River. This part of the river is known locally as Big Bend. The narrow neck between parallel reaches is capped by loess-mantled Tertiary gravel at elevations ranging generally between 450 and 500 feet (Gildersleeve, 1975). The floodplain is approximately 410 feet A.M.S.L. North of Big Bend is a broad band of interconnected small valleys which forms a rather linear pattern of mostly lowlands trending northwest. It merges with the broad flat of the Rough River, joining the Green River a few miles west at Livermore. The appearance suggests that Green River formerly continued north and west from the Big Bend, but abandoned its course during entrenchment, perhaps utilizing nearby tributary valleys as its new channel. A zone of low saddles, only about 100 feet above the floodplain, separates the river from its apparent former valley. The saddles are at about the same elevation as the Tertiary gravels capping the Big Bend neck.

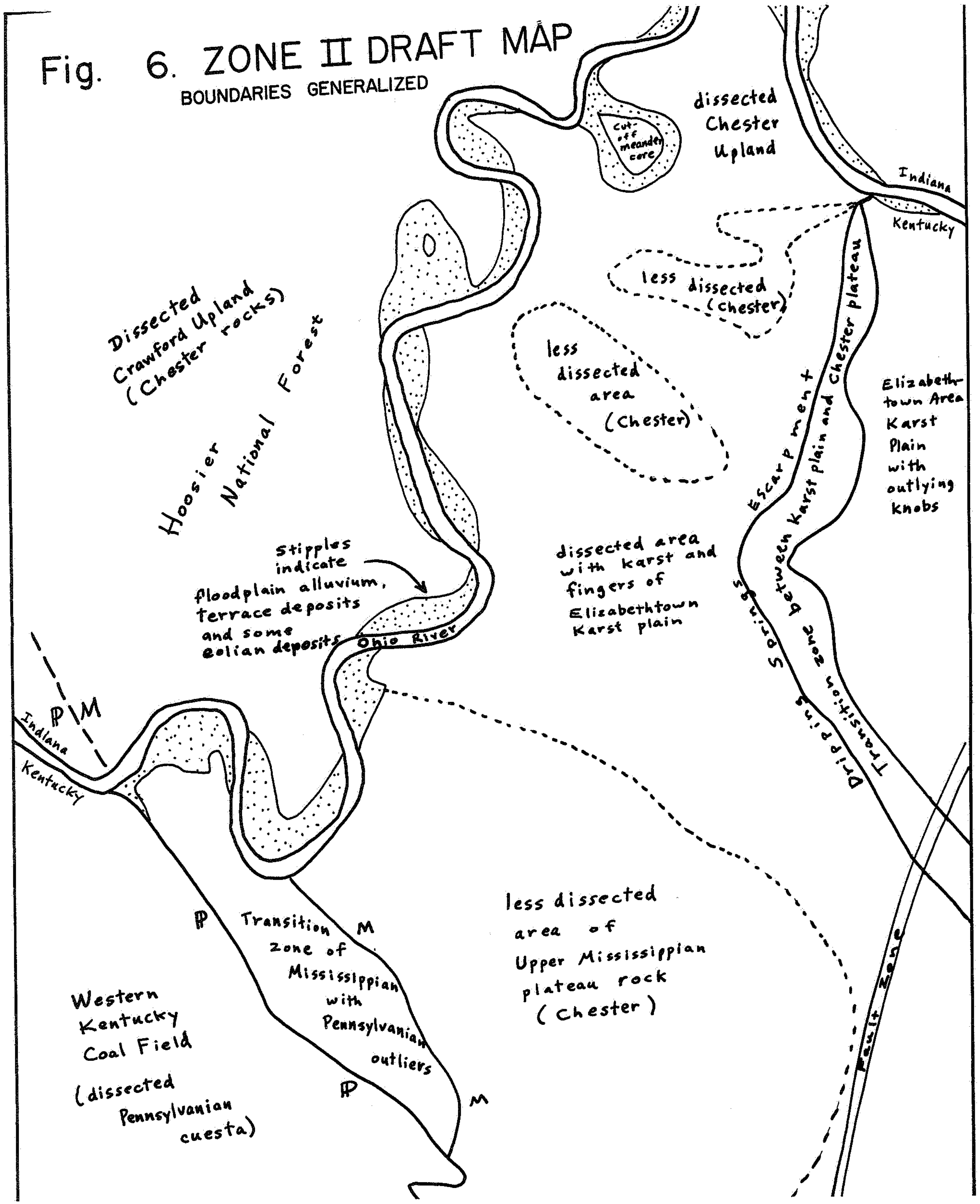
The northwestward trend, for many miles, of the Green River and its possibly abandoned course is but an extension of the Barren River's trend. In the southeastern part of Zone I, the Green flows from the east to receive Barren River, which has been flowing northwestward from the Pennyroyal Plain. Older literature generally presents the northwestward trend of Western Kentucky master streams as inherited from the Tertiary regional consequent slope on beds tilted toward the Illinois Basin.

ZONE II

Rolling topography is typical of much of Zone II (Figure 6) which is primarily the northern section of the Chester Mississippian plateau (Northern Clifty Area). Sandstone beds dominate, more resistant to erosion than the limestones exposed in small areas in the northeastern portion. Thus a tableland appearance is given to parts of the area. Dissection and local relief increase westward into an area of Pennsylvanian strata, northward to the Ohio River, and south to the Rough River. Where erosion has breached the sandstones to expose underlying limestones, cliffs are prominent, with minor benches appearing to result from interbedded shales and limestones (Sauer, 1927). Sinkholes resulting from subjacent karst are present. The drainage system of Sinking Creek in Breckinridge County encompasses in part of its course broad limestone dolines flanked by sandstone uplands. Its mouth is at the Ohio River, but its headwaters extend eastward into the Elizabethtown area, the northern equivalent of the Pennyroyal Plain (Sauer, 1927). Zone II thus contains finger-like extensions of the karst plain. The plain is separated from the dissected tableland by the Dripping Springs Escarpment, and relief of more than 200 feet (McGrain and Currens, 1978).

North of the Ohio River in Indiana is a highly dissected extension of the Mississippian plateau, the Crawford Upland (Malott, 1922). It is part of the Hoosier National Forest.

Fig. 6. ZONE II DRAFT MAP
BOUNDARIES GENERALIZED



ZONE III

Located at the southern portion of the wider study area, Zone III (Figure 7) is divisible into several generally east-west belts strongly influenced by lithologic and structural factors. With an overall northward dip toward the axis of the Moorman Syncline, successively older truncated rocks are exposed in a southerly direction.

At the northern part of Zone III is a small area of Pennsylvanian Coal Field strata, locally ending at fault lines separating them from Mississippian rock. The Pennsylvanian strata constitute the irregular edge of a south-facing dissected cuesta ("Pottsville Escarpment") with generally narrow ridgetops, and local relief up to about 200 feet (McGrain and Currens , 1978).

South of the Pennsylvanian rock, the Mississippian Chester rocks crop out, forming another dissected plateau. Extensive smooth uplands underlain by sandstone are present, separated by deep gorges. Locally karstification has occurred in the underlying limestones, especially at the southern margin. This plateau is a less karstified continuation of the "Mammoth Cave Plateau", beneath which the Mammoth-Flint Ridge Cave system developed farther to the east, in south central Kentucky. The plateau surface is separated from a karst plain to the south by a scarp and outliers constituting the south-facing Dripping Springs Escarpment.

The Pennyroyal Plain is a gently rolling plain with shallow sink-holes called basin karst by Dicken (1935). Nearest the Dripping Springs Escarpment the karst plain is formed mostly on Ste. Genevieve limestone, and farther south on St. Louis strata. Sinking streams, springs, and relatively small caverns are present. Lithologic differences, especially the presence of chert beds, give local variation to the style of karstification. Several feet of red earth mantle the surface of the upland swells and sinkhole bottoms. Although

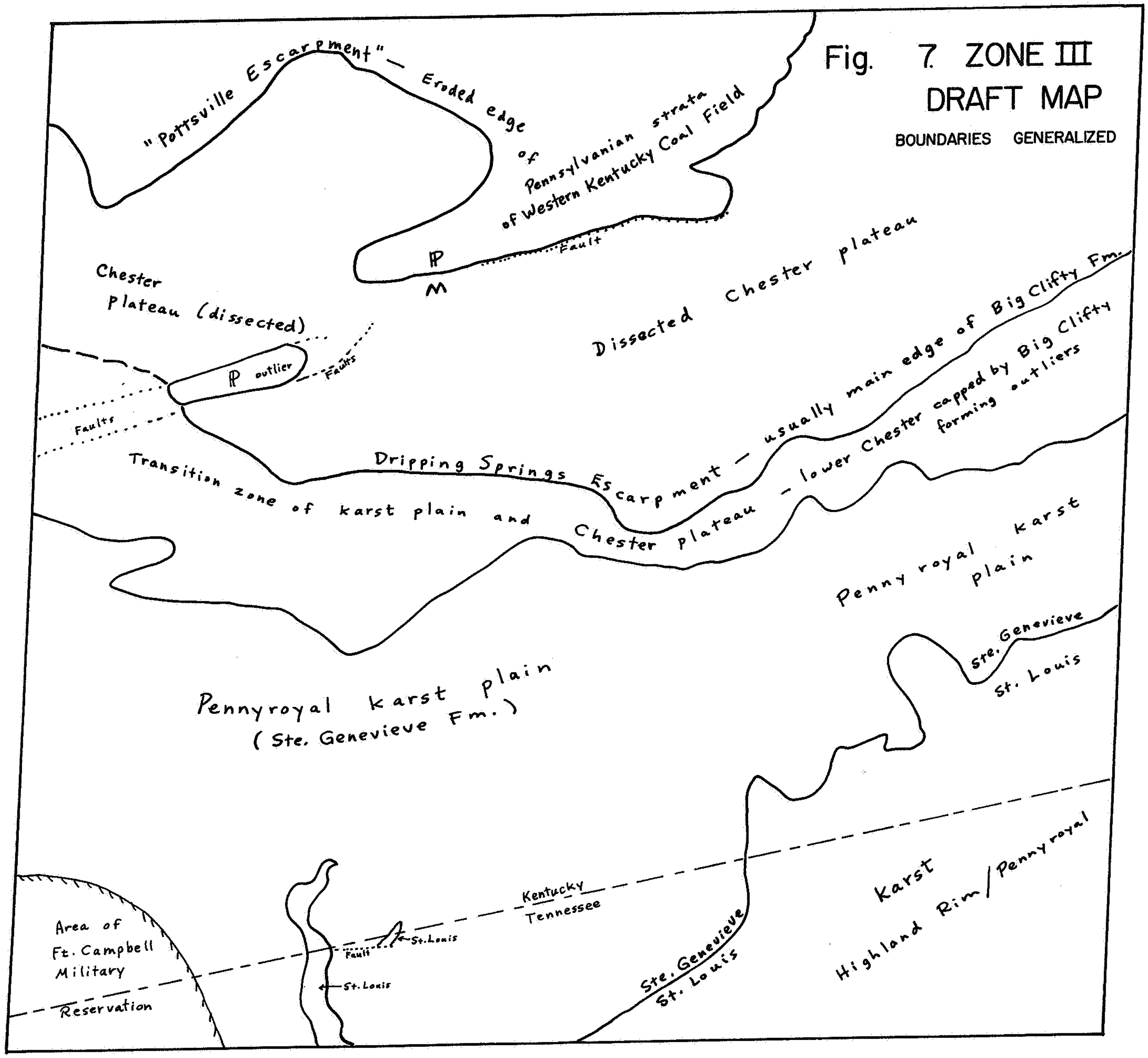


Fig. 7. ZONE III DRAFT MAP

BOUNDARIES GENERALIZED

usually referred to as residuum, the red silty clay has likely undergone great amounts of reworking to form colluvium and alluvium, and mixed with loess.

Several small surface streams, fed in part by emerging subterranean waters, aid in drainage. Most head in the Chester plateau area and drain southward in entrenched valleys to the Cumberland River. However, some portions of the karst plain serve as headwaters for streams draining northward downdip through the Dripping Springs and Pottsville Escarpments to enter the basin of Green River in the Coal Field. A small part of Zone III occurs in Tennessee, where the plain is considered part of the Highland Rim.

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