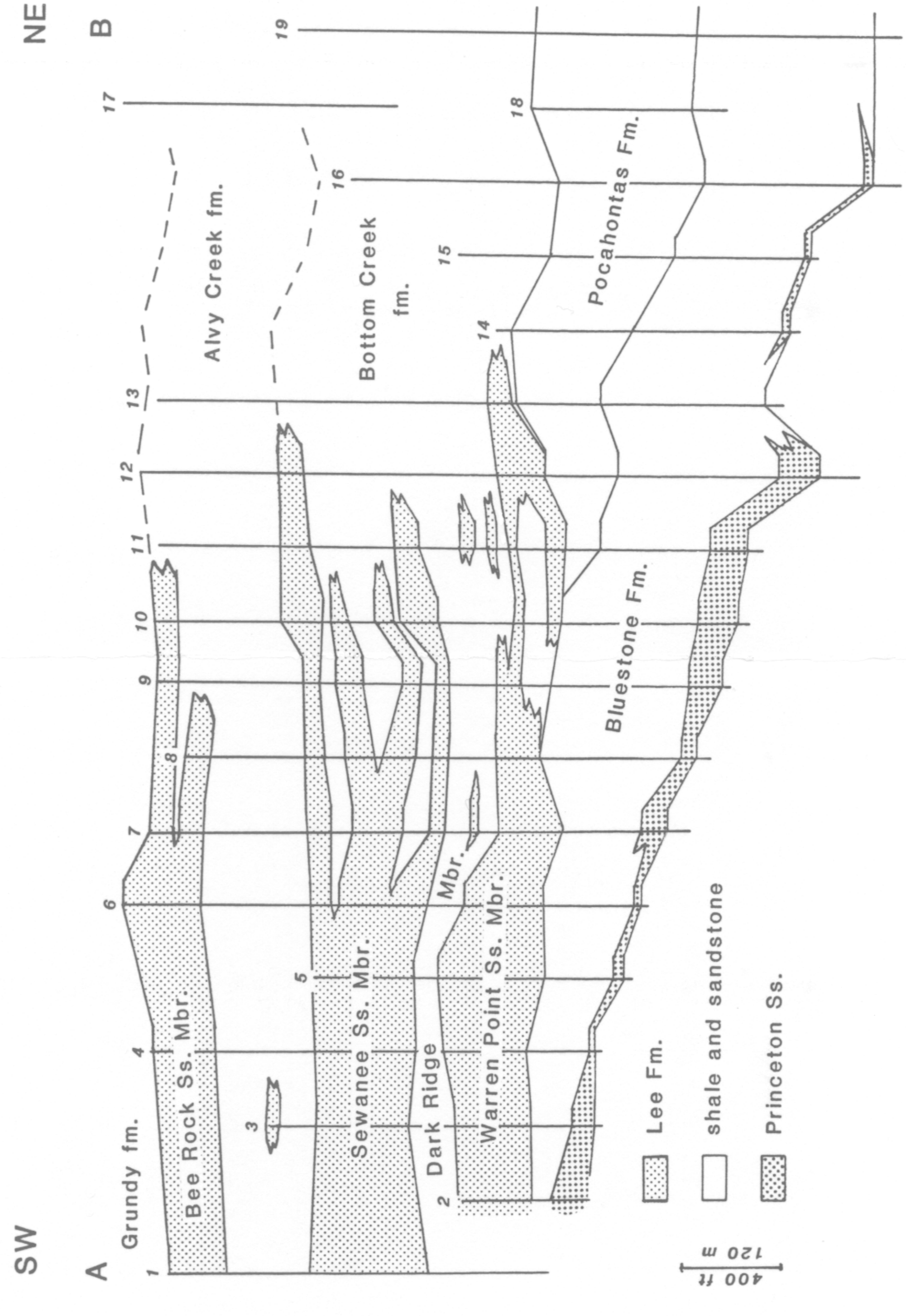
Figure 21. Reinterpretation of Englund and DeLaney's (1966) section (Fig. 20).


SW
A
NE
B
Grundy fm.
Bee Rock Ss. Mbr.
Sewanee Ss. Mbr.
Dark Ridge Mbr.
Warren Point Ss. Mbr.
Alvy Creek fm.
Bottom Creek fm.
Pocahontas Fm.
Bluestone Fm.
Lee Fm.
shale and sandstone
Princeton Ss.
400 ft
120 m
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

throughout the extent of the Warren Point in the Lake City dip section (Fig. 15), and the sandstone can be seen to pinch out to the northwest.

In addition to the northwest-thinning, the Warren Point Sandstone also thins to the southeast in the Catlettsburg and Grundy dip sections, and to the northeast in the northeastern quarter of the Harlan strike section (Fig. 18). The overall shape of the Warren Point in the study area is a belt, oriented northeast-southwest, with a lense-shaped cross section approximately 40 miles (64 km) in width. The southeastern edge of the Warren Point interfingers with the Bottom Creek formation of the Breathitt Group, whereas, the northwestern edge pinches out entirely. The southeastern edge is absent in the Booneville and Lake City dip sections because Carboniferous rocks are not preserved further southeast of these sections.

The Warren Point Sandstone overlaps the Pennington Group to the northeast, but in the southeastern quarters of the Catlettsburg and Grundy dip sections and the extreme northeastern part of the Harlan strike section, the Warren Point overlies the Pocahontas Formation. The beds of the Warren Point do not appear to be parallel to the underlying strata of the Pennington or of the Pocahontas.

SEWANEE MEMBER

The Sewanee Member (Fig. 19) is a Lee sandstone occurring above the Bottom Creek formation, and below the Alvy Creek formation (both formations are described below). The Bottom Creek and Alvy Creek formations are composed of Breathitt lithologies including shale, sandstones, and coal. In parts of southeastern Kentucky and northeastern Tennessee, the Bottom Creek formation is thin or absent and the Sewanee overlies similar sandstones of the Warren Point Member of the Lee Formation. Where this occurs, these sandstones are grouped together as the Warren Point-Sewanee member of the Lee Formation. The eastern occurrence of the Sewanee is equivalent to quartzose sandstones in the middle part of the New River Formation as mapped in Virginia and West Virginia. The Sewanee was previously mapped only in Tennessee.

The Sewanee Member occurs in all the cross sections and pinches out to the northwest. The northwestern extent is difficult to discern in the Catlettsburg (Fig. 12), Grundy (Fig. 13), and Booneville (Fig. 14) dip sections because overlying and underlying shale units become thin and discontinuous and the Sewanee comes in contact with similar sandstones of the Warren Point and the Bee Rock in this direction. Extrapolation of the thinning trend of the Sewanee, and the tracing of discontinuous shale beds are used to estimate its northwestern extent in these dip sections. In the Lake City dip section (Fig. 15), however, the shale units are not absent and the northwestern pinchout of the Sewanee is easily seen. Isolated lenses of the Sewanee can be recognized in the southwestern half of the Hazard strike section (Fig. 16), and probably mark the irregular northwestern edge of the sandstone. The Sewanee is continuous in the northeastern half of the Hazard and all of the Pineville (Fig. 17) strike sections and most of the Harlan section (Fig. 18).

The Sewanee also thins to the southeast in the southeastern parts of the Catlettsburg and Grundy dip sections and to the northeast in the northeastern part of the Harlan strike section where the sandstone interbeds with and disappears into the Bottom Creek and Alvy Creek formations of the Breathitt Group. The Sewanee forms a belt oriented northeast-southwest as in the Warren Point, but located further to the northwest. The belt is approximately 50 miles (80 km) in width. The full width of the belt is not preserved in the Booneville and Lake City dip sections due to the location of the southeastern limit of preserved Carboniferous rocks.

The Sewanee irregularly overlies the Pennington Group throughout the Hazard strike section and in the central parts of the Catlettsburg and Grundy dip sections. To the southeast, the Sewanee overlies either the Warren Point or the Bottom Creek.

BEE ROCK SANDSTONE MEMBER

The Bee Rock Sandstone Member (Fig. 19) is a thick sandstone sequence, separated from the stratigraphically lower Sewanee by the intervening Alvy Creek formation (described below). Cross sections developed in this study indicate that the Bee Rock Sandstone (originally used by Stevenson, 1881, p.230; and Campbell, 1893, p.17,36) includes sandstone units originally mapped as the Rockcastle Sandstone or Rockcastle Conglomerate in Kentucky (first used by Campbell, 1898, p.3) and Tennessee (used by Campbell, 1899, p.3). The name Bee Rock has priority over the name Rockcastle. The Bee Rock, as used here, locally contains lenses mapped previously as the Naese, K, and G sandstones.

The Bee Rock Sandstone occurs in all the cross sections, and is continuous throughout the Lake City dip section (Fig. 15), and the Hazard (Fig. 16) and Pineville (Fig. 17) strike sections, but thins and pinches out to the northwest in the northwestern parts of the Catlettsburg (Fig. 12), Grundy (Fig. 13, and Booneville (Fig. 14) dip sections. The sandstone becomes difficult to discern in the northwestern parts of the Catlettsburg, Grundy, and Booneville dip sections, however, because shale units overlying and underlying the Bee Rock are thin or absent, and the Bee Rock comes in contact with the similar sandstones of the Sewanee and Corbin members. The northwestern occurrence of the Sewanee is estimated by extending the thinning trend of the sandstone and by tracing the isolated shale beds.

The Bee Rock also thins to the southeast in the southeastern parts of the Catlettsburg and Grundy dip sections, and the northeastern part of the Harlan strike section (Fig. 18), where the Bee Rock interbeds with and ends in the Alvy Creek formation of the Breathitt Group. The Bee Rock forms a northeast-southwest belt approximately 57 miles (91km) in width. This belt is located northwest of the Sewanee belt, but partially overlaps it. The southeastern edge of the belt is not found in the Lake City and Booneville dip sections, and the northwestern edge is not found in the Lake City dip section, due to the limits of upper Carboniferous outcrop in the southern part of the study area.

The Bee Rock overlies the Slade and Pennington strata in the northwestern parts of the Catlettsburg, Grundy, and Booneville dip sections, but elsewhere, overlies either the Alvy Creek formation of the Breathitt Group or the Sewanee Member.

The upper part of the Bee Rock Sandstone interbeds with the overlying Grundy formation in the Grundy and Booneville dip sections, and in the Pikeville and Harlan strike sections. The top of the Bee Rock raises slightly stratigraphically to the northwest as a result of this interbedding.

CORBIN SANDSTONE MEMBER

The Corbin Sandstone Member (Fig. 19) is a series of local sandstone bodies in the Lee Formation that interfinger laterally with the Grundy formation (described below). The Corbin Sandstone is recognized along the northwestern part of the study area.

The Corbin Member is present in the northwestern parts of the Catlettsburg (Fig. 12), Grundy (Fig. 13), and Booneville (Fig. 14) dip sections, and occurs as isolated lenses in the southwestern halves of the strike sections (Figs. 16-18). The Corbin sandstone bodies are much smaller in extent than the Bee Rock, Sewanee, and Warren Point sandstones, and are apparently restricted to the northern and northwestern part of the study area.

To the north, the Corbin Sandstone is difficult to discern from the underlying Bee Rock Sandstone, because intervening shale units are thin or absent. In the northwestern parts of the Catlettsburg and Grundy dip sections, the Corbin thins and becomes isolated lenses separated by remnants of the Slade Formation. In the northwestern parts of these dip sections, the Corbin overlies the Borden, Slade, and Pennington strata, but to the southwest of these sections and in the other sections, the Corbin overlies either the Grundy shales or the Bee Rock sandstones. The sandstones of the Corbin interbed with the Grundy formation and dissappear to the southeast near the central parts of the Catlettsburg, Grundy, and Booneville dip sections.

The Corbin Sandstone forms a narrow belt, oriented northeast-southwest, approximately 40 miles (64 km) wide. Most of the northwestern edge of the Corbin is absent.

The Breathitt Group

The Breathitt Group (Fig. 19) includes shales, siltstones, "dirty" sandstones, coal, and some thin limestones, and contains most of the coal beds of the Central Appalachian Basin. Because of scale limitations, not all the coal and sandstone beds were drawn. For this reason, only larger units within the Breathitt were used in drawing the cross sections. It was determined after construction of the sections that several widespread and easily identified marine units within the Breathitt, as well as some quartz-rich sandstones of the Lee Formation, could be used to subdivide the Breathitt into formations approximately equal in thickness. The lower part of the Breathitt is subdivided into formations by members of the Lee Formation and by coal beds in areas where the Lee is absent. The upper part of the Breathitt is subdivided by the marine members. Because the Breathitt is subdivided into formations, the Breathitt Formation is informally elevated to group status. The Breathitt formations are described below, in ascending order.

Problems in correlation exist in parts of Tennessee due to two reasons. First, much of the Breathitt is preserved only in isolated mountains where sections and cores are generally poorly described. These mountains are widely spaced and therefore, data may be too widely spaced for secure correlations. Second, confusion in correlation may exist because the occurrence of additional marine shale intervals in the section may be mistaken for the key stratigraphic marine zones. Many of these problems can be overcome in the future, with better data and with changes in orientation of cross sections.

POCAHONTAS FORMATION

This unit (Fig. 19) is composed of interbedded sandstone, siltstone, shale, and coal, and occurs only in Virginia and West Virginia, where it contains most of the Pocahontas coals. The Pocahontas Formation, as used here, is equivalent to the Pocahontas Formation as mapped in Virginia and West Virginia. However, the lithologies of the Pocahontas Formation are identical to those of the Breathitt Group and, therefore, the Pocahontas Formation is included in the Breathitt Group as a unit in this study. The Pocahontas Formation was reported by Englund and others (1979) to be interbedded with the underlying Bluestone Formation of the Pennington Group. Similarly, in the extreme southeastern part of the study area, the upper part of the Pocahontas may be conformable with the overlying Bottom Creek formation (described below). Elsewhere, to the north and west in parts of Virginia and southern West Virginia, beds of the Pocahontas Formation are overlain by the Warren Point Member of the Lee Formation and are progressively absent (Miller, 1974, fig. 47) to the northwest until they become absent.

The Pocahontas is found only in the southeastern quarters of the Catlettsburg (Fig. 12) and Grundy (Fig. 13) dip sections and in the extreme northeastern part of the Harlan strike section (Fig. 18). The Pocahontas thickens to the southeast and the northeast, respectively, in these sections. The Pocahontas Formation may be conformable with the Pennington Group below, but is down-section progressively absent to the northwest in the two dip sections, and to the southwest in the Harlan strike section, where the Pennington is overlain by the Warren Point Sandstone. In the extreme southeastern parts of the two dip sections, where the Warren Point is absent, the Pocahontas may be conformably overlain by the Bottom Creek formation.

BOTTOM CREEK FORMATION

The Bottom Creek formation (Fig. 19) is composed of interbedded sandstone, siltstone, shale, and coal, and has its maximum development in West Virginia and Virginia. The Bottom Creek formation is named for outcrops near Bottom Creek in the Keystone Quadrangle, West Virginia. The formation is separated from the similar lithologies of the underlying Pocahontas Formation by the Warren Point Member of the Lee Formation, and where the Warren Point is absent, by the Pocahontas No. 8 coal bed. The Bottom Creek is separated from the similar lithologies of the overlying Alvy Creek formation by the Sewanee Member of the Lee Formation, and where the Sewanee is absent, by the Kennedy coal bed in West Virginia and Virginia, and by the Rex coal bed in

Tennessee. Northwest of its occurrence in Virginia and West Virginia, the Bottom Creek formation is interbedded with and progressively replaced by the Warren Point-Sewanee members. Cross sections contructed in this study indicate that the Bottom Creek in Virginia and West Virginia is equivalent to the Breathitt lithologies only, in the lower half of the New River Formation, which contains both Lee and Breathitt lithologies. The cross sections also indicate that the Bottom Creek is equivalent to the Dark Ridge Member (Fig. 21), Signal Point Shale, and the lower part of the Fentress Shale mapped in Tennessee.

The Bottom Creek is present in the southeastern part of all the dip sections (Figs. 12-15), in the eastern quarters of the Pineville (Fig. 17) and Harlan (Fig. 18) strike sections, and in the western half of the Harlan strike section. It is absent in the Hazard strike section (Fig. 16). Thick development of the Bottom Creek is resticted to the southeastern parts of the Catlettsburg and Grundy dip sections, and to the northeastern part of the Harlan strike section; elsewhere, in the southern part of the study area, it is a thin but persistent shale unit.

The Bottom Creek formation is overlain by the Alvy Creek formation in the southeastern quarter of the Catlettsburg and Grundy dip sections, but in other areas, it is overlain by the Sewanee Member.

ALVY CREEK FORMATION

The Alvy Creek formation (Fig. 19) is composed of interbedded sandstone, siltstone, shale, and coal. The Alvy Creek formation is named for outcrops near Alvy Creek in Big A Mountain Quadrangle, Virginia (obtained from Miller and Meissner, 1977). This formation is separated from the underlying Bottom Creek formation by the Sewanee Member of the Lee Formation. Northwest of its occurrence in Virginia and West Virginia, the Alvy Creek formation is interbedded with and is progressively replaced by the Bee Rock Sandstone and the Sewanee member. Cross sections constructed in this study indicate that the Alvy Creek is equivalent to the Breathitt lithologies only, in the upper half of the New River Formation mapped in Virginia and West Virginia, which contains both Lee and Breathitt lithologies. In the south-central part of the study area, the Alvy Creek is much reduced in thickness and is equivalent to part of the Hensley Member of the Lee Formation mapped in Tennessee, Kentucky and Virginia. In the southwestern part of the study area in Tennessee the Alvy Creek can be demonstrated in cross sections to be equivalent to the Fentress Member mapped in Tennessee, and to part of the Lower Tongue of the Breathitt Formation mapped in south-central Kentucky.

The Alvy Creek is present in all the cross sections, but has its thickest development in the southeastern quarters of the Catlettsburg (Fig. 12) and Grundy (Fig. 13) dip sections and in the northeastern quarter of the Harlan strike section (Fig. 18). Another area of moderate thickness is reflected in the northwestern half of the Lake City dip section (Fig. 15) and the southwestern third of the Hazard strike section (Fig. 16). Elsewhere, in the southern half of the study area, the Alvy Creek is a thin, but persistent shale unit. The Alvy Creek is very thin or absent in the northwestern part of the Catlettsburg, Grundy, and Booneville (Fig. 14) dip sections.

The Alvy Creek overlies the Sewanee Member throughout the study area except in the northwestern part of the Lake City dip section and the southwestern half of the Hazard strike section, where it overlies Pennington strata at places where the Sewanee is absent. The Alvy Creek is overlain by the Grundy formation in the southeastern part of the Catlettsburg and Grundy dip sections, and in the northeastern part of the Harlan strike section. Elsewhere, the Alvy Creek is overlain by the Bee Rock Sandstone.

GRUNDY FORMATION

This formation (Fig. 19) is composed of interbedded sandstone, siltstone, shale, and coal. The Grundy formation is named after outcrops in the area of the Grundy

Quadrangle, Virginia. The top of the Grundy formation is placed at the base of the overlying Betsie Shale, described by Rice and others (1987), of the Pikeville formation (described below). The Betsie Shale is a very distinctive, laterally persistent, thick marine and brackish-water shale sequence. The stratigraphic usefulness of this shale sequence, mapped as the Cannelton Limestone in Kentucky, was also independently recognized by Rice, and others (in press). They reveal correlation problems between shales mapped as Cannelton in Kentucky and the type Cannelton Limestone in West Virginia and suggest that the Cannelton Limestone as mapped in Kentucky should be renamed the Betsie Shale.

At the top of the Grundy is the Manchester coal bed (and its equivalents), a laterally persistent bed overlain by the Betsie Shale. The base of the Grundy formation is at the top of the Bee Rock Sandstone Member of the Lee Formation where present, and at the Kennedy coal where the Bee Rock is absent in the southeastern part of the study area.

The Grundy formation, the most extensive of the Breathitt formations, is present in all the cross sections. The Grundy thickens to the southeast in the dip sections, and remains approximately equal in thickness in the strike sections. This formation contains sandstone lenses of the Corbin Sandstone Member in the northwestern parts of the

Catlettsburg (Fig. 12), Grundy (Fig. 13), and Booneville (Fig. 14) dip sections, and in the southwestern parts of the strike sections (Figs. 16-18). The Grundy also interbeds with the Bee Rock Sandstone, such that the lower part of the Grundy is stratigraphically lower to the southeast, as reflected in these dip sections. The Gladeville Sandstone, a marker bed used extensively in Virginia and parts of West Virginia (Miller, 1974; Mitchell and others, 1982), occurs in the upper third of the Grundy formation in the southeastern part of the Grundy dip section, and the northeastern part of the Harlan strike section.

The correlation of major coal beds of the Grundy are seen in Table 2. The coal bed names in West Virginia, Virginia, and Tennessee are those encountered from subsurface records obtained for this study, and are not necessarily the correct correlations used throughout these states. Internal correlation problems within these states has become apparent, but cannot be corrected in this study.

PIKEVILLE FORMATION

The Pikeville formation (Fig. 19), composed of interbedded sandstone, siltstone, shale, and coal, is named after exposures near Pikeville, Kentucky. The Pikeville is the lowermost formation of the Breathitt Group that does not

Table 2. Preliminary coal bed correlation chart of the study area. During this study, correlations problems between the part of West Virginia bordering Kentucky and the Kanahwa Valley in central West Virginia were discovered. Coal bed names in West Virginia in this chart are those encountered in industry records in the southwestern border area. Similar problems exist in Tennessee.

Formation	Cumberland Plateau: Tennessee	Cumberland Plateau: Kentucky	Cumberland Plateau: Virginia and West Virginia	Cumberland Overthrust Sheet: Tennessee	Cumberland Overthrust Sheet: Kentucky	Cumberland Overthrust Sheet: Virginia
Princess formation		Princess No. 9 Princess No. 8	Upper Freeport			
	unnamed?	Princess No. 7	Middle Kittanning			
	Wild Cat?	Hazard No. 12, Princess No. 6	Lower Kittanning			
	Cold Gap?	Hazard No. 11, Richardson, Princess No. 5	No. 5 Block			
	Grassy Spring?	Hazard No. 10, Upper Broas zone	Clarion zone			
	Stoney Fork?	**Stoney Fork**	**Stoney Fork?**			
Four Corners formation	Rocksprings? Pinebald?	Hindman, Hazard No. 9, Lower Broas zone	Stockton		Black Mountain zone	
	Petree?	Peach Orchard zone: Francis	Coalburg zone: Coalburg			
	Big Wheel, Splitseam?	Peach Orchard zone: Hazard No. 7	Coalburg zone: Buffalo Creek			No. 13
	Pewee Walnut Mountain	Hazard zone: Hazard rider Hazard, Hazard No. 5	Winifrede	unnamed	Highsplint?, Red Springs?, No. 12?	No. 12
	Red Ash	Haddix		unnamed	Lowsplint?, Morris?, No. 11	No. 11, Morris
	Magoffin	**Magoffin**	**Winifrede**	**Magoffin**	**Magoffin**	**Magoffin**
Hyden formation	Sharp, unnamed, (Beech Grove)	Copland	Chilton "A"	(Rock Springs)	Limestone coal Pardee, Wax, Gin Creek, No. 8 & 9 zone	Parsons
	Beech Grove	Hamlin zone		unnamed	? Smith zone ? unnamed ?	Phillips?
	Big Mary	Fire Clay Rider	Chilton zone	Big Mary, (Petree)	Hignite zone; Wallins Creek zone; Fire Clay	No. 8?
	Windrock	Fire Clay		Windrock		No. 7, Phillips
	Craig Pioneer zone Armes	Whitesburg zone	Hernshaw Dingess	Pioneer zone; Hignite zone	Stray zone	No. 6
	Kendrick	**Kendrick**	**Dingess**	**Kendrick**	**Kendrick**	**Kendrick**
Pikeville formation	Jordon Indian Fork	Amburgy zone	Williamson	Poplar Lick	Creech zone: Sterling, Jackrock Poplar Lick, No. 5 1/2	Lowsplint No. 5 1/2, Lowsplint
	Stockstill	Upper Elkhorn No. 3 1/2, Nosben		Buckeye Springs	Buckeye Springs, Verda	No. 5 1/4
	Joyner, Lick Fork	Upper Elkhorn No. 3	Cedar Grove	(Jordon)	Darby-Kellioka zone	No. 5, Darby-Kellioka, Taggart zone
	Jellico	Jellico zone: Upper Elkhorn No. 2 Upper Elkhorn No. 1	Alma	Jellico zone: Lick Fork, (Joyner) (Mason)	Mingo zone; Harlan zone; Wilson (Mason)	Standiford, Collier, Wilson
	Blue Gem	Blue Gem, Lower Elkhorn, Pond Creek	No. 2 Gas	Rich Mountain	Path Fork zone: Imboden, (Mason)	Imboden zone: Bolling, (Kelly)
	Petros, Dixie, Black Wax				L. St. Charles, Penn, Lee	Kelly
	Betsie	**Betsie**	**Betsie**	**Betsie**	**Betsie**	**Betsie**
Grundy formation	Coal Creek, Swamp Angel?	Manchester	Clintwood	Kent, Coal Creek, (Jellico)	Hance zone: Hance, Bennett Fork (Dorchester)	Addington Clintwood
	Poplar Creek	Blair-Glamorgan zone	Blair-Glamorgan zone	Poplar Creek, (Blue Gem)	Mason zone	Dorchester, Norton, Blair Gladeville Sandstone
	Hoppeç (Rex)	Hagy-Splashdam	Hagy-Lower Banner zone	unnamed	Splitseam?	unnamed, Hagy-Banner?
	Crossville Ss.	Elswick-Lower Banner zone		unnamed	Clear Fork?	unnamed, Lower Banner?
	Rex	Bee Rock Member	Kennedy	unnamed	Naese unnamed	Kennedy
New River Formation	Bee Rock Member	Bee Rock Member	New River Formation	Bee Rock	Bee Rock	New River Formation

Key stratigraphic marine zone (shaded) — Lee Formation (stippled) — Parentheses indicate common, incorrect coal bed names contain any sandstones of the Lee Formation (as recognized in this study). The base of the Pikeville is at the base of the Betsie Shale, a thick, marine- to brackish-shale sequence discussed above. The Amburgy coal zone at the top of the Pikeville is overlain by the Kendrick Shale of the Hyden formation (described below).

The Pikeville formation thins to the north and is difficult to discern from overlying sequences in northeastern Kentucky because the units are thin and data are sparse. The Pikeville is present in all the cross sections; in the dip sections (Figs. 12-15) it thickens to the southeast, whereas, in each strike section (Figs. 16-18) it has an almost constant thickness.

The regional coal bed correlation of the Pikeville formation is illustrated in Table 2.

HYDEN FORMATION

The Hyden formation is composed of interbedded sandstone, siltstone, shale, and coal, and is named after exposures along the Daniel Boone Parkway near Hyden. Kentucky (Cobb and others, 1981). The base of the Hyden (Fig. 19) is designated as the base of the Kendrick Shale Member, a marine shale sequence. The Copland coal zone at the top of the Hyden formation is overlain by the Magoffin

Member, a laterally persistant, marine shale sequence of the Four Corners formation (described below).

Although, the Hyden formation is found throughout the study area, it thins to the north and is difficult to differentiate from adjacent units in northeastern Kentucky because all the units are thin and data are sparse. The Hyden occurs in all of the cross sections. In the Catlettsburg (Fig. 12), Grundy (Fig. 13), and Booneville (Fig. 14) dip sections, the Hyden thins to the northwest: its occurrence in the Lake City (Fig. 15) is so small that its thickness trend cannot be determined. The Hyden is approximately equal in thickness in each of the strike sections (Figs. 16-18).

Coal bed correlations of coals in the Hyden can be seen in Table 2.

FOUR CORNERS FORMATION

The Four Corners formation (Fig. 19) is composed of interbedded sandstone, siltstone, shale, and coal. This formation is named after a series of roadcuts called the Four Corners (Cobb and others, 1981; Chesnut, Cobb and Kiefer, 1986) at the intersection of the Daniel Boone Parkway, Kentucky Highway 80, and Kentucky Highway 15 near Hazard, Kentucky. The base of the Four Corners is at the base of the laterally persistent Magoffin Member. The Hindman coal at the top of the Four Corners formation is overlain by the Stoney Fork Member, a marine shale in the Princess formation (described below).

The Four Corners formation thins to the north and is difficult to discern from adjacent units in northeastern Kentucky due to a lack of adequate data. This formation is present in Tennessee but is poorly known because of sporadic exposures and uncertainty about the position of the Magoffin and Stoney Fork Members there. The Four Corners is present in all the cross sections, but is more restricted in occurrence than the Breathitt formations below. In the Catlettsburg (Fig. 12), Grundy (Fig. 13), and Booneville (Fig. 14) dip sections the Four Corners thins to the northwest, but its occurence in the Lake City dip section (Fig. 15) is too small to indicate which direction it thins. The Four Corners is approximately constant in thickness throughout each of the strike sections (Figs. 16-18).

The correlation of the major coal beds of the Four Corners formation are illustrated in Table 2.

PRINCESS FORMATION

The Princess formation (Fig. 19), composed of interbedded sandstone, siltstone, shale, and coal, is named after the Princess Coal District and the Princess coal beds in northeastern Kentucky. The base of the Princess formation is the base of the Stoney Fork Member, a marine shale. The Princess formation is overlain by the Conemaugh Formation, which contains red beds, sandstones, shale, marine zones, and poorly developed coals: the base of the Conemaugh Formation is the Upper Freeport coal.

Due to the sporadic and poorly exposed nature of the Princess formation on widely-spaced hilltops, it is not known how well the Hindman coal or Stoney Fork Member will correlate over the entire region. Where it is known to occur, the Stoney Fork Member is a well-developed marine zone (Garrison, 1977; Ping, 1978). Such a well-developed marine zone probably indicates a widespread occurrence. However, the sporadic exposures at this stratigraphic level and lack of adequate data in Tennessee cause details of the unit to be uncertain there.

The Princess formation is the uppermost unit of the Breathitt Group. The Princess thins to the north and is there difficult to distinguish from adjacent units. The Princess occurs in the Catlettsburg (Fig. 12), Grundy (Fig. 13), and Booneville (Fig. 14) dip sections, and in the central parts of the Hazard (Fig. 16) and Pineville (Fig. 17) strike sections. In the central part of the study area, the Princess is found along hilltops and its upper contact is not present. However, in the northwestern parts of the Catlettsburg and Grundy dip sections, complete sections of the Princess are found in the Allegheny synclinorum (Parkersburg syncline). The possibility exists that basal Princess strata occur at the tops of the highest mountains in the Lake City dip section (Fig. 15) and in the Harlan strike section (Fig. 18), but data are not sufficient to prove this.

The correlation of coal beds in the Princess formation is shown in Table 2.

The Conemaugh-Monongahela Formations

The Conemaugh and Monongahela formations (Fig. 19) occur only in the northern part of the study area. Elsewhere, they apparently have been eroded. These coal-bearing units are not part of the Breathitt Group. The Conemaugh consists of red (and some green) shales and siltstones, gray shales, sandstones, few coals, and some marine rocks. The overlying Monongahela Formation is similar in lithology to the Breathitt Group (i.e., few red beds, better developed coals compared to the Conemaugh). The base of the Conemaugh Formation has been designated as the Upper Freeport coal (Rice and Smith, 1980). The base of the Monongahela Formation in West Virginia is placed at the base of the

Pittsburgh coal. However, the Pittsburgh is not readily found in northern Kentucky, and there, the Conemaugh and Monongahela formations are mapped together. These two formations are Late Pennsylvanian in age.

The Conemaugh-Monongahela formations were recorded only in the Allegheny synclinorum (Parkersburg syncline) in the northwestern parts of the Catlettsburg (Fig. 12) and Grundy (Fig. 13) dip sections. The base of this interval in the Catlettsburg section is placed at the level of the lowermost reported red beds. The nature of drillers' logs and insufficient data density preclude adequate correlation of the Breathitt Group and Conemaugh-Monongahela formations in this section. The base of the Conemaugh-Monongahela formations in the Grundy section was determined from published geologic quadrangle maps in the Allegheny Synclinorum due to insufficient subsurface data. The Conemaugh and Monongahela formations in the Booneville, Lake City, Hazard, Pineville, and Harlan sections have been completely eroded, if they were ever present.

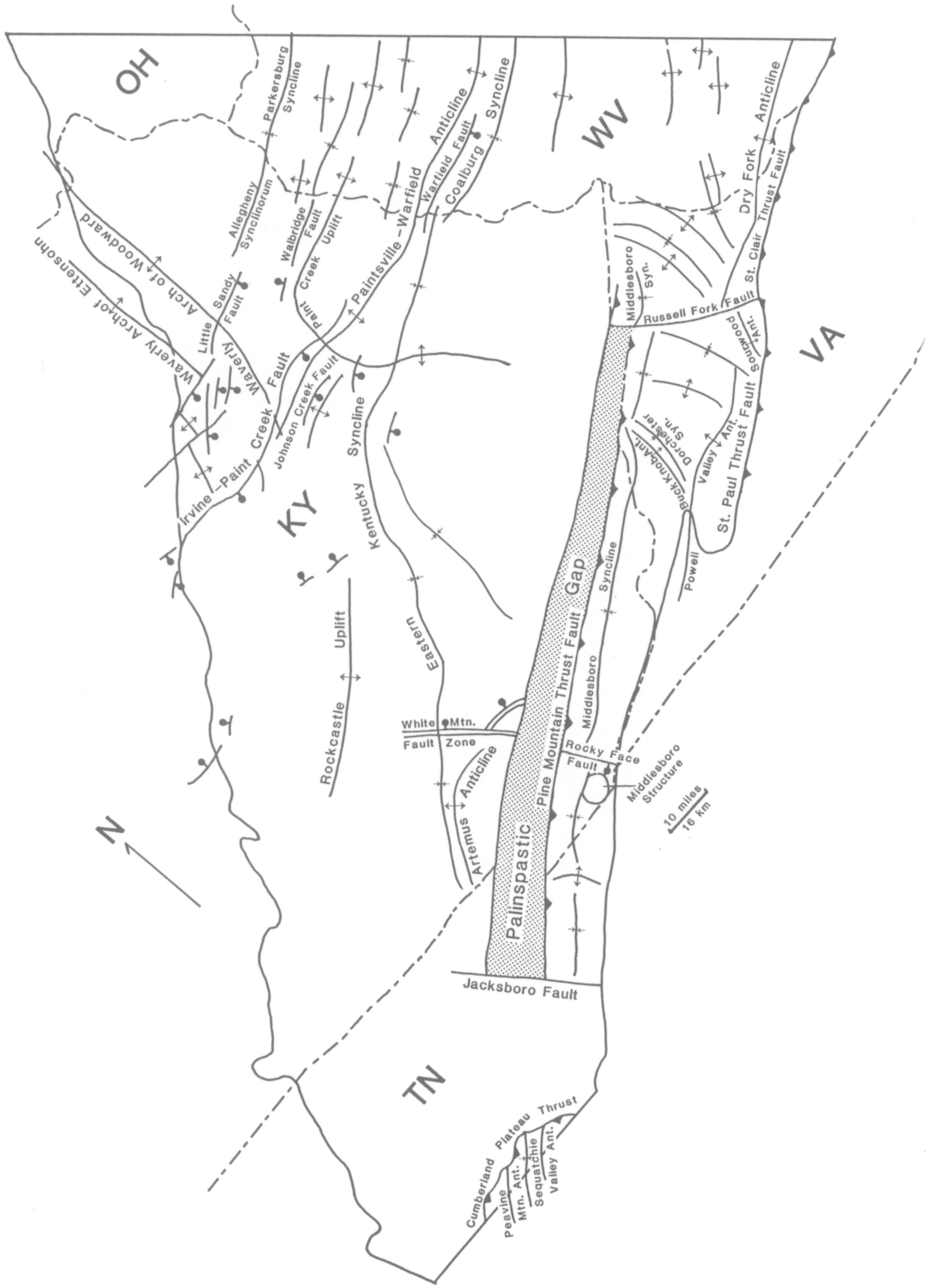
Structural Framework

The structural framework of the Central Appalachian basin includes large-scale structures that are recognized in structure-contour maps and in the cross sections (Figs. 12-18). The structure contour map of a surface bed was used to illustrate near surface structural features, whereas the cross sections were used to determine subsurface structures. These cross sections were constructed using sea level as the datum, and provide information leading to a structural framework for the younger Paleozoic rocks in the basin. The cross sections alone, however, do not provide sufficient information to determine the orientation of some of the features observed in the sections or to generate a coherent structural framework. Because the dip cross sections are far apart, a structure contour map is necessary to identify some of the structural features recognized in the cross sections.

Structural features in the study area (Fig. 22) were compiled from maps prepared by Stearns (1954), Woodward (1961), Huddle and others (1963), Miller (1974), Ettensohn (1975), Arkle and others (1979), and Kevin (1980). These previously described structural features were used to identify features disclosed by the cross-sections.

Figure 23 is a structure-contour map on the Fire Clay coal bed of the Hyden formation (Breathitt Group) in Kentucky. Because the Fire Clay coal occurs near the surface throughout most of this area, the map also reflects the general trends of the surface geological structure.

Figure 22. Structural features of part of the Central Appalachian basin, compiled from maps prepared by Stearns (1954), Woodward (1961), Huddle and others (1963), Miller (1974), Ettensohn (1975), Arkle and others (1979), and Kevin (1980). Original position of Pine Mountain reconstructed.


OH
WV
KY
VA
TN
N
Parkersburg Syncline
Allegheny Synclinorum
Walbridge Fault
Paint Creek Uplift
Paintsville-Warfield Anticline
Warfield Fault
Coalburg Syncline
Dry Fork Anticline
St. Clair Thrust Fault
Middlesboro Syn.
Russell Fork Fault
Sourwood Ant.
St. Paul Thrust Fault
Valley Ant.
Dorchester Syn.
Buck Knob Ant.
Powell
Waverly Arch of Woodward
Waverly Arch of Ettensohn
Little Sandy Fault
Irvine-Paint Creek Fault
Johnson Creek Fault
Eastern Kentucky Syncline
Rockcastle Uplift
White Mtn. Fault Zone
Artemus Anticline
Palinspastic Pine Mountain Thrust Fault Gap
Middlesboro Syncline
Rocky Face Fault
Middlesboro Structure
10 miles
16 km
Jacksboro Fault
Cumberland Plateau Thrust
Peavine Mtn. Ant.
Sequatchie Valley Ant.