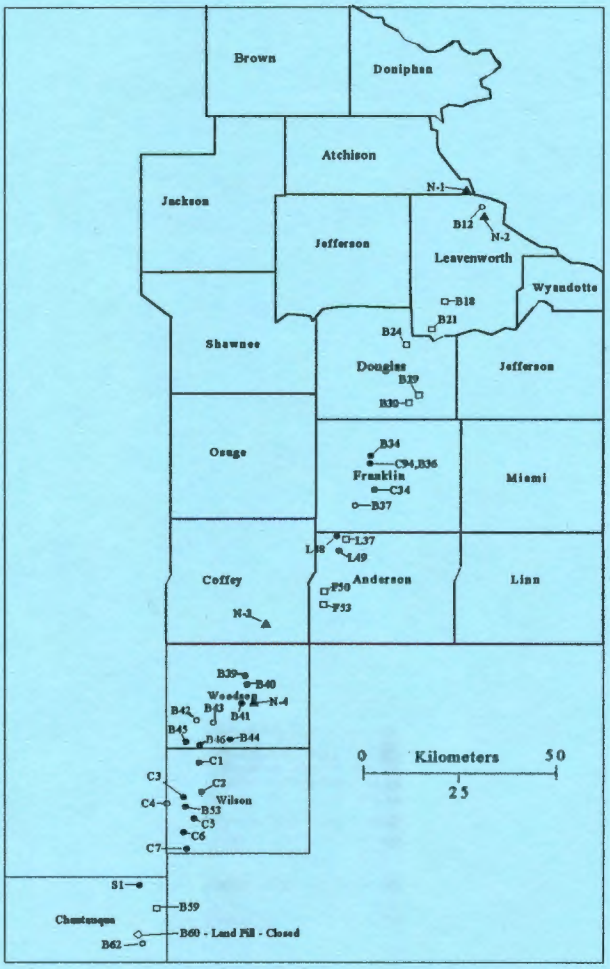
Haskell Limestone Member (Stephanian);

in Eastern Kansas



□ Haskell observed with myalinids
● Haskell observed
○ Haskell not found
▲ New localities with myalinids

B - Locality of Ball 1985
F - Locality of Fishburn 1962
S - Locality of Van Buskirk 1986
L - Locality of Linebeck 1961

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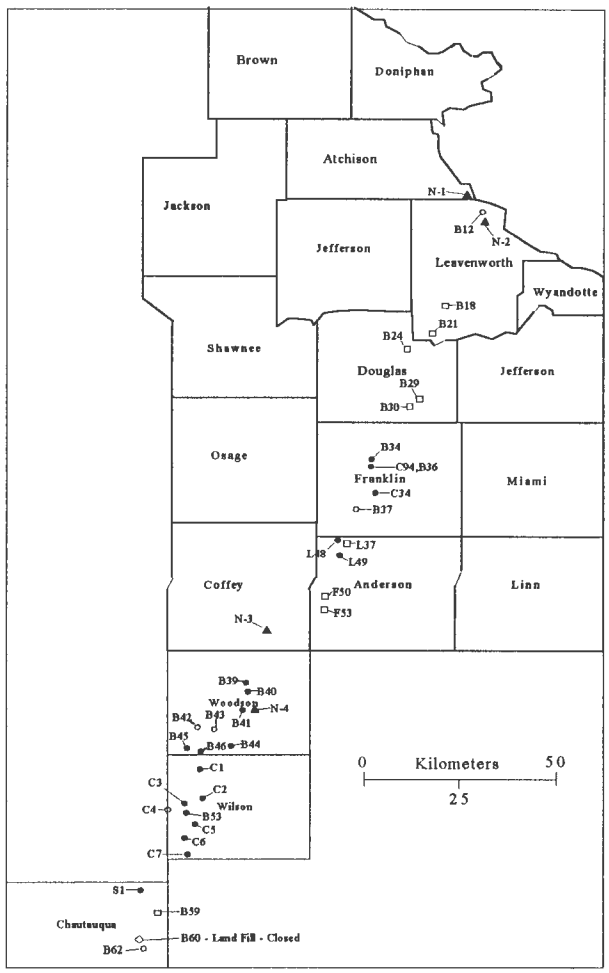
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Abstract: Widespread deformation of the southern United States occurred during the Stephanian. Convergent plate boundaries existed between North America, South America, and Africa. Subsidence of the "Haskell" basin provided accommodation space for thick siliciclastic deposits to the south. The most important tectonic elements affecting the "Haskell" depositional basin were the Ozark Dome to the east, the Ouachita Mountains and Arbuckle Uplift to the south, and Siouxia to the north. These areas provided significant amounts of siliciclastics to the "Haskell" depositional basin.

The Haskell is a transgressive limestone deposited in a relatively high energy, shallow marine basin extending from Nebraska to Oklahoma. Four major facies can be recognized in surface exposures of the Haskell: shoreward, open marine, algal mound, and siliciclastic.

North America migrated from the southern hemisphere into an equatorial position during the Stephanian. The equatorial position of the "Haskell" depositional basin is partially responsible for the types and amounts of sediment deposited during the interval referred to as Vinland-Haskell-Robbins. When the climate lithofacies model of Archer and West (1993) is applied to the Vinland-Haskell-Robbins interval, variations from monsoonal/tropical-rainy to "humid" wet-dry seasonal climatic conditions can be recognized.

The Haskell thins to the north as the shoreward facies becomes flaggy and onlaps the craton. Deposits in Franklin, Anderson, and Woodson counties represent the open marine facies of the Haskell, possibly the deepest and most marine deposits. In Wilson and Chautauqua counties, the Haskell represents shallow water deposits in the algal mound facies. Siliciclastic facies (shallow water deposits) dominate in Oklahoma, near the southern source areas.

INTRODUCTION

The Haskell limestone (Figure 1) of the Douglas Group has been interpreted as a transgressive limestone in the Kansas cyclothem model of the mid-continent (Heckel, 1977). It was deposited in a relatively high energy, equatorial, shallow marine depositional basin extending from Nebraska to Oklahoma (Ball,1985; Scotese and Golonka,1992).

During the Stephanian, Kansas was tectonically unstable as a result of the collision of North America with both South America and Africa (Rascoe and Alder, 1983). This caused tectono-eustacy created by reactivation of pre-existing faults and the formation of new faults. Positive tectonic elements present during the Stephanian include: Nemaha Anticline, Ozark Dome, Arbuckle Uplift, Ouachita Mountains, and Siouxia.

A reasonable modern analog for the depositional basin of the Haskell is the Selat Karimata Basin in Indonesia. The inferred latitudinal position, orographic features, basin geometry and tectonic setting of the "Haskell" basin are similar to those of the Selat Karimata Basin.

The purpose of this paper is to review variables influencing deposition of the Haskell limestone. Identification of basinal facies, relative depth, relative energy, and source areas for sedimentation in the basin plays an important role in evaluating the Haskell Limestone Member.

TECTONIC FRAMEWORK OF THE MID-CONTINENT

Active Structures

The Stephanian was a time of tectonic instability and crustal disturbance: the Bourbon Arch, Nemaha Anticline, and Ouachita Mountains were active during this time (Rascoe and Alders, 1983). Principal tectonic elements of the mid-continent can be seen in Figure 2.

The Bourbon Arch was actively being uplifted during the Stephanian (McKee and Crosby, 1975). Although the arch represented a positive tectonic element, based on our observations of the Haskell and the under and overlying strata, it did not effectively separate the "Haskell" basin. Sedimentary units deposited during the Stephanian lie conformably on the arch; suggesting that the

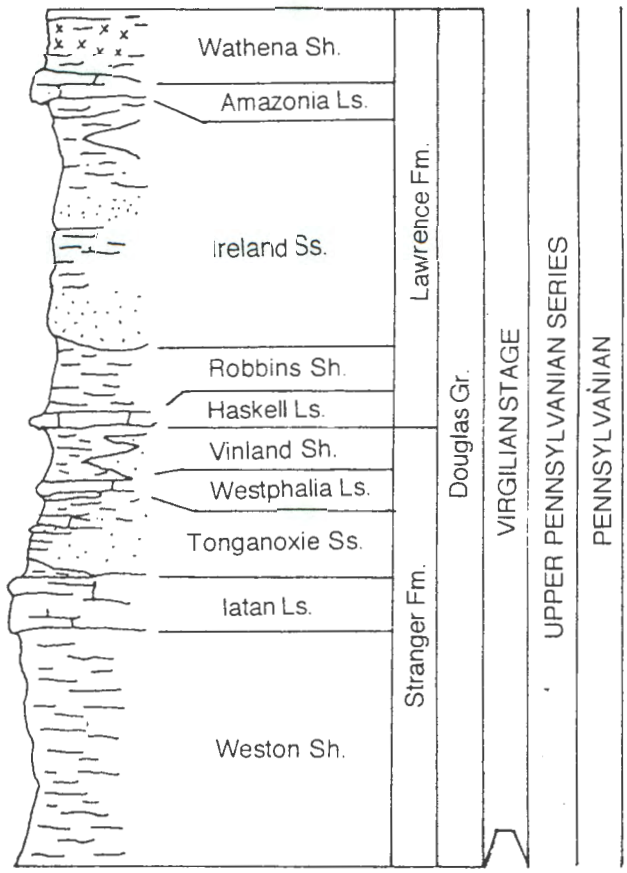


Figure 1.-- Schematic Stratigraphic Column of the Douglas Group (after Ball, 1985).

impact of the arch on sedimentation was negligible.

The Nemaha Anticline was active during the Westphalian (Rascoe and Alders, 1983). According to Eardley (1951, p. 52) "Structural relief is 3600 feet in the central part of the range, and the east flank is so steep and straight that a block fault movement has been visualized. The range was eroded rapidly so that the Pennsylvanian strata, partly derived from the range itself, encroached on its flanks and, together with much exotic material perhaps in part from the early Ouachitas, finally buried the range." The amount of relief invariably caused subsidence on the edges of the anticline and provided a low area for sediment accumulation. Movement on the anticline has been suggested to have occurred by reactivation of Precambrian faults associated with the Mid-Continent Rift System (Chelikowsky, 1972).

The Ouachita Mountains were active from the Westphalian to Stephanian, but had a long evolutionary history (Figure 3). Extension along the southern margin of North America occurred from Upper Precambrian to Tournaisian (Viele and Thomas, 1989). Compression existed throughout the Carboniferous, with first indications of uplift and erosion during the Westphalian (Viele and Thomas, 1989). The Ouachita Mountains then became a major contributor of siliciclastics to the "Haskell" basin.

Eustatic sea level changes in the Arkoma Basin were caused by two main processes, thermal subsidence and isostatic adjustment. Cooling of igneous rocks caused contraction and subsidence in the Arkoma Basin (Viele and Thomas, 1989). This

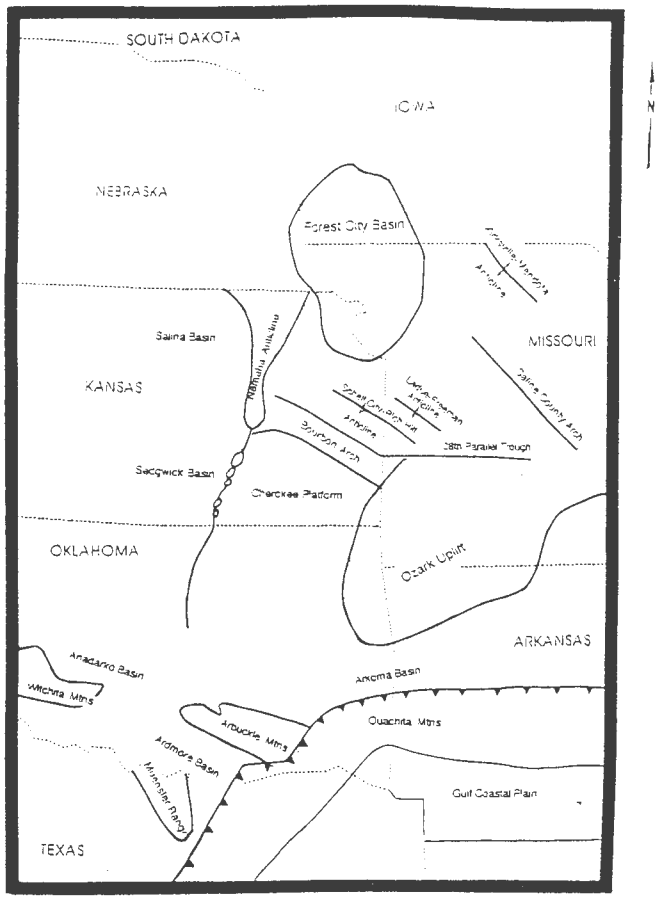


Figure 2.-- Tectonic Map of the Mid-Continent (modified from Rascoe and Alder, 1983).

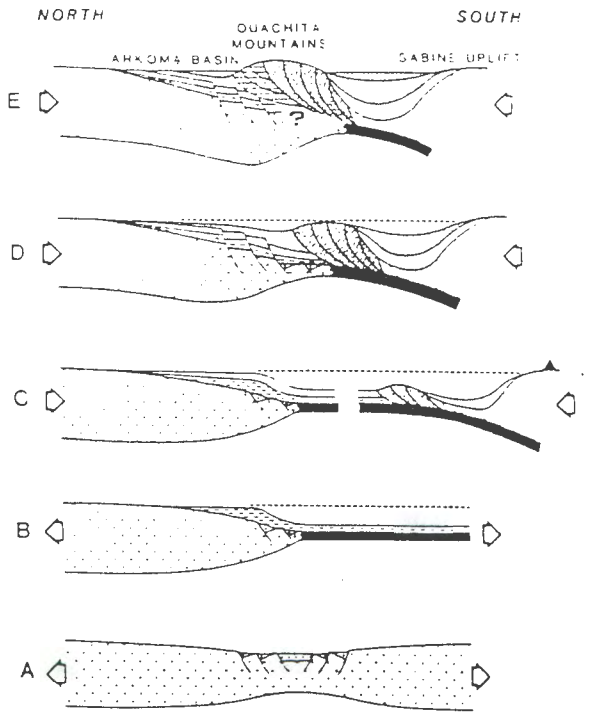


Figure 3.-- Schematic Cross-Section showing the Tectonic Development of the Southern Margin of North America and Ouachita Belt. A) Upper Precambrian - earliest Paleozoic, B) Upper Cambrian-Tournaisian, C) Tournaisian-Lower Westphalian, D) Westphalian, E) Upper Westphalian-Stephanian (after Viele and Thomas, 1989).

subsidence created new accommodation space for sediments and caused a sea level lowering. More important to the cause of tectono-eustacy were isostatic adjustments. These were caused by sediment loading periodically reactivating faults under the Arkoma Basin (Denison, 1989) (Figure 3-E).

Movement in the Arbuckle Uplift began in the Westphalian with intense deformation in the Upper Westphalian continuing through the Stephanian (Denison, 1989). In this area, subsidence was caused by thermal contraction and isostatic adjustment to form the Anadarko Basin (Viele and Thomas, 1989). Erosion of the uplifted region provided sediments to the southern part of the "Haskell" basin, but little or none to the northern "Haskell" basin (Denison, 1989).

The Wichita Uplift, separating the Anadarko Basin to the north from the Ardmore Basin to the south, became active in the Lower Carboniferous and underwent active uplift and erosion in the Namurian (Viele and Thomas, 1989). The area was again reactivated from the Upper Westphalian to Lower Stephanian (Viele and Thomas, 1989). It provided sediments to both the Anadarko (southwestern "Haskell" basin) and Ardmore Basins with no significant influence on the Arkoma Basin (southeastern "Haskell" basin) (Viele and Thomas, 1989).

The Muenster Range was active in the Stephanian and is located south of the Wichita Uplift (McKee and Crosby, 1975). Although it was a positive feature during this time, its relative position (Figure 2) makes it an unlikely source of sediment for the "Haskell" depositional basin.

Pre-existing Structures

In association with the active structures of the mid-continent, many pre-existing structures were present. These pre-existing structures were a potential source of sediment, as well as accommodation zones for sediment accumulation due to subsidence.

The Ozark Dome was active during the Namurian and underwent very minimal post-Namurian deformation (McKee and Crosby, 1975). During the Upper Stephanian the Ozark Dome was a topographic high. Due to the sheer size and elevation of the dome it is probable that it was a source of sediment to the surrounding low lying areas.

The Missouri Platform, uplifted during the Namurian, was a broad topographic high (Eardley, 1951). Miscellaneous anticlines in Missouri, associated with the uplift of the platform, occur on its flanks (Eardley, 1951). Uplift of these areas are thought to have occurred along pre-existing fault systems which were developed in the Proterozoic basement rocks during the accretion of the mid-continent; all have a similar structural trend, northwest-southeast according to Berendsen and Blair (1986). The amount of detritus from these areas was most likely minimal.

The Cherokee Platform, formed in the Namurian, actively subsided in the Stephanian to become the Cherokee Basin (McKee and Crosby, 1975). The platform provided a topographic low for sediment accumulation and contributed a minimal amount of detritus to the "Haskell" basin.

Siouxia was formed in the Precambrian as part of the stable craton. During the Stephanian it was a broad stable topographically high area, which contributed siliciclastics to surrounding low areas.

Upper Carboniferous Plate Tectonics

In an effort to better understand the structural geology and tectonics of the mid-continent during the Upper Carboniferous, an understanding of the plate interactions of the continents needs to be addressed.

Upper Carboniferous continental reconstruction is one of a convergent plate boundary between South America and Africa with North America (Figure 4).

During the Mid-Carboniferous the South American Plate was over-riding the North American Plate; however, by the Upper Carboniferous and Permian the subduction boundary changed to one of suturing between the plates (Condie, 1989). This suturing resulted in the Ouachita Orogeny, subsidence of the Arkoma Basin, and deformation of the Wichita Uplift and Nemaha Anticline (Rascoe and Alder, 1983). Collision of the plates resulted in overall crustal instability during the Upper Carboniferous which reactivated many ancient fault systems and created new fault systems (Condie, 1989).

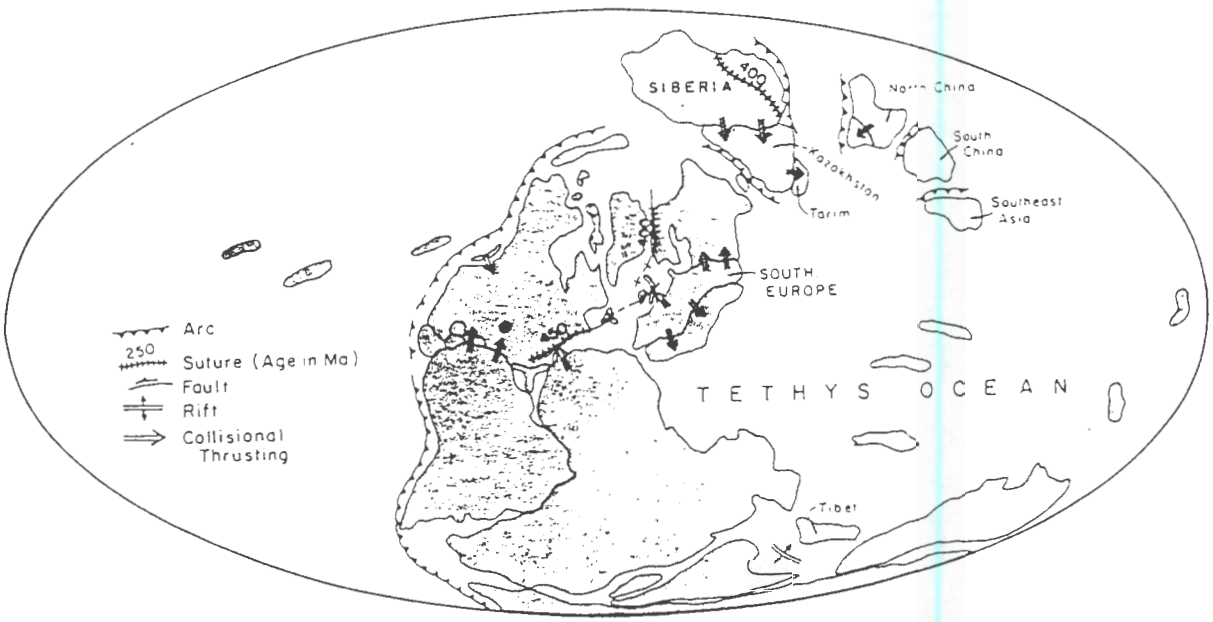
Structural Influence on Sedimentation

The structure contour map on the top of the Lansing Group (Figure 5) shows the general northwest dip in eastern Kansas, with elevations ranging from 244 meters to -305 meters (Merriam, 1963). Apart from this general trend, the southwestern part of the study area shows a change in dip to the southwest with elevations ranging from -183 meters to -640 meters (Merriam, 1963).

When comparing the isopach maps of the Lansing Group (Figure 6) and the Douglas-Pedee Groups (Figure 7), it can be seen that both groups thicken in the southern part of the study area. This thickening is in the areas of the Cherokee and Sedgwick Basins, which implies greater accommodation space for sediment. These depositional basins could be an extension of the same tectonic environment that created the Arkoma Basin (Viele and Thomas, 1989). The trend (thickening to the south) can also be seen in younger strata of the Shawnee Group (Figure 8).

DEPOSITIONAL SETTING

The Haskell limestone (and coeval strata) was deposited in a relatively high energy, shallow marine (within the photic zone), equatorial basin extending from Oklahoma to Nebraska (Ball, 1985; Scotese and Golonka, 1992). Siouxia, Ouachita



● - Approximate location of Kansas

Figure 4.-- Continental Reconstruction for the Upper Carboniferous (after Condie, 1989).

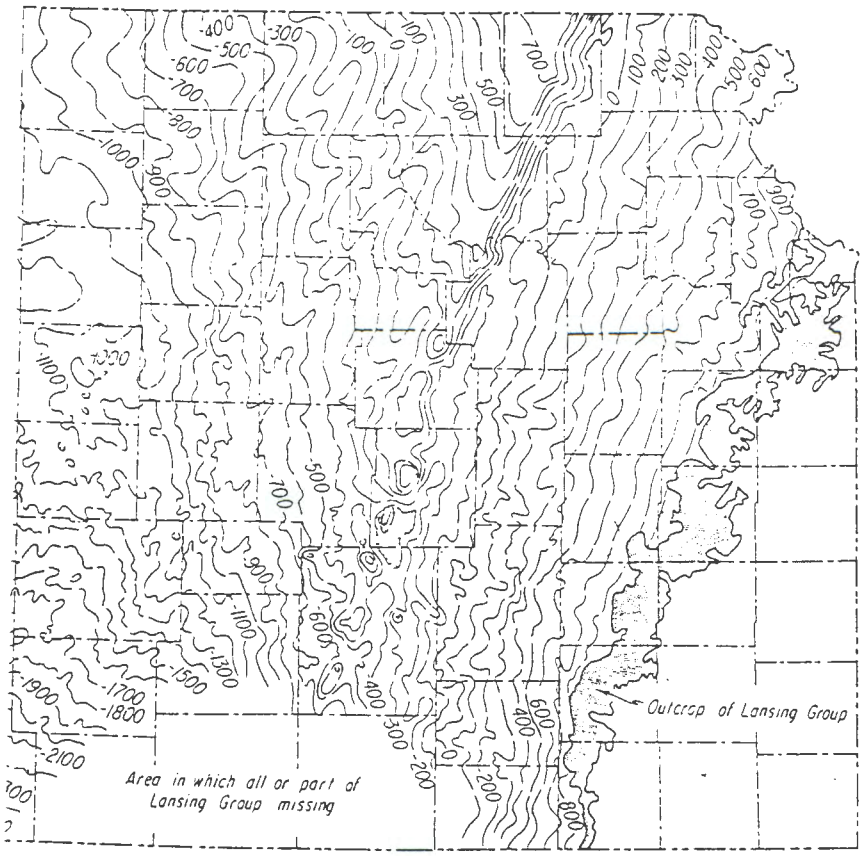


Figure 5.-- Structural Contour Map at the top of the Lansing Group in Eastern Kansas. Stippled area indicates outcrop (after Merriam, 1963).

Mountains, Arbuckle Uplift, and Ozark Dome (Figure 9) were the primary source areas that supplied siliciclastics to the "Haskell" depositional basin (Ball, 1985; Archer et al, 1994). The Ouachita Mountains and Arbuckle Uplift supplied siliciclastics to the southern part of the depositional basin. Siouxia is a possible source area of siliciclastics for the northern and central part of the basin. Siliciclastics were also possibly shed to the north, central, and southern parts of the "Haskell" depositional basin from the Ozark Dome.

During the Stephanian, sedimentation rates nearly equaled rates of accommodation maintaining a shallow marine environment. Myalinids, grainstones (with osagid coated grains), and algal mound facies support the interpretation of a shallow water basin during deposition of the Haskell limestone (Ball, 1985; Van Buskirk, 1986).

The boundary between the Vinland shale and lower Haskell limestone is gradational, reflecting greater siliciclastic input than during deposition of the upper part of the Haskell limestone. Input of siliciclastics from the south and east slowed dramatically during deposition of the upper part of the Haskell limestone, resulting in "cleaner" carbonate deposition (Ball, 1985).

Four major facies (Figure 10) have been identified in the Kansas cyclothem model of the mid-continent: shoreward (abundant osagid coated grainstones), open marine (fossiliferous wackestones), algal mound (algal build-up), and siliciclastic facies (fossiliferous mudrocks). Each of these facies can be recognized in surface exposures of the Haskell limestone in eastern Kansas . An isopach map of the Douglas Group (Figure 11) demonstrates a southern thickening and thinning to the north. The Haskell limestone thickens to the south

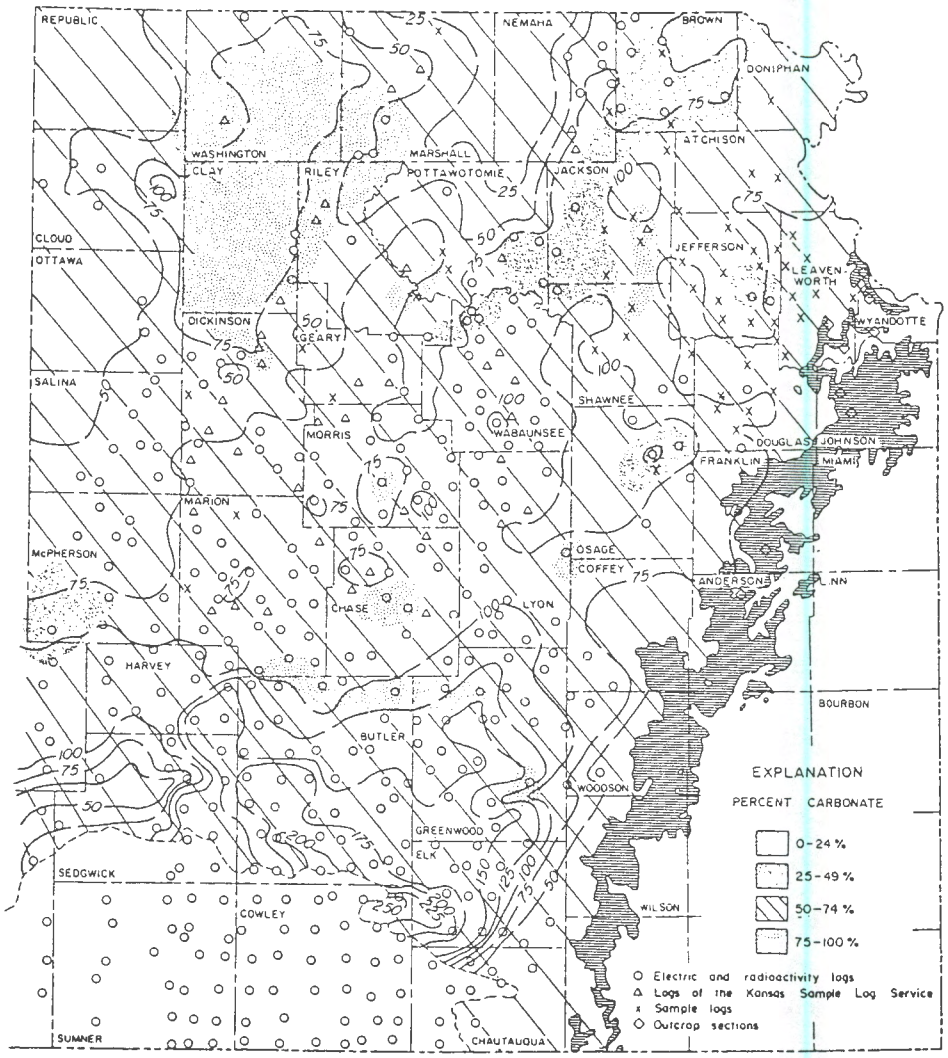


Figure 6.-- Isopach and Percent Carbonate Map of the Lansing Group in Eastern Kansas. Ruled area indicates outcrop (after Merriam, 1963).

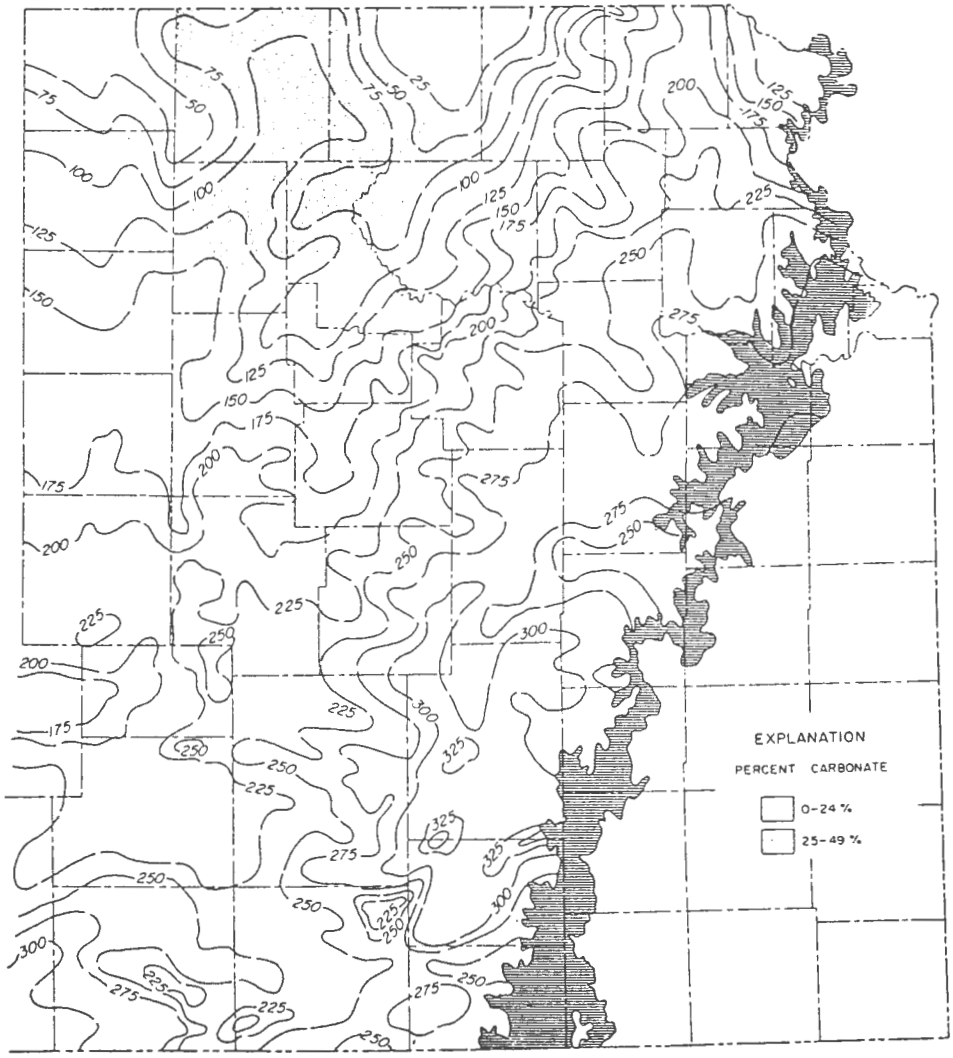


Figure 7.-- Isopach and Percent Carbonate Map of the Douglas-Pedee Groups in Eastern Kansas. Ruled area indicates outcrop (after Merriam, 1963).

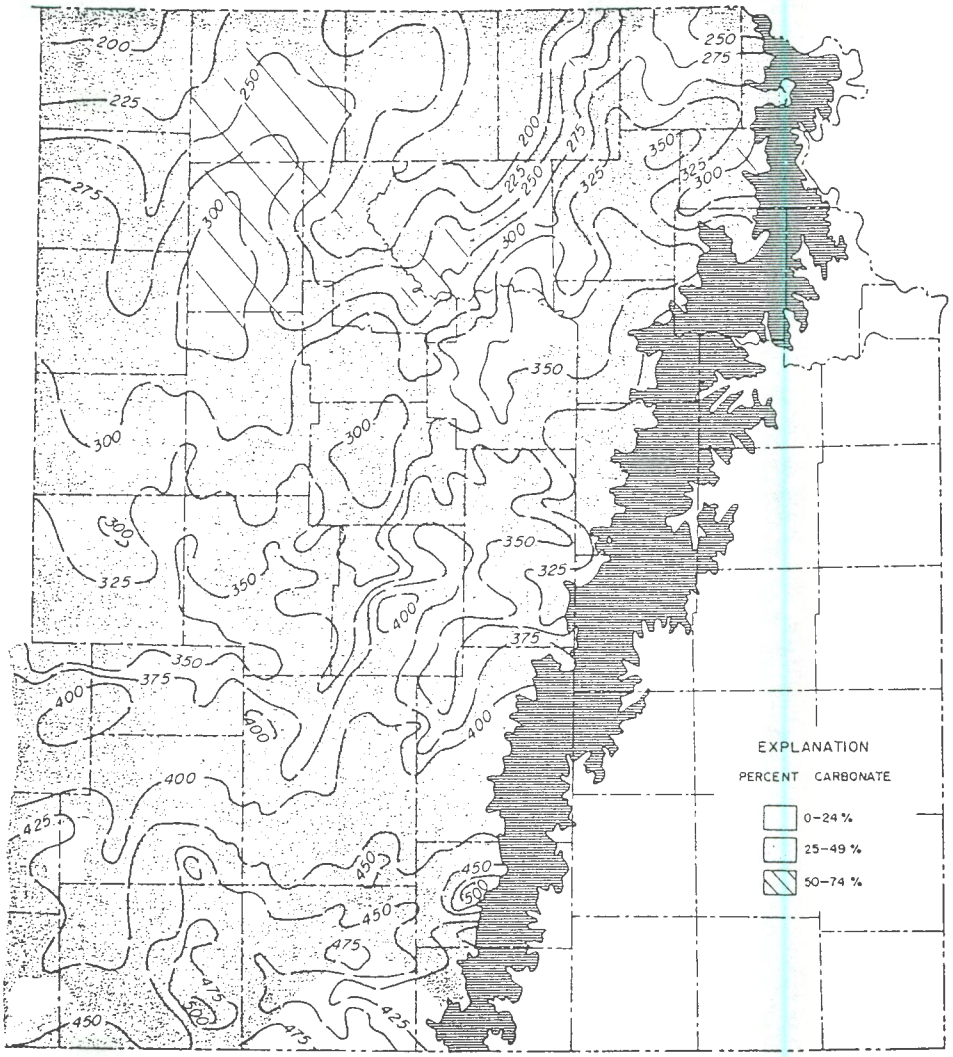


Figure 8.-- Isopach and Percent Carbonate Map of the Shawnee Group in Eastern Kansas. Ruled area indicates outcrop (after Merriam, 1963).

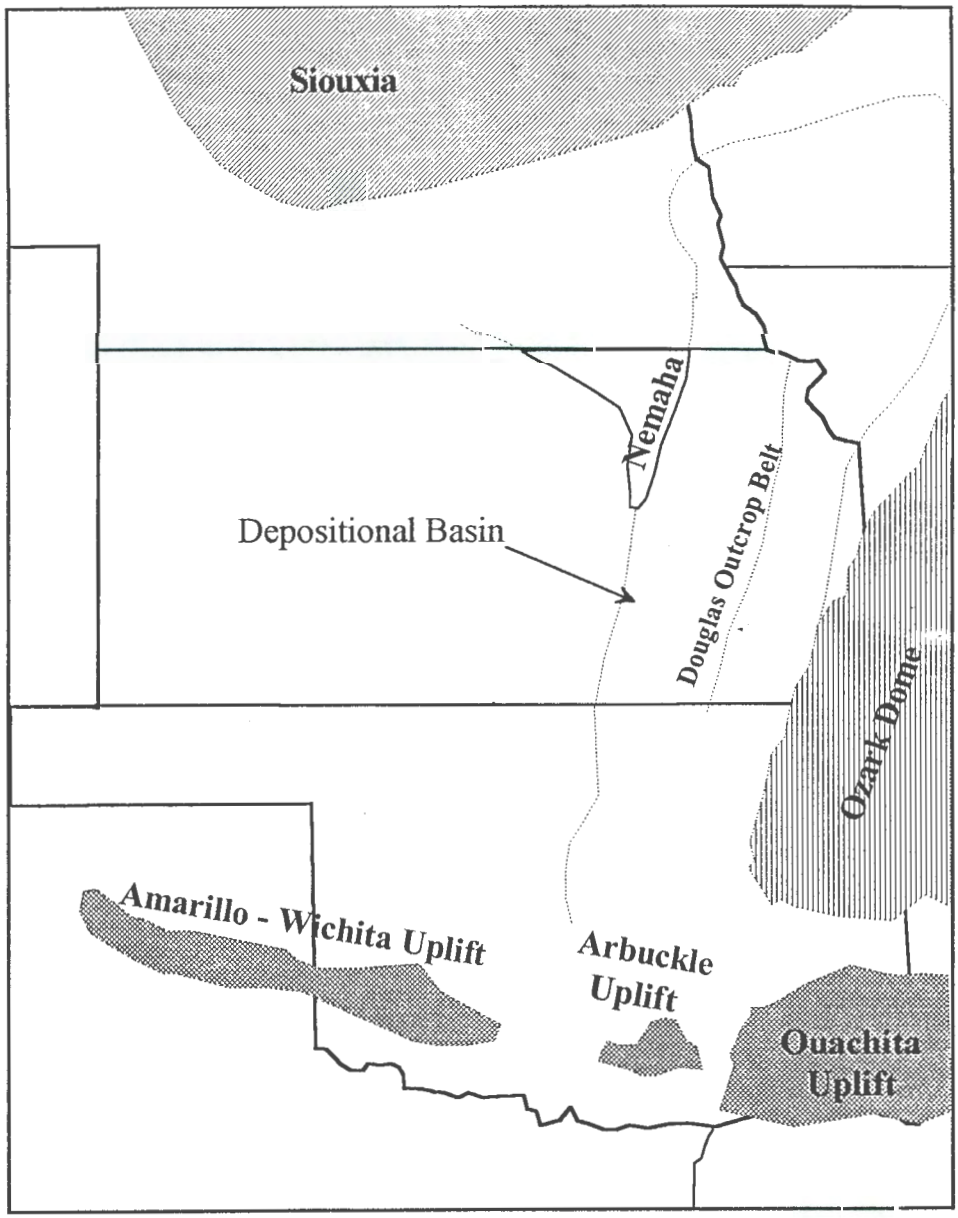


Figure 9.-- Possible Source Areas of Siliciclastics in the Haskell Limestone Member (after Mathews, 1978).

due to: 1) algal mound build-up and 2) greater siliciclastic influx. Osagid coated myalinid valves in Chautauqua and Woodson counties suggests shallow water depth (within the photic zone and wave base). In the north, the Haskell is thin, flaggy, and onlaps the craton, supporting a shallow, nearshore environment. Possibly the deepest and most marine deposits are located near the middle of the basin, and are represented by fossiliferous wackestones.
Evidence supporting this basin topography is: 1) the Haskell becomes flaggy in the north as it onlaps, 2) the Haskell grades into thick siliciclastic lithologies in the south, 3) the occurrence of algal mounds in the south, 4) the encrusting of myalinid valves by an osagid coating on all sides, in southeast Kansas, 5) that, in the central area, the Haskell is a dense, hard, fossiliferous wackestone.

PALEOGEOGRAPHIC SETTING

During the Middle to Upper Carboniferous, the North American continent was migrating north from the southern hemisphere. This migration resulted in a paleogeographic location of Kansas within three degrees of the paleoequator during the Stephanian (Figure 12). The latitudinal position of the depositional basin (during Haskell deposition) suggests climatic constraints for the types and amounts of accumulated sediment (Cecil, 1990).

The intertropical convergence zone is the primary control of climate at the equator. It is a narrow band of constant rainfall that, at present, migrates across the equator. The air circulation patterns of the earth cause different climatic conditions at different latitudes on the earth's surface (Figure 13). At the equator, air is warmed which causes it to rise and become less dense. This decreases the air's ability to hold moisture causing it to rain heavily along the intertropical convergence zone. As the warm air rises it migrates north and south to 30 degrees latitude where it cools and sinks back toward the earth's surface. The cool dry air then moves back toward the equator and collects moisture along the way, creating an arid environment between 10 to 30 degrees north and south latitudes (Stowe,1979).

MODERN ANALOG

Climatic Setting of Selat Karimata

Latitudinal position, orographic features, basin size, and approximate basinal depth are variables that were used in identifying potential modern analogs. The modern basin of the Selat Karimata area (Figure 14), separating Sumatra and Malaysia, was chosen as a modern analog because both the "Haskell" basin and Selat Karimata Basin have: 1) similar latitudinal positions, 2) similar orographic features, 3) similar basin width, 4) shallow depth (150 m), and 5) similar tectonic setting (Figure 15).

Gastaldo and Huc (1992) studied modern sediment facies in Kalimantan, Indonesia. The modern facies that were studied near the Mahakam River Delta located between 0^0 21' and 1^0 10' South Latitude (Figure 14). Deltaic sedimentation began in the Middle Miocene and continues today (Gastaldo and Huc, 1992). Data obtained from vibracores was used to recognize ten lithofacies: (1) bioclastic sand, (2) massive-bedded sand, (3) sand-mud couplets, (4) bioturbated sand-mud couplets, (5) mud with sand laminae, (6) tan-gray silt-mud couplets, (7) sandy mud, (8) grayblack mud, (9) organic rich mud, and (10) peat (Gastaldo and Huc, 1992).

Archer and West (1993) modified Cecil's (1990) generalized climate curve to create a climate-lithofacies model (CLFM) (Figure 16). The CLFM model assigns ranks to lithofacies and the inferred climatic conditions associated with their production. Using the climate-lithofacies model and applying it to the sediment facies in Kalimantan, Indonesia, we

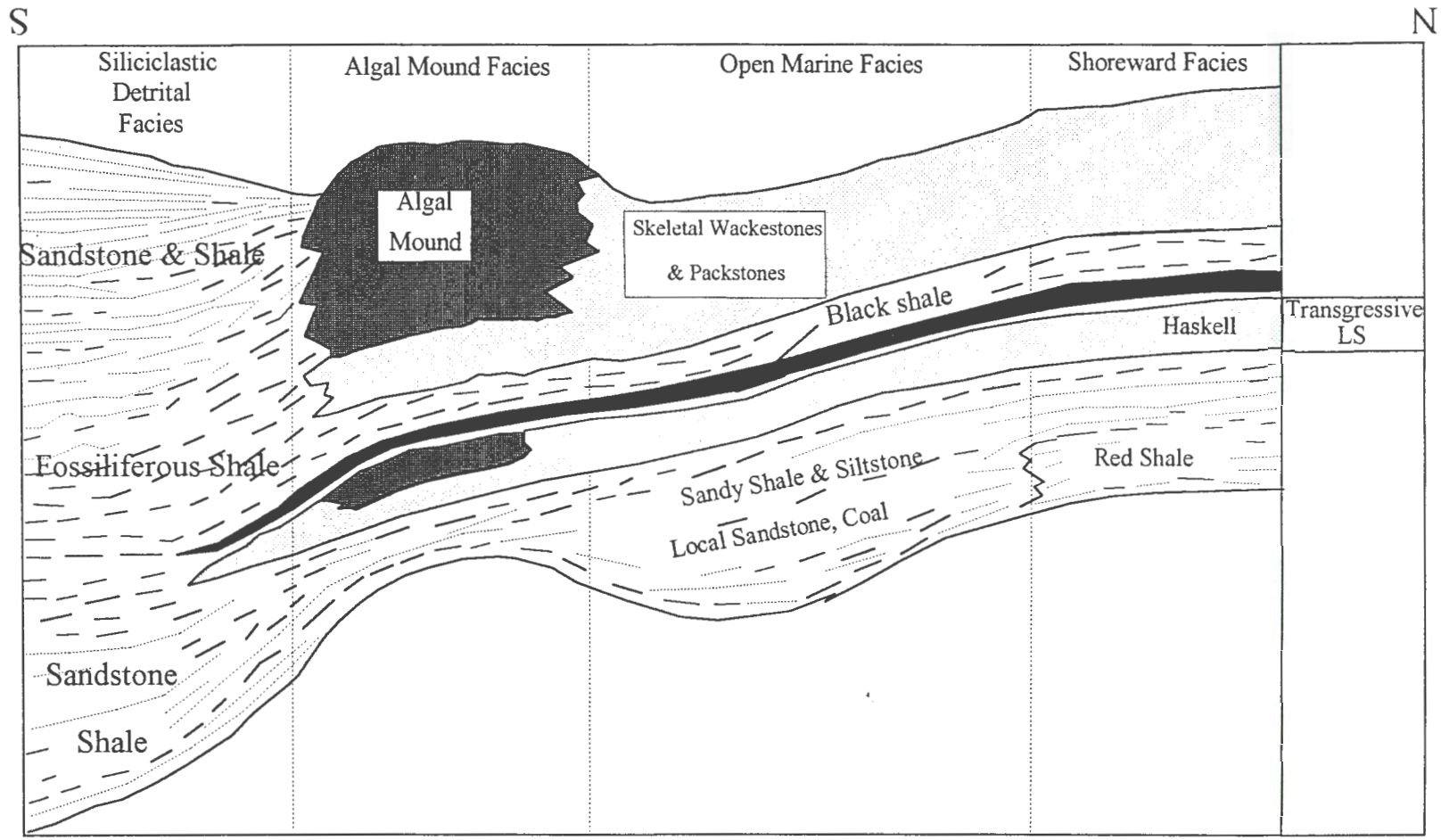


Figure 10.-- Schematic of Basinal Facies that can be recognized in the Haskell Limestone Member (modified from Heckel, 1977).

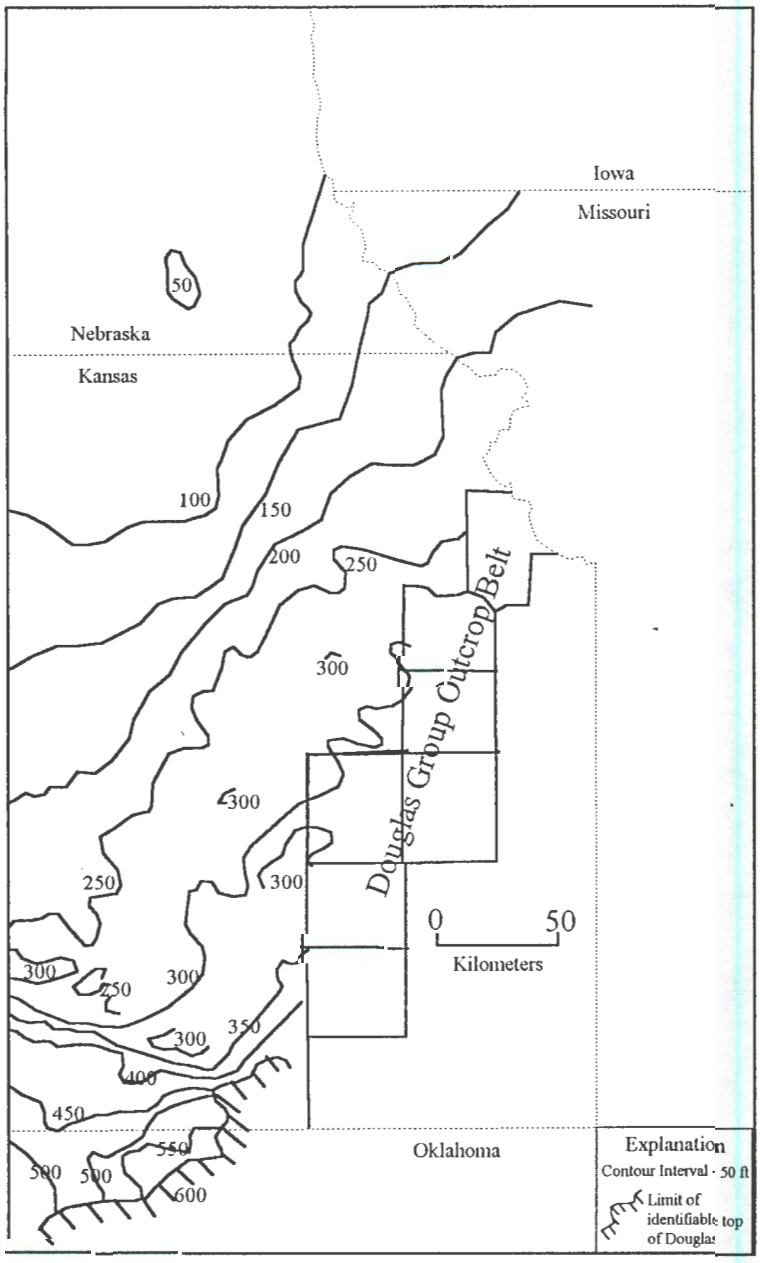


Figure 11.-- Isopach Map of the Douglas Group (after Ball, 1985).

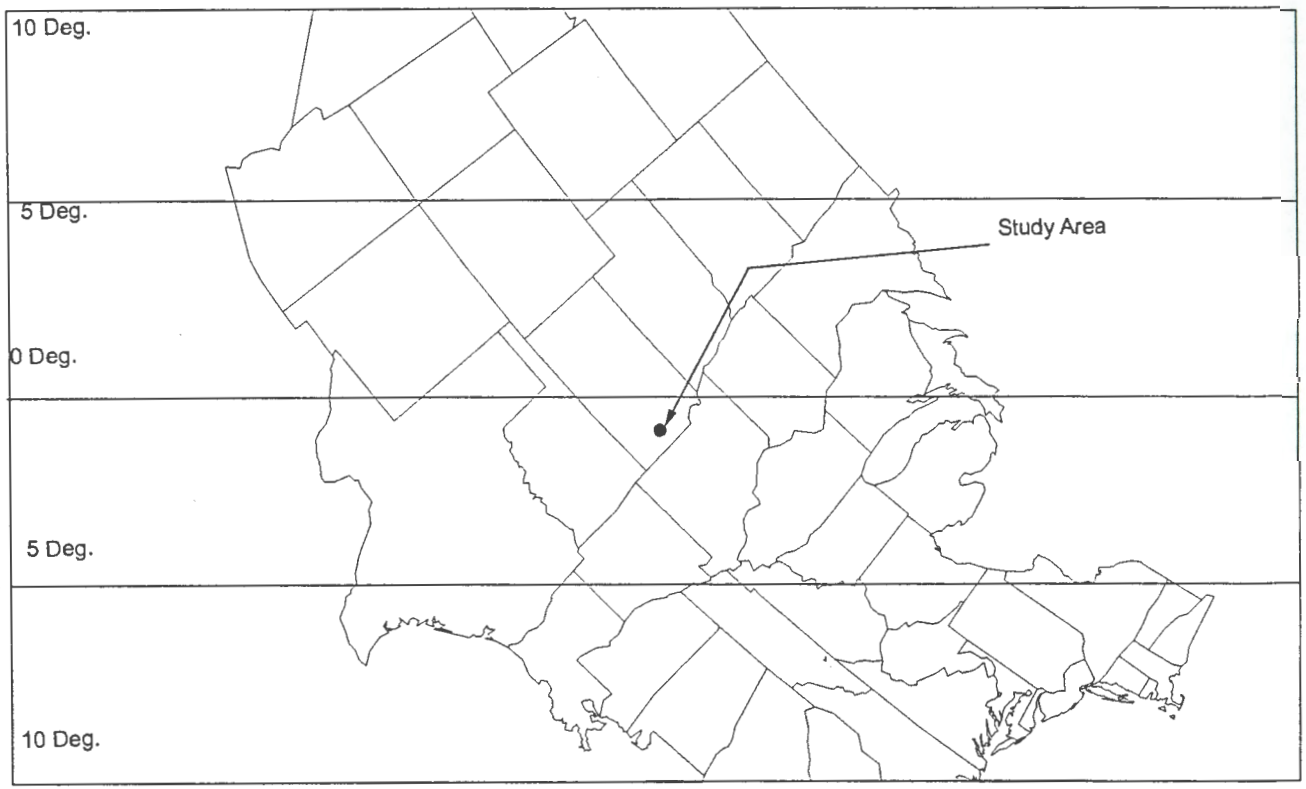


Figure 12.-- Paleogeographic Location of Kansas during the Stephanian (modified from Scotese and Golonka, 1992).

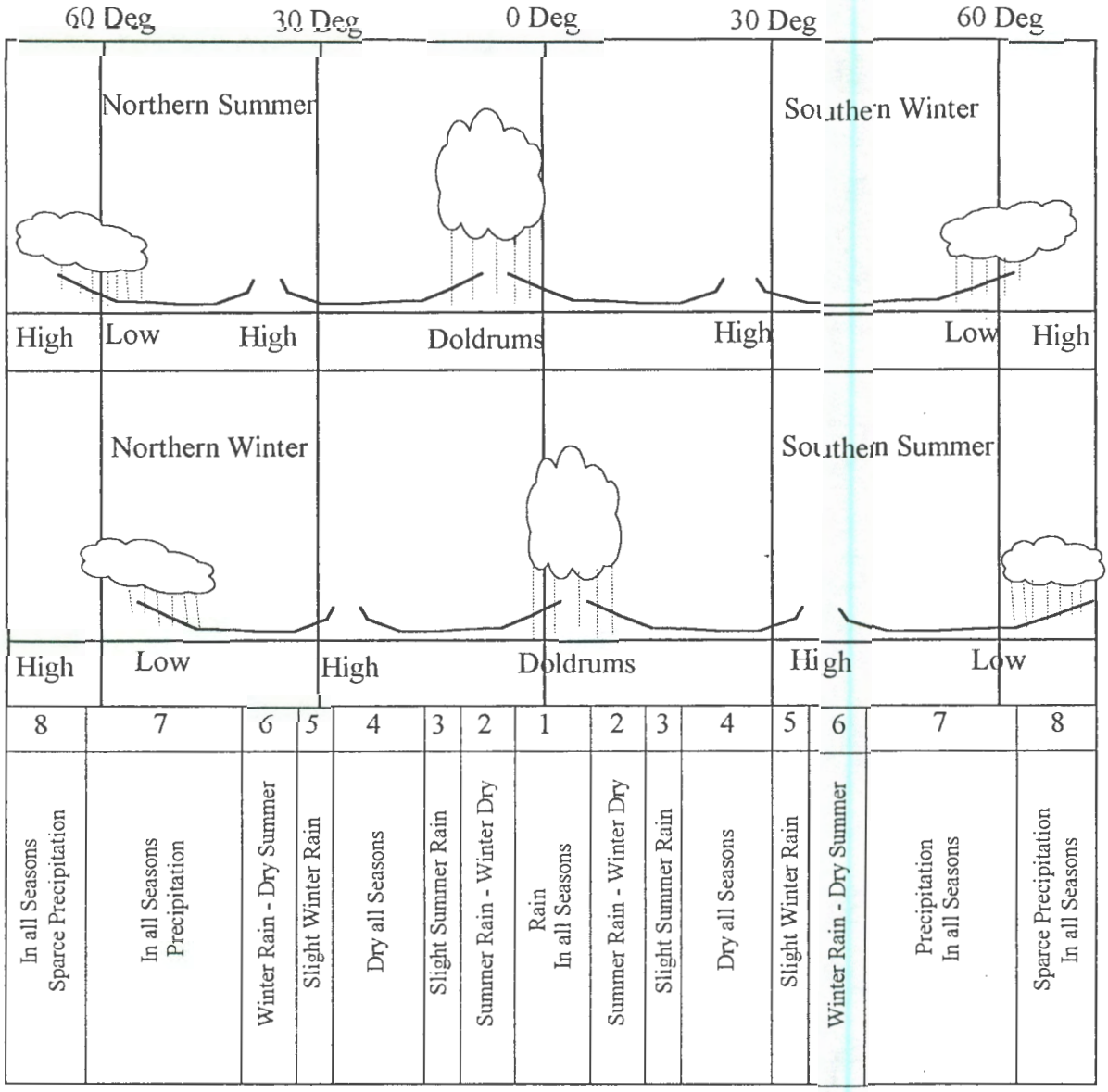


Figure 13.-- Modern Fluctuation in the Intertropical Convergence Zone (after Espenshake, 1986).

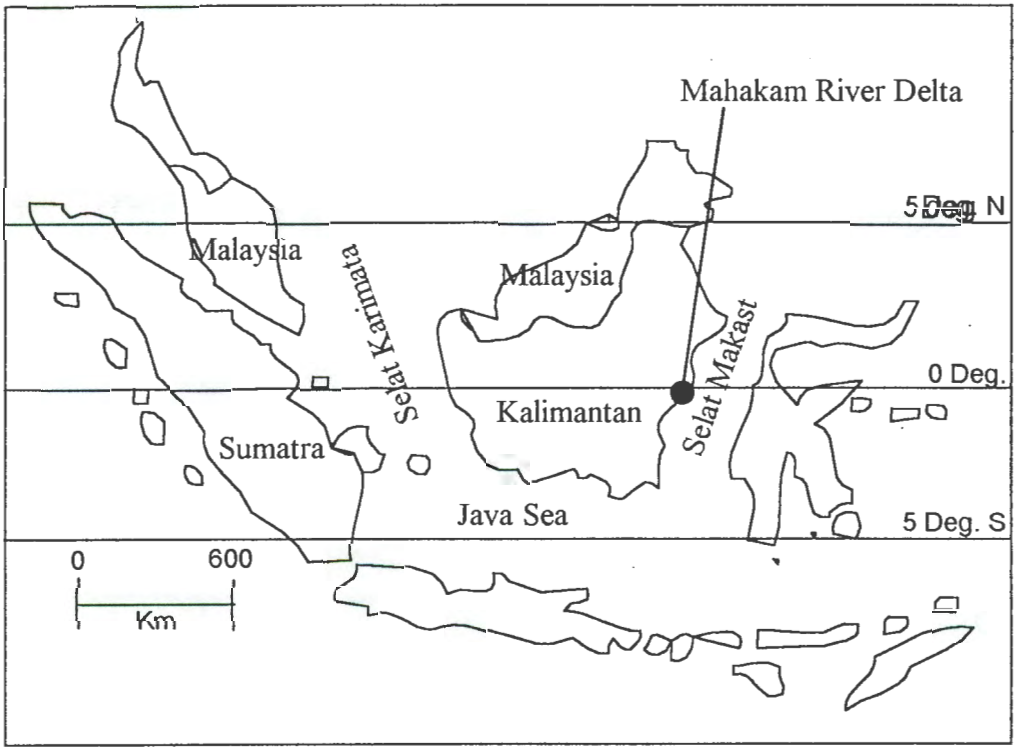


Figure 14.-- Location of Indonesia (after Espenshake, 1986).

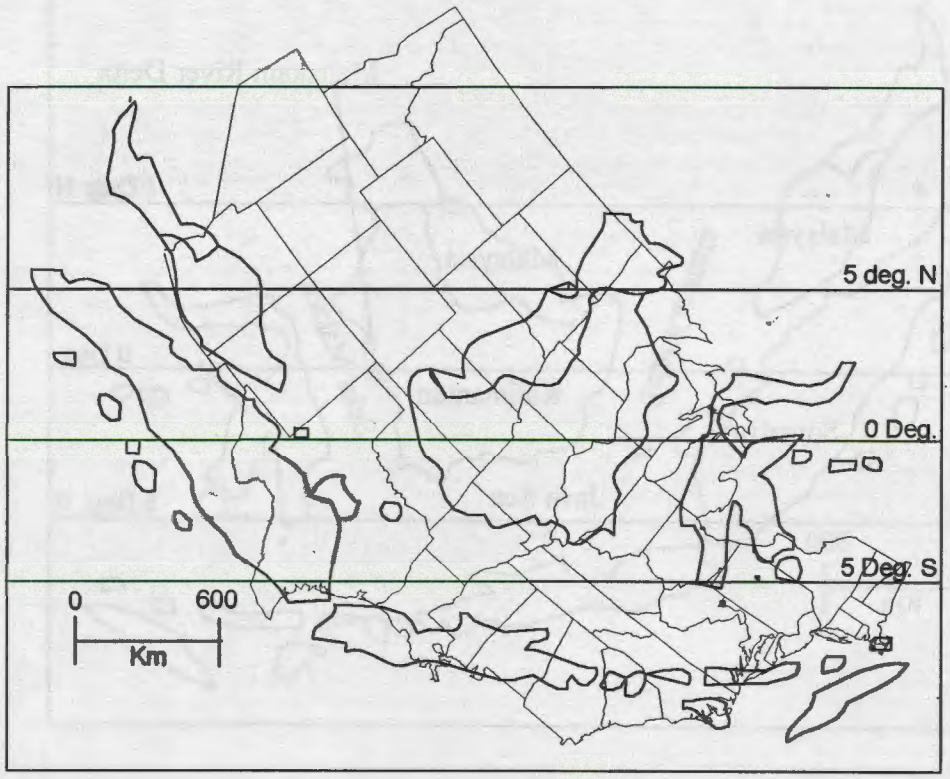


Figure 15.-- Paleogeographic Location of Kansas during the Stephanian (Modified from Scotese and Golonka, 1992) with overlay of Indonesia (Figure 14), both maps same scale.

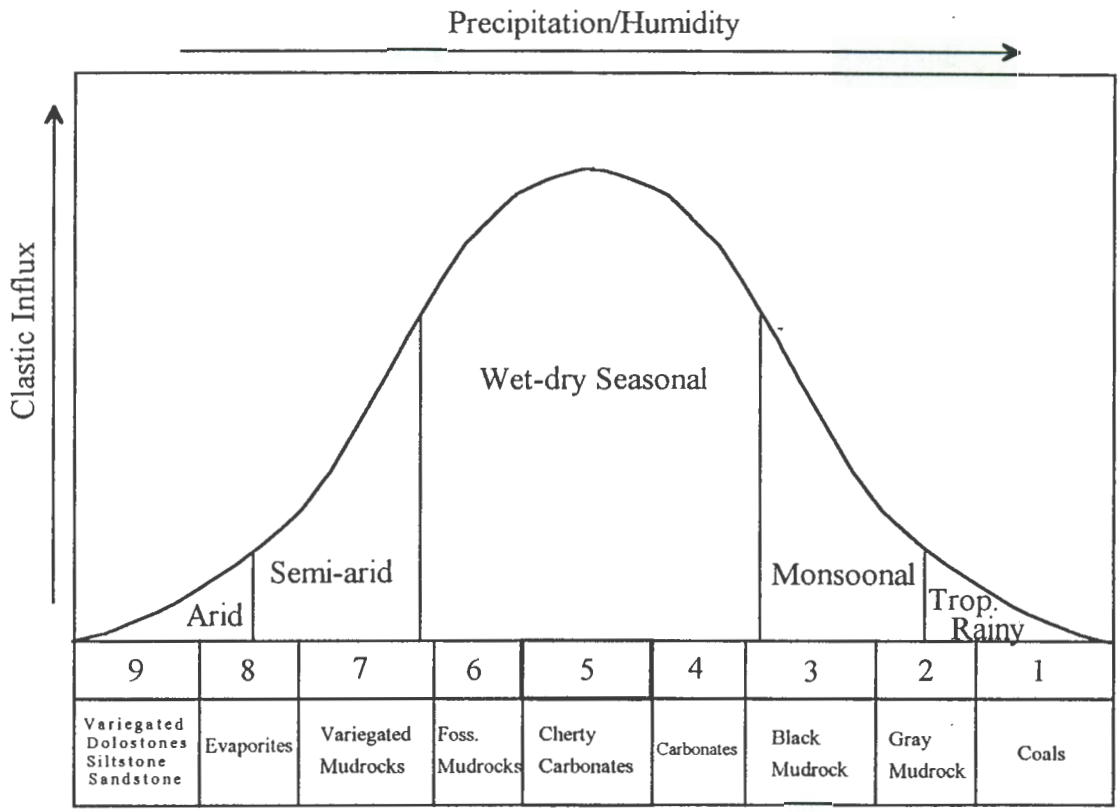


Figure 16.-- Climate Lithofacies Model (after Archer and West, 1993).

can predict that the climate is dominated by tropical-rainy weather (CLFM Rank 2) patterns with a minor tendency towards monsoonal climatic conditions.
In fact, it is located at the equator within the intertropical convergent zone. It has a tropical rainforest fauna with an average annual range in temperature of less than 3^0 celsius and receives over 1.02 meters of rain per year (Espenshake, 1986). The depositional climate for the Mahakam River Delta can be interpreted correctly using the climate-lithofacies model (Figure 16).

Applying this CLFM, the lithofacies ranks of the Vinland-Haskell-Robbins interval are 2, 4, and 3 respectively. The Vinland shale is a fossiliferous mudrock that is ranked "2" on the CLFM. This lithology represents sediment deposited during monsoonal to tropical-rainy climatic conditions. The Haskell limestone, with a diverse fossil assemblage and no chert, ranked "4". This CLFM rank indicates a swing from monsoonal/tropical-rainy conditions to "humid" wet-dry seasonal climatic conditions. This climatic shift, from more arid conditions reversed during deposition of the Robbins shale which is ranked "3", indicating a shift back to more humid climatic conditions. These codes represent climates dominated by wet-dry seasonal to monsoonal/tropical-rainy climatic conditions producing a spectrum of lithologies from black mudrocks to carbonates and fossiliferous mudrocks (gray mudrock of Archer and West, 1993).

Tectonic Setting of Indonesia

Climate and latitudinal position, as well as the tectonic setting of Indonesia is comparable to that of the mid-continent during the Upper Carboniferous. Both areas consist of a convergent plate boundary with associated island arc systems, including fore-arc and back-arc basins, and suture zones with related mountain building events (Condie, 1989; Letouzey et al, 1990).

Indonesia and associated islands are located on the Sunda platform just north of the Sunda volcanic arc (Figure 17) (Letouzey et al, 1990). Development of the linear Sunda volcanic arc is a result of the subduction of the Indian Ocean Plate beneath the Southeast Asian Plate (Letouzey et al, 1990). Figure 18 is a generalized structural cross-section of the eastern Sunda shelf inversions. The parallel features of the southern mid-continent during the Upper Carboniferous are inferred on cross-section A (Figure 17) to better illustrate the similiarities of the two regions.

Sumatra is a volcanic inner arc of which the Barisan Range forms the central part of the island (Paltrinieri et al, 1976). The Barisan Range separates the volcanic inner arc from the non-volcanic outer arc; represented by the islands of western Sumatra (Paltrinieri et al, 1976). A number of basins are associated with the arc system. They include the Northeast Sumatra Basin, Central Sumatra Basin, and the South Sumatra Basin (Paltrinieri et al, 1976). Separation of the basins is achieved by intervening mountain ranges, such as the Tigapuluh Mountains which separate the Central and South Sumatra Basins (Paltrinieri et al, 1976). The basins are a result of strike-slip tectonics and pull-apart geometry (Bellier and Sebrier, 1994). A similar structural configuration exists for Java. Deep back-arc basins exist north of the axial volcanic arc which forms Java (Paltrinieri et al, 1976).

The plate tectonic setting for both the southern mid-continent (during the Upper Carboniferous) and recent Indonesia is a convergent plate boundary. Similar orographic features, mountain ranges with intervening basins, exist for Indonesia and the lower mid-continent due to similar tectonic settings. As a result of these similarities, Indonesia should provide a reasonable modern analog to Upper Carboniferous units of the lower

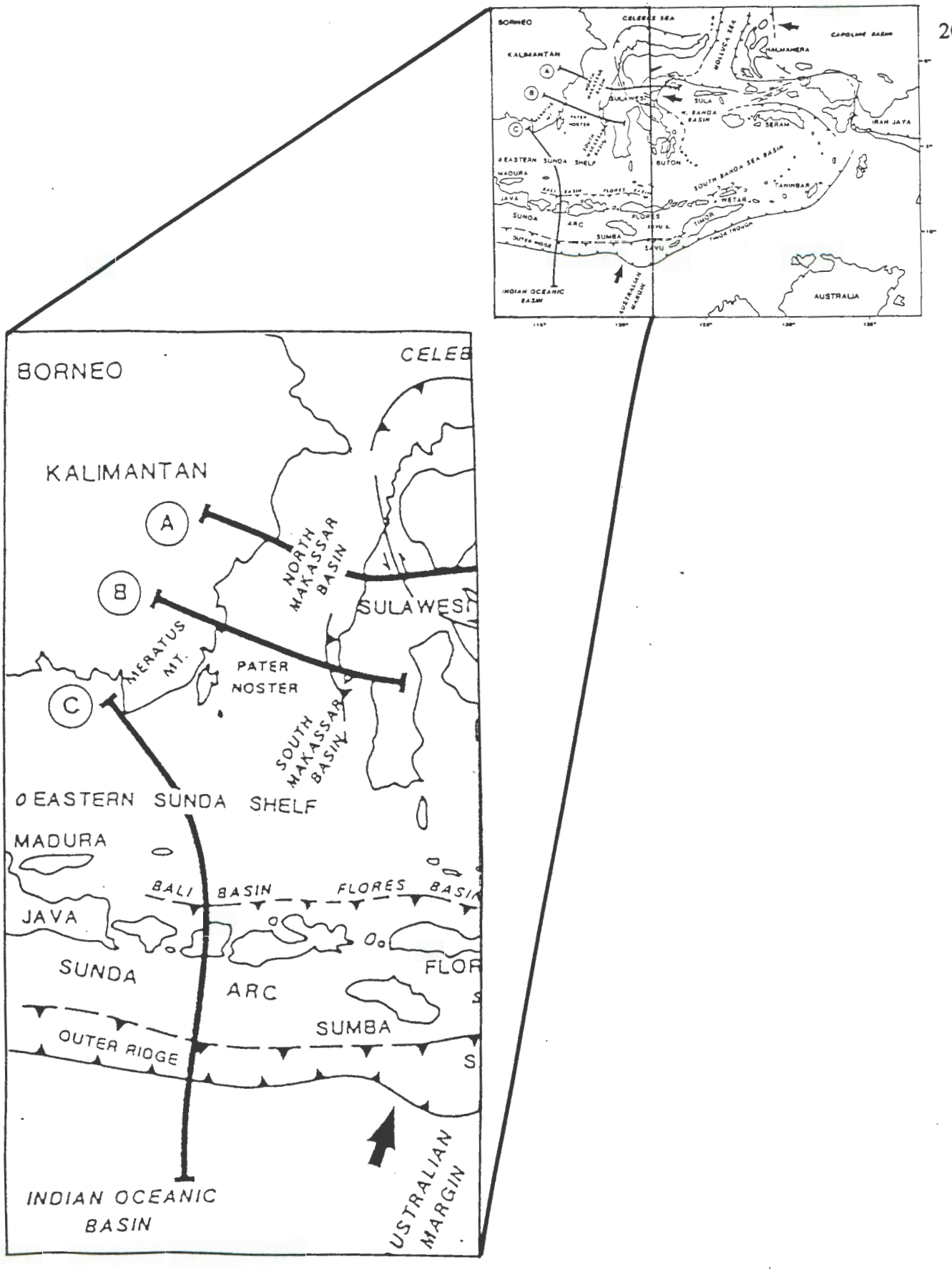


Figure 17.-- Map of Regional Structures: Eastern Sudan Shelf (Indonesia) (after Letouzey et al, 1990).

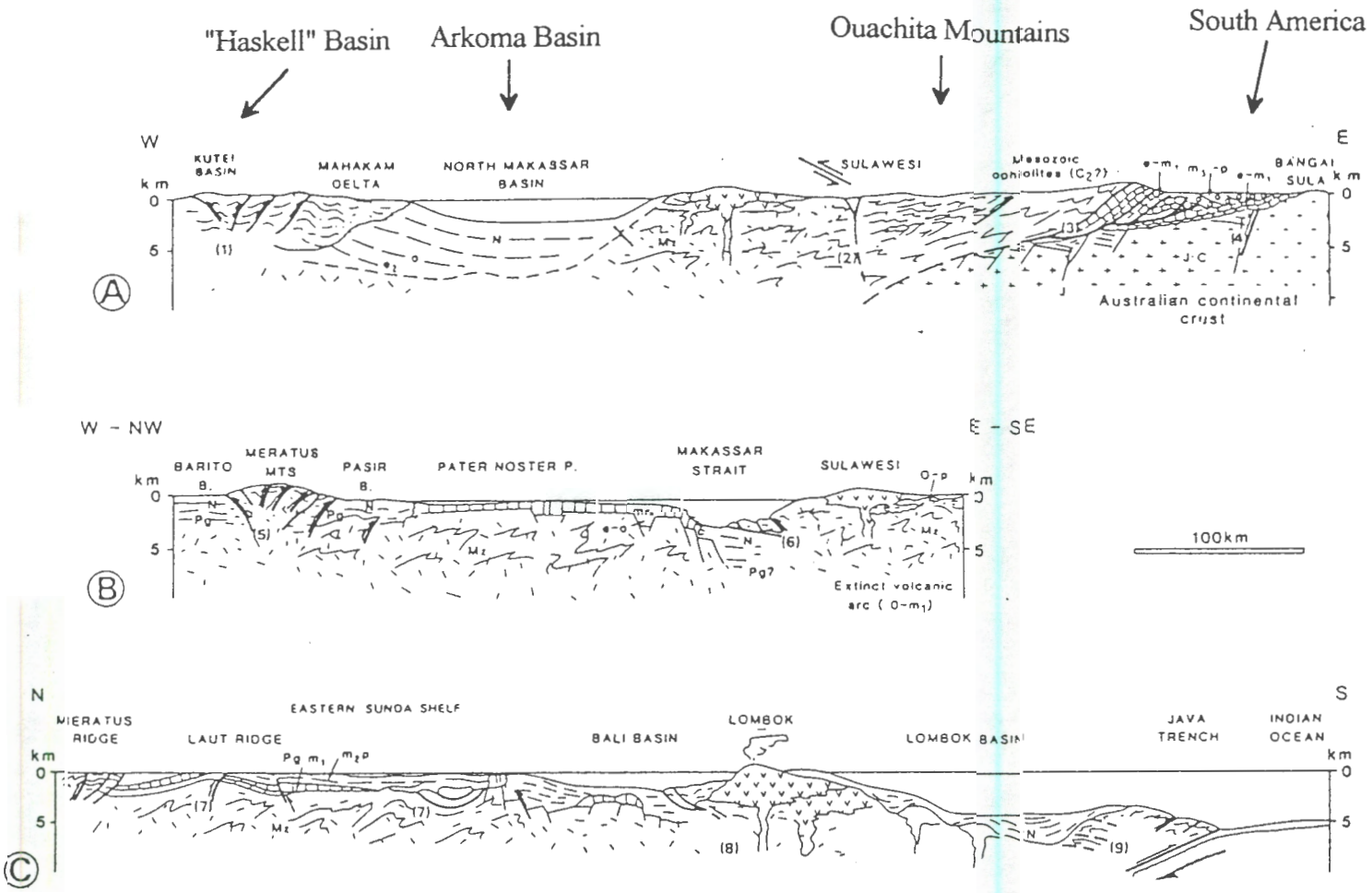


Figure 18.-- Generalized Cross-Section through the Eastern Sudan Land Area (after Letouzey et al, 1990).

mid-continent.

CONCLUSIONS

Active, as well as pre-existing tectonic elements, influenced deposition of the Haskell limestone during the Stephanian. The Ozark Dome, Ouachita Mountains, Arbuckle Uplift, and Siouxia had the greatest affect on sedimentation.

The Ozark Dome to the east of the "Haskell" basin influenced sedimentation by providing: (1) a topographic barrier, (2) accommodation space due to loading, and (3) a source area for siliciclastics.

The Ouachita Mountains to the south of the "Haskell" basin affected sedimentation by providing: (1) accommodation space due to loading, (2) a source area for siliciclastics, and (3) an area for sediment accumulation due to the formation of grabens and half-grabens along the northern front of the mountain range (southern extent of the "Haskell" basin) by fault reactivation.

The Arbuckle Uplift created some subsidence, but it was more localized than the Ouachita Mountains. Siliciclastics shed from the uplift were deposited rapidly in close proximity to the source area.

Siouxia, to the north of the "Haskell" basin, influenced sedimentation by providing: (1) a broad topographic high, and (2) a source area for siliciclastics to the basin.

Features such as the Bourbon Arch, Nemaha Anticline, Amarillo-Wichita Uplift, Muenster Range, and Missouri Platform provided little siliciclastic influx to the "Haskell" depositional basin in the study area.

The Bourbon Arch probably had little affect on deposition of the Haskell limestone. The presence of the Haskell on the arch, as well as the flanks of the arch indicate that it did not inhibit deposition of the limestone.

The Nemaha Anticline, west of the Haskell study area, influenced sedimentation by providing: 1) accommodation space due to loading on the edges of the anticline, and 2) a minor source area for siliciclastics.

The Amarillo-Wichita Uplifts created some subsidence, but it was more localized than the Ouachita Mountains. Siliciclastics shed from the uplifts were deposited rapidly in close proximity to the source areas.

The Missouri Platform and associated flanking anticlines may have provided some siliciclastics, but the amount of uplift of these structures was minimal and localized.

The Haskell limestone was deposited in a shallow, relatively high energy, equatorial basin. Deposition across the "Haskell" basin created four major facies recognized as the: 1) shoreward, characterized by fossiliferous osagid coated grainstones, 2) open marine, characterized by fossiliferous wackestones, 3) algal mound, characterized by the build-up of algal mounds, and 4) siliciclastic, resulting in fossiliferous mudrocks. The basin had to be within the photic zone (shallow) and have sufficient energy to roll the grains around to coat them, on all sides, with an osagid coating. The open marine facies represents a deeper, lower energy environment with a more open marine biota. The algal mound facies was produced by the formation and progradation of algal build-ups into the (deeper water) open marine facies. Abundance of algae suggest that the basin was shallow (within the photic zone) and that the aggradation of algae kept pace with increasing accomodation space. The depositional basin shallows (water depth) significantly in Oklahoma as thick siliciclastic sequences onlap and aggrade with increasing accomodation space. The depositional environment of each of these facies suggest that the depositional basin of the Haskell was shallow in the north and south, with the deepest-water facies in Franklin, Anderson, and Woodson counties Kansas.

The equatorial position of the "Haskell" depositional basin during the Stephanian greatly

influenced lithologies produced in the Douglas Group. The Vinland-Haskell-Robbins interval can be assigned climate lithofacies ranks of 2, 4, and 3 respectively (Archer and West, 1993). These lithologies indicate fluctuations in climatic conditions from monsoonal/tropical-rainy to "humid" wet-dry seasonal. The Haskell limestone was probably deposited during "humid" wet-dry seasonal climatic conditions.

The plate tectonic setting for the modern analog in Indonesia compares well to the Upper Carboniferous plate configuration. Both areas consist of a convergent plate boundary with associated back-arc basins and suture zones.

Convergence of the plates both for the Upper Carboniferous and the modern analog created mountain ranges and basins. Sumatra has a number of associated basins that are separated by intervening mountain ranges. The Upper Carboniferous Ardmore and Arkoma Basins are likewise separated by uplifts.

The generalized stratigraphy of the basins in Sumatra and the southern mid-continent during the Upper Carboniferous are similar; siliciclastic rocks overlain by carbonate rocks (Viele and Thomas, 1989; Paltrinieri et al, 1976). Basins of Sumatra have more volcanic deposits, the basins near the Ouachita Mountains lack abundant volcanic detritus which suggests that the active volcanic arc was not immediately adjacent.

Although the Indonesian area is similar to the "Haskell" basin in size, depth, orographic features, latitudinal position, and tectonic setting, further study and complete basinal analysis of the Selat Karimata Basin is needed to establish analogous lithofacies trends. Hopefully, future analysis of shelf sediments will provide evidence corroborating the suggested analog between these areas.

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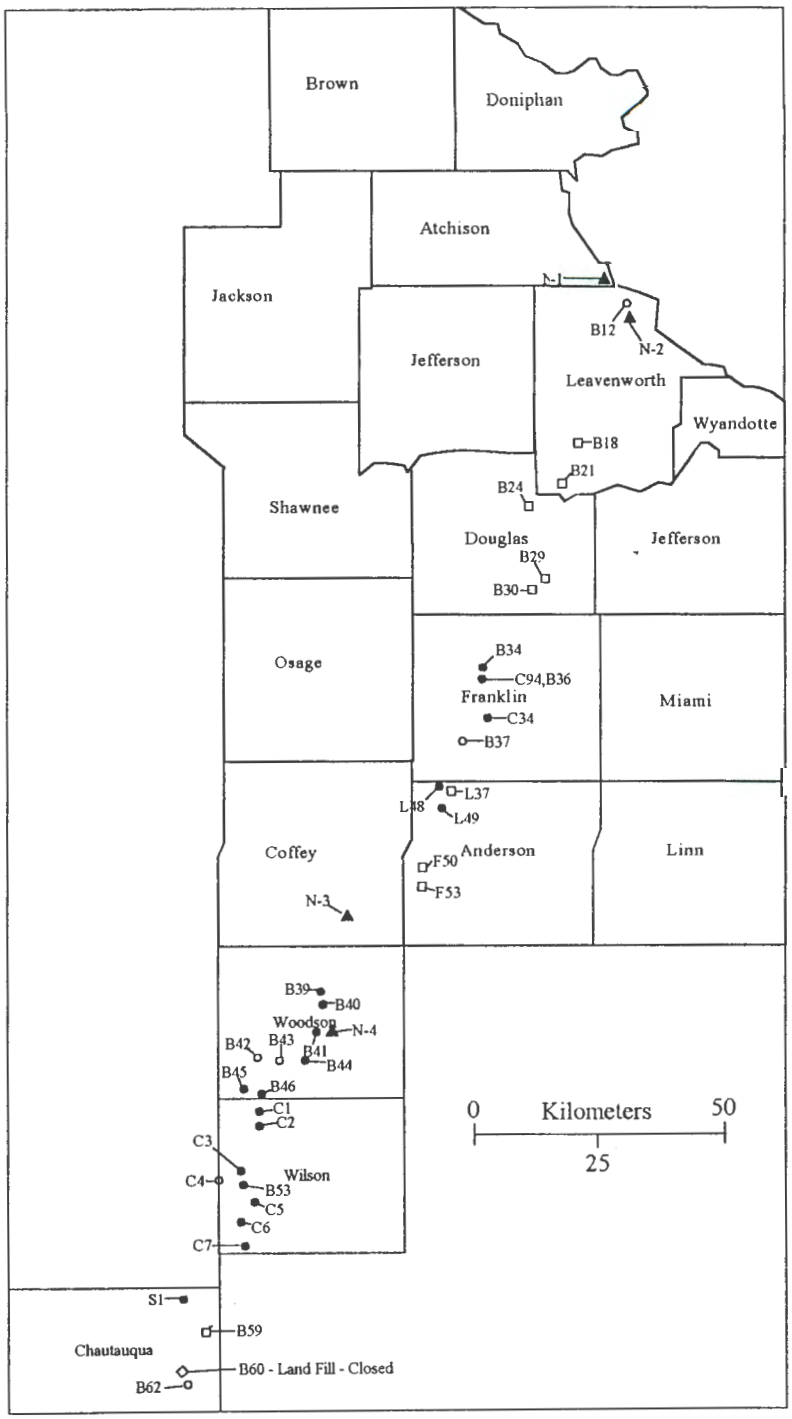
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Appendix



□ Haskell observed with myalinids
● Haskell observed
○ Haskell not found
▲ New localities with myalinids

B - Locality of Ball 1985
F - Locality of Fishburn 1962
S - Locality of Van Buskirk 1986
L - Locality of Linebeck 1961

Anderson County

F50 Sec. 13, T-21-S, R-17-E

Stranger Formation

Haskell Limestone Member..... 0.49 m

F53 CWL, E 1/4, Sec. 25, T-21-S, R-17-E

Stranger Formation

Haskell Limestone Member

Dark-blue, dense, massive, jointed limestone weathers with dark black iron-stained surface; fossiliferous zone 5 cm from top with abundant broken brachiopods and osagid-coated grains..... 0.37 m

Vinland Shale Member

Gray, blocky, sandy shale weathers gray..... 1.21 m

L37 NW 1/4, NW 1/4, Sec. 33, T-19-S, R-18-E

Stranger Formation

Robbins Shale Member

Probably present, goethite nodules..... 0.61 m

Haskell Limestone Member

Dark-gray hard dense brittle limestone, fusulinids, lower part more fossiliferous. ..... 0.46 m

Vinland Shale Member

Covered silty shale ..... 3.04 m

L48 NE 1/4, NE 1/4, Sec. 20, T-19-S, R-18-E

Stranger Formation

Robbins Shale Member

Goethite concretions indicate Robbins..... 0.61 m

Haskell Limestone Member

Gray, fine-grained, hard, dense, brittle limestone, fusulinids..... 0.49 m

Vinland Shale Member

Covered shale..... 1.21 m

L49 SE 1/4, NE 1/4, SE 1/4, Sec. 23, T-20-S, R-17-E

Stranger Formation

Robbins Shale Member

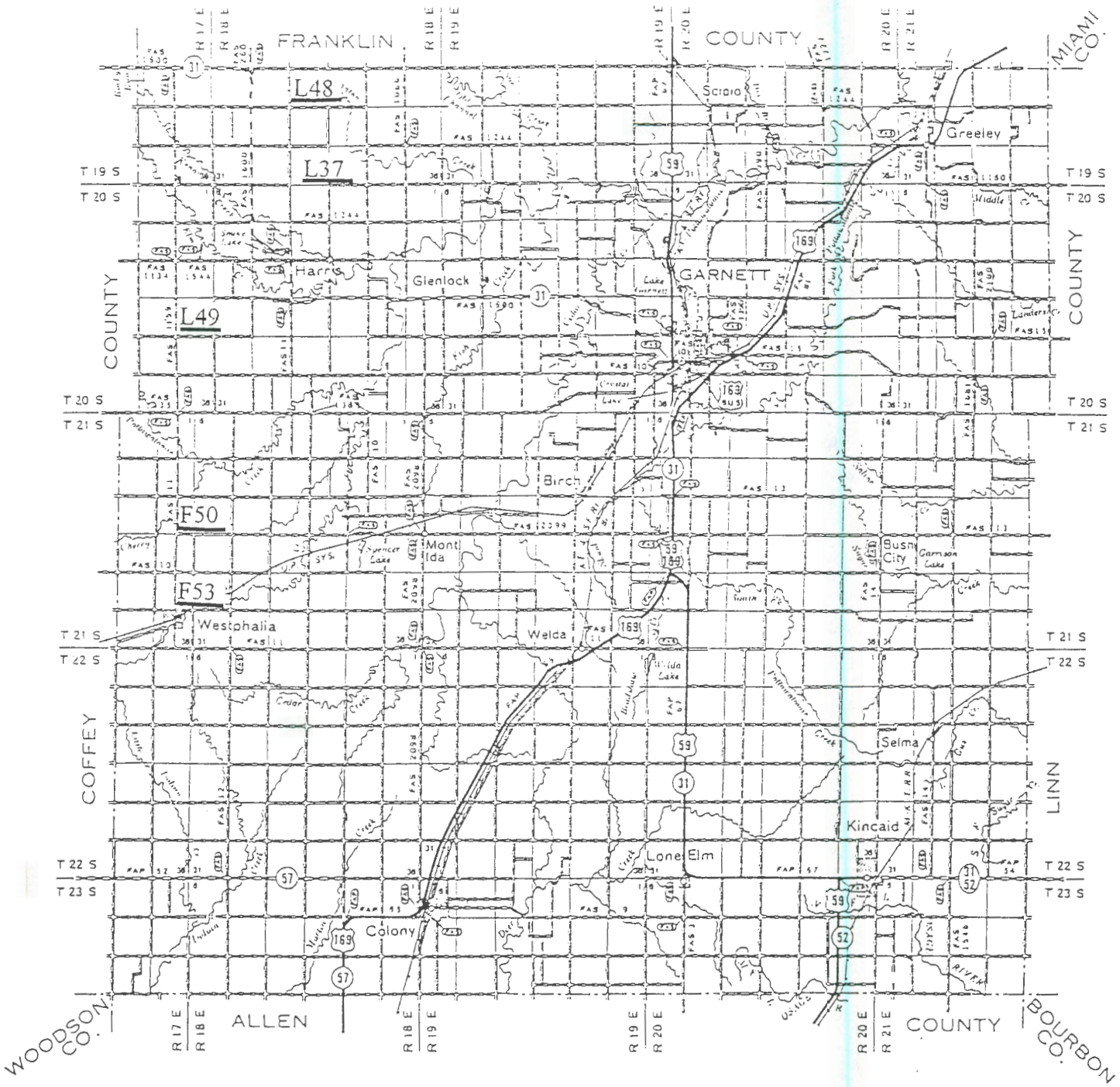
Goethite concretions indicate Robbins..... 0.61 m

Haskell Limestone Member

Gray, fine-grained, hard limestone..... 0.46 m

Vinland Shale Member

Covered shale..... 0.61 m



LEGEND

ROADS AND ROADWAY FEATURES

- TIVE ROAD
- PROVED ROAD
- ED AND DRAINED ROAD
- SURFACED ROAD
- EL OR STONE ROAD
- Y GRADED OR DRAINED
- EL OR STONE ROAD
- IDED AND DRAINED
- EL OR STONE ROAD WITH
- BILIZED SURFACE
- DIMOUS ROAD-LOW TYPE
- D ROAD
- ED HIGHWAY
- WAY WITH FULL CONTROL OF
- SES AND INTERCHANGE

ROAD SYSTEM DESIGNATION

- FEDERAL AID INTERSTATE HIGHWAY SYSTEM
- FEDERAL AID PRIMARY HIGHWAY SYSTEM
- FEDERAL AID SECONDARY HIGHWAY SYSTEM
- INTERSTATE NUMBERED HIGHWAY
- U. S. NUMBERED HIGHWAY
- STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
- END OF DESIGNATED SYSTEM OR MARKED ROUTE

KEY TO COUNTIES

FA SYSTEM REVISED TO DEC. 15, 1965

GENERAL HIGHWAY MAP

ANDERSON COUNTY KANSAS

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1982

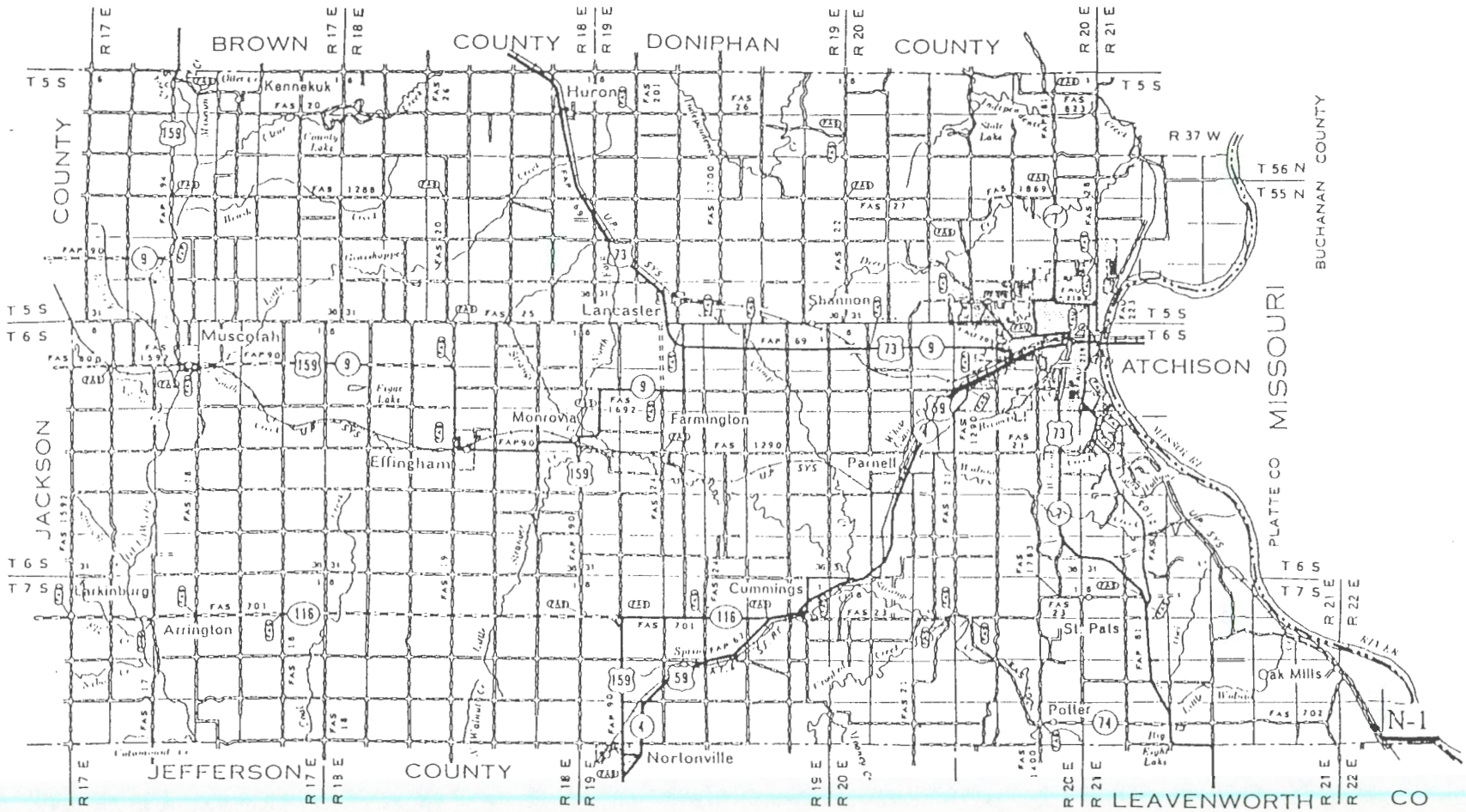
Atchison County

N-1 NE 1/2, SE 1/4, Sec. 19, T-7-S, R-22-E,

Stranger Formation

Haskell Limestone Member

Platy, brownish-gray, limestone, fossiliferous, myalinids present..... 0.41 m



LEGEND

ROADS AND ROADWAY FEATURES

- PRIMITIVE ROAD
- UNIMPROVED ROAD
- GRADED AND DRAINED ROAD
- SOIL SURFACED ROAD
- GRAVEL OR STONE ROAD—NOT GRADED OR DRAINED
- GRAVEL OR STONE ROAD—GRADED AND DRAINED
- GRAVEL OR STONE ROAD WITH STABILIZED SURFACE
- BITUMINOUS ROAD—LOW TYPE
- PAVED ROAD
- DIVIDED HIGHWAY
- HIGHWAY WITH FULL CONTROL OF ACCESS AND INTERCHANGE

ROAD SYSTEM DESIGNATION

- FEDERAL-AID INTERSTATE HIGHWAY SYSTEM
- FEDERAL-AID PRIMARY HIGHWAY SYSTEM
- FEDERAL-AID SECONDARY HIGHWAY SYSTEM
- INTERSTATE NUMBERED HIGHWAY
- U S NUMBERED HIGHWAY
- STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
- END OF DESIGNATED SYSTEM OR MARKED ROUTE

KEY TO COUNTIES

FA SYSTEM REVISED TO APRIL 1, 1968

GENERAL HIGHWAY MAP
ATCHISON COUNTY
KANSAS

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FEDERAL HIGHWAY ADMINISTRATION

SCALE

1984

Chautauqua County

B59 NW 1/4, Sec. 9, T-33-S, R-13-E

Stranger Formation

Robbins Shale Member ..... 4.60 m

Haskell Limestone Member ..... 0.12 m

Vinland Shale Member ..... 5.20 m

B60 NEC, Sec.15, T-34-S, R-12-E

Old land fill, closed.

B62 Roadcut CEL, NE 1/4, SE 1/4, Sec. 23, T-34-S, R-12-E

Stranger Formation

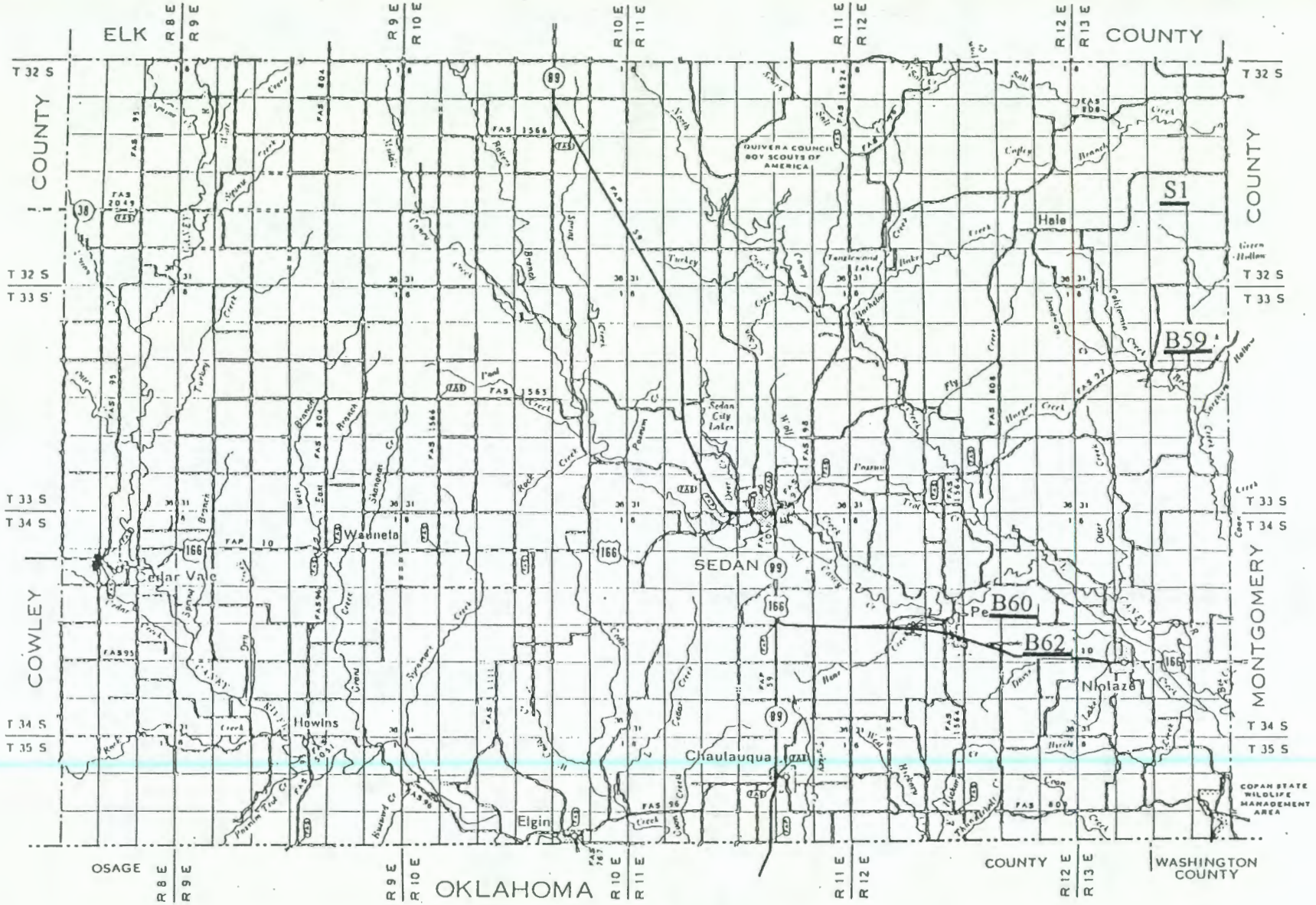
Robbins Shale Member ..... 4.60 m

Haskell Limestone Member ..... 0.12 m

Vinland Shale Member ..... 0.60 m

S1 Roadcut Near NCL NW 1/4, SEC. 21, T-32-S, R-13-E

Haskell Limestone Member ..... 0.30 m



LEGEND

ROADS AND ROADWAY FEATURES

- PRIMITIVE ROAD
- UNIMPROVED ROAD
- GRADED AND DRAINED ROAD
- SOIL SURFACED ROAD
- GRAVEL OR STONE ROAD— NOT GRADED OR DRAINED
- GRAVEL OR STONE ROAD— GRADED AND DRAINED
- GRAVEL OR STONE ROAD WITH STABILIZED SURFACE
- BITUMINOUS ROAD—LOW TYPE
- PAVED ROAD
- DIVIDED HIGHWAY
- HIGHWAY WITH FULL CONTROL OF ACCESS AND INTERCHANGE

ROAD SYSTEM DESIGNATION

- FEDERAL-AID INTERSTATE HIGHWAY SYSTEM
- FEDERAL-AID PRIMARY HIGHWAY SYSTEM
- FEDERAL-AID SECONDARY HIGHWAY SYSTEM
- INTERSTATE NUMBERED HIGHWAY
- U S NUMBERED HIGHWAY
- STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
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KEY TO COUNTIES

FA SYSTEM REVISED TO APRIL 1, 1968

GENERAL HIGHWAY MAP
CHAUTAUQUA COUNTY
KANSAS

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SCALE

1964

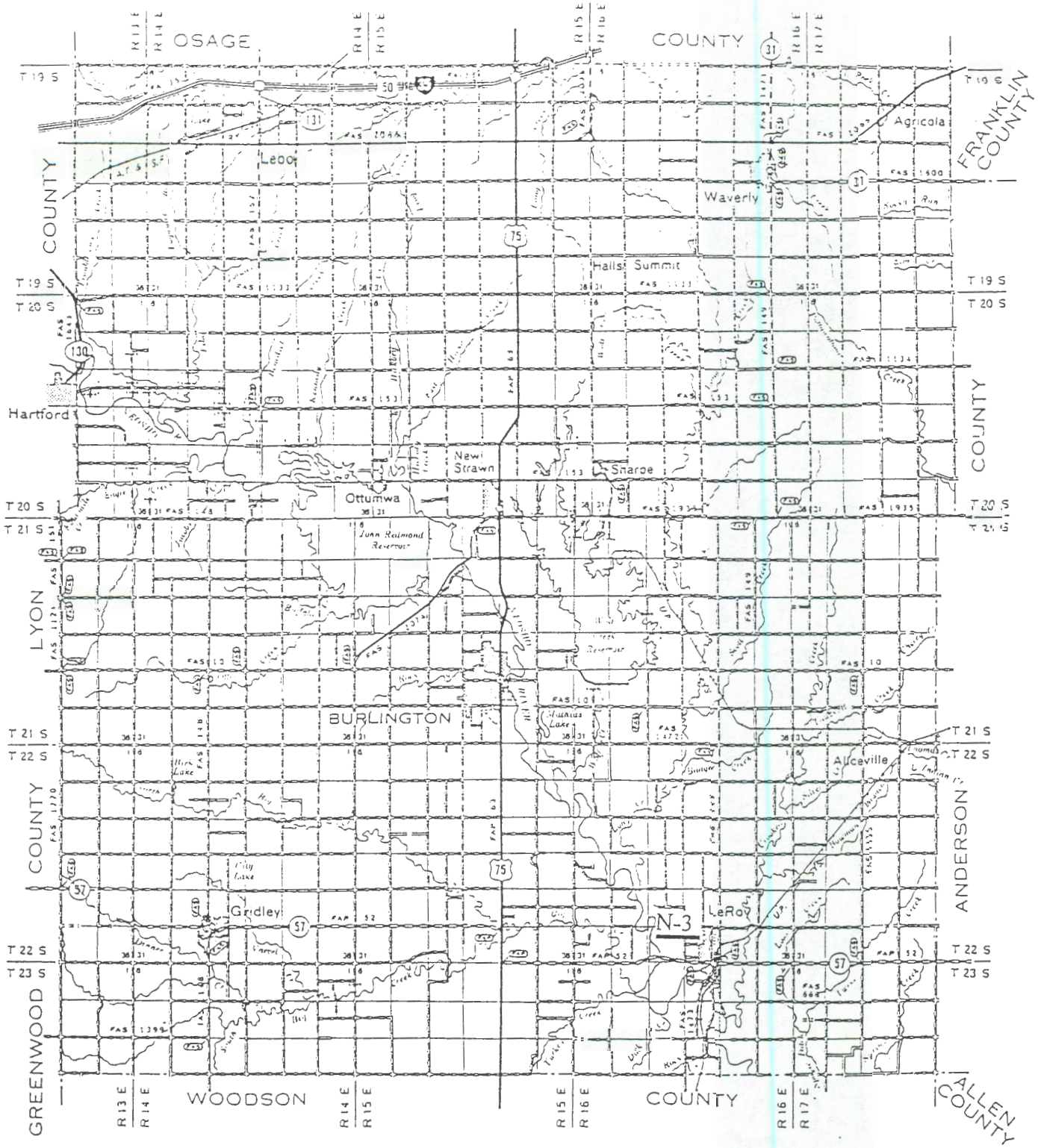
Coffey County

N-3 SE 1/4, SE 1/4, Sec. 28, T-22-S, R-16-E

Stranger Formation

Haskell Limestone Member

Massive, blue-grey limestone, fossiliferous, jointed..... uncertain



LEGEND

ROADS AND ROADWAY FEATURES

- PRIMITIVE ROAD
- IMPROVED ROAD
- GRADED AND DRAINED ROAD
- SURFACED ROAD
- GRAVEL OR STONE ROAD NOT GRADED OR DRAINED
- GRAVEL OR STONE ROAD GRADED AND DRAINED
- GRAVEL OR STONE ROAD WITH STABILIZED SURFACE
- BITUMINOUS ROAD—LOW TYPE
- PAVED ROAD
- DIVIDED HIGHWAY
- HIGHWAY WITH FULL CONTROL OF ACCESS AND INTERCHANGE

ROAD SYSTEM DESIGNATION

- FEDERAL AID INTERSTATE HIGHWAY SYSTEM
- FEDERAL AID PRIMARY HIGHWAY SYSTEM
- FEDERAL AID SECONDARY HIGHWAY SYSTEM
- INTERSTATE NUMBERED HIGHWAY
- U S NUMBERED HIGHWAY
- STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
- END OF DESIGNATED SYSTEM OR MARKED ROUTE

GENERAL HIGHWAY MAP

COFFEY COUNTY KANSAS

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1986

FA SYSTEM REVISED TO DEC. 20, 1990

Douglas County

B24 Roadcut, NE corner, NW 1/4, Sec. 5, T-13-S, R-20-E

Stranger Formation

Robbins Shale Member..... 0.60 m

Haskell Limestone Member..... 1.00 m

Vinland Shale Member..... 2.40 m

B29 Spillway, NCEL, SW 1/4, NE 1/4, Sec. 26, T-14-S, R-20-E

Stranger Formation

Haskell Limestone Member..... 0.80 m

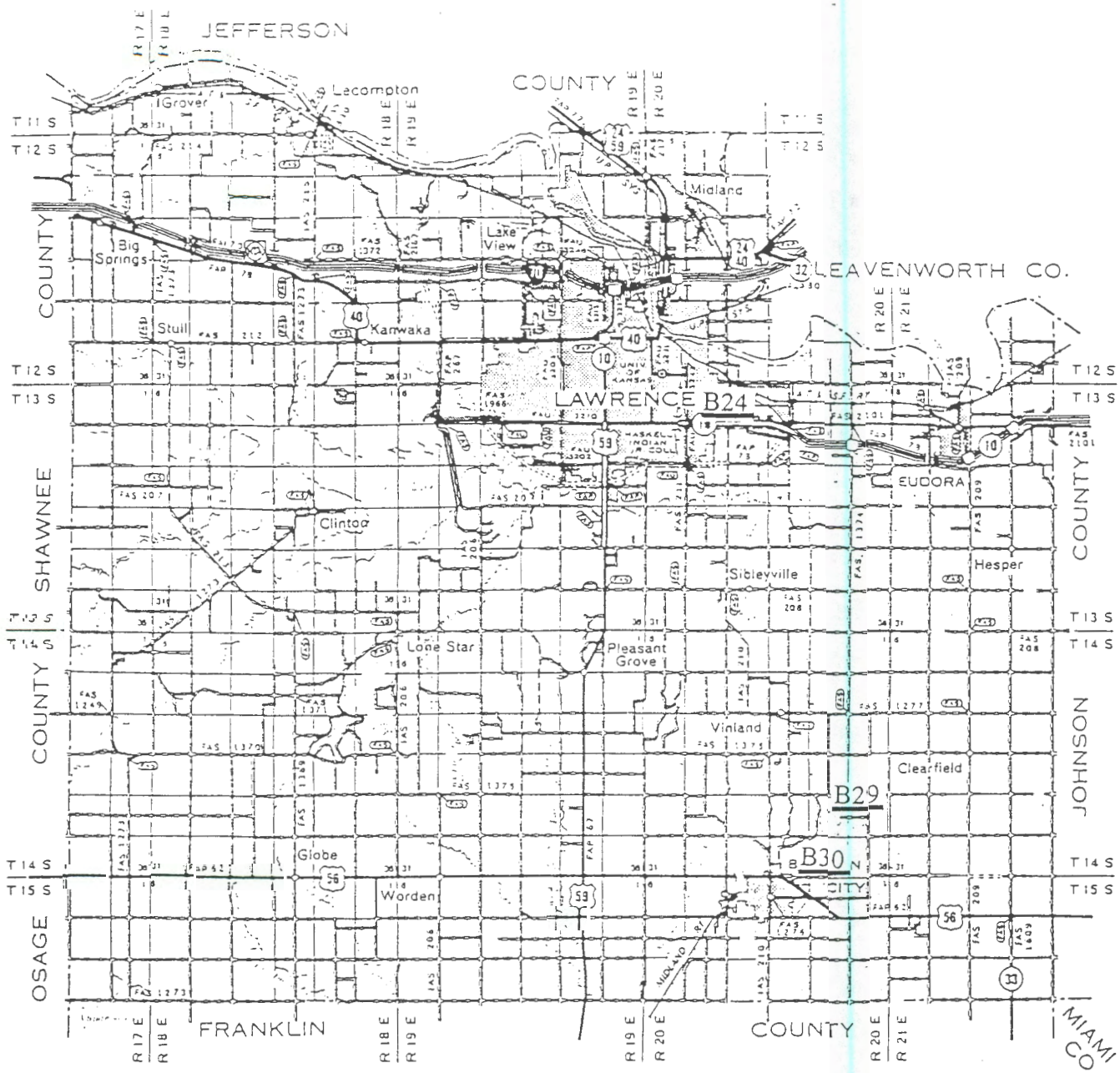
B30 Roadcut, near NE corner, Sec.34, T-14-S, R-20-E

Stranger Formation

Robbins-Ireland members..... 4.00 m

Haskell Limestone Member..... 0.90 m

Vinland Shale Member..... 0.90 m



LEGEND

ROADS AND ROADWAY FEATURES

PRIMITIVE ROAD
UNIMPROVED ROAD
GRADED AND DRAINED ROAD
SOIL SURFACED ROAD
GRAVEL OR STONE ROAD NOT GRADED OR DRAINED
GRAVEL OR STONE ROAD GRADED AND DRAINED
GRAVEL OR STONE ROAD WITH STABILIZED SURFACE
BITUMINOUS ROAD-LOW TYPE
PAVED ROAD
DIVIDED HIGHWAY
HIGHWAY WITH FULL CONTROL OF ACCESS AND INTERCHANGE

ROAD SYSTEM DESIGNATION

FEDERAL AID INTERSTATE HIGHWAY SYSTEM
FEDERAL AID PRIMARY HIGHWAY SYSTEM
FEDERAL AID SECONDARY HIGHWAY SYSTEM
INTERSTATE NUMBERED HIGHWAY
U S NUMBERED HIGHWAY
STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
END OF DESIGNATED SYSTEM OR MARKED ROUTE

KEY TO COUNTIES

FA SYSTEM REVISED TO JUNE 17, 1987

GENERAL HIGHWAY MAP
DOUGLAS COUNTY KANSAS

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SCALE

1989

Franklin County

B34 NE corner, SE 1/4, Sec. 11, T-17-S, R-18-E

Stranger Formation

Haskell Limestone Member..... 0.50 m

B36 NCWL, NW 1/4, SW 1/4, Sec. 14, T-17-S, R-18-E

Stranger Formation

Haskell Limestone Member..... uncertain

C94 WL, Sec. 12, 13, T-17-S, R-18-E

Stranger Formation

Haskell Limestone Member

Massive, dense, fine-grained, blue-gray limestone, fossiliferous, float blocks..... 0.61 m

C34 SW 1/4, SW 1/4, Sec. 12, T-18-S, R-19-E

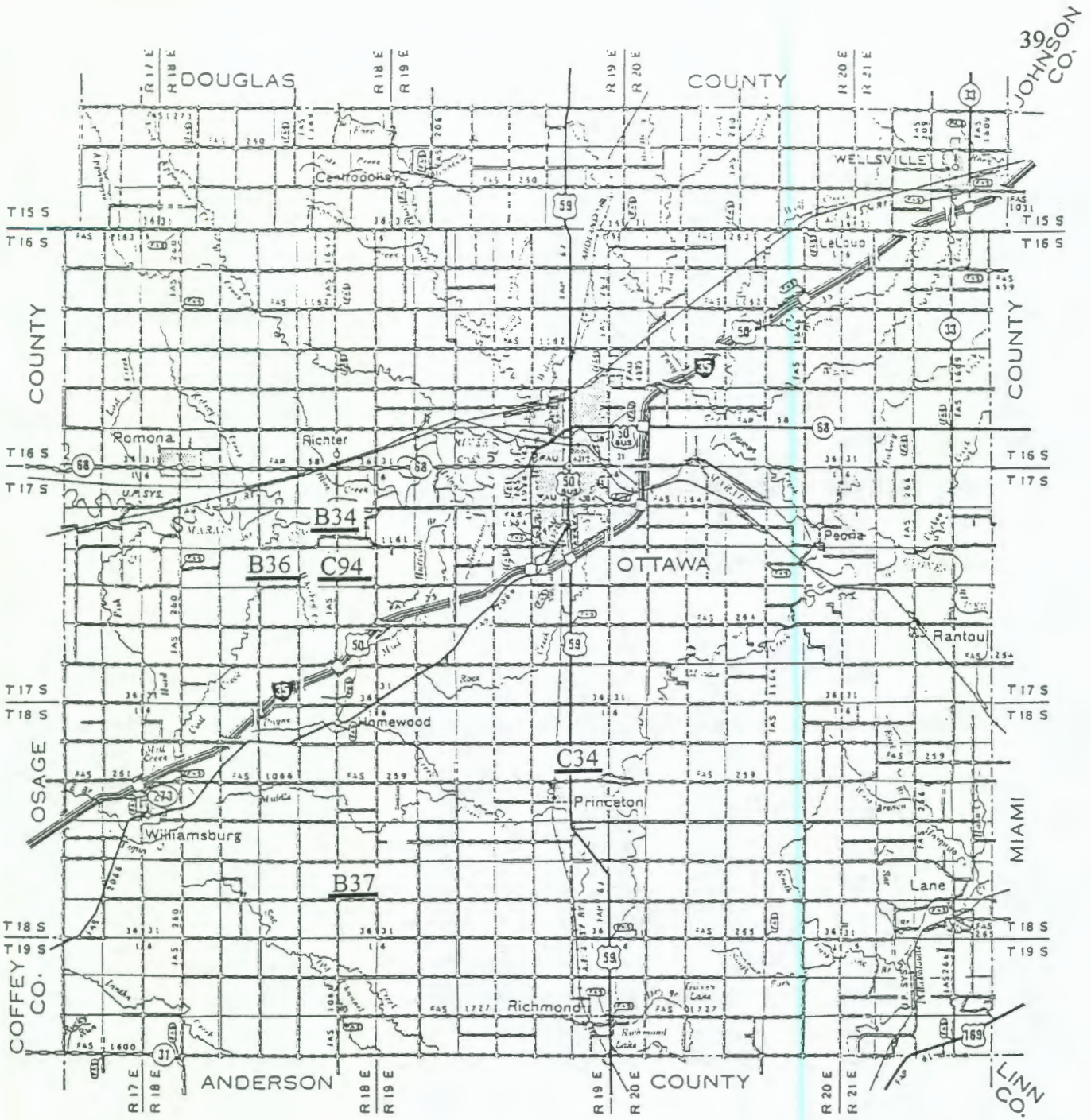
Stranger Formation

Haskell Limestone Member

Massive, dense, vertically jointed, blue-gray limestone, fossiliferous, bioturbated upper surface..... 0.55 m

B37 NC, NE 1/4, NE 1/4, Sec. 26, T-18-S, R-18-E

Haskell Limestone Member..... not found



LEGEND

ROADS AND ROADWAY FEATURES

- PRIMITIVE ROAD
- UNIMPROVED ROAD
- GRADED AND DRAINED ROAD
- SOIL SURFACED ROAD
- GRAVEL OR STONE ROAD— NOT GRADED OR DRAINED
- GRAVEL OR STONE ROAD— GRADED AND DRAINED
- GRAVEL OR STONE ROAD WITH STABILIZED SURFACE
- BITUMINOUS ROAD—LOW TYPE
- PAVED ROAD
- DIVIDED HIGHWAY
- HIGHWAY WITH FULL CONTROL OF ACCESS AND INTERCHANGE

ROAD SYSTEM DESIGNATION

- FEDERAL-AID INTERSTATE HIGHWAY SYSTEM
- FEDERAL-AID PRIMARY HIGHWAY SYSTEM
- FEDERAL-AID SECONDARY HIGHWAY SYSTEM
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- U S NUMBERED HIGHWAY
- STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
- END OF DESIGNATED SYSTEM OR MARKED ROUTE

KEY TO COUNTIES

FA SYSTEM REVISED TO AUG. 16, 1946

GENERAL HIGHWAY MAP
FRANKLIN COUNTY
KANSAS

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SCALE

1987

Leavenworth County

B12 SEC, NW 1/4, Sec. 4, T-8-S, R-22-E

Stranger Formation

Haskell Limestone Member

Massive dense blue-grey limestone, jointed, fossiliferous (brachiopods, crinoid fragments, coated grains)..... 0.50 m

Tonganoxie - Vinland members..... 6.10 m

B18 CSL, SW 1/4, SE 1/4, Sec. 3, T-11-S, R-21-E

Stranger Formation

Haskell Limestone Member

Massive dense blue-grey limestone, jointed, fossiliferous, myalinids present..... 0.70 m

Vinland Shale Member..... 1.80 m

B21 NW 1/4, Sec. 7, T-12-S, R-21-E

Stranger Formation

Robbins Shale Member ..... 1.80 m

Haskell Limestone Member..... 0.70 m

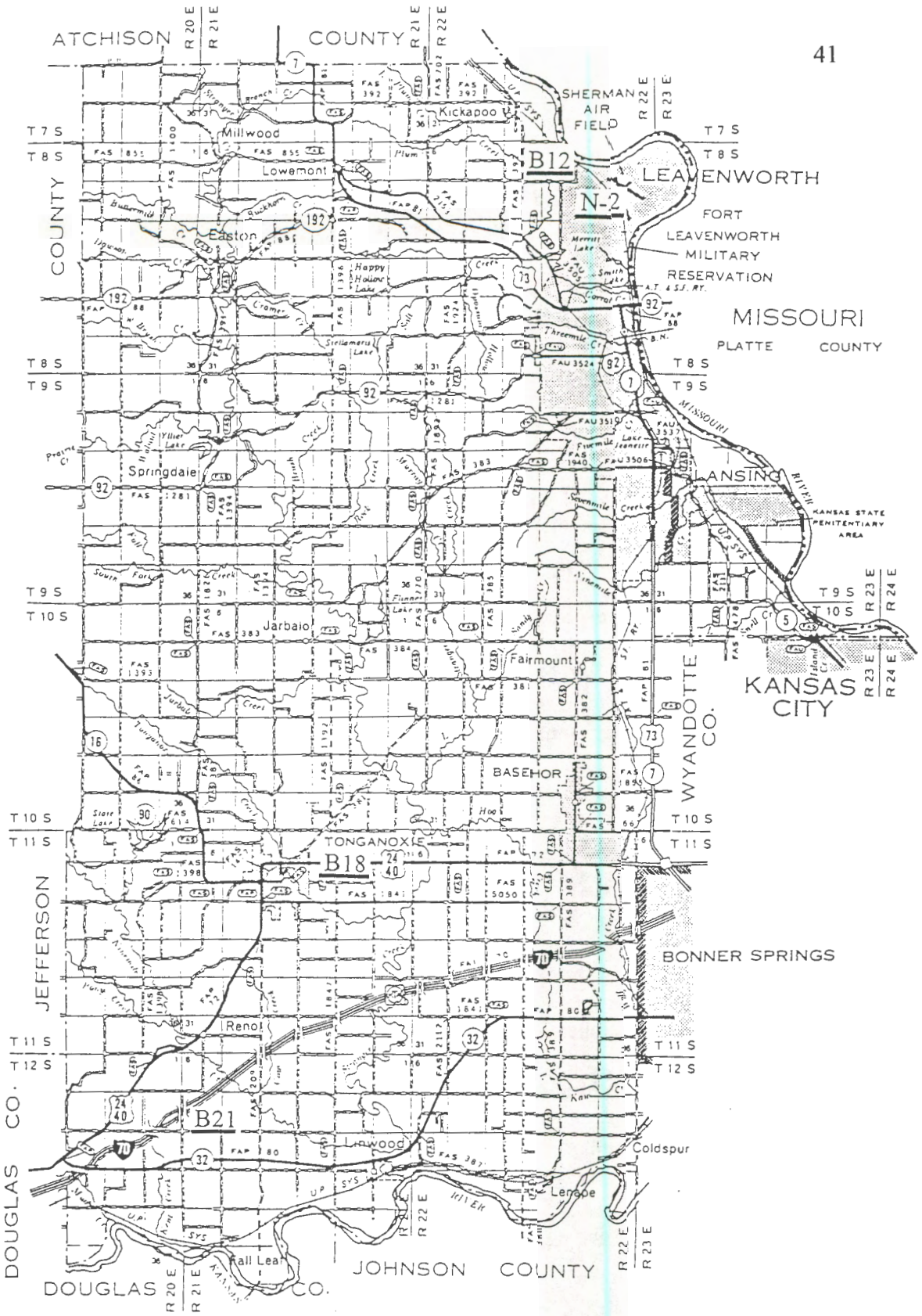
Vinland Shale Member..... 1.50 m

N-2 W 1/2, Sec. 10, T-8-S, R-22-E

Stranger Formation

Haskell Limestone Member

Massive dense blue-grey limestone, fossiliferous, myalinids present..... 0.70 m



LEGEND

ROADS AND ROADWAY FEATURES

- PRIMITIVE ROAD
- UNIMPROVED ROAD
- GRADED AND DRAINED ROAD
- SOIL SURFACED ROAD
- GRAVEL OR STONE ROAD—NOT GRADED OR DRAINED
- GRAVEL OR STONE ROAD—GRADED AND DRAINED
- GRAVEL OR STONE ROAD WITH STABILIZED SURFACE
- BITUMINOUS ROAD—LOW TYPE
- PAVED ROAD
- DIVIDED HIGHWAY
- HIGHWAY WITH FULL CONTROL OF ACCESS AND INTERCHANGE

ROAD SYSTEM DESIGNATION

- FEDERAL-AID INTERSTATE HIGHWAY SYSTEM
- FEDERAL-AID PRIMARY HIGHWAY SYSTEM
- FEDERAL-AID SECONDARY HIGHWAY SYSTEM
- INTERSTATE NUMBERED HIGHWAY
- U.S. NUMBERED HIGHWAY
- STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
- END OF DESIGNATED SYSTEM OR MARKED ROUTE

KEY TO COUNTIES

FA SYSTEM REVISED TO APRIL 10 1969

GENERAL HIGHW

LEAVENWORT

KANSA

PREPARED BY THE
KANSAS DEPARTMENT OF TRA
BUREAU OF TRANSPORTATI
IN COOPERATION WITH T
U. S. DEPARTMENT OF TRANS
FEDERAL HIGHWAY ADMINI

1986

Wilson County

C1 SW 1/4, NW 1/4, Sec. 5, T-27-S, R-14-E

Stranger Formation

Haskell Limestone Member

Massive, blue-grey limestone, fossiliferous..... 0.30 m

C2 SE 1/4, SE 1/4, Sec. 7, T-27-S, R-14-E

Stranger Formation

Haskell Limestone Member

Massive, dense, blue-grey limestone, fossiliferous..... 0.50 m

C3 SE 1/4, SE 1/4, Sec. 23, T-28-S, R-13-E

Stranger Formation

Haskell Limestone Member

Massive, dense, blue-grey limestone, fossiliferous..... 1.80 m

C4 SW 1/4, SW 1/4, Sec. 11, T-29-S, R-13-E

Stranger Formation

Haskell Limestone Member

Poor Exposure..... 0.60 m

C5 SW 1/4, SW 1/4, Sec. 19, T-29-S, R-14-E

Stranger Formation

Haskell Limestone Member

Massive, brittle, dense, jointed, blue-grey limestone, fossiliferous..... 0.60 m

C6 W 1/2, Sec. 13, T-30-S, R-13-E

Stranger Formation

Haskell Limestone Member

Massive, brittle, dense, jointed, blue-grey limestone, fossiliferous..... 0.50 m

C7 Sec. 31, T-30-S, R-14-E

Stranger Formation

Haskell Limestone Member

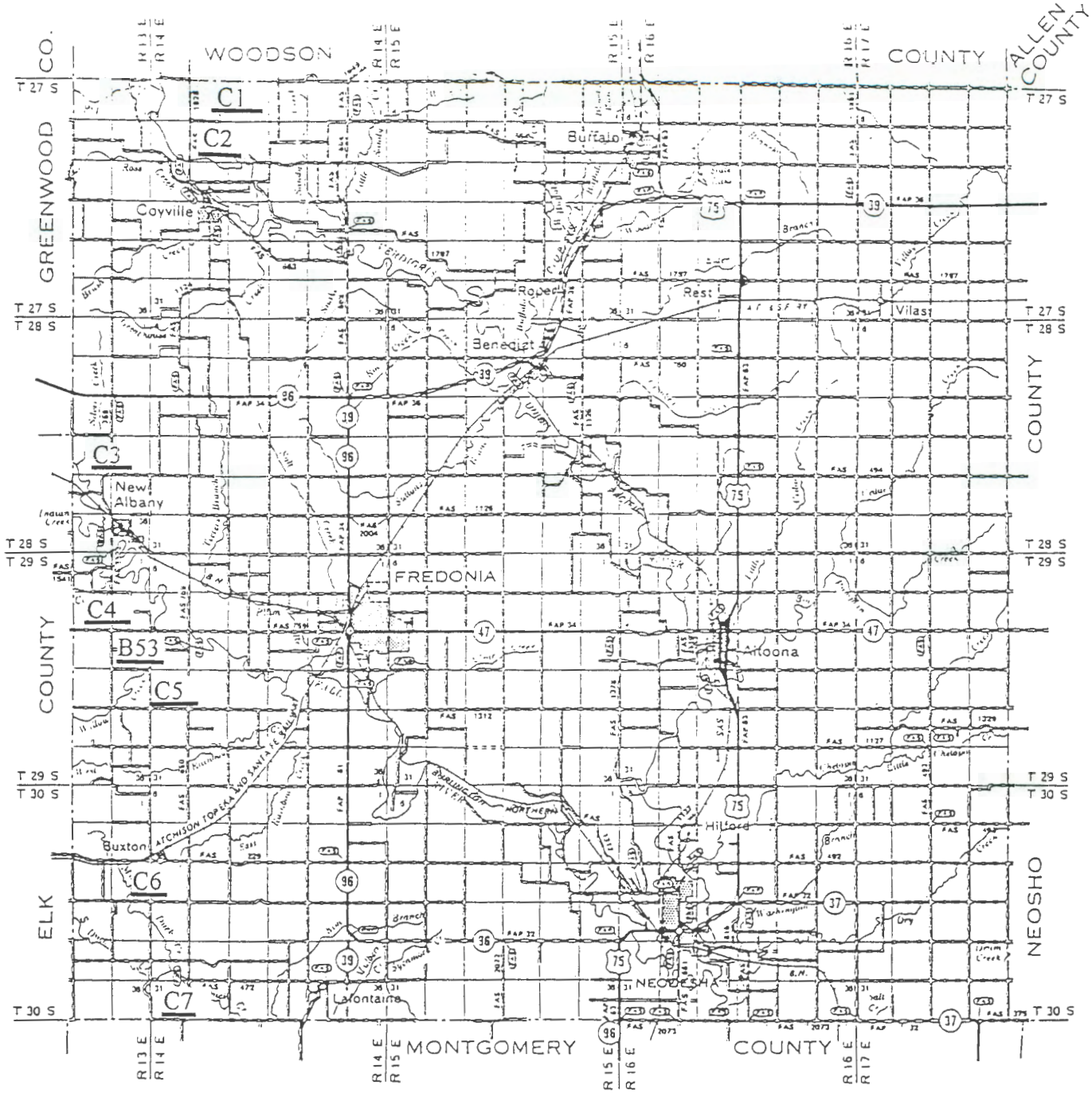
Massive, brittle, dense, jointed, blue-grey limestone, fossiliferous..... 0.60 m

B53 CWL, NW 1/4, Sec. 13, T-29-S, R-13-E

Stranger Formation

Haskell Limestone Member..... 1.80 m

Vinland Shale Member..... 0.30 m



LEGEND

ROADS AND ROADWAY FEATURES

IMITIVE ROAD
MPROVED ROAD
ADED AND DRAINED ROAD
L SURFACED ROAD
AVEL OR STONE ROAD
OT GRADED OR DRAINED
AVEL OR STONE ROAD
RADED AND DRAINED
AVEL OR STONE ROAD WITH
ABULATED SURFACE
UMINOUS ROAD—LOW TYPE
VED ROAD
IDED HIGHWAY
HWAY WITH FULL CONTROL OF
CCESS AND INTERCHANGE

ROAD SYSTEM DESIGNATION

FEDERAL-AID INTERSTATE HIGHWAY SYSTEM
FEDERAL-AID PRIMARY HIGHWAY SYSTEM
FEDERAL-AID SECONDARY HIGHWAY SYSTEM
INTERSTATE NUMBERED HIGHWAY
U S NUMBERED HIGHWAY
STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
END OF DESIGNATED SYSTEM OR MARKED ROUTE

KEY TO COUNTIES

FA SYSTEM REVISED TO JAN. 15, 1968

GENERAL HIGHWAY MAP

WILSON COUNTY KANSAS

PREPARED BY THE
KANSAS DEPARTMENT OF TRANSPORTATION
BUREAU OF TRANSPORTATION PLANNING
IN COOPERATION WITH THE
U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

1983

Woodson County

B39 CWL, SW 1/4, SW 1/4, Sec. 25, T-24-S, R-15-E

Stranger Formation

Haskell Limestone Member..... 0.40 m

B40 NE 1/4, NW 1/4, Sec. 1, T-25-S, R-15-E

Stranger Formation

Robbins Shale Member ..... 0.90 m

Haskell Limestone Member..... 0.50 m

Vinland Shale Member..... 0.90 m

N-4 CEL, SE 1/4, Sec. 13, T-25-S, R-15-E

Stranger Formation

Haskell Limestone Member..... uncertain

B41 CNL, NE 1/4, Sec. 24, T-25-S, R-15-E

Stranger Formation

Haskell Limestone Member..... uncertain

B42 NE 1/4, Sec. 14, T-26-S, R-14-E

Stranger Formation

Haskell Limestone Member..... not found

B43 CWL, SW 1/4, Sec. 13, T-26-S, R-14-E

Stranger Formation

Haskell Limestone Member..... not found

B44 CWL, SW 1/4, Sec. 15, T-26-S, R-15-E

Stranger Formation

Haskell Limestone Member..... 0.70 m

B45 CSL, NW 1/4, Sec. 34, T-26-S, R-14-E

Stranger Formation

Haskell Limestone Member..... 0.50 m

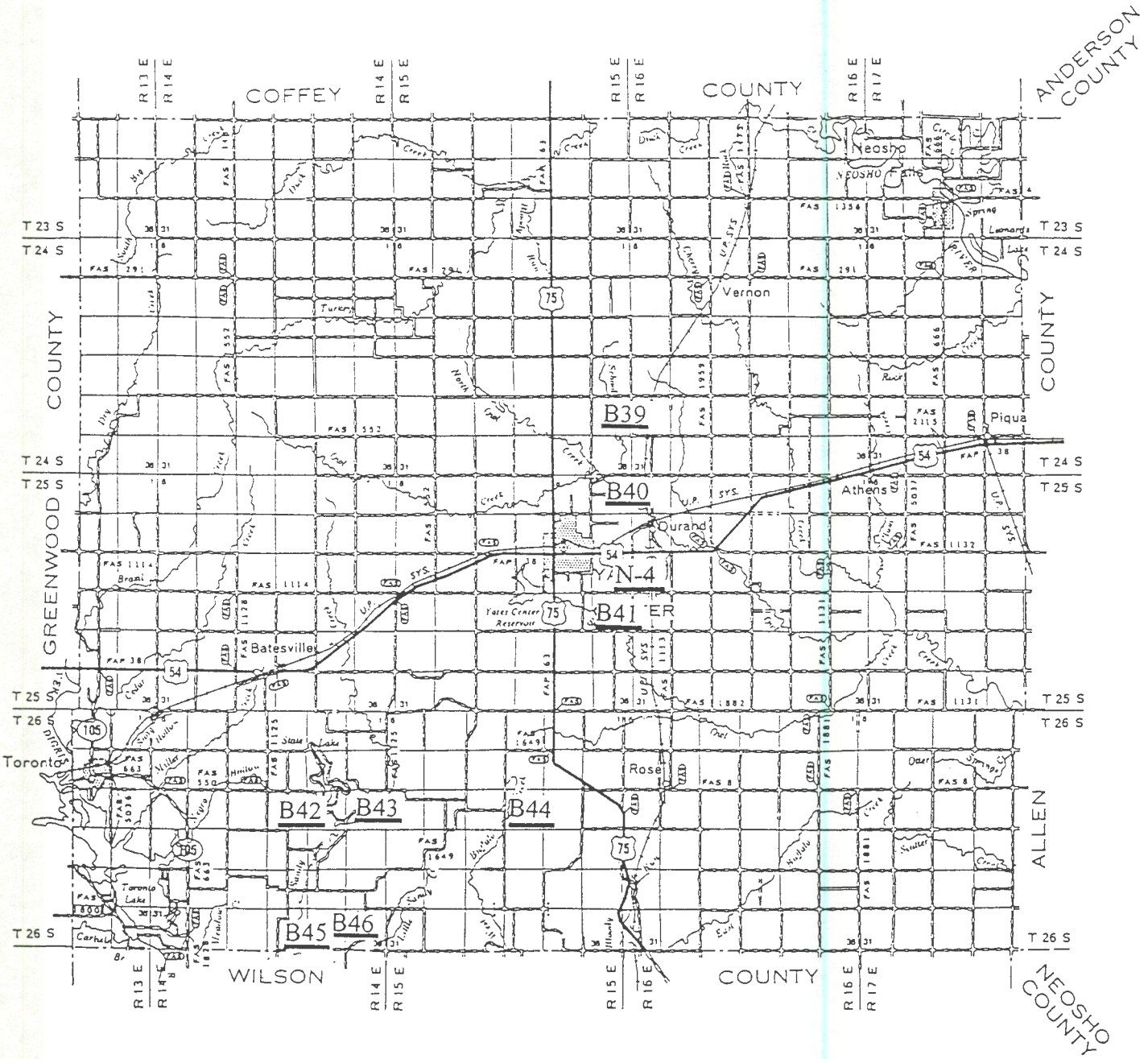
Vinland Shale Member..... 1.80 m

B46 CSL, SW 1/4, Sec. 35, T-26-S, R-14-E

Stranger Formation

Haskell Limestone Member..... 0.50 m

Vinland Shale Member..... 0.90 m



LEGEND

ROADS AND ROADWAY FEATURES

- INTTYE ROAD
- MPROVED ROAD
- ADED AND DRAINED ROAD
- L SURFACED ROAD
- AVEL OR STONE ROAD—
- NOT GRADED OR DRAINED
- AVEL OR STONE ROAD—
- RADED AND DRAINED
- AVEL OR STONE ROAD WITH
- TABILIZED SURFACE
- UMINOUS ROAD—LOW TYPE
- VED ROAD
- TORED HIGHWAY
- HWAY WITH FULL CONTROL OF
- CCESS AND INTERCHANGE

ROAD SYSTEM DESIGNATION

- FEDERAL-AID INTERSTATE HIGHWAY SYSTEM
- FEDERAL-AID PRIMARY HIGHWAY SYSTEM
- FEDERAL-AID SECONDARY HIGHWAY SYSTEM
- INTERSTATE NUMBERED HIGHWAY
- U S NUMBERED HIGHWAY
- STATE HIGHWAY SYSTEM OR STATE NUMBERED HIGHWAY
- END OF DESIGNATED SYSTEM OR MARKED ROUTE

KEY TO COUNTIES

FA SYSTEM REVISED TO APRIL 1, 1968

GENERAL HIGHWAY MAP
WOODSON COUNTY
KANSAS

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KANSAS DEPARTMENT OF TRANSPORTATION
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U S DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

SCALE

1983