AN ABSTRACT OF THE THESIS OF

Dennis C. White for the Master of Science Degree in Physical Science presented on May 7, 1990.

Title: Lineament Study of Stream Patterns in a Portion of East-Central Kansas.

Abstract Approved: James S Aber

Committee Members: Dr. James S. Aber, Chairperson

Dr. Thomas E. Bridge

Dr. Larry Scott

An investigation into the influence of structure on the pattern of stream development in a Butler, Greenwood and Chase Counties was undertaken based on a Landsat Thematic Mapper (TM) subscene and field observations. Surface drainage in the 225 km^2 study area is related to the: Walnut, Cottonwood/Neosho, and Fall/Verdigris Rivers in Kansas. The area is a grassland with soils developed on cherty limestones of Permian age.

The lineament study used Landsat TM data in a digital format and a geographic information system (Panacea) for display and manipulation. Lineament orientations of stream valleys were compared to the orientations of the regional joint system. The joint system orientations are a combination of field measurements and a previous joint pattern study by Ward (1968).

A comparison of the two studies indicates a relationship between the lineament orientations and the joint system in the area. Major lineament orientations correspond to major joint orientations. The orientations and frequencies of lineaments in the study area also correspond to the patterns of stream lineaments in eastern Kansas and the trend of the Humboldt Fault in Kansas. The Humboldt Fault is the controlling factor in the orientations of the joint systems in eastern Kansas.

Based on the observations of this study it is apparent that the Humboldt Fault and its associated geologic structures, namely joints, control the pattern of stream development in eastern Kansas.

LINEAMENT STUDY OF STREAM PATTERNS IN A PORTION OF EAST-CENTRAL KANSAS

A Thesis

Presented to

the Physical Science Division

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By

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Approved for the Graduate Council

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CHAPTER 1

INTRODUCTION

The geomorphology of an area is controlled by three fundamental factors: structure, process and time (Short and Blair 1986). Structure includes folds, faults, joints, lithology, stratification, and the internal fabric of the rock or sediment body. Structure may be passive or active. Process is the eroding or depositing agent: glacial ice, wind, water, or wave action. In general, process and structure combined with time produce the observed surface features of today.

The extent of this research is to determine the influence of structure on the pattern of stream development in a portion of south-central Kansas. This is a two step investigation: (1) use of a Thematic Mapper (TM) subscene for lineament study and (2) field work measuring the orientation of joint systems and geologic structures.

A study area was selected in northeastern Butler County and adjacent Chase and Greenwood Counties. The area is relatively homogeneous with respect to the underlying bed-rock, surface cover, land use and geomorphic processes over time. The geomorphic processes of the area are dominated by surface water and streams. The area is beyond the extent of Kansan glaciation, so the pattern of stream development was not directly influenced by glaciation. Wind-deposited loess is a minor addition to the regional geomorphology.

The area is representative of the headwaters of three drainage systems (Fig. 1-1): Walnut River, Fall/Verdigris River and Cottonwood/Neosho River. Tributary streams from these systems converge in northeastern Butler County and represent different morphologic times of development at the triple point (Frye and Leonard 1952). Further investigation of these systems could help shed light on the redirecting of drainage routes and stream piracy in Kansas (Law 1986). Knowledge of the influence of structure on the drainage pattern should prove useful for further study of Kansas geomorphology.

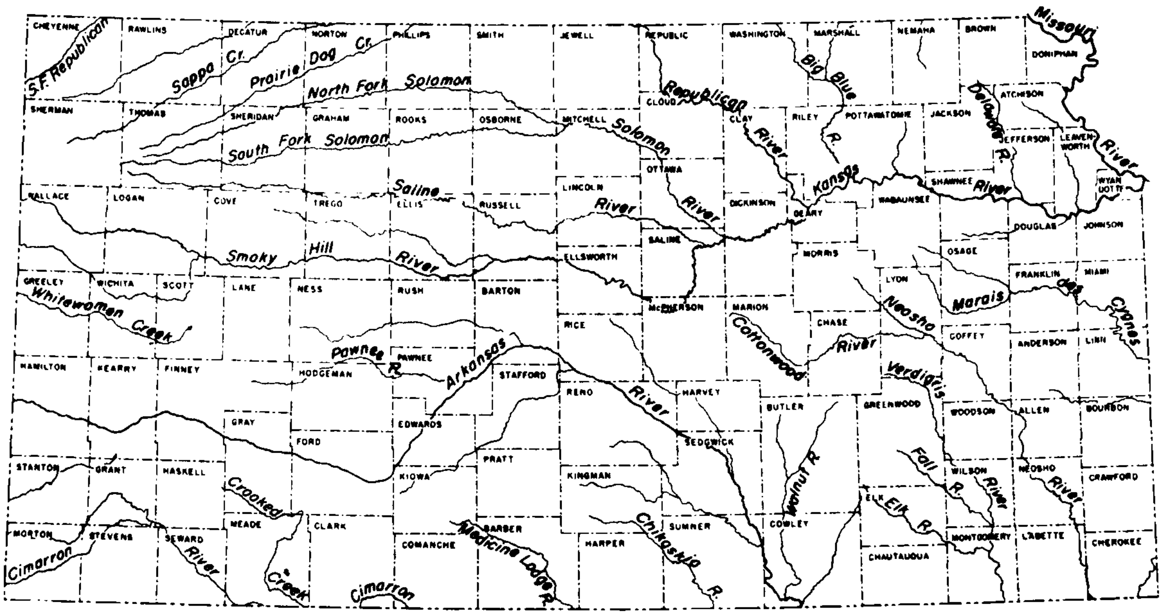


FIGURE 1-1: Map of major Kansas rivers.

CHAPTER 2

LOCATION ANALYSIS

GEOGRAPHY

The study area consists of 225 km^2 centered on the point 38° 2' 30" N latitude - 96° 32' 30" W longitude. The study area is defined by the geometry of a TM subscene shape; corner points and orientation are discussed in Chapter 4. Figure 2-1 is provided as a reference for the following description.

The area is situated in parts of Butler, Greenwood and Chase Counties in central Kansas. It is located on the escarpement of the Flint Hills Uplands and includes a small portion of the Osage Cuestas of the state's physiographic provences (Frye and Leonard 1952). Both of these are sub-divisions of the Central Lowland province of North America (Fig. 2-2).

Topographic features of the Flint Hills Uplands are a series of benched hills capped with resistant cherty limestone of Permian age. Resistant limestones are separated by shales and dip from east to west at approximately 1°. The portion of the Flint Hills Upland included in the study area is the face and the dip slope of the Flint Hills escarpment. The dip slope of the region is relatively flat topography that is covered by a veneer of residual chert, 1-2 meters in depth, and up to 1 meter of loess.

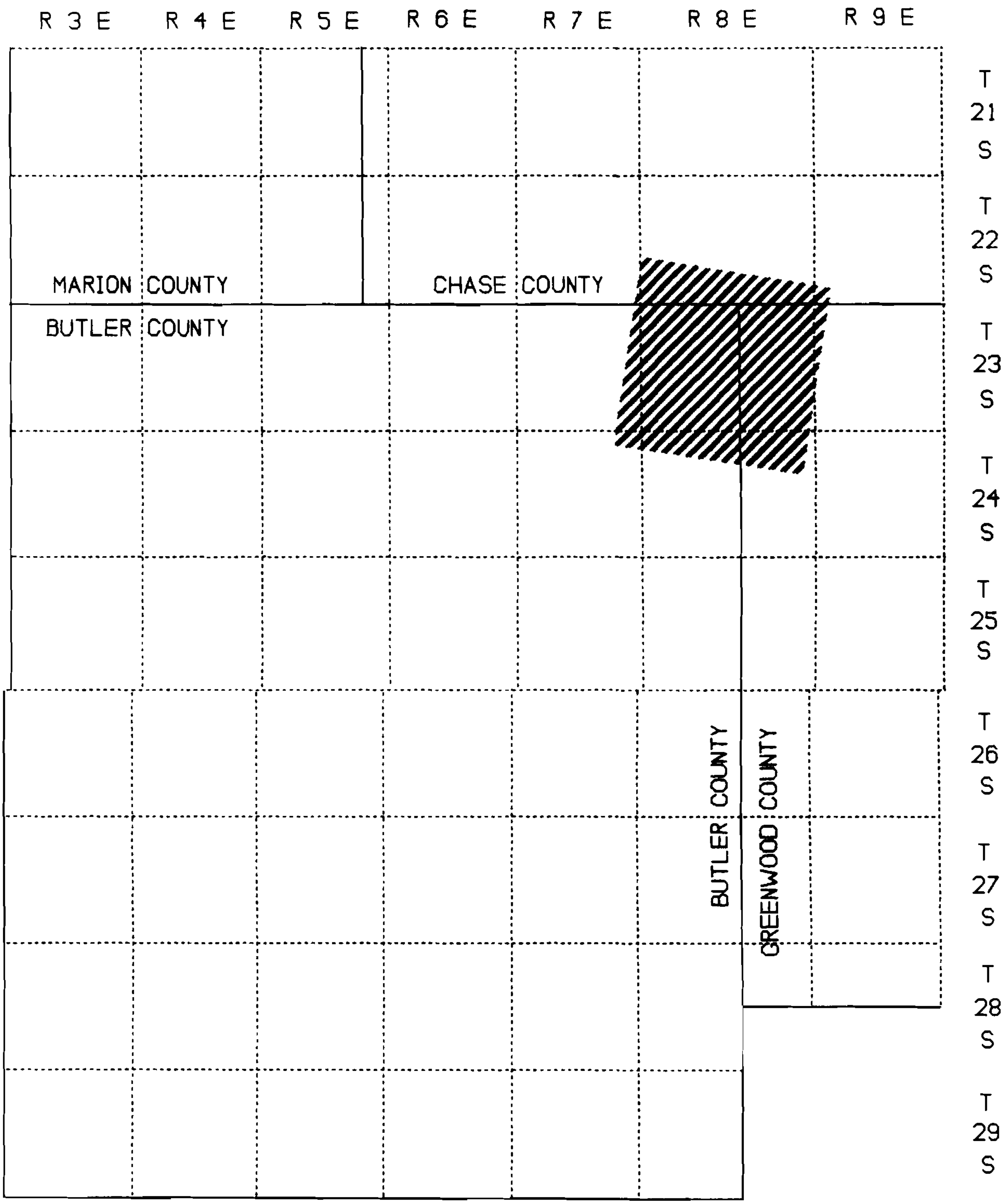


FIGURE 2-1: Location of study area in Kansas

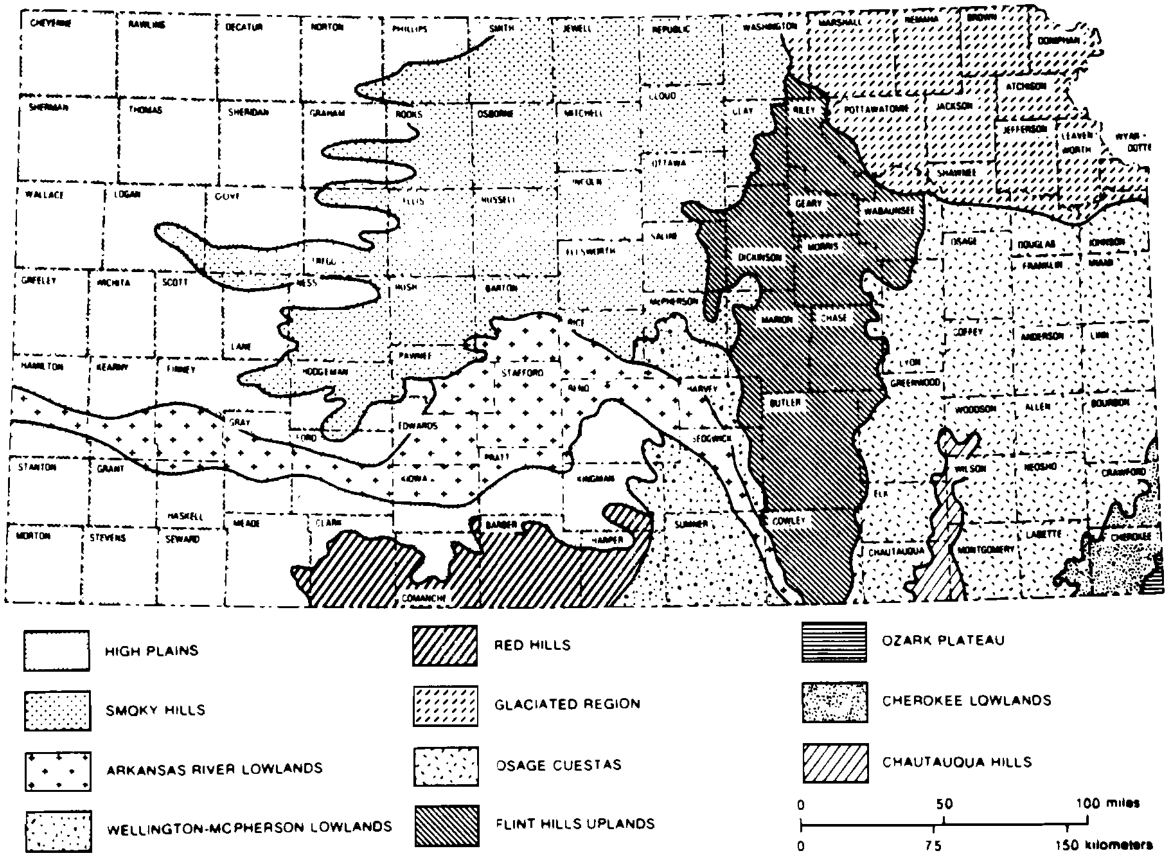


FIGURE 2-2: Physiographic map of Kansas. Taken from Buchanan and McCauley (1987 p.12).

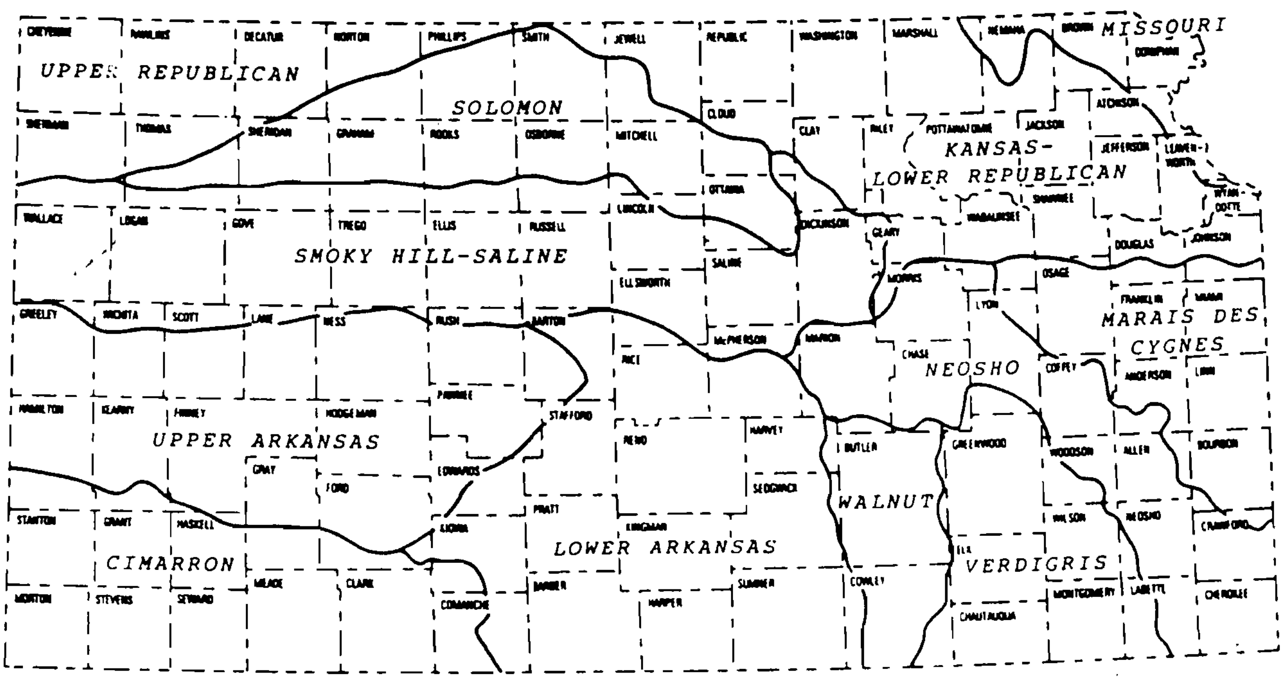


FIGURE 2-3: River drainage basins of Kansas. Taken from Buchanan and McCauley (1987 p.15).

The portion of the Osage Cuestas is the first of a series of shale valleys that separate the limestone scarps. Although the Osage Cuesta area is generally associated with Pennsylvanian age rocks in Kansas, the portion included in the study area is lowermost Permian bedrock.

DRAINAGE

Surface drainage is related to three major drainage basins: Walnut River, Cottonwood/Neosho River and Fall/ Verdigris River (Fig. 2-3). The basins are represented in the area by intermittent streams that are related to seasonal moisture. The northern half of the area is drained by the Cottonwood/Neosho River basin. Tributary streams of the Cottonwood River include: Therman Creek, Mercer Creek and the South Fork of the Cottonwood River. The direction of drainage is northward into the Cottonwood which joins the Neosho River to the east of Emporia in Lyon County.

The southwestern quarter of the study area is drained by the Walnut system. The direction of drainage is also southwestward in the East Branch of the Walnut River and Durechen Creek. This system is the youngest of the three and is associated with Wisconsin Stage of drainage development in Kansas according to Frye and Leonard (1952).

Drainage in the southeastern quarter of the study area is through Cat Creek, Battle Creek, Otis Creek and the West Branch of the Fall River. The Fall River empties into the

Verdigris near the Wilson-Montgomery County line. The Verdigris has drained this region since the Nebraskan Stage (Frye and Leonard 1952) with only minor adjustments (Law 1986) over time.

A Neogene drainage system, the Old Osage River, drained from west to east crossing the Flint Hill Uplands (Aber and Sleezer 1990). The location of the Old Osage River was determined through studies of upland chert gravels. Contained in the upland gravels are erratic pebbles of quartz and quartzite that place the Old Osage headwaters west of the Flint Hills (Aber 1988). A major tributary of the Old Osage River flowed across northern Greenwood County and possibly southern Chase County. This tributary was subsequently captured by the Verdigris River in eastern Greenwood County (Fig. 2-4).

CLIMATE

The climate of the region as defined by the Koppen system of classification (McIntyre 1980) is Cwa in most years and Dwa in the years with extreme winters. The Flint Hills uplands, as a region, is a transition zone between the BSk climate of the High Plains, Cfa of southeastern Kansas and Dfa to the northeast. Extreme variations from year to year are the norm of a transitional climatic zone. Droughts are common, the earliest on record was in the 1860s followed by the 1880s, 1930s and the 1980s. These have been followed by

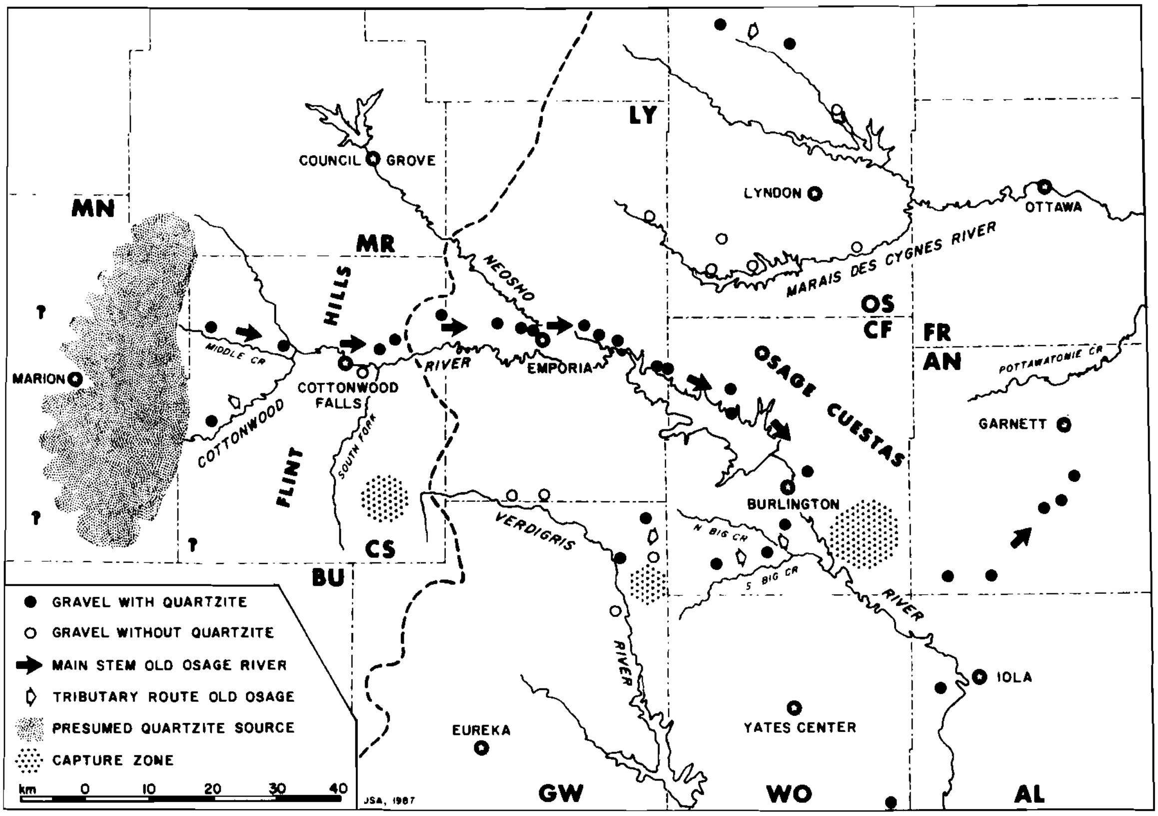


FIGURE 2-4: Map of east-central Kansas showing the route of Old Osage River, upland chert gravel deposits and capture zone in Greenwood County (GW). Taken from Aber (1988 fig.1).

periods of generally wetter conditions; however, no cyclic pattern has been identified.

Precipitation averages approximately 81 cm (32 inches) per year with 70% falling between April and September (Neill 1974). The principal source of moisture is from the Gulf of Mexico. Winters are dry with an average of 38 cm (15 inches) of snow. Temperature averages are 0° C (32° F) for January and 27° (80° F) in July. Temperature extremes for the area are -33° to 47° C (-28° to 117° F), precipitation extremes range from 43 cm (17 inches) for the year in 1936 and 130 cm (51 inches) in 1951.

SOILS

Agriculture in the region is almost entirely dedicated to cattle ranching. Although the climate is favorable to farming, the soils are not. Arable land is less than 1% of the total land area in the three-county region (Subreconnaissance Land Classification Kansas 1971).

Soils of the region fall into two main categories, the Florence type and the Dwight type (Neill 1974). These soil types are related to the topography, the drainage basins and the underlying bedrock or parent material.

The Florence soils are associated with the scarp-face of the Flint Hills Uplands. This area is drained by the Fall and Cottonwood Rivers and constitutes the steepest slopes and greatest topographic relief. They are well drained soils

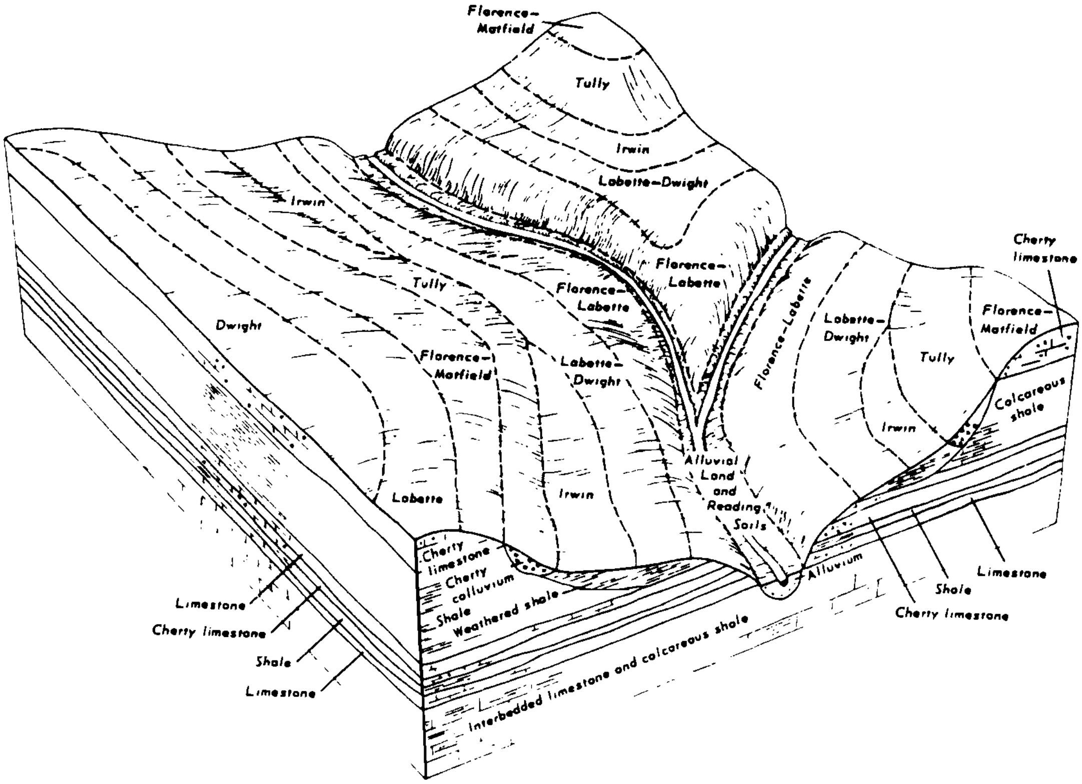


FIGURE 2-5: Pattern of soils in the Florence Association and location of Dwight Soils relative to Slope. Taken from Neill (1974, fig. 3).

formed on cherty limestone; depth to bedrock is 1-1.5 m (3-5 feet). The parent limestone is weathered directly leaving residual dark gray chert and reddish brown silty clay. The Florence Association includes several other soil series (Fig. 2-5) that are related to each other on the basis of slope and composition.

On the slope face of the escarpment, the portion drained by the Walnut River system, the Dwight type is dominant. This group of soils are developed on cherty limestone, limestone and shale with minimal slope. The Dwight and its series are hard-pan soils that are well drained and highly susceptible to erosion.

Both soils associations are primarily used as range land for the cattle industry, although limited in extent, the Dwight is suitable for field crops. The natural vegetation cover of both soils is Bluestem grasses (Gates 1937).

Big Bluestem (*Andropogon furcatus*) is the native perennial grass of bottom land where more moisture is available. Little Bluestem (*Andropogon scoparius*) is adapted to relatively dry soil conditions and occupies the upland Florence and Dwight soils of the region. Both grasses are highly palatable, nutritious for grazing animals, and with favorable conditions productive throughout the growing season.

GEOLOGY

The bedrock geology of the area includes portions of the Chase Group and Council Grove Group of the Lower Permian Series (Fig. 2-6). Exposures of the formations are mainly in road cuts along the Kansas Turnpike, other highways, and in quarries. Exposures are limited in extent and accessibility.

The stratigraphy of the area as it relates to topography is taken from Kellogg's "Aerial Geology of Butler County, Kansas" (1975). The Flint Hills escarpment is capped by the Barneston Limestone, which consists of 3 members: Florence Limestone, Oketo Shale and Fort Riley Limestone. Florence Limestone is a light tan, massive, cherty limestone with an average thickness of 9 m (30 feet). Chert is tan to gray and accounts for 30% of rock mass. The Florence also caps the hills in this area and is a source of residual chert that covers the slope of the escarpment. The Oketo Shale is absent in the study area. The Fort Riley Limestone forms a gentle grass covered slope with a basal portion forming a prominent ledge. The average thickness of the Fort Riley Limestone is 15 m (50 feet).

The next major bench lower on the scarp face is formed by the Wreford Limestone. It is composed of two cherty limestones separated by a shale: the Threemile Limestone, Havensville Shale and Schroyer Limestone. Average thickness of the Wreford is 10 m (32 feet). It is separated from the

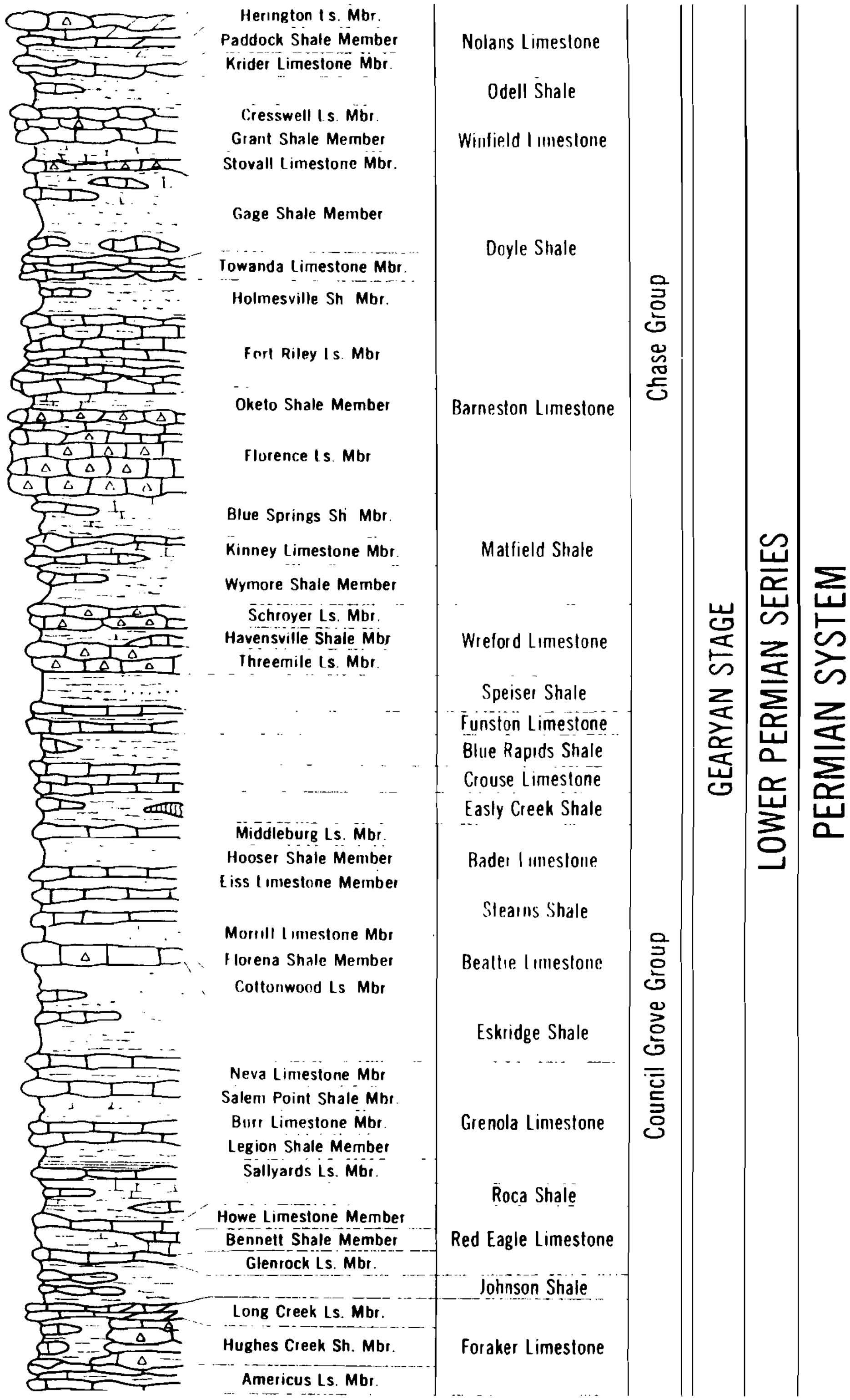


FIGURE 2-6: Stratigraphic Column of Kansas Lower Permian. Taken from Lutz-Garihan and Cuffey (1979, fig. 3).

Florence by a grassy, chert covered slope developed on the Matfield Shale.

The Matfield Shale consists of three members: the Blue Springs Shale, Kinney Limestone and Wymore Shale. The Kinney Limestone produces a small bench that is not readily traceable, because it is covered by slumping of the Blue Springs Shale in many locations. The thickness of the Matfield Shale Formation averages 18 m (60 feet) and is 75% to 90% shale in composition.

The next major bench is 42 m (135 feet) below the Wreford and is formed by the Cottonwood Limestone. Cottonwood Limestone averages 1.2 m (4 feet) in thickness, and is massive, white to gray and fossiliferous. The slope between the Wreford bench and the Cottonwood bench is grass covered with minor benches formed by the Funston, Crouse and Eiss Limestones.

Exposures below the Cottonwood Limestone are limited, generally to the Eskridge Shale and Neva Limestone, which are in contact with Quaternary alluvium in stream valleys. The alluvium has a thickness of 1.5 m (5 feet) or greater (Aber 1990).

No major geologic structures have been identified within the boundaries of the study area (Fath 1951, Ward 1968). However the regional dip of 1° westward does alter to a northwestward orientation on the northern side of the Scott Oil Field (Bass 1936). This change in dip is limited in extent and does not correspond to other structural features. Oil production in this area is not related to structural traps; oil production in the study region exploits the shoestring sand deposits of the Cherokee Group (Bass 1936).

The Nemaha Ridge is the major subsurface structural feature of the region, but it is not related to the surface synclines, anticlines and domes of Butler and Greenwood Counties (Ward 1968). Orientation of the Nemaha Ridge in Kansas has a general trend northeast to southwest, plunging to the southwest. However the trend in relation to the study area is approximately north-south (Fig. 2-7).

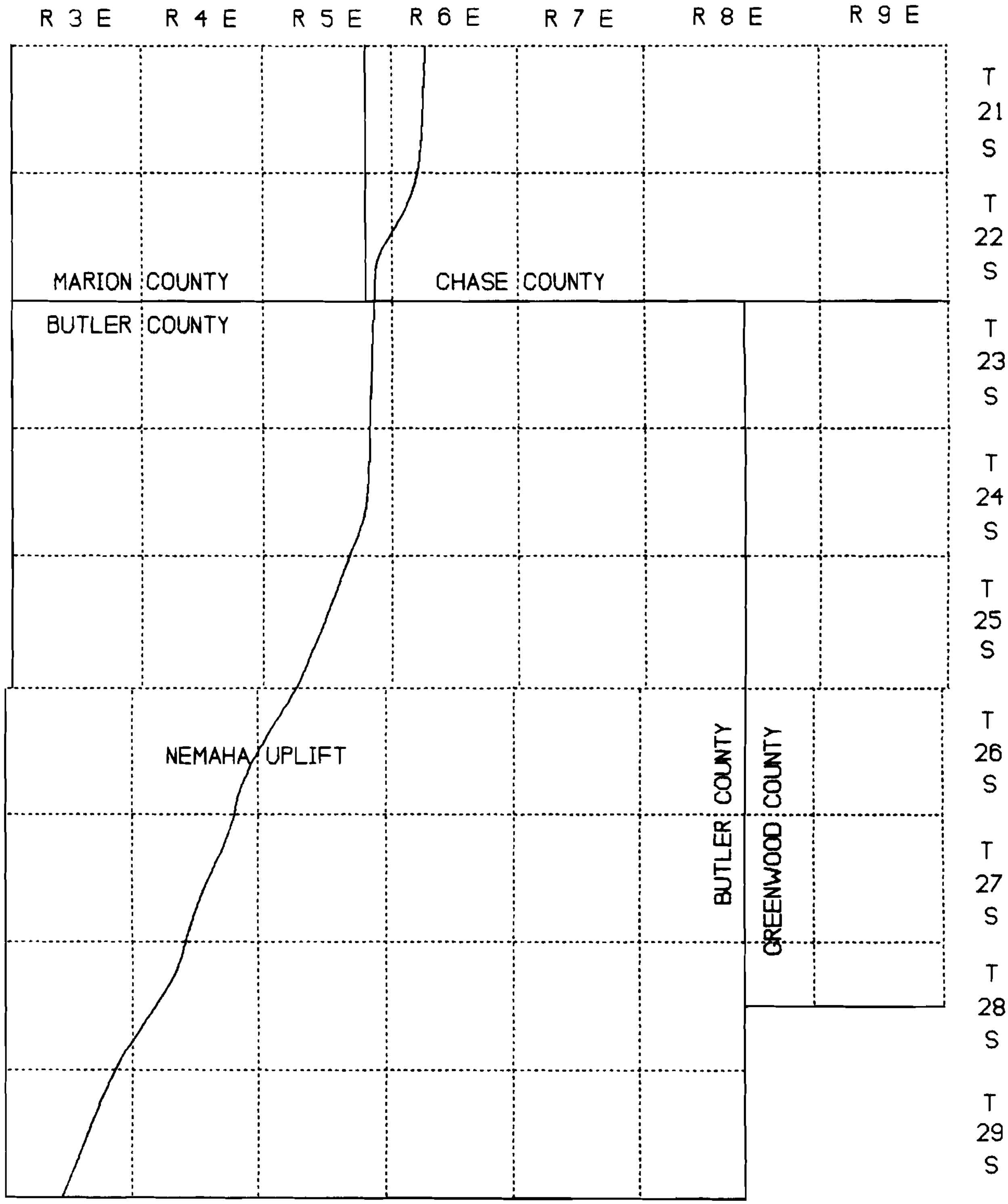


FIGURE 2-7: Trend of Nemaha Uplift in relation to study area. Adapted from Kellogg (1975, Fig. 22).

CHAPTER 3

PREVIOUS STUDIES

JOINT PATTERNS

Numerous studies of the joint patterns of the mid-continent have been done. In 1968, John Ward completed a study of the joint pattern of the lower Permian in Kansas. His study centered on Butler County and surrounding counties to develop a regional pattern.

Ward's (1968) study identified two major joint sets, Set I and Set II. Set I has an average strike of 60° and the strike of Set II is 325°. The average angle between sets I and II is 95°. Ward also noted additional sets at certain locations; for example, T22-23S/R8E has an additional set with a north-south strike. The majority of joint planes are vertical and were formed as a result of wrench-fault tectonics associated with Ouachita uplift and a possible, counter force from the Rocky Mountains. Figure 3-1 is a representation of his work.

Ward (1968) also noted that the joint sets appeared to exert control on the topography in two ways. The orientations of sinkholes and of stream patterns closely follow the patterns of major joints in areas of competent bedrock.

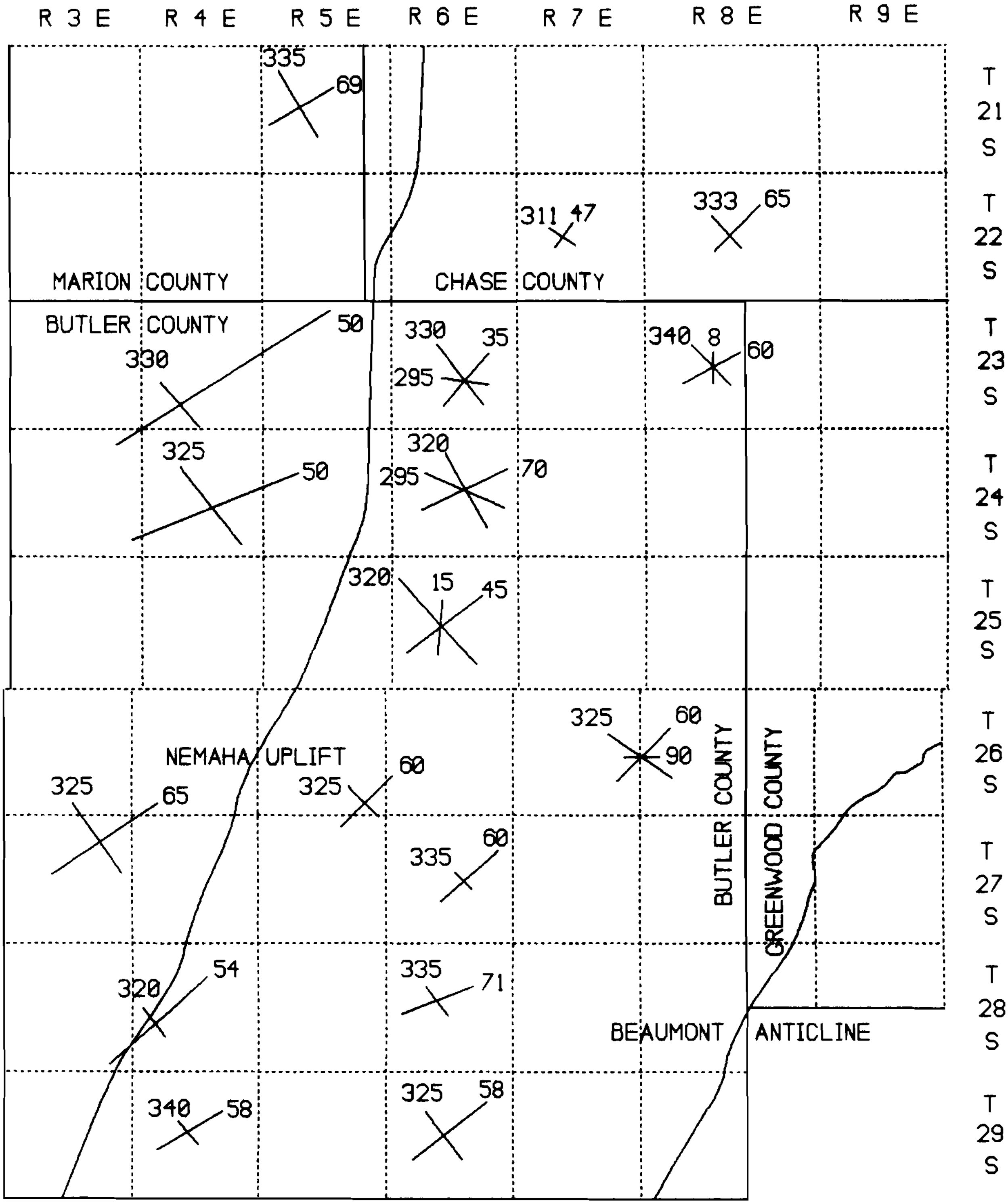


FIGURE 3-1: Major joint sets in relation to study area. Adapted from Ward (1966, Table 1 and Plate 1).

LINEAMENT STUDY

A five year study, funded by the U.S. Nuclear Regulatory Commission, was completed by the geological surveys of Kansas, Nebraska, Oklahoma and Iowa (Burchett, Luza, Van Eck and Wilson 1983). Frank Wilson was the principal investigator for the Kansas Geological Survey. The purpose of the study was to locate potential earthquake sites within the state. The study concentrated on the Humboldt Fault, a system of faults associated with the Nemaha Uplift (Fig. 3-2). This information was considered useful as an aid in locating nuclear power plant sites.

Figure 3-3 is a lineament map based on interpretation of Landsat images as part of the study. The purpose of the map was to indicate the locations for possible faults in the subsurface. Straight lines are stream segments, and the curved lines are based on tonal differences in the images and stream patterns. However, there were no comparisons made by Burchett et al. (1983) with the joint patterns of the area as a controlling factor of stream pattern development.

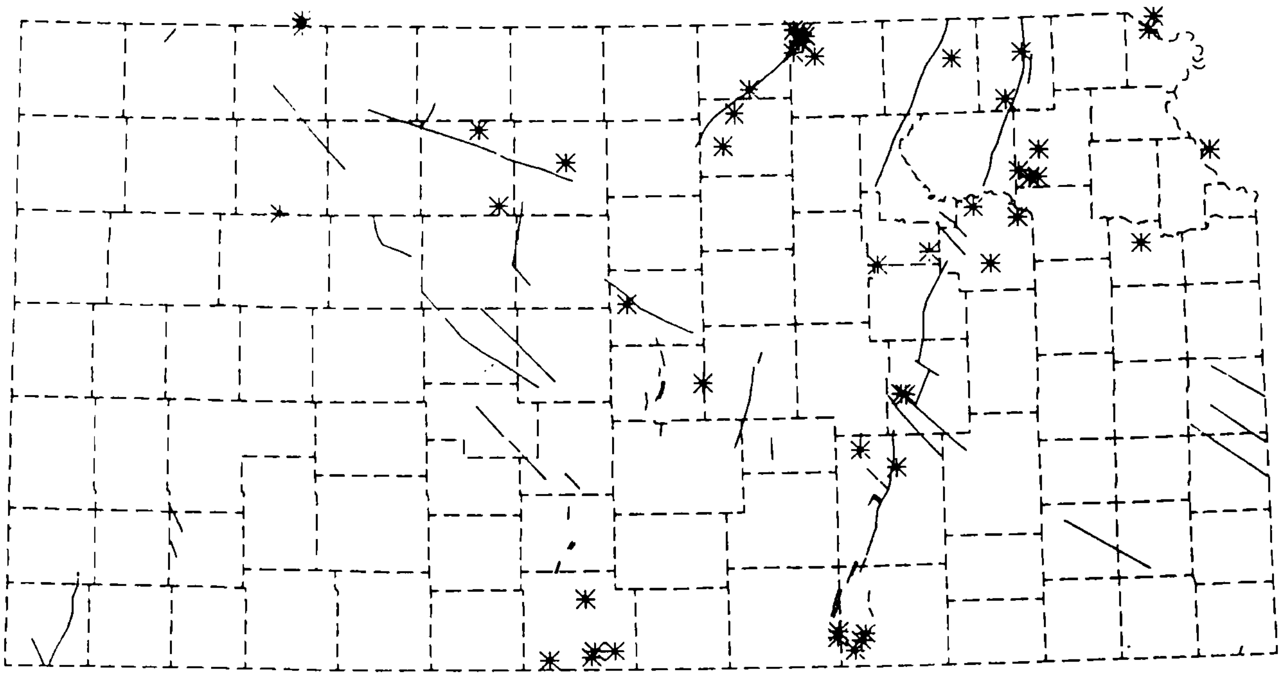


FIGURE 3-2: Location of Humbolt Fault (\) and related microearthquakes (*). Adapted from Burchett et al. (1983, Fig. 4).

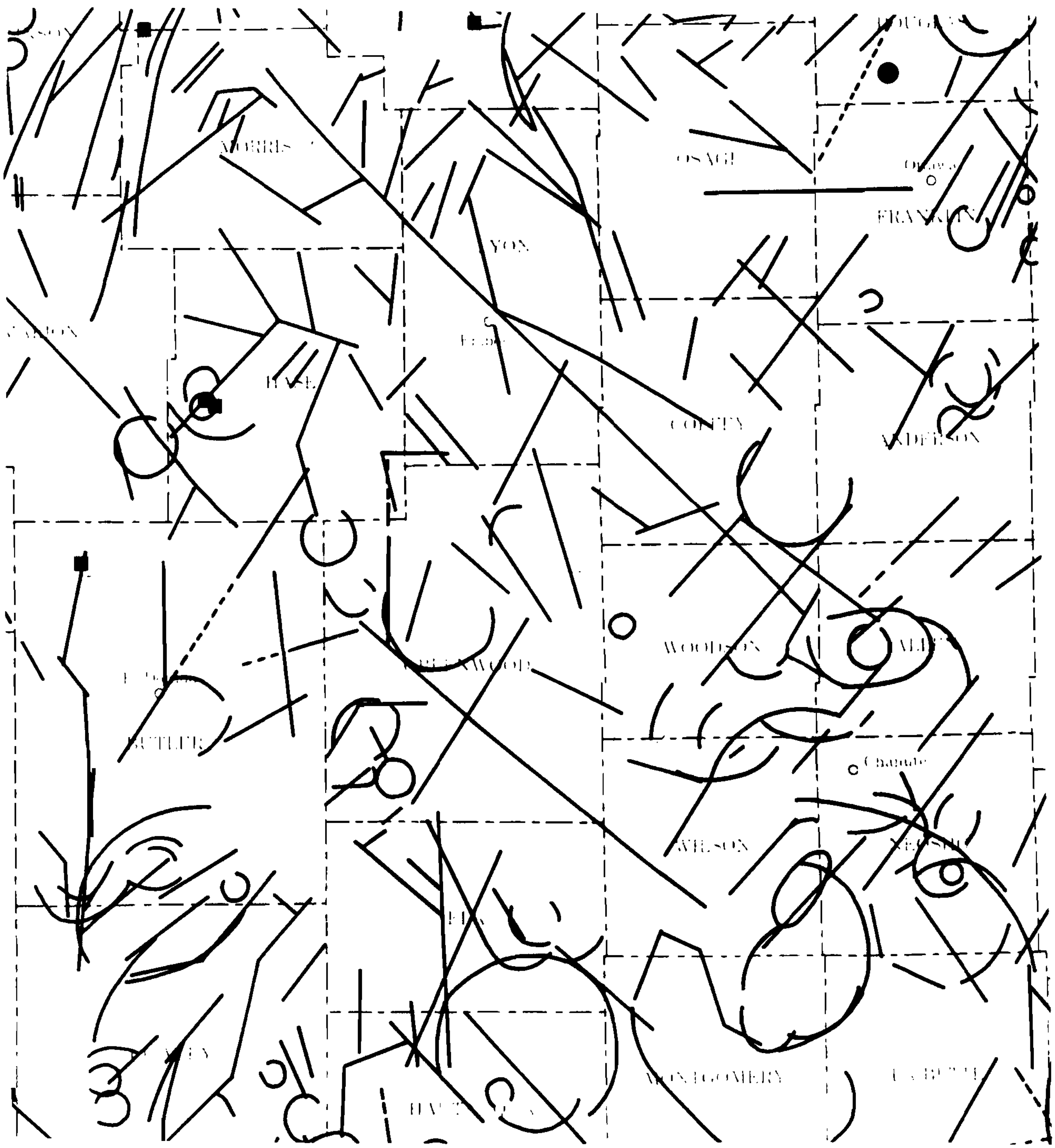


FIGURE 3-3: Map of lineaments in east-central Kansas.

Adapted from Burchett et al. (1983, Plate 3).

CHAPTER 4

LANDSAT

In 1967 NASA instituted the Earth Resources Technology Satellite (ERTS) program (Drury 1987). The project was designed to collect spectral data of the biological and physical properties of the planet. The first satellite in the program, ERTS-1 was launched in 1972. In 1975 the program was renamed LANDSAT (land satellite) and remained under NASA control until 1982. At that time management was transferred to the National Oceanic and Atmospheric Administration (NOAA). In 1984, management of the Landsat program was transferred to a private organization, the Earth Observation Satellite Company (EOSAT).

Landsats-1,-2 and -3 were placed in sun-synchronous orbits that crossed the equator at an altitude of 900 km (Avery and Berlin 1985). Each satellite orbited the Earth at an 8o angle to the poles, 14 times per day with each successive orbit being shifted 2760 km to the west. Using this regime, spectral data of the Earth's surface were collected from 82o N latitude to 82o S latitude every 18 days. Data from a given location on the Earth's surface was collected 20 times a year by each satellite at approximately the same time of day.

Landsats-1, -2, and -3, were equipped with two imaging systems, a four-channel, multispectral scanner (MSS) and a Return-beam Vidicon (RVB). MSS is a line scanner that records reflected radiation simultaneously in four spectral bands, that range in wavelength from 0.5 to 1.1 microns of the electromagnetic spectrum (Drury 1987). A scene has 2340 lines and takes 25 seconds to produce. Each scan line is comprised of 3240 picture elements (pixels) representing 185 km on the ground with a resolution of 80 m. Because of the rotation of the Earth and time required for scanning, the scene shape is a parallelogram 185 km by 185 km. Scene orientation is not true north because of the orbit angle.

MSS images provided a view of the Earth's surface that had not previously been available. The scale and information contained in the MSS images initiated a revolution in the scientific community (Short 1982). Remotely sensed data is used by a wide variety of professionals including: geologists, geographers, hydrologists, agronomists and meteorologists.

Landsat-4 and -5 were placed in orbit in the 1980s with a new primary sensor, the Thematic Mapper (TM). The TM is a multispectral line scanner similar to MSS, but it uses seven bands and has improved resolution and better overall geometric quality (Avery and Berlin 1985). Figure 4-1 provides the ranges of the seven bands used by the TM. The resolution of the TM is 30 m except for the band-6, which has a resolution of 120 m. To improve the ground resolution of the TM, the altitude over the equator was lowered to 700 km.

Band Number	Wavelength Range (µm)	Spectral Region	Application
1	0.45– 0.52	B'ue	Designed for water body penetration, making it useful for coastal water mapping; also useful for differentiation of soil from vegetation, and deciduous from coniferous flora
2	0.52– 0.60	Green	Designed to measure visible green reflectance peak of vegetation for vigor assessment
3	0.63– 0.69	Red	A chlorophyll absorption band important for vegetation discrimination
4	0.76– 0.90	Reflected infrared	Useful for determining biomass content and for delineation of water bodies
5	1.55– 1.75	Reflected infrared	Indicative of vegetation moisture content and soil moisture; also useful for differentiation of snow from clouds
6	10.40–12.50	Thermal infrared	For use in vegetation stress analysis, soil moisture discrimination, and general thermal mapping
7	2.08– 2.35	Reflected infrared	Potential for discriminating rock types and for hydrothermal mapping

FIGURE 4-1: Characteristics and uses of Thematic Mapper on Landsat-4 and -5. Taken from Avery and Berlin (1985, Table 7.7).

The lower orbit reduced the coverage frequency to 16 days for each satellite. Scene shape, area imaged, and orientation remained the same. The MSS was also included to provide continued coverage.

In 1991 EOSAT has scheduled the launch of Landsat-6. The imaging systems include a high resolution panchromatic RBV and the seven band TM (EOSAT Catalogue, Landsat Products and Services). The MSS system will not be included in the next series of Landsat satellites.

SCENE COMPOSITION

The TM line-scanning system is composed of a set of three mirrors and a bank of photoelectric detectors (Drury 1987). The photoelectric detectors are tuned to specific wavelengths of the electromagnetic spectrum and record information in a digital format for that range or band (Fig. 4-1). The mirrors are used to collect and focus radiation on the detectors. A scan mirror rotates to collect reflected and emitted radiation, and additional mirrors are used to focus.

The scan mirror has an instantaneous field of view of 30 m on the ground (Drury 1987). At any given instant the scan mirror is collecting data from a 30 m X 30 m area of the Earth's surface, called a ground resolution cell (Avery and Berlin 1985). A ground resolution cell corresponds to one pixel in the final scene. Each band of a TM scene contains 41 million pixels arranged in a rastor format starting in the upper left corner of the scene. Spectral data for each band from each ground resolution cell are assigned a digital number (DN) to the corresponding scene. This is accomplished simultaneously for all seven bands so that each image in a scene corresponds geometrically.

The DN designated to a pixel represents the electromagnetic amplitude radiated by the ground resolution cell (Avery and Berlin 1985). The DN range of an image is 0-255; 0 DN is minimum radiance, and 255 DN is maximum radiance. Images are recorded in a panchromatic format with 0 DN being black, and 255 DN is white. The range between 0 and 255 is represented by gray-tone intensities.

The intensity of a pixel in an image is related to the wavelength of that band and the physical composition of the ground resolution cell (Drury 1987). Figure 4-2 represents the physical components that effect the reflectance of a ground resolution cell. Each 30 m by 30 m cell includes different features, cell A-1 and B-1 are the only pure cells, the rest are mixed cells. The radiation response of a mixed cell would differ from that of a pure cell. The response of additional surface categories affects the intensity of the ground resolution cell. The reflectance of cell A-2, mixed grasses would not be the same, as B-2 which contains the farm. The farm is not visible in the corresponding pixel, however, because of the resolution of the scanner system.

Most pixels are mixed. The pixels of the plowed field

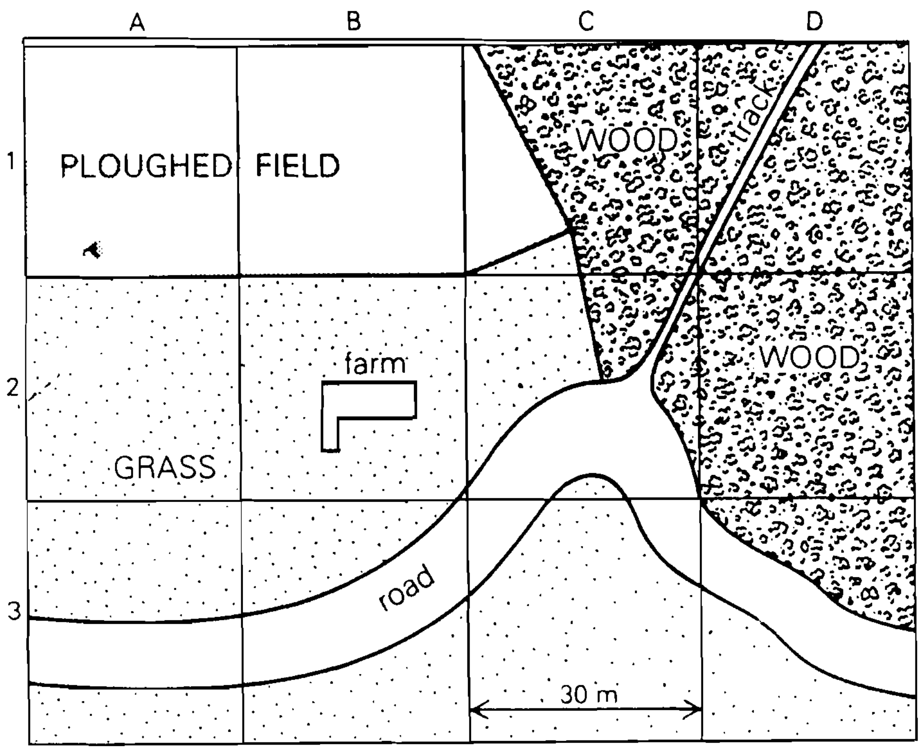


FIGURE 4-2: 30m by 30m pixels superimposed on ground surface resolution cells to display the affect of mixed categories on Thematic Mapper images. Taken from Drury (1987 Fig. 3.14).

are affected by soil type, moisture content, size of soil clumps and other factors (Short 1982). The DN of these pixels fall within a specific range and are normally distributed about the mean DN of the soil pixels. This distribution of DNs is the spectral signature of the plowed field category. All surface categories have their own spectral signature which differ from band to band. Certain cover categories are highlighted by different bands of the electromagnetic spectrum. Figure 4-1 describes the type of application for which each band is used.

OBTAINING LANDSAT DATA

Landsat products can be obtained through EOSAT's Customer Service Department in Latham, Maryland or the EROS Data Center in Sioux Falls, South Dakota. The Landsat product acquired for the study was TM digital data. Data is supplied on 5.25-inch floppy disks in PC/MS-DOS format for use on personal computers. The data of this user-selected area, represents a TM subscene 512 pixels by 512 lines and correlates to a ground area of 15 km by 15 km. The subscene consists of seven floppy disks, each containing digital data for a single TM band in ASCII format. Image files are identified by the band contained on the disk: Bandn, where "n" represents the TM band, 1-7.

Prior to ordering the TM data, several preliminary steps were taken. First, parameters for the area were developed.

These include competent bedrock, stage of development, accessibility, morphologic process and the availability of additional data for reference. Aerial photos of Butler County were available as an additional data source, and the area fulfilled the other requirements of the study.

A geographic search for Landsat data was instituted in April, 1989. EOSAT uses a path-row format for archiving Landsat scenes. The path and row of a scene is the center point for that scene. The path is the orbit number and the row is the center point of a scene along that path. Path/Row maps for the U.S. are available from EOSAT.

Butler County falls between paths so the longitude and the latitude of the counties corner points were used as a location for the search. Maximum cloud cover allowed for the search was 10% with minimum acceptable image quality rating of 8 (0-poor, 8-good). Included in a geographic search is the preferred time of year that the data was collected. Spectral data collected at different times of the year can accent the information contained in the scene. For example, winter scenes tend to enhance topographic features because of the low sun angle. Linear patterns of streams could be enhanced by sun angle and the response of natural vegetation to climatic change. 1988 had been a dry year throughout the state, and this fact would enhance differences in the response of Bluestem grasses of the region. The dates chosen for the search were June of 1988 through January of 1989.

The geographic search yielded 15 TM scenes that met the requirements of the search. An additional 14 MSS scenes were included. MSS acquisitions are processed to film a few days after acquisition and the percent of cloud-cover is assessed manually (EOSAT, TM Customer Note). The percentage of cloud-cover in a TM scene is assessed electronically and is less accurate than the MSS method. Since MSS/TM scenes are collected simultaneously, the MSS scene is provided for greater accuracy in determining scene cloud-cover. The location of the study area was selected and the center point for the TM subscene acquisition determined.

The geographic search included three overlapping path/row coordinates: (1) path 27/row 34, (2) path 28/row 33 and (3) path 28/row 34. The location of the study area center point was contained in two path/row coordinates; 27/34 and 28/33 for which nine scenes were available. Of these nine, six had 0% cloud-cover. This was reduced to three on the basis of acquisition dates. The final scene (#Y5163916314XO) selected was acquired in late August (08/26/89). The selection was made because precipitation received earlier in that month enhanced the reflectance of lowland vegetation in moist locations.

A problem arose with the availability of data that is supplied in the TM floppy disk format. Only TM scenes that EOSAT had previously processed are available, and new acquisitions are not accepted. The August '89 scene initially selected was not available in floppy disk format. EOSAT instituted a search for processed data that met all of the criteria for the study area. This search resulted in only one available scene (#501356294XO). The date of acquisition, 07/14/84, was acceptable for the study, and a TM subscene was ordered. Figure 4-3 is the header information that is included with each floppy disk.

TM LANDSAT Band 2 Byte Data	DO27-034
DATE OF ACQUISITION: 7/14/84	SCENE ID: Y5013516294X0
MAP PROJECTION: SOM	RESAMPLING TECHNIQUE: CUBIC CONVOLUTION
WINDOW EXTRACTED(SL,SS,NL,NS): (945,730,512,512)	EXTRACTED FROM QUADRANT: 1
IMAGE LAT/LON CENTER: N038D 02M 30S 30S	OVERALL GEOMETRIC QUALITY: ACCEPTABLE W096D 32M
IMAGE UPPER LEFT LAT/LON: N038D 07M 03S W096D 36M 32S	IMAGE UPPER RIGHT LAT/LON: N038D 05M 42S W096D 26M 44S
IMAGE LOWER LEFT LAT/LON: N037D 59M 18S W096D 38M 15S	IMAGE LOWER RIGHT LAT/LON: N037D 57M 56S W096D 28M 27S

FIGURE 4-3: Header file of Thematic Mapper band-2 image of study area. Includes path/row (DO27-034), geographic location of center and corner co-ordinates of TM image and date of acquisition (7/14/84). The Window Extracted Information is the pixel co-ordinates of the TM subscene in relation to full acquisition scene. The subscene is contained in quadrant 1 of a full scene that divided into 4 quadrants using path/row co-ordinates.

CHAPTER 5

METHODS AND PROCEDURES

LINEAMENT STUDY

The lineament study was conducted using TM band-5 and -7 images. These bands were chosen through a comparison of image contrast, pattern, and spectral use. Images were displayed through the use of a personal computer and Geographic Information System (GIS) software. A GIS is used to display, analyze and organize spatial information in a digital format (Avery and Berlin 1985).

The GIS used in the study, "Panacea", was developed by Earth Imaging Systems (1988) based in Cambridge, Massachusetts. Panacea is a raster based GIS, designed for image-oriented data display and manipulation (Drury 1987). The Panacea program includes sub-routines and data-base utilities to manipulate image data. Sub-routines and utilities are: Character Editor, Overlay Editor, Color Editor, Convert Utility, Histogram Utility, Analytical Utility and Print Utility.

The seven TM images were converted to the Panacea format using the Convert Utility. Panacea uses the same format as TM images for representing data. The range is 0 to 255 and raster format begins in the upper left corner. Panacea converts data to an overlay format that is displayed by using the Overlay Editor section of the program.

The Overlay Editor uses a color file to display and enhance the contrast of converted data. The default color file is not adapted for TM images and lacks contrast between spectral ranges. Dr. James Aber developed a color file for use with a TM sub-scene of the Grand Canyon. The Grand Canyon color file provided acceptable contrast for the study area TM sub-scene and was used for the investigation.

The pixel distribution of band-7 DNs was compressed in the lower half of the DN range. To improve the contrast of the band-7 image a linear stretch of the DN range was done using the Analytical Utility. The DNs of the image were multiplied by a factor of two, and an overflow trapping limit set at 255. Example: A DN of 80 times 2 equals a DN of 160, a DN of 195 times 2 equals 255, as 255 is the upper limit of any DN. The results for band-7 are shown in Figure 5-1.

The Panacea Histogram Utility prints the frequency and the range of pixel DNs of an overlay. By comparing the overlay image to its histogram, spectral signatures of categories are identified. Identified categories include: water, Kansas Turnpike (I-35), and grasses. The grass categories comprised more than 80% of the 262,144 pixels of each image. The grass categories were subdivided on the basis of image pattern and linear relationship. The identified categories were assigned graphical symbols using the Character Editor for printed output (Fig. 5-2). Four category symbols were used to print the band-7 overlay.

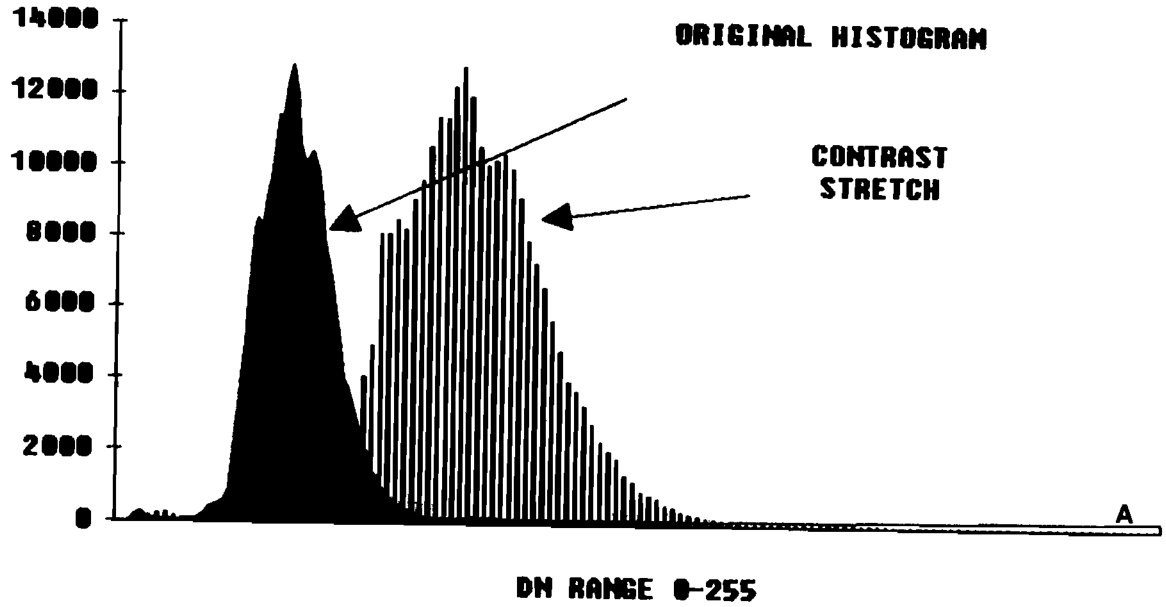


FIGURE 5-1: Histogram of band-7 showing normal pixel distribution and distribution after linear contrast strech. Line "A" is series distribution of DN values.

FIGURE 5-2: Example of symbols used to print overlay of band-7. Spectral signatures shown are water (wavy box), bare ground (sign) and grasses (cows and bushes).

However, the band-5 overlay required eight category symbols because of the distribution of pixel DNs covered the entire DN range (Fig. 5-3).

The printed TM overlays measured 18 m^2. Because of the size of the printed overlay certain spectral categories were used to locate the position of lineaments for transfer to a final map. The categories used for this purpose were roads and bodies of water. Bodies of water were also used in the lineament study.

The observed lineaments were plotted onto the printed overlay manually, using a computer displayed image as a reference. The relationships of the observed lineaments to the study area were identified using 1:24,000 topographic maps. Lineaments related to stream valleys were transferred to topographic maps and compass orientations of lineaments were measured using a protractor.

JOINT PATTERN STUDY

The purpose of the joint pattern study was to define the joint systems of the structural domains of the study area (Davis 1984). The joint system study differs from Ward's (1968) regional study of dominant joint sets, in that all joint orientations are considered. The structural domains are the major features of the study area that affect the development of drainage. The main structural domains are within the Barneston Limestone and Wreford Limestone.

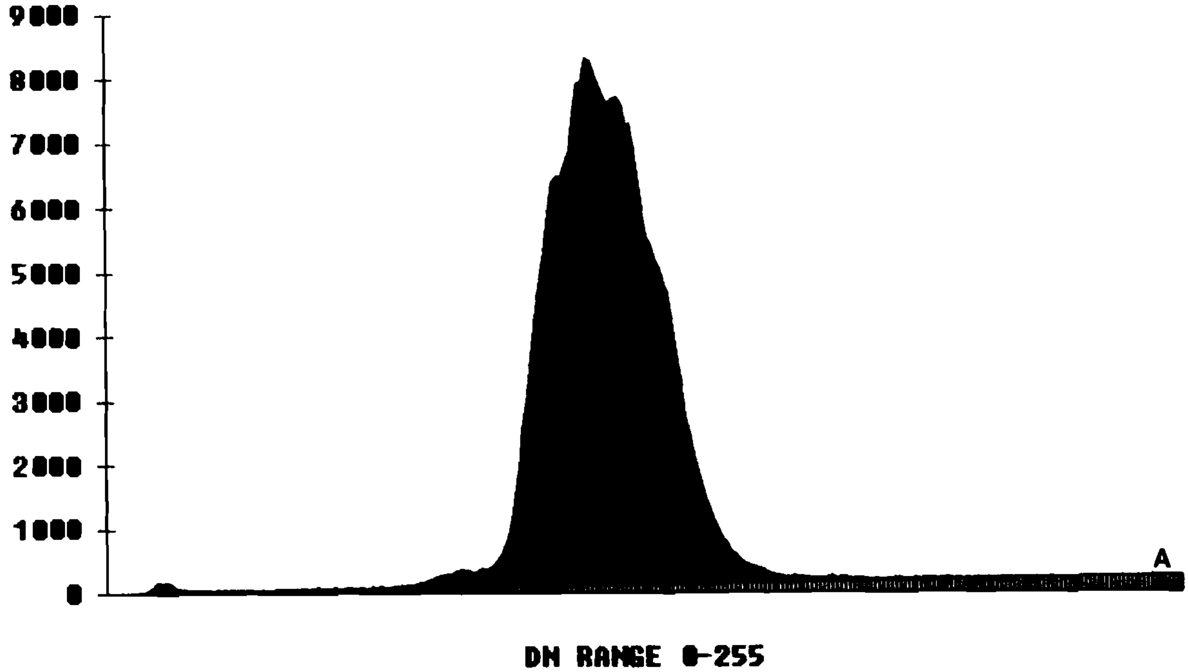


FIGURE 5-3: Histogram of band-5 image. Line "A" is series distribution of DN values.

Barneston Limestone joint system data was collected at a quarry in the $NE^1/_4$ of $NW^1/_4$, Sec.6, T23S/R9E. The study site for Wreford Limestone exposure was a road cut outside the study area, at Teterville in Greenwood County (T23S/R9E).

Both sites for the joint study include exposures of the bedding planes of the rock bodies. Joints were selected for measurement that dissected all exposed bedding planes and exhibited evidence of weathering on the vertical sides of the joints. In the southeastern corner of the quarry, the overburden of loess and residual chert had been removed exposing the surface of the Fort Riley Limestone. This area was included in the study by selecting the weathered joints.

Joint orientation measurements were converted to compass orientations and plotted on a polar co-ordinate diagrams. Joints in a 10° range were plotted beginning at a center point of 0°. The number of joints in a 10° sector were plotted with one orientation for each concentric circle of the diagrams.

CHAPTER 6

RESULTS AND OBSERVATIONS

LINEAMENT STUDY

Band-7 produced 39 plotted lineaments (Fig. 6-1) of stream valleys, Fox Lake, and large ponds. Other identified features included: north-south county roads, the Kansas Turnpike, the Scott oil field and portions of east-west county roads. The east central portion of the band-7 map included the selected signatures, however, the patterns lacked obvious linearity. An attempt to plot lineaments in this area would increase error of the data.

Figure 6-2 is the polar co-ordinate plot of the band-7 lineaments. Each circle represents one lineament orientation; the range of orientation is 0°-359°. Orientations were plotted in 10° sections, with 5° on either side of a compass direction. Example: 90° orientation is east, range for the orientation is 85°-94°.

Major lineament orientations are: 90°, 10°, 30°, 300°, 0°, and 330°. Secondary orientations include: 20°, 40°, 50°, 60°, 320°, 340°, and 350°. No lineament orientations were measured at 80° or 310°.

The higher contrast of the TM band-5 image was better suited for the lineament study. A total of 50 topographic related lineaments were plotted utilizing the band-5 image (Fig. 6-3). Additional features of the image are: all county

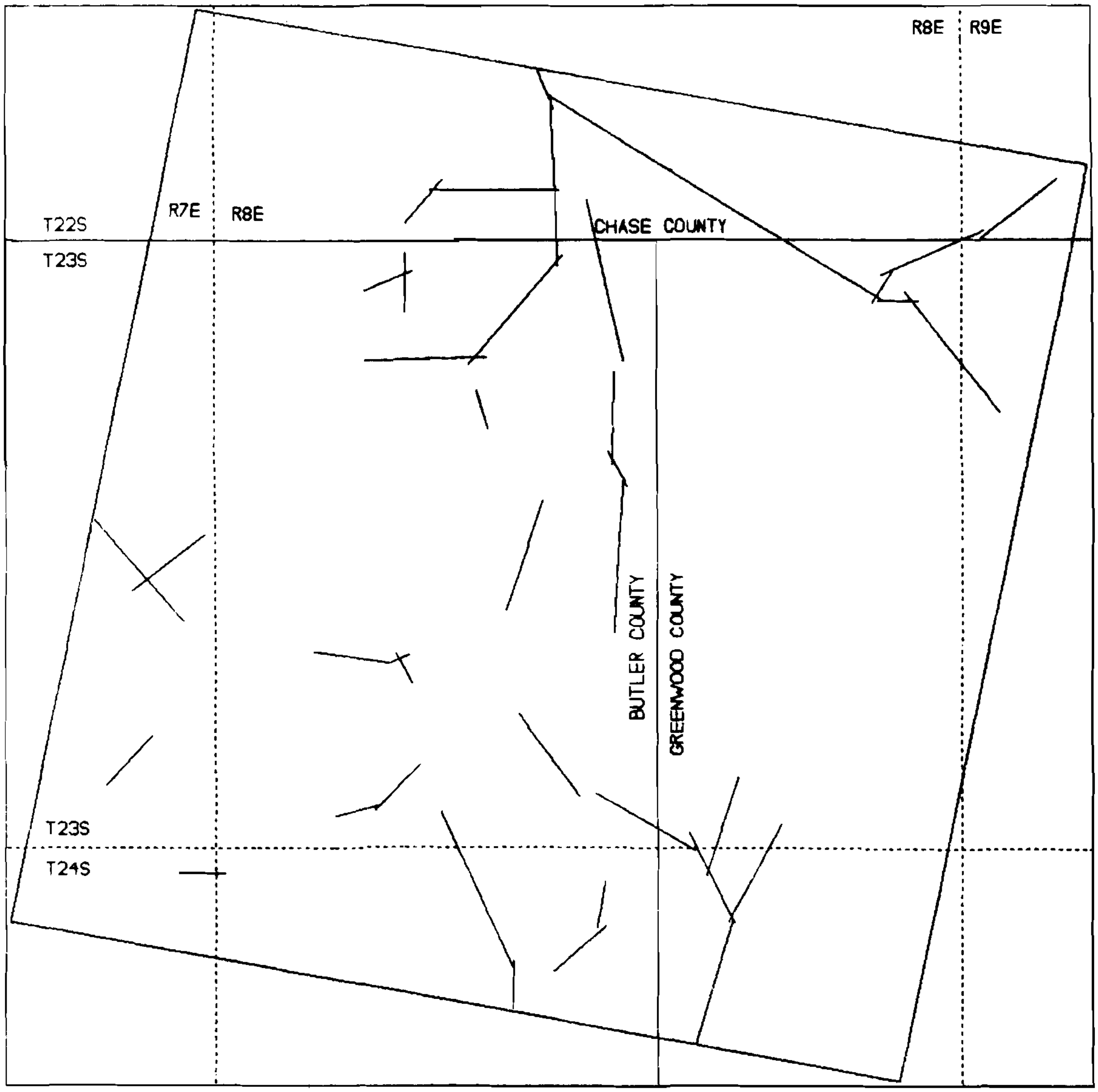
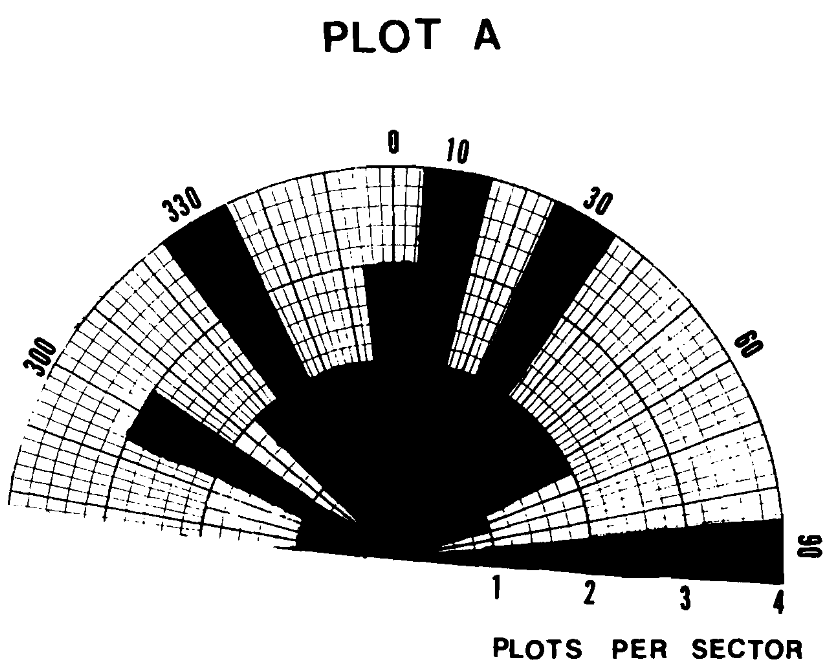


FIGURE 6-1: Lineament map of band-7 image.



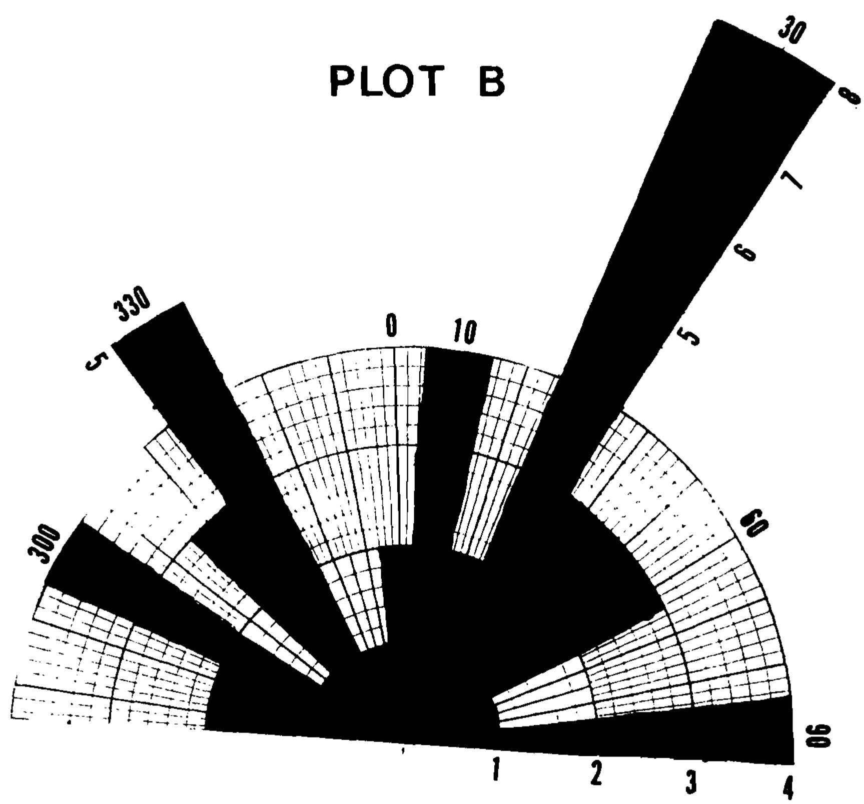


FIGURE 6-2: Polar co-ordinate lineament plots, plot A is band-7 lineaments and plot B is band-5 lineaments.

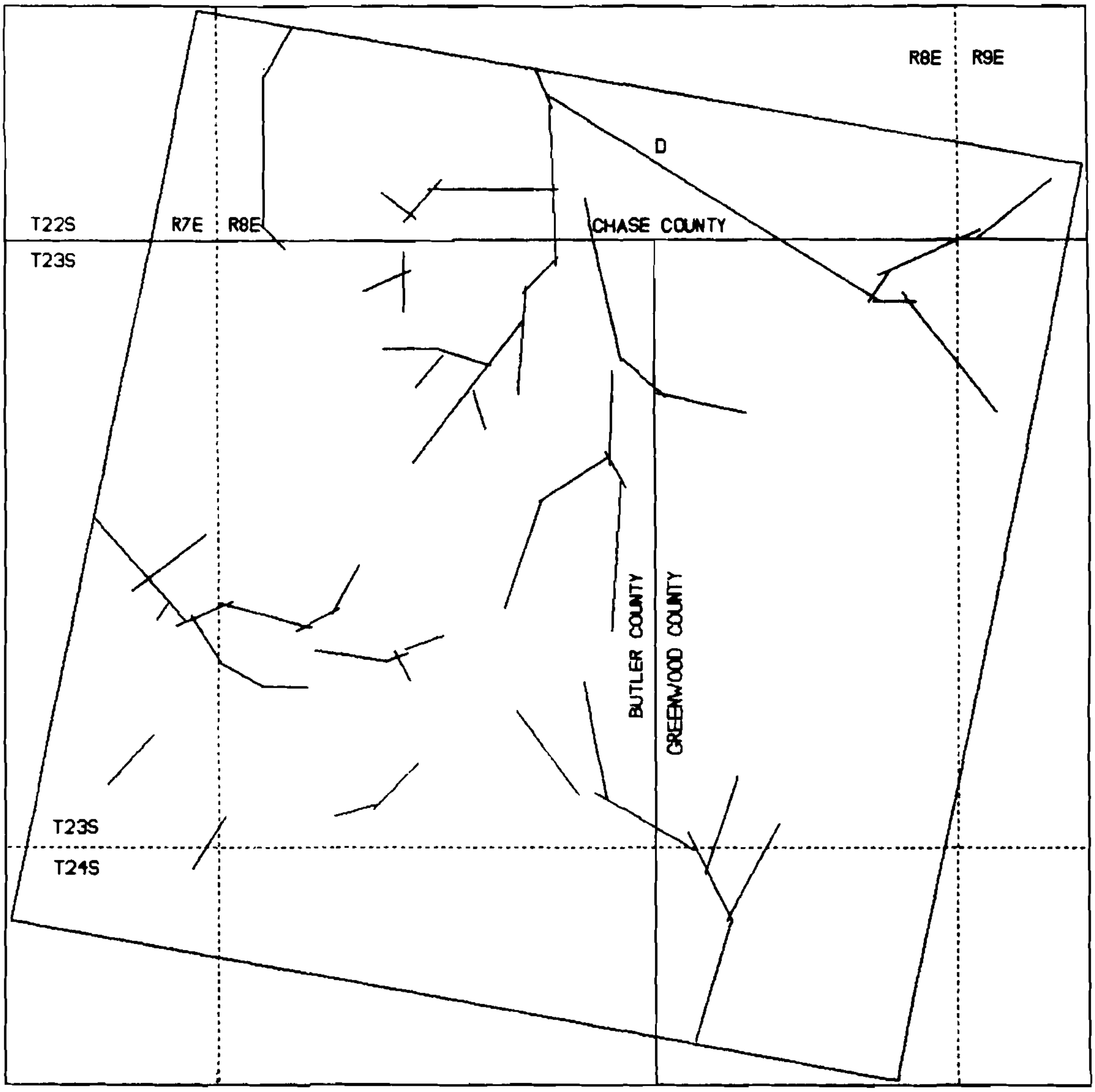


FIGURE 6-3: Lineament map of band-5 image.

roads, Scott oil field, oil field roads, the Kansas Turnpike and the trend of a buried gas line. Both lanes of the Kansas Turnpike and the Matfield Green service area are visible in the image.

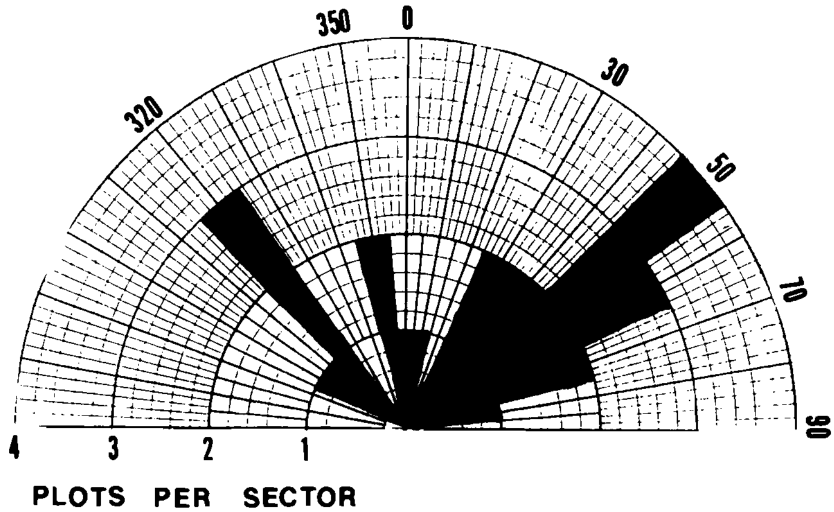
The polar co-ordinate diagram (Fig. 6-2) of TM band-5 lineaments indicates a major trend at 30°. Secondary orientation trends are: 10°, 50°, 60°, 90°, 300°, 310°, and 330°. All sectors of the polar co-ordinate diagram for band-5 contained at least one lineament orientation.

The band-5 and band-7 polar co-ordinate plots are similar in overall comparison. Related lineaments produced the same orientation measurement. However, the frequency of the 0° trend in the band-5 lineament plot was reduced, while all other orientation trends increased in frequency.

JOINT SYSTEM STUDY

The joint system of the Wreford Limestone measured at Teterville (T23S/R9E) is displayed in Figure 6-4. A total of 23 joint orientations were measured at the site. The plotting of joint orientations on the polar co-ordinate diagram uses the same format as the lineament study. Major joint orientations are: 50°, 60° and 320°. Secondary orientations are: 30°, 40°, 70° and 350°. No joint orientations were plotted at: 20°, 90°, 280°, 290°, 330° and 340°. Most joint orientations have complementary orientations at 90°

PLOT A



PLOT B

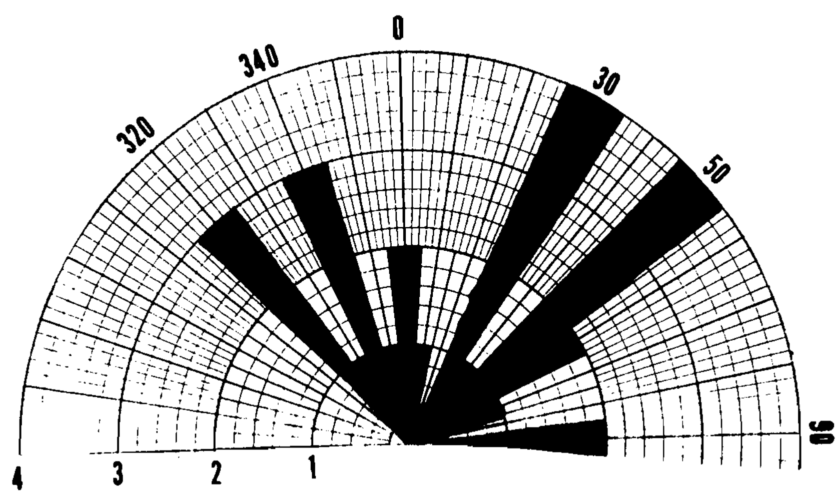


FIGURE 6-4: Polar co-ordinate joint plots, plot A is Wreford Limestone joints and plot B is Barneston Limestone joints.

intervals, however, a 90° complementary joint set was not observed for the 60° joint orientation.

The polar co-ordinate plot of the joint system of the Barneston Limestone (Fig. 6-4) is from the quarry in T23S/R8E. A total of 25 joints were plotted with major joint orientations at: 30°, 50°, 320°, and 340°; secondary joint orientations include: 0°, 60° and 90°. No joints were measured with orientations at: 20°, 80°, 280°, 290°, 300° and 310°. A 90° complimentary joint orientation was not observed for the 30° orientation.

Orientations of the Barneston and Wreford Limestone joint systems were added to Ward's (1968) data (Fig. 6-5). Also added were joint orientations in T29S/R8E, in southeastern Butler County, measured by Aber (1990).

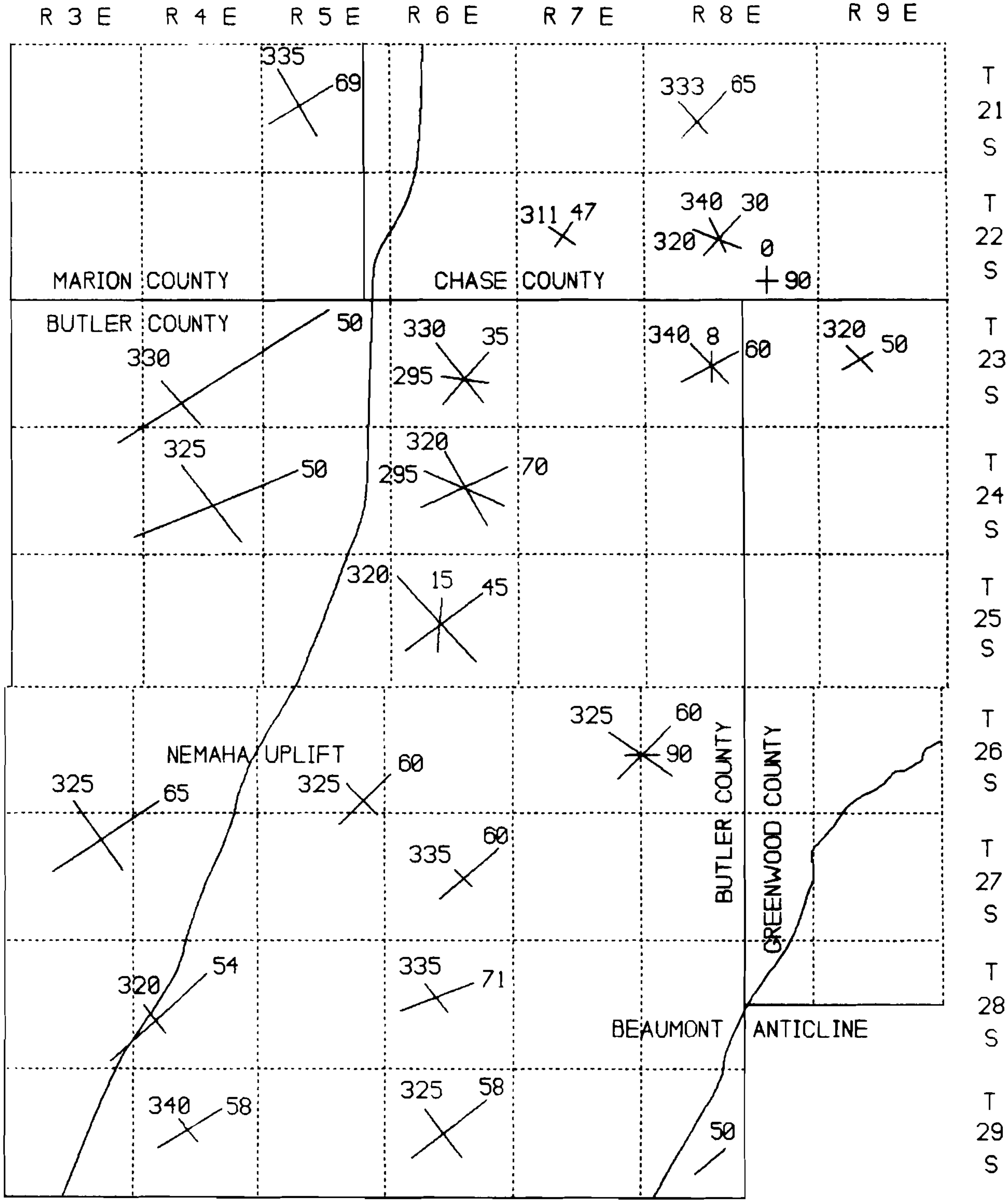


FIGURE 6-5: Regional joint system of study area. Adapted from Ward (1968).

CHAPTER 7

INTERPRETATIONS

Ward's (1968) analysis of joints determined the orientations of major joint sets of the region and not the orientation of the joint system. The combination of joint studies (Fig. 6-5) provides a representation of the joint system in the study area.

The lineaments that were plotted from the TM band-5 and -7 images represent intermittent streams related to the major drainage basins in the study area. The stream valleys in the images were enhanced by the spectral signature of the Big Bluestem grasses, which responds faster to climatic conditions than the Little Bluestem grasses. Late June and early July in 1984 had been hot and dry in the region (Climatological Data for Kansas 1984). The spectral response of the Big Bluestem, to the dry conditions, produced a lower DN range in the band-5 and -7 images.

The July 1984 TM image used in the study highlighted a specific set of lineaments. TM images with different acquisition dates would be affected by the seasonal and climatic conditions related to that image. Differences in seasonal/climatic conditions could enhance lineaments that were not observed in this study and eliminate lineaments that were visible.

A comparison of polar co-ordinate plots of the band-5 and band-7 lineaments to the joint system indicates a relationship between the two. Major lineament orientations correspond to major joint orientations. In addition, lineament orientations with lower frequency of occurrence correspond to less common joint orientations.

The 30° lineament trend corresponds to the 30° (T22S/R6E) and 35° (T23S/R6E, Fig. 6-5) joint trends. A high frequency of lineament orientations are present in band-5 and -7 from 30° to 60°. This is followed by a decline of lineament orientations in the 70° and 80° trends. The frequency of lineament orientations then increase in the 90° trend. The joint orientations display similar trends, with one plot in the 70° to 80° range in T28S/R6E and an increase of joint orientations in the 90° trend. Other related lineament/joint orientations are: 300°/295°, 320°/320° and 330°/330°.

The longest lineament observed in the study is lineament D in Figure 6-3. The orientation of lineament D is within the 300° trend. Lineament D corresponds in orientation to the longest lineaments in Figure 3-3. The corresponding lineaments in Figure 3-3 are related to the Neosho River (Morris, Lyon and Coffee Counties) and the Fall River (Greenwood County). The 90° compliment of lineament D is the 30° orientation trend. This is the lineament orientation with the highest frequency of plots in the band-5 image and a major orientation trend in the band-7 image. A comparison of the 30° lineament trend to Figure 3-3 reveals a similar relationship. The lineaments in this trend are shorter in length, but higher in frequency. No relationship to the curved features in Figure 3-3 was observed in the images of the study area.

Lineament D also parallels the trend of part of the Humboldt Fault Zone in the same region (Fig. 3-2). The Humboldt Fault is a left-lateral wrench fault system (Fig. 7-1) that crosses the state at an angle of approximately 30°. This fault system developed in conjunction with the Ouachita Orogeny during the Pennsylvainian Period. Geologic structures associated with the Humboldt Fault Zone are: Nemaha Uplift/ Anticline, domes, basins, and regional joint patterns. The trend of the Humboldt Fault to west of the study area is north-south or 0°. The complimentary angle of 0° is 90°, these trends are also minor lineament orientations of band-5 and -7 images.

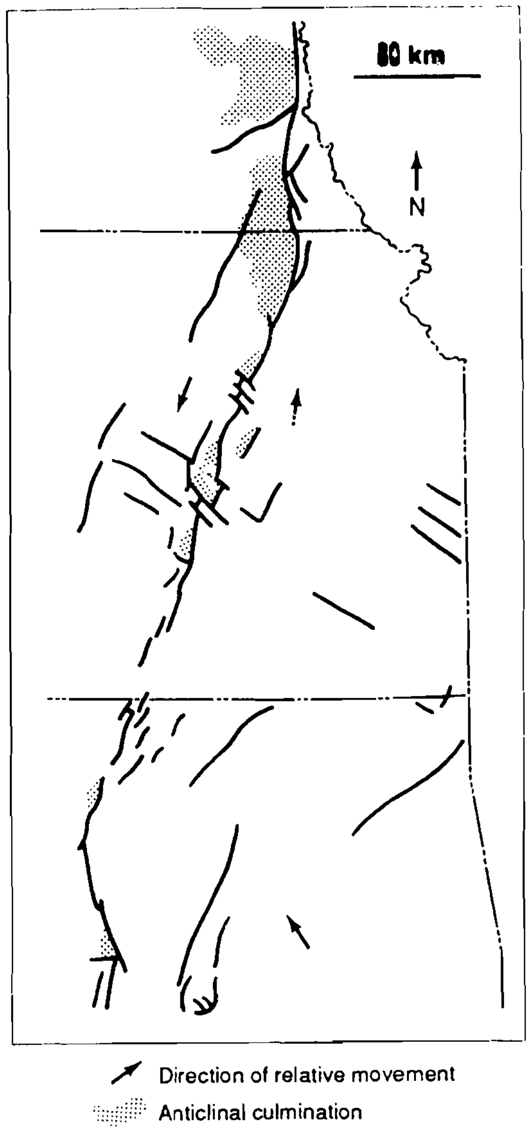


FIGURE 7-1: Trend of the Humboldt Fault zone in eastern Kansas, Nebraska and Oklahoma. Adapted from Baars, Watney, Steeples and Brostuen (1989, Fig. 6).

CHAPTER 8

CONCLUSIONS

Through a comparison of the present study and previous work the following conclusions can be made: (1) The pattern of stream morphology in the study area is controlled by the joint system. (2) There is a relationship between the major lineaments and their orientations and frequencies to parts of the Humboldt Fault zone in the study area. (3) The trend of the Humboldt Fault to the west of the study area exerts control on the orientation of minor lineaments in the study area. (4) The lineaments in the study area are related in general to the lineaments of eastern Kansas. The orientations, lengths, and frequencies of stream valleys correspond to lineaments visible in Landsat images and to joints measured in the field.

Based on the conclusions of this study it is apparent that the Humboldt Fault and associated geologic structures, namely joints, control the pattern of stream development in eastern Kansas. This association includes the orientations of major rivers, their tributaries, and headwater streams.

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