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GRADUATE COLLEGE

QUANTITATIVE STUDY OF THE CHEROKEE-MARMATON GROUPS, WEST FLANK OF THE NEMAHA RIDGE, NORTH-CENTRAL OKLAHOMA

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

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ΒY

ORVILLE ROGER BERG

Norman, Oklahoma

QUANTITATIVE STUDY OF THE CHEROKEE-MARMATON GROUPS, WEST FLANK OF THE NEMAHA RIDGE,

NORTH-CENTRAL OKLAHOMA

APPROVED BY Ç 6 0

DISSERTATION COMMITTEE

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QUANTITATIVE STUDY OF THE CHEROKEE-MARMATON GROUPS, WEST FLANK OF THE NEMAHA RIDGE, NORTH-CENTRAL OKLAHOMA

INTRODUCTION

Purpose of Investigation

This study is an investigation of the subsurface Cherokee-Marmaton rocks in north-central Oklahoma. The purpose was to establish the distribution and nature of the sedimentary rocks in order to gain some clues as to sedimentary environments involved during their deposition.

In addition, the relationship of the Nemaha Ridge was examined in order to determine its role in the contribution and distribution of sediments.

As is true in most studies, other aspects not previously considered developed and of necessity had to be integrated into the study.

Location

The area encompassed by this investigation includes Tps. 10 to 29 N. and Rs. 1 to 10 W., comprising approximately

7,000 square miles. As outlined, the area includes all of Grant, Garfield, Kingfisher, and Canadian Counties, parts of Kay, Noble, Payne, Logan, and Oklahoma Counties to the east, Alfalfa, Major, and Blaine Counties to the west, and Caddo, Grady, and Cleveland Counties in the south (Fig. 1).

Tectonic Setting

The area under consideration is on the northern shelf of the Anadarko Basin (Fig. 2). Tectonic features which dominate the area are the Nemaha Ridge and the Sedgwick Basin. Closely related features are the Anadarko Basin to the southwest and the Cherokee Basin to the east. Positive tectonic elements in proximity to the area under consideration include the Arbuckle and Wichita-Amarillo Uplifts in the south and southwest and the Central Kansas Uplift to the northwest.

Previous Investigations

Since 1945, rocks of this area have been investigated in progressively more detail. Many of these studies are of a local nature such as oil-pool studies, whereas others are more regional in aspect. In the following discussion only those studies of a semi-regional or regional nature will be considered.

A series of stratigraphic cross-sections showing the

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general lithologic correlation of formations across northeastern and central Oklahoma was issued in 1930 by the research committee of the American Association of Petroleum Geologists (Levorsen, 1937). Lukert (1949) published a series of stratigraphic cross-sections which dealt with Pennsylvanian rocks in north-central Oklahoma. Wheeler (1947-48), in connection with a study of the Anadarko Basin, published a number of structure, isopach, and paleogeologic maps. Pate (1959) discussed the stratigraphic traps on the northern shelf of the Anadarko Basin. McElroy (1961) made an isopach and lithofacies study of the Desmoinesian Series in north-central Oklahoma. Rascoe (1962) included this area in a stratigraphic analysis of Pennsylvanian and Permian rocks of the Mid-Continent. More recently, Swanson (1967) presented a number of maps and cross-sections in a paper on the Anadarko Basin. Klinger and Ash (1967) published several cross-sections and maps in a recent article on the northeast flank of the Anadarko Basin.

A number of theses based on subsurface studies have been completed by graduate students at the University of Oklahoma, these include: Allen, 1954, Arnold, 1956, Benoit, 1957, Beveridge, 1954, Caylor, 1956, Dana, 1954, DeJong, 1959, Ford, 1954, Gibbons, 1960, Kimberlin, 1955, McKenney, 1953,

Nolte, 1951, Stanbro, 1960, and Ward, 1958.

Method of Study

As earlier stated, this study is subsurface in nature, therefore, electric well-logs and sample logs were the principal sources of data.

The original plan called for the use of five electric logs per township. In many instances, however, wells were not available due to sparsity of drilling and the fact that only a few could be utilized. These conditions were prevalent especially in the western and southwestern parts of the area. All available wells were used except those in the extreme southwestern townships where distances between wells and intervening facies changes made the use of those wells difficult and the results open to question.

Electric logs were traced to form a series of crosssections, one east-west section for each row of townships (a total of twenty) and a north-south section for each column of townships (a total of ten). The center well in each township appeared in both cross-sections passing through it. This was done in order to establish accurate control on all correlations whether in a single cross-section or looped through any number of cross-sections. That is, correlation could be carried from one well in any direction through

several others and back to the original. A few additional wells were added later and correlated with wells in the network of cross-sections.

Sample logs were used to identify and maintain control on lithology. They were selected so as to cover as much of the area under examination as was possible.

A total of 820 electric logs and 30 sample logs were ultimately used in the investigation.

When correlation was completed, thicknesses and lithologies of the units were recorded. From these data isopach and isolith maps of the units were made. A computer was utilized to calculate the data necessary for a lithofacies map of the Marmaton Group. In addition, cross-sections were made to illustrate the horizontal and vertical relationships of the units mapped.

The isopach maps were based on the premise that definable lithologic markers extended across the area under consideration. At some places, markers disappeared as a result of facies changes, thus ending the isopach at that point.

Isoliths depicting thicknesses of sandstones and/or limestones present within the isopached intervals vary as to the contour interval used in order to best illustrate behavior of that particular unit.

During compilation of sandstone thicknesses within a unit care was taken to keep the values for individual sands separate because more than one sand could occur at any given control point. In the case of the units within the Cherokee Group, no more than one thick sandstone (20 feet plus) was present at a control point although one or more thin sands might be present.

The isoliths were made by first contouring the thicker sandstones as it was felt that they were generally contemporaneous and would be most significant in interpretation. The thinner units, in particular, those less than 10 feet thick were often not equivalent. It was felt, however, that treating them as equivalent for isopaching purposes would not adversely affect the pattern of sandstone distribution and would delineate those areas which contained no sand deposits. A contour interval of 10 feet was used where isopaching the sandstones of the Cherokee Group. Sand bodies of 20 feet or less were colored yellow while those of greater thickness are shown in orange (see plates in folder).

These procedures had to be modified in the case of the upper unit of the Marmaton Group. Sandstones in that unit occasionally reach a thickness in excess of 100 feet and often more than one thick sandstone is present in a well.

In addition, a strong divergence is present in the unit which is partially related to a facies change that occurs in the limestones of the lower Marmaton. Because of an absence of marker beds, the unit did not lend itself to further subdivision, therefore, the isolith was made on the total thickness of all sandstones present in the unit. Because of the greater thicknesses involved, a contour interval of 20 feet was used and the 40 foot isolith line was selected as the arbitrary break between thick and thin sandstones.

Contouring of sands was often stopped sooner than control point data would necessitate especially where isopaching unusually thick sandstones. The distribution of the sands was considered to be most significant and crowding of contour lines to illustrate true thickness would simply clutter the map.

Units containing limestones were generally more difficult to handle. It was observed that the number of limestones varied over the area in any given increment and that the limestones might thicken individually to the point of becoming dominant. The maps were designed, therefore, to illustrate the pattern of thickening. In order to eliminate thinner limestones, a minimum thickness was established for individual limestones above which they would be included in

the isolith. The minimum thickness used varied from map to map as did the isolith contour interval both being determined by the particular thicknesses involved. The vertical position of the individual limestone was designated by use of the following letters: U (upper), M (middle), and L (lower). The color scheme used for the limestones, although varying in value, was uniform as to significance. The thickest areas are dark blue, those of medium thickness are medium blue, and areas of minimum thickness are shown in light blue (see plates in folder).

The control point spacing, scale of the map, and the necessity for spacing between isolith contour lines has resulted in considerable exaggeration of the dimensions of some of the isoliths. This is especially true for the sandstone isoliths, where the sands are unusually thick. It is recommended that this be kept in mind when examining the maps to prevent any misunderstandings regarding the extent of these lithologic units.

The cross-sections included in this investigation do not include the number of wells present in the working crosssections. In general, only one well per township was used. Although some correlations may appear to be incorrect, all are based on the correlations described earlier, using the

working cross-sections.

Nomenclature of Marker Defined Units

Marker defined units have been included in several classifications of lithologic units. Forgotson (1957) proposed that these units be named "formats" with the following definition:

<u>Format</u> is here defined in general terms as a rock unit which is related at one point (or in one area) to a unit of formal stratigraphy, but which crosses facies boundaries and cut-offs to reach other areas where other formal units are employed. The term format would apply to marker-defined operational units that are segregations of strata sandwiched between markers which can be traced through facies changes affecting the enclosed strata.

Busch has suggested "genetic increment of strata" as a suitable term for these units (personal communication). He has defined it as:

An interval of strata representing one cycle of sedimentation in which each lithologic component is genetically related to all the others; the upper boundary must be a lithologic time marker and the lower boundary might be either a lithologic time marker or an unconformity. It frequently includes the sum total of all sedimentary deposition during one stage of cyclic subsidence.

He has also suggested "genetic sequence of strata" to include two or more genetic increments of strata. The definition is:

An interval of strata consisting of two or more

genetic increments of strata, representing continuous sedimentation; it must be devoid of any significant breaks.

The Cherokee-Marmaton in the area of study appears to conform well to the definition of the genetic sequence of strata. In addition, each marker-defined unit is best described by the definition of the genetic increment of strata. Therefore, these terms as defined by Busch, will be used in the following discussions.

Gross Characteristics of Sandstones

The following remarks are directed to those genetic increments of strata in the Cherokee and Marmaton Groups which contain sandstone bodies. In the following discussions, sandstones of the individual genetic increments will be described and often tentatively interpreted. In order to facilitate these comments the gross characteristics of sand bodies pertinent to this study will be discussed briefly.

Potter (1967) summarized sand bodies and their characteristics. He recognized six major classifications of sandstones: alluvial, tidal, turbidite, barrier island, shallow water marine, and desert eolian. Characteristics of these sand bodies which may be recognized (in a qualified way) in this study are size, shape and orientation. The following remarks on each sand body type are confined basically

to those characteristics and are largely from Potter's article.

(1) Alluvial sand bodies:

Commonly very elongate. Width ranges from a few tens of feet to composites of 30 miles. Dendritic as well as anastomosing and bifurcating patterns. Elongate downdip.

Bar-finger sand bodies (related to alluvial sand bodies): These sand bodies are elongate downdip, may be 250 feet thick, 5 miles wide, and 30 miles long, and thin and narrow upstream. These sand bodies may be intercalated with alluvial sands of a flood plain origin in an alluvial-delta complex. Down dip bifurcation is characteristic of barfinger sands whose interbranch width increases seaward (modified from Potter, 1967).

Andresen (1961), Hopkins (1958), Sievers (1959) and others have made studies of Pennsylvanian sandstones of the Illinois Basin. Sand bodies are found to be largely of the previous categories which will be shown to be important in the following discussions. Potter (1962) summarized the results of these studies:

Pennsylvanian sand bodies are classified into two basic types--elongate and sheet. Widespread sheet sandstones contrast with narrow, elongate sand bodies. The patterns of sandstones found in subsurface are diagrammatically shown in Figure 3A. (See Fig. 3.)



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The common elongate sand bodies of the basin occur as wide belts, relatively narrow dendroids, and small isolated lenses or pods of generally limited extent. Throughout most of the basin the elongate sand bodies are generally at least 20 feet thick but rarely exceed 125 feet in thickness.

Typically, the belt sand bodies have weakly meandering outlines. They consist of anastomosing, coalescing dendroid sand bodies that form fairly continuous belts up to 25 to 45 miles wide. Such belts nearly always contain "islands" of no permeable sand. Belts are considered to have resulted from either the lateral migration of dendroid sand bodies or their lateral coalescence.

Dendroid sand bodies have patterns that are commonly sinuous and weakly to strongly meandering. Dendritic and anastomosing patterns are typical. Deltaic distributary patterns do occur, but are not In any part of the basin, both belt and as common. dendroid sand bodies generally show a well defined, prevailing linear trend. Dendroid sand bodies may be as narrow as 25 feet or as wide as 2-3 miles. With increasing width, they grade into belts. In contrast, the transition of either dendroid or belt sand bodies to sheets is commonly relatively distinct and abrupt. Transition can occur within 660 Observation indicates that these transitions feet. are generally the result of erosion at their base.

Small isolated pods or lenses of sandstones are also present throughout the basin.

Sheets have somewhat less distinctive patterns. In subsurface the sheet sand body may be either very uniform over a wide area or it may be more patchy and consist of relatively small sand bodies of limited extent. In the latter case preferred direction may not be well defined.

(2) Tidal sand bodies:

A few tens of feet to more than 1,000 feet wide, mostly very elongate. Long axis at right angles to shoreline or parallel with estuarine axis. Straight to moderately meandering, dendritic patterns, the latter as tidal inlets. Also lunate bars in passes between barrier islands. (3) Turbidite sand bodies:

Elongate sand bodies up to several miles; fairly straight but dendritic and bifurcating possible. Extend downdip into basin. Excellent correlation of directional structure and shape. Sheet and blanketlike deposits probably predominate. Large olistostromes not uncommon.

(4) Barrier-island sand bodies:

Widths from a few hundreds of feet to more than several miles. Thickness 20-60 feet. Very elongate, parallel with strandline. Sandstone bodies generally straight to gently curved.

(5) Marine-shelf sand bodies:

Size and shape, highly variable, ranging from irregular, small pods through elongate ribbons to widespread sheets of many miles. Bifurcating and dendritic patterns absent. Elongate bodies have variable orientation with respect to depositional strike: parallel, perpendicular, and random.

Off (1963) has studied similar occurrences of this

sand body type and recognizes two kinds; the "tidal current

ridge" defined as:

a rhythmic series of ridges oriented parallel with a tidal current,

and sand waves:

These are large ripple marks oriented perpendicular to the current direction.

(6) Desert eolian sand bodies:

Most ancient eolianites consist of widespread thick sheets of cross-bedded sandstone. Conceivably, eolian sands may contain the largest of all contiguous sand bodies.

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These sands appear to be the most difficult to recognize on the basis of the data available in this study.

Other information which is of use in the interpretation of sand bodies is their relationship to the paleoslope. For this purpose the isopach of the genetic increment becomes useful. As is usually the case, no specific answer can be obtained from this information. Shoreline sand bodies are generally considered to be parallel to the paleoshoreline, in this case, parallel to the contour lines of the isopach. On the other hand, sandstones of a fluvial nature should be essentially normal to the paleostrandline.

Part of this study is one of examining sandstones and determining something about their depositional environment. It should be remembered that these sands are the product of current (wind or water) and wave energy. Therefore, the pattern of the sandstones within a genetic increment of strata must also be recognized as a map of the currents which generally prevailed during the deposition of that increment. The size of individual sand bodies may also suggest something of the strength or duration of these currents.

A major difficulty encountered in this type of study is related to control density. It is felt that a general idea of sand body distribution and depositional environment

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can be determined with the control density used. However, a somewhat greater control density would improve definition of the sand bodies and their interpretation.

Relative Scale

During the previous discussions little reference has been made to scale. It may be suspected that perhaps the area under consideration is large enough that all features present within an increment would be time transgressive. Figure 4 shows a scale comparison of part of the Gulf Coast and the Mississippi River Delta and the Grand Banks of the Bahamas. They were selected as being present day examples of clastic and carbonate deposition. The sediments in these areas would be considered by most geologists as being very close to time equivalent. Comparing these areas to the area under study, it is obvious that the area of investigation is not too great. That is, the area under consideration is of such a magnitude that all features present within an increment could be considered geologically time contemporaneous.



STRATIGRAPHY

General Statement

The Cherokee and Marmaton Groups comprise the Desmoinesian Series of Middle Pennsylvanian age.

The Cherokee Group of Lower and Middle Desmoinesian age has been divided by Oakes (1953) into the Krebs and Cabaniss Groups on evidence of an unconformity at the top of the Boggy Formation (Cheney, 1945). An unconformity at this stratigraphic position was not evident in this investigation; therefore the Krebs and Cabaniss Groups have been included in the Cherokee Group following current subsurface usage.

The base of the Cherokee could not be established with certainty in the Anadarko Basin proper. For this reason, the base of the Pennsylvanian was selected as the lower limit of the study. The base of the Big Lime-Oswego limestone sequence (Fort Scott) was used as the division between the Marmaton and Cherokee Groups.

The top of the Marmaton is said to be marked by a regional disconformity (Oakes and Jewett, 1943) occurring at the base of the Seminole Formation. This would lie between

the Checkerboard Limestone and the top of the Big Lime (see cross-section, Plate II). Except for some localized channeling at the base of a sandstone which is present in this interval, no evidence of a regional disconformity has been found in this investigation. For this reason, the base of the Checkerboard Limestone (Missourian in age), which is easily recognized over the entire area studied, was selected as the top. Because of its widespread persistence, the Checkerboard was also used as the datum for all major cross-sections.

Division of the Cherokee and Marmaton Groups into their component formations (as recognized in surface exposures) was not feasible in this investigation. Other natural divisions were therefore utilized in order to pursue this study.

In the Cherokee Group, a number of marker beds were found to be persistent over most of the area. These markers were traced to the east into those utilized by Cole (1968). Cole has partially correlated his work with surface and subsurface studies in eastern Oklahoma and has found that the upper two markers (in ascending order) are equivalent to the Verdigris and Fort Scott limestones. The other three also in ascending order are equivalent to the Brown, Inola, and Pink (Tiawah) limestones of Oklahoma. For purposes of this

study, however, these will be referred to in ascending order as: markers "A", "B", "C", "D", and "E" (Plate II and III). Marker "A" is the uppermost "Brown" lime of subsurface, "B" is the Inola Limestone, "C" is the Pink lime, "D" is the Verdigris Limestone and "E" is the base of the Fort Scott.

The genetic increments of strata demarcated by these markers will be the subject of following discussions. In order to simplify them, the increments will be referred to, in ascending order, as: Brown-Undifferentiated, Bartlesville, Red Fork, Skinner, and Prue, each name being taken from a persistent rock unit within the increment.

Thin markers were not used in the breakdown of the Marmaton Group. It was found possible to subdivide the Group into four genetic increments using easily definable limestone beds. In ascending order these increments are: Oswego (Fort Scott), Labette, Big Lime, and Seminole. Each is named for the same reason mentioned above.

Pre-Pennsylvanian Rocks

The lower boundary of the Desmoinesian genetic sequence as defined in this study is the widespread unconformity separating Pennsylvanian and pre-Pennsylvanian rocks on the shelf areas northeast of the Anadarko Basin.

Figure 5 illustrates the subcrop pattern of these



rocks in the area under consideration. It will be noted that rocks of Mississippian age dominate in areal extent; rocks as old as Cambrian being found in the core of structures associated with the Nemaha Ridge.

The subcrop map resembles that of Jordan (1962) except for one modification. The checkered area outlines a proposed extension of Chester rocks. North-south cross-sections across the area show that a limited facies change occurs at the southern edge of the proposed extension. Limestones develop at the base of the Chester in close proximity to the Mississippian limestone and then quickly revert to a shale again northward (see Cross-section A-A'). In addition, all cross-sections show no change in thickness of the Osage-Meramec (Mississippian) limestone except at the edge of the checkered area. A change in thickness of the Mississippian limestone would not be expected to occur unless truncated or if a facies change were present. The relationship between the position of thinning of the limestone and the proposed edge of the Chester shale suggests the thinning was due to truncation.

Apparently the development and subsequent disappearance of the limestone at the base of the Chester and the difficulty in distinguishing between the Cherokee and Chester

shales hindered the recognization of this extension. Only after the entire area had been crisscrossed by a network of intercorrelated cross-sections was the existence of a Chester extension recognized.

<u>Isopach of the Cherokee-Marmaton</u> (Desmoinesian) <u>Genetic Sequence of Strata</u>

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The Cherokee-Marmaton rocks in the area under consideration (Plate I) range in thickness from 290 feet in T. 29 N., R. 1 W. to a maximum of 2,184 feet in T. 12 N., R. 9 W.

The isopach reveals thickness divergences (thickening) in two directions. The greater of these lies southwest of the Nemaha Ridge, showing that the Anadarko Basin underwent active subsidence during the deposition of these rocks. The other divergence is eastward toward the eastern and southeastern margins of the map reflecting the presence of the Cherokee Basin (or Central Oklahoma Platform) and the adjacent Arkoma Basin.

Two unusually thin areas are present in the northeast and northwest corners of the map. The one in the northeast is the northernmost expression of the Nemaha Ridge in the area of study. The area in the northwest corner is an expression of the "Barber-Woods" swell of northwest Oklahoma, a southern extension of the Central Kansas Uplift.

An abrupt change from irregularly spaced contours to more evenly spaced contours occurs in the southwest along a line from T. 17 N., R. 10 W. to T. 10 N., R. 3 W. This change appears to mark the approximate position of the "hinge line" between the Anadarko Basin proper and the shelf area to the northeast. The gentle, generally even subsidence of the basin resulted in a more rapid and continuous deposition of sediments than did the sporadic pulsations on the shelf.

Other contouring anomalies visible on the map are the isopachal nosings and local thinning along the eastcentral side of the map from north to south designating the position of the Nemaha Ridge. In the vicinity of T. 20 N., R. 4 W. the "Ridge" changes direction from a general southeast-northwest trend to a southwest-northeast alignment. Thinning in this area is an expression of local structures related to the "Ridge" whereas the contour nosing marks the approximate position of the Nemaha Ridge itself. Parallelism of contours, as shown in T. 27 N., R. 1 W. and T. 11 N., R. 2 W., may reflect the presence of pre-Pennsylvanian fault scarps with an overlying draping of sediments.

A number of local "thick" areas lie in a northeastward trending line from T. 21 N., R. 9 W. to T. 25 N., R. 4 W.

These are partially enclosed by a 600 foot contour line which outlines a thickened section extending along the same axis. The extension of Chesterian rocks (Fig. 3) earlier discussed is approximately in the same position. Preservation of the Chester in this locality may be related to the development of a northeast-southwest trough. Cross-section B-B' (Plate III) illustrates a cross-axis view of this sag or trough with a resulting thicker accumulation of Desmoinesian rocks. The isopach map, also showing this thicker accumulation of sediments, suggests that the trough must have continued subsiding slightly during at least part of the deposition of the Cherokee-Marmaton rocks.

The remaining local thick and thin areas scattered over the map are probably related to local conditions of sedimentation or structure. Isopachal nosing, such as that present in T. 15 N., R. 8 W., may be due to channeling in the pre-Pennsylvanian rocks. The overlying thick section of rocks with its inherent variations in thickness has altered the pattern so that it is difficult to do more than make a guess concerning its origin. Later maps will be of use in reaching a solution for this problem.

Cross-section A-A'

Cross-section A-A' (Plate II) is oriented in a northeast-southwest direction across the area of study. Since the cross-section will be referred to again in later discussions, only a few comments will be made at this time.

The southwest end of the section (left) is located in the Anadarko Basin. Thickening of the section in that direction is a result of continued subsidence of the basin during the deposition of this genetic sequence. The sequence thins in a northeastward direction due to onlap of the sedimentary rocks. On this cross-section the thinning and onlapping of the lower genetic increments is partially due to the presence of the Nemaha Ridge; well number one is located near its crest.

Truncation of the underlying rocks is well-illustrated by this cross-section especially in the case of the Manning Zone. The wedge-out of the Chester shales to the northeast (and east) also demonstrates the influence of the "Ridge" on pre-Pennsylvanian sedimentary rocks.

The only facies change of any consequence is the "shale-out" of the Marmaton limestones in a southwesterly direction. This change and its consequences will be discussed in greater detail later in this report.
A final point concerns the sandstones of this sequence; note that they are scattered, vary greatly in thickness, and for the most part, are not correlatable between wells.

Cross-section B-B'

Cross-section B-B' (Plate III) illustrates the eastwest relationships of the genetic increments of strata which make up the Cherokee-Marmaton rocks. The easternmost well (well number 17) is located on the Nemaha Ridge. Westward in the vicinity of well number 19 is the sag in the Mississippian rocks which was discussed earlier.

Westward Mississippian rocks climb in stratigraphic position reflecting the presence of the Central Kansas Uplift to the northwest. The genetic increments of strata thin eastward over the Nemaha Ridge and northwestward toward the Central Kansas Uplift.

As mentioned in the discussion of Cross-section A-A', individual sandstones are scattered, variable in thickness, and usually not correlatable between wells. No major facies changes occur in the area illustrated by the cross-section.

Isopach and Lap-out Map of the Cherokee Group

The isopach of the Cherokee Group (Plate IV) resembles that of the Cherokee-Marmaton genetic sequence, although in greater relief.

Assuming the base of the datum marker "E" (base of the Oswego lime) to have been deposited in an essentially horizontal position, the isopach should then reflect the paleotopography of the pre-Pennsylvanian unconformity. The number of control points for the area involved, thickness of the Cherokee sediments, and variations within the wedge of sediments allows only delineation of the more pronounced features by the isopach. Much of this will be better illustrated by later maps in this report.

The position of the Nemaha Ridge is more apparent than on the previous map due to the thinner section of sedimentary rocks involved. As a matter of general interest and for purposes of orientation, the large structure illustrated in the vicinity of T. 11 N., R. 3 W. is the Oklahoma City Uplift. The trough discussed earlier is still present although its axis appears to have shifted eastward closer to the Nemaha Ridge.

The break between closely-spaced, parallel and irregularly spaced, non-parallel contouring, or the "hinge

line" is in approximately the same position as on the earlier map. Its apparent shift slightly northward may be due to the use of 20 foot contouring rather than the 50 foot interval used for the Cherokee-Marmaton genetic sequence of strata.

Some isopachal patterns, as those in T. 14 N., R. 9 W., T. 14 N., R. 6 W., and T. 25 N., R. 1 W., appear to be related to channeling of the pre-Pennsylvanian unconformity surface. They will be discussed more fully in later sections of this study.

The lap-out part of this map demonstrates the maximum onlap position of the individual genetic increments of strata which make up the Cherokee and pre-Cherokee Groups. The direction of marine onlap (Melton, 1947) is northward, although local structure causes variations in direction to the northeast and northwest. A comparison of the distances between maximum onlap positions of individual increments shows that the maximum onlap occurred during the deposition of the Bartlesville genetic increment. The lap-out map demonstrates that the Nemaha Ridge, although completely covered by the end of Cherokee time, did exist as progressively smaller areas of nondeposition during Cherokee deposition. The last area to be covered was the Oklahoma City Uplift

during the deposition of the Prue genetic increment.

Brown-Undifferentiated Genetic Increment of Strata

On Cross-section A-A' (Plate II) the Brown-Undifferentiated genetic increment of strata is located at the left and is defined by Marker "A" at its top and the pre-Pennsylvanian unconformity at its base.

The isopach of this genetic increment (Plate V) shows it to be preserved in three areas. Two areas along the eastern margin of the map represent the Brown genetic increment of the Cherokee Basin east of the "Ridge." These are based on correlations derived from Cole (1968) whose area of study lies east of this area.

Isopachs in the southwest corner of the map include all rocks from the base of the Bartlesville increment (marker "A") down to the top of the Mississippian. Because of a considerable difference in the rate of thickening, a contour interval of 50 feet was selected rather than the 20 foot contour interval used for the eastern area.

These undifferentiated rocks include probable Lower Desmoinesian, Morrowan, and Atokan sediments. If represented, rocks that are time equivalent to the Brown genetic increment of the Cherokee Basin occupy the upper part of this sequence. The zero isopach should then represent the approximate position of maximum transgression of the "Brown Sea." It is evident that the shelf west of the "Ridge" underwent little subsidence during deposition of this increment. Maximum subsidence of the shelf occurred east of the Nemaha Ridge in the Cherokee Basin and greatest subsidence occurred in the Anadarko Basin to the southwest.

The pattern of contouring in the isopached areas suggests that channeling of the pre-Pennsylvanian surface is present. Based on the density of control points it becomes apparent that only those channels of major size are shown. " A dot-dash-dot pattern is used to trace the courses of these pre-Brown-Undifferentiated streams.

The isolithed pods or lenses of sandstone shown in the eastern isopached areas are not widely distributed. Their position relative to the zero isopach and thinness suggest that they may be the result of beach or near-shore activity.

Sandstones are present in the Morrowan (?) rocks of the undifferentiated area in the southwest. They were not mapped because they are not equivalent to the sands of the Brown genetic increment.

Bartlesville Genetic Increment of Strata

The Bartlesville genetic increment of strata (Plate VI) is defined at its base by marker "A" where the Brown-Undifferentiated genetic increment is present and by the pre-Pennsylvanian unconformity elsewhere. Its upper limit is defined by marker "B" (Inola Limestone).

As mentioned earlier, the greatest rate of onlap occurred during deposition of this increment. Assuming the upper marker to have been deposited horizontally, the isopach should reflect the paleotopography of the pre-Pennsylvanian surface. Those areas where the Bartlesville increment overlies the Brown-Undifferentiated increment should be eliminated from consideration.

East-west along the northern margin of the map and north-south along the Nemaha Ridge, Bartlesville shales overlie pre-Pennsylvanian rocks of a carbonate facies. In these areas the paleotopography of the pre-Bartlesville surface is easily demonstrated.

A dot-dash-dot pattern is again used to plot postulated courses of pre-Bartlesville channels. The well-defined nosing present in the row of townships of 13 N. indicates some of the channels to be large.

The isopach map outlines several areas of nondepo-

sition or "positive areas." Most of these are related to the Nemaha Ridge, the exception being the positive area in the northwest corner of the map. This area of nondeposition is probably due to the influence of the Central Kansas Uplift to the northwest. It should be noted that the pattern of channeling radiates around these high areas.

South of a line from T. 25 N., R. 10 W. to T. 20 N., R. 5 W. and west of a line from T. 20 N., R. 5 W., Pennsylvanian rocks are underlain by Chesterian strata. Since both are shale, pinpointing the exact location of the intervening unconformity is nearly impossible. By careful correlation on each side of the unconformity, its position has been narrowed to a zone some 20 to 40 feet in thickness. Because of this difficulty, the isopach in this area cannot be construed as reflecting pre-Pennsylvanian topography.

The isolith shows the sandstones in this genetic increment to be sparse and erratically developed. Those present occur in isolated lenses and perhaps sheet (T. 18 N., R. 2 W.) sand bodies. The greatest concentration is east of the large positive area in the east-central part of the map and west of the high in the northeast corner of the map.

Little can be stated with certainty about the origin of these sands. Their position with respect to areas of

nondeposition suggests their accumulation to be related to beach activity. With further speculation, it would not be difficult to visualize the sand body west of the high area in the northeast corner of the map as a large spit or offshore bar. This would also require the assumption that the paleocurrent direction was to the west or northwest in order that the sand could have accumulated on the lee side of the positive area.

The Nemaha Ridge has been suggested as a possible source of clastics for Cherokee rocks. The pattern of channeling indicates that it was being actively eroded. However, the small size of these positive areas, the dominance of carbonate rocks, and the lack of any particular concentration of clastics, especially on the west side, indicate that the "Ridge" was no more than a minor source in Oklahoma.

Red Fork Genetic Increment of Strata

The Red Fork genetic increment of strata overlying the Bartlesville increment is defined at its top by marker "C". The isopach map of the Red Fork (Plate VII) shows a considerable reduction in size of the positive areas. Rapid thickening in the southwest portion of the area as shown on previous maps indicates continued subsidence of the Anadarko Basin. Two anomalous conditions apparent in the contour pattern merit additional comment.

The first is a thick zone occurring in the vicinity of T. 21 N., R. 4 W. Relating this area to the same position on the pre-Pennsylvanian subcrop map (Fig. 3), faulting is found present in the pre-Pennsylvanian rocks. It appears that movement occurred on these faults during deposition of this increment, allowing development of a thicker section.

The second anomalous condition involves the area enclosed by 80 and 100 foot contour lines in the northern half of the map. The 100 foot contour indicates an irregular thickening (T. 23 N., R. 7 W.) with isolated closed 100 foot contours outlining other areas in a north-northeast direction. The 80 foot contour line encloses this entire area. Apparently the area underwent mild downwarping during deposition of the Red Fork increment allowing a thicker accumulation of sediments. This appears to be related to the sag in Mississippian rocks and subsequent preservation of Chester rocks mentioned earlier.

Little of the Nemaha Ridge in Oklahoma remained positive; on the basis of areal extent alone, it is obvious that the "Ridge" could not have been more than a minor source of sediments at this time.

The isolith of sandstones in the Red Fork increment shows individual sands to be thicker. The areas covered by sand bodies are larger, although still concentrated in the east and north.

The sand bodies occur in dendroids and lenses often outlined by sheet sands. Some dendroids meander slightly as those in the northeastern part of the map, whereas others (vicinities of T. 19 N., R. 2 W. and T. 24 N., R. 3 W.) have bifurcating patterns suggestive of a distributary system.

Distribution pattern and concentrations of sand bodies along the eastern margin of the map suggest that perhaps the source area lay to the east or north. In addition, the absence of large concentrations of sand on the west side of the Nemaha Ridge implies that it acted to some extent as a sediment barrier.

Two large, elongate, east-west sand bodies present in the northern part of the area are part of the "Cherokee" sands described by Pate (1959) and Stanbro (1960). Stanbro found that they are related to pre-Red Fork topography occupying east-west valleys. Busch (1959) has described similar sand bodies, applying the name "strike-valley sands." Their position with respect to the general pattern of the isopach and paleoshoreline to the north, coupled with the work done by Pate and Stanbro, indicates that they may be barrierisland sands.

If these interpretations are correct, it is then possible to speculate concerning paleocurrents of Red Fork time. These currents would have swept north-south along the eastern margin of the area picking up sediments from the stream systems, and then swung westward across the northern part of the area. Under proper conditions, the currents would have deposited the sand in the form of an elongate bar. Shifting of the strandline would have permitted development of later parallel sand bars.

Isolated sand bodies scattered west of the Ridge may be related to marine-shelf sands. It is also possible that they are the remnants of sand bars or perhaps a once much larger system, which has been partially destroyed by erosion. Isolated pods and sheets of sand along the margins of positive areas as mentioned earlier, may be related to beach activity.

In some areas (T. 14 N., R. 1 & 2 W., T. 18 N., R. 2 W., and T. 20 N., R. 2 W.) nosing of the contour pattern conforms to the presence of sandstones in the genetic increment.

Skinner Genetic Increment of Strata

The Skinner genetic increment overlies the Red Fork, its upper boundary being defined by (Verdigris Limestone) marker "D" (Plate II). The isopach of the Skinner increment continues to show southwestward thickening (Plate VIII). The greater thickness of this increment (300 feet) and the Red Fork (260 feet) when compared to the Bartlesville genetic increment implies greater subsidence of the basin during the deposition of these increments.

The Nemaha Ridge is still reflected in the form of local thins (T. 22 N., R. 3 W.), contour noses (T. 15 N., R. 3 W. and T. 25 N., R. 2 W.), and a local positive area in the vicinity of T. 11 N., R. 3 W. During deposition of this increment, the "Ridge" seems to have been no longer an effective barrier to distribution of sediments. An exception may have been in the immediate vicinity of the positive area in the southeast corner of the map.

The isolith of the sandstones shows them to be more widespread, although still concentrated in the east half of the area. The dominant types of sand bodies are widespread sheet sands with scattered pods and dendroids of sandstone. A number of areas of no sand deposition are present throughout the area of sheet sands. The thin, narrow, elongate sand bodies present in the area outlined by Tps. 15 through 19 N. and Rs. 4 through 8 W. have the appearance of bar-finger sands. The bifurcations of the longest sand body (vicinity of T. 16 N., R. 7 W.) is particularly suggestive of a bar-finger deposit. The north-south sand body which bifurcates and meanders slightly through Tps. 10, 11, 12, and 13 N., and R. 4 W. also seems to be of the bar-finger origin.

The large area of thick sands present in the northeast quarter of the map (vicinity of T. 24 N., R. 2 W.) has the appearance of a composite alluvial sand body. Potter (1967) defines this body as:

The anastomosing complex of a valley-fill deposit of a large alluvial river in its lowest reaches.

Assuming these interpretations to be essentially correct, then the unidentifiable sand lenses in the area may also be related to these sand body systems. Alluvial sands may be intercalated with the bar-finger sand bodies to form a large alluvial-delta complex in this area.

Isolated areas of no sand deposition in the sheet sands could be interpreted as resulting from swamp or marsh accumulations or more simply, may be areas of "tight" sandstone.

In T. 11 N., R. 1 W. the isopach of the genetic

increment is adjusted to the presence of a sandstone in the increment.

In summary, the distribution of the sand bodies appears to be related to an alluvial-delta paleoshoreline complex with an easterly or northeasterly source.

Prue Genetic Increment of Strata

The uppermost genetic increment of the Cherokee Group is the Prue. The isopach of the increment (Plate IX) continues to show southwest divergence (thickening), although not as great as did the previous two increments.

The Nemaha Ridge was no longer exposed and little evidence for its presence is visible. The thin area in the vicinity of T. 11 N., R. 3 W. and some obscure nosing of the contours along the vicinity of its axis are the only suggestions.

The distribution of sandstones indicates that a major change may have occurred in the source area or areas. The overall thinness and reduced areal extent of the isolith indicates a reduction in the source area as may be caused by baseleveling, subsidence, or a decrease in precipitation. The concentration of the sandstones in the southeast suggests that whatever this change, the source area or areas to the southeast became dominant. The pattern of sand body distribution still suggests an ancient shore line. The sheet sands continue to dominate the area with zones of no sand deposition present. Thick sand bodies are sparse making their tentative interpretation extremely difficult. The projections of sandstone to the northwest appear to be composites of various sand bodies. These sand bodies could include remnants of bar-fingers, spits, turbidites, or alluvial sands. Whatever the type of sand deposit involved, the isolated sand bodies to the west appear to be related to them. Along the northern margin of the map there are scattered small pods of sandstone about which nothing of consequence can be said.

In the northwest corner of the map, a thin limestone bank occurs in the upper part of the increment.

<u>D-Function Lithofacies and Isopach Map</u> of the Marmaton Group

The isopach of the Marmaton Group (Plate X) continues to show a marked thickening to the southwest and a minor thickening to the southeast in the southeast corner of the map. Nosing of the contour lines in the approximate position of the Nemaha Ridge indicates that the "Ridge" continued to have some influence during the deposition of at least part of this group. Comparison of the Cherokee and Marmaton isopachs shows that the Anadarko Basin did not subside as much during Marmaton time. In addition, the subsidence did not appear to be related to a "hinge line" as in the Cherokee; rather, there seems to be a regional tilting to the south during Marmaton times.

Because the Marmaton Group contains relatively large and locally fairly equal amounts of sandstone, shale, and limestone it is particularly suited for the construction of a lithofacies map (Plate X). After some consideration, Pelto's D-function procedure was selected for the construction of such a map.

A detailed discussion of the mathematics and procedures is not warranted in this discussion. For a detailed explanation it is recommended that the reader examine Pelto (1954); for brief discussions Forgotson (1960) or Krumbein and Sloss (1963) are suggested.

Pelto's D-function procedure in this case is applied to a continuous three-component system: that is, sandstone, shale, and limestone. The D-function divides the system into seven classes, each having a maximum "D" value of 100. When the D-function values are contoured they illustrate the continuous and gradual shift of end members within a class to the

maximum value possible (100). At that point, that class containing the appropriate proportion of the components would then be utilized.

The triangle in the legend of Plate X graphically illustrates the breakdown of the three-component system into seven classes. Theoretically, the "D" values within each may be contoured, the values ranging from a maximum on all margins of the class to some minimum value within. As the map demonstrates, such is not always the case. Returning to the seven classes, three have a one-component end mixture, three have end mixtures of two components, and one class has essentially equal amounts of the three end member components.

Forgotson (1960) has analyzed the information conveyed by this type of map and summarizes it as follows:

Divides a system into classes based on the differences in amounts of components. Provides information on the relative proportion of a specific end member within its own class.

He also points out the shortcomings of the D-function lithofacies map:

Does not distinguish between end members. Provides no information on absolute amount of components.

An attempt was made in this study to distinguish and show any shift toward a component end member within a class by using a numerical subclass. The "D" values remained the same for the class and were not affected by the subdivision. The contouring or defining was based on the original classes and the D-function values were then contoured within each class. The numerical subclass could be used while contouring to give some indication of the shift in the proportions of the component end members.

The D-function lithofacies map of the Marmaton Group is mainly concerned with the center, upper, and right sides of the triangular plot shown in its legend. The map shows that the southern half of the area is in the dominantly shale class (subclasses 13 and 14). The northern part is dominated by the class (subclasses 24 and 25) containing roughly equal amounts of the shale and limestone end members. Some exceptions are present in the northern half where an increase in the proportions of sandstone or shale cause a shift of classes in the appropriate direction.

The most apparent anomalies present in the general pattern of the map occur in the central part through the row of townships 18 N. and 19 N. This is also roughly the line of transition between the dominant classes of the area. These anomalies are in the central class; that is, they contain roughly equal amounts of sandstone, shale, and limestone. When related to the surrounding classes, this simply means that the

sandstone end member has increased proportionately.

Another major anomaly is present in the central and western halves of the rows of Tps. 22 N., 23 N., 24 N., and 25 N., and is dominated by the shale component. The peculiar shape in the outline of this class is not considered to be significant. Perhaps it is a result of the widespread control, but probably it is due to the method of contouring employed.

Summarizing what may be discerned from the map, it is apparent that limestones play a considerable role in the sedimentary history of the northern half of the area. Increases in percentages of sandstone and decreases in limestone content or increases in shale have caused local variations in this area.

The southern half of the area is overshadowed by the shale end member. The decrease in the D-function values in a southerly direction implies a considerable increase in the footage of shale over the amount of limestone present in the Oswego-Big Lime section.

The scattered presence of the central class through the center part of the map is the result of an increase in the amount of sandstone. This may be considered as indicating the presence of major sand bodies.

It must be pointed out that this map does not yield any information regarding the nature of the limestones or sandstones. Also it does not illustrate the distribution of the limestones or sandstones except in a very general and nebulous manner. It does not show any particular reason for the changes which occur in classes except as a result of variations occurring in the proportionate amounts of the component end members.

The following maps of individual genetic increments of strata making up the Marmaton Group may shed some light on the nature and causes of the changes which occur on this map.

Oswego Genetic Increment of Strata

The Oswego genetic increment of strata is the lowest increment of the Marmaton Group. The isopach of the increment (Plate XI) shows that its thickness ranges generally from 60 to 100 feet. Numerous thick and thin areas are scattered over the map rarely varying more than 20 feet from the immediately surrounding area. Three unusually thick areas are present in the southwest, the largest being 60 to 70 feet greater than the surrounding area. A loss of limestones and correlative markers results in the abrupt and rapid thinning of the genetic increment along its southern edge.

Cross-sections A-A' and B-B' illustrate the relationships of the limestones present within the genetic increment. A number of thin limestones dominate the northern part of the area. Moving southward the number of limestones decrease until only three remain. At the same time, thickness of individual limestones increases. It was determined, however, that only the upper and middle limestones thicken appreciably. Generally only one unit will undergo considerable thickening at any given locality. North of T. 18 N. only the upper limestone thickened. South of the line both upper and middle units thicken in the vicinity of T. 15 N., R. 8 W. Over the rest of this area, only the middle limestone increases and it is terminated in the south by a facies change.

It was felt that a means of illustrating the pattern of thickening of individual limestones would be useful. Since more than one limestone was usually present, a means of selectively eliminating the thinner limestones was necessary. This was accomplished by establishing a minimum thickness of 40 feet before isopaching a limestone (see Method of Study).

A number of minor thick limestones are distributed over the area. Three dominant "thicks" or banks are present in the southwest at the positions of the three thick areas outlined by the isopach of the genetic increment.

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Cross-section A-A' shows a maximum thickening of the middle limestone occurring at the edge of the facies change. Figure 6 is a detailed cross-section illustrating this banking. The poor development of this thickening on the southeastern margin may be due to the proximity of the Nemaha Ridge. Although the "Ridge" is buried, it may have caused a local shoaling of the Oswego sea with minimum subsidence, so that carbonates did not accumulate to any great thickness.

These limestone buildups did not develop abruptly nor are they very thick (maximum thickness 108 feet). It is felt that they should be considered banks rather than reefs.

Labette Genetic Increment of Strata

The Marmaton limestones have generally been subdivided into the Oswego and Big Lime. It became apparent with the completion of correlations in this study, that this sequence of limestones could be subdivided into three parts. The principal reason for this decision is that three vertically and to some extent, horizontally separated limestone banks are present on the basinward "shale-out" edge of the limestones. The intervening limestone is correlative to the Labette Shale of northeastern Oklahoma and, therefore, is referred to as the Labette Limestone in this study.

The isopach of the Labette genetic increment of



strata (Plate XII) shows a considerable variation in thickness. It ranges from a minimum of 5 feet in the extreme northeast corner of the map to a maximum of 93 feet in T. 17 N., R. 10 W. A number of thick and thin areas are locally present as shown by isopachs. In several instances they are related to the presence or absence of a limestone within the increment. In other cases their origin is not determinable. It is felt that they may be related, at least partly, to the development of thick or thin areas in the lower Oswego genetic increment; the thins developing in response to the presence of a thick area in the lower increment.

In the southern part of the area under consideration the isopach ends abruptly at the zero isolith. Although the limestones begin to disappear farther northward, markers were still present allowing the continuation of the isopach. Because of the disappearance of the limestone and the increasing difficulty in correlating, all contours were discontinued at the zero isolith.

The isolith of the limestones was constructed in the same manner as that of the Oswego. That is, only individual limestones which had developed above a minimum thickness of 20 feet were included in the isolith.

In the northern part of the area no limestone is

present; moving southward a facies change occurs and limestones begin to develop. Farther southward the limestones increase in thickness reaching a maximum of some 60 feet in the vicinity of T. 17 N., R. 10 W. Beyond this the limestones shale out abruptly.

As was true in the case of the Oswego genetic increment the thickest limestone development occurs at the southern margin of the Labette increment, the greatest thickness being along the southwest edge of the limestone bank. A number of thinner banks are present in the southeastern extension of the limestone. In addition, a number of small banks are developed on the margins on basinward extensions of the limestone (T. 16 N., R. 10 W., T. 17 N., R. 8 W., T. 13 N., R. 6 W., and T. 12 N., R. 5 W.).

Speculating on the manner of distribution of the limestone, it appears that the Nemaha Ridge still exercised some indirect influence. It seems to have restricted the development of thick limestones in its sphere of influence, but did allow the carbonates to accumulate farther southward. Beyond the influence of the "Ridge" it would appear that thicker limestones were able to accumulate.

Big Lime Genetic Increment of Strata

The Big Lime genetic increment of strata is the uppermost of the Marmaton limestones. The isopach of the increment (Plate XIII) shows a few scattered thick areas (T. 20 N., R. 7 W. and T. 26 N., R. 3 W.) which generally correspond to lime bank buildups. Other thick or thin areas are probably inversely related to thicks and thins in the underlying Labette genetic increment. For the same reasons given in the discussion of the Labette genetic increment the isopach contours were terminated at the zero limestone line.

The limestones of the Big Lime increment are not as thick as those of the Oswego genetic increment. Therefore, a contour interval of 10 feet was employed to isopach those limestones 30 feet or more in thickness. The isolith map shows three separate east-west trending groups of lime banks. The most southerly of these occurs at the facies change present in Tps. 17 and 18 N. It is also the thickest of the three trends reaching a maximum of 74 feet in T. 17 N., R. 7 W. The pattern of thickening is highly irregular with well-defined thin areas (T. 17 N., R. 7 W., T. 17 N., R. 5 W., and T. 18 N., R. 2 W.). The two northern trends are not as well-defined nor as continuous. Cross-section A-A' shows that the lower limestone is the one generally responsible for these banks. The Nemaha Ridge does not appear to have had much influence on the distribution of limestones, there being no southward change in their pattern in the vicinity of the "Ridge." However, there is some thinning of the lime banks in the immediate vicinity of the "Ridge." It is difficult to say whether this is due to the proximity of the "Ridge" or to some other cause.

Three small limestone banks (T. 22 N., R. 2 W., T. 21 N., R. 4 W., and T. 20 N., R. 6 W.) are shown on the map. By correlation they are related to the overlying Seminole genetic increment, but by origin are most similar to the underlying Marmaton limestones. Hence their inclusion in this genetic increment.

Two sandstones equivalent to the Big Lime limestones are present in T. 15 N., R. 5 W. and T. 14 N., R. 1 W. An explanation for their presence is difficult, but it may be related to that of the sandstones present in the Seminole genetic increment in the same area.

Discussion of Marmaton Limestones

Marmaton limestones are similar to Pennsylvanian limestones described by Van Siclen (1958) in West Texas. He considers the attitude of the limestones to reflect the sloping topography of the sea floor at the time of their deposition. As a result of this observation, he was able to relate the limestones to the undaform, clinoform, and fondoform concept of Rich (1951) (see Fig. 7).

Van Siclen recognized thick limestones on the seaward edge of the undaform which, because of their internal characteristics, he considered organic reefs. For these lime developments he proposed the name undaform-edge reefs or banks.

He also found that progressively younger limestones (clino limestones) developed successively westward. This he interpreted as indicating the progressive filling-in of the sea by a coastal plain advance accompanied by a net raise in relative sea level.

Because of previous discussions it is apparent that there are a number of similarities between the Marmaton limestones in this study and those examined by Van Siclen. Crosssections using the Checkerboard Limestone as the datum (Crosssection A-A') show the Marmaton limestones to be slightly inclined. Undaform limestones, undaform-edge banks, and somewhat obscure clinoform limestones, particularly in the Oswego, may be seen.

Besides the fact that the limestones studied by Van Siclen are thicker, the principal difference between the



limestones of the two areas is their relationship to each other in each area. Figure 7 illustrates these relationships and shows the differences between the two.

The direction of the source from the undaform-edge appears to explain the differences between the areas. In each case, the major subsidence occurred beyond the shale-out zone of the limestones. In the West Texas area, Van Siclen suggested that the source lay somewhere to the east-northeast in a shelfward direction. Increased denudation of these areas would result in a westward or basinward shift of progressively younger limestones.

In this study, the reverse of the above situation was found to be the case; that is, younger undaform-edge limestones lie progressively shelfward. A progressive increase in the rate of erosion of the source to the south, coupled with a gradually rising sea, could result in a shelfward migration of younger limestones. The rate of migration would be related to the volume of clastics reaching the area of limestone development. Source areas could be the Arbuckles, Wichitas, Ouachitas (?), or related uplifts. Subsidence of the Anadarko Basin would explain the clinoform topography of the limestones. In addition, its subsidence between the source and the limestone bank would serve to obscure the wedge

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of sediments which might have otherwise developed.

Seminole Genetic Increment of Strata

The Seminole genetic increment of strata is the upper increment of the Marmaton Group as defined in this study and is the only noncarbonate increment therein.

The isopach of the Seminole genetic increment (Plate XIV) shows a range in thickness from 60 feet at the northern margin of the map to 980 feet in the southwest. This sedimentary wedge reflects a slight increase in the rate of subsidence of the Anadarko Basin. It also is due to the shaleout of progressively older Marmaton limestone increments to the south. Comparison between the isopach of this increment and the maps of the Marmaton limestone increments show that the position of the facies change for an individual increment will often correspond to a band of closely-spaced contour lines on the isopach of the Seminole. Therefore, south of T. 17 N., the isopach partially represents the shale equivalent of the Marmaton limestone section.

Variations in contouring are usually related to thickness variations in underlying limestones. Attention is also drawn to contour nosing along the appoximate position of the buried Nemaha Ridge. These suggest that the "Ridge" although long buried, still had some influence on the deposition or differential compaction of this increment.

The sandstone present in the Seminole genetic increment is commonly referred to as the Cleveland Sand. Rather than complicate this discussion and the literature by using another name, this name will be retained. It must be pointed out before continuing that this isolith is composed of several vertically separated sandstones (see <u>Method of Study</u>). Therefore, this isolith illustrates an extreme composite view of the distribution of sand bodies within the increment.

The most obvious feature of the isolith is the major sandstone body trending east-west through Tps. 18 N. and 19 N. This development is due to two vertically separated thick sands that reach a combined thickness in excess of 100 feet. At two control points the lower sandstone is in contact with the underlying limestone and appears to have channeled into it. The anastomosing and meandering pattern of these sand bodies, together with the channeling, suggests that they are the product of current activity.

The sandstones in the northern part of the area are not as thick as are the middle sandstone bodies. Their dendritic pattern coupled with what appears to be bar-finger sands (?) suggests that they are related to a distributary

system. This system is probably closely related to the middle sand development just discussed.

South of the middle sandstone belt, other major sandstones are present which also have a pattern similar to a distributary system. The general pattern of the sandstones indicates that the source might have been somewhere to the south. It is highly possible that all sandstone bodies present on this map are related as to source, origin, or both.

The sandstones in the southeastern area could bear more examination. The following remarks are highly speculatively based on data available from this study, for the most part.

Several thin vertically separated sandstones are found within the Seminole increment in the southeastern part of the area. When related to the overlying horizontal Checkerboard Limestone in cross-section these sands are found to shift progressively downward to the north and west, in other words, a northwestward direction. This continues until they are roughly equivalent in vertical position to the undaform-edge banks of the Big Lime genetic increment.

Figure 8 shows three possible interpretations based on cross-section studies. The upper interpretation shows the sand as being separate sandstone bodies with an en echelon



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relationship to one another. The principal difficulty with this interpretation is determining how these sand bodies could have developed. The middle interprets the sands as being regressive facies in the Seminole increment. The lower interpretation is based on the simple correlativeness of the sandstones. This is the interpretation upon which the isolith of the Cleveland Sand is based. The results were discussed earlier; a possible origin for these sandstones is now considered.

The sands are found in association with a large wedge of sediments which thicken to the south. Using the Checkerboard Limestone as the datum the slope for these sands was calculated to be less than 10 feet per mile. If these sands are related to a fluvial distributary system in association with this wedge of sediments, this slope would not be excessive for a gradient.

In the earlier discussion of the Marmaton Limestones it was suggested that perhaps the progressive retreat of the individual increments might be due to the development of a wedge of sediments from the south. This wedge of clastics would be a vertical continuation of that wedge.

The abrupt change from carbonates in the Marmaton limestone genetic increments to the clastics of the Seminole

is certainly proof that a drastic change occurred in the source areas. In this case, that appears to be the development of a major source or sources somewhere to the east as evidenced by the major sand development through the center of the map. In addition, it would seem that there had been developing somewhat earlier, local source areas somewhere to the south. The sediments from this direction gradually pushed back the limestones of the Marmaton until in combination with those clastics from the east, they were able to completely invade the area of previous carbonate deposition.
SUMMARY AND CONCLUSIONS

Cherokee Group

The study has shown the rocks of the Cherokee Group to be mostly clastic. Shale is the dominant rock with a varying amount of sandstone.

Isopach maps show that the Anadarko Basin actively subsided in varying degrees during the deposition of each genetic increment of strata. In addition, there was a northward transgression of the increments over the shelf with accompanying burial of the Nemaha Ridge.

Isoliths of the sandstones for each genetic increment indicate that the source area or areas lay somewhere to the north or east. By deposition of the final genetic increment (Prue) a change had occurred in the source so that it seems to have diminished and shifted to the southeast.

The pattern of sandstone bodies suggests that they are associated with ancient shoreline features. Tentative interpretations indicate the presence of distributary fluvial systems with associated bar-finger sand bodies, sand bars,

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widespread sheet sands and scattered sandstone lenses.

The distribution of the sandstones indicates that the Nemaha Ridge in Oklahoma provided very little, if any, of the clastics. It would further appear that the "Ridge" acted as a barrier to the distribution of the sands preventing their westward migration. After the burial of much of the Nemaha Ridge, the sandstones were free to move farther to the west. The maximum movement occurred during the deposition of the Skinner genetic increment. During the following and final genetic increment (Prue), a retreat and decrease in the sandstones occurred, accompanied by the previously mentioned shift in source areas. It was also during the final stages of the Prue genetic increment that the first limestones preceding the massive carbonates of the Marmaton developed.

Marmaton Group

The end of Cherokee deposition and the beginning of Marmaton sedimentation is marked by widespread appearance of thick limestones. These carbonates did not cover the entire area under consideration, but they had their maximum development during the initial genetic increment (Oswego) in both areal extent and thickness. Each succeeding increment of the

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Marmaton limestones retreated shelfward (northward) to some degree, the major retreat occurring between the Oswego and Labette increments. In each increment massive limestone developments are present on the basinward margin of the limestone. Similar banks have been studied by Van Siclen (1958) and it is suggested that his term (undaform-edge banks) for them be applied.

The sudden and widespread development of carbonates indicates that a rather drastic change had occurred in the northern source areas. Their effectiveness as sources for clastics had been severely reduced. Why this happened is conjectural; perhaps the common explanations would apply, such as: baseleveling of the source area; decrease in precipitation over the source; or erection of a barrier between.

Marmaton limestone deposition was terminated abruptly by the influx of clastics which make up the overlying Seminole genetic increment of strata. It is highly possible that this was caused by the reversal of one of the conditions just mentioned or by tectonic activity in some part of southern Oklahoma.

A major sandstone body is present through the approximate center of the area, oriented in a general east-west direction. The position of the Anadarko Basin to the southwest

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and the overall pattern suggests that its source is somewhere to the east or northeast.

Sandstones in the northern half of the area also have a pattern suggestive of fluvial sands and are probably related to the major sandstone just discussed.

The sands in the southern half are essentially confined to the southeastern corner. They are found in association with a large wedge of shales that are equivalent to the Marmaton limestones in their lower part. The pattern of the sandstone distribution and the direction of wedging suggests a southerly source.

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APPENDIX I

LIST OF WELLS IN CROSS-SECTIONS

CROSS-SECTION A-A'

No.	Operator and Well	Sec.	Twp.	Rge.
1	Cities Service Oil Co. No. 1 Nichols	34	29N	1W
2	McIntyre-Sherman-Cummings No. Mathews	11	28N	2W
3	Finston & Gulf No. 1 Grinaud	30	27N	2W
4	The Texas Co. No. 1 P. P. McMahan	17	26N	ЗW
5	Chapman & Poland No. 1 Muegge	18	25N	ЗW
6	British-American Oil Prod. No. 1 Rehorn	34	24N	4W
7	Blackwood & Nichols No. Probus	21	23N	4W
8	Amerada Petr. Corp. No. 1 Fred Riesen	35	22N	5W
9	George J. Greer No. 1 Hammer	2	20N	5W
10	King-Stevenson Oil Co. No. 1 Kudlac	15	19N	6W
11	Jones & Pellow No. 1 Moery	14	18N	7W
12	L. H. Armer No. 1 Gazin	14	17N	7W
13	Pure Oil Co. etal. No. 1 Redbird Unit	30	16N	7W
14	Pan Am. Petr. Corp. No. 1 Muggenborg	32	15N	8W
15	Tidewater Oil Corp. No. 1 Paints Yellow	28	14N	9W
16	Exploration Oil & Gas No. 1 Ethel Hadlock	30	13N	9W

CROSS-SECTION B-B'

17	Dave Morgan Oil Co. No. l Newcomb	21	28N	1W
18	Fleet Drilling Co. No. 1 Schoolland		28N	2W
19	Walter Duncan No. 1 Forsythe	21	28N	ЗW
20	Kenneth Ellison No. 1 Schwertfeger	15	28N	4W
21	The Texas Co. No. 1 Petrik	22	28N	5W
22	Calvert Drilling Inc. No. 1 Stella Dahlem	22	28N	6W
23	Woods Petr. Co. No. 1 Johnson	16	28N	7W
24	Calvert Drilling Inc. etal. No. 1 Leisure	9	28N	8W
25	Woods Petr. Co. No. 1 Christensen	21	28N	9W
26	Robert F. Dewey No. 1 Mary Jack	21	28N	10W













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PLATE II

NORTHEAST - SOUTHWEST CROSS-SECTION A - A' ILLUSTRATING VERTICAL AND HORIZONTAL RELATIONSHIPS

OF THE GENETIC INCREMENTS OF STRATA (G. I. S.)

See Appendix For Well Names & Loc.

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> See Appendix For Well Names & Loc.

ORVILLE ROGER BERG Ph.D. 1966



PLATE 🎞

EAST-WEST CROSS-SECTION B-B' ACROSS TOWNSHIP 28 NORTH ILLUSTRATING VERTICAL & HORIZONTAL RELATIONSHIPS OF THE GENETIC INCREMENTS OF STRATA (G. J. S.)

> See Appendix For Well Names & Loc.

Ph.D. 1966



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See Appendix For Well Names & Loc.

ORVILLE ROGER BERG Ph.D, 1966

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