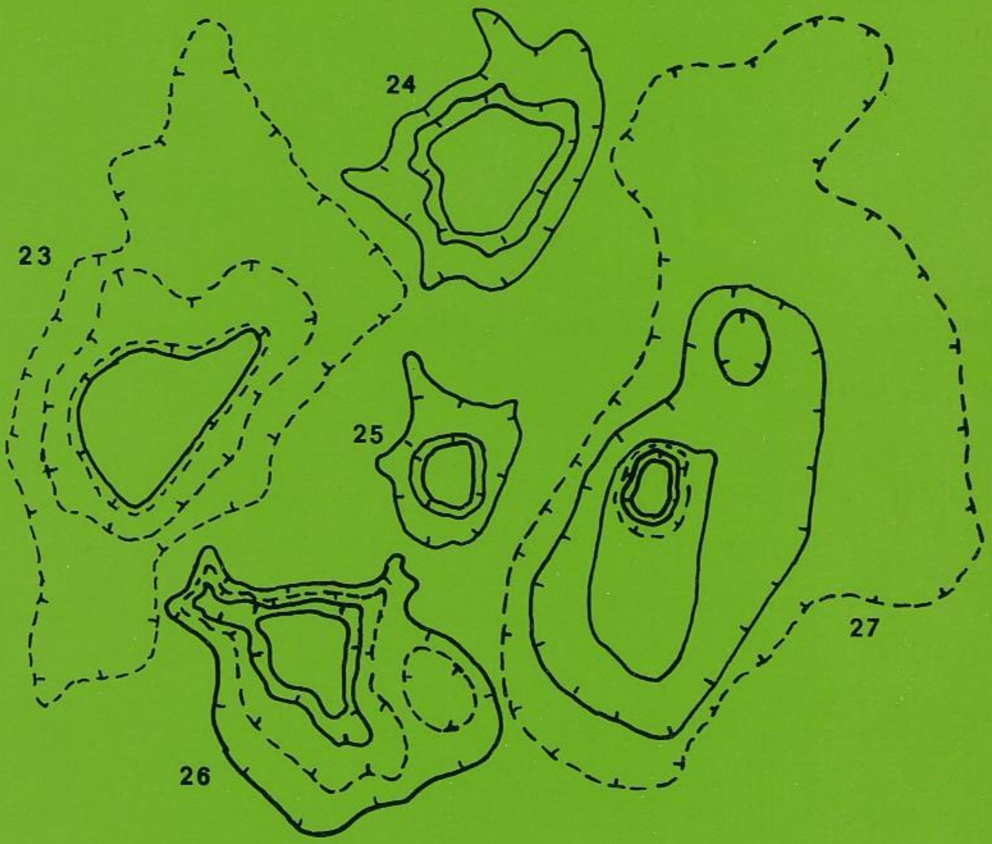
# BAYLOR GEOLOGICAL STUDIES



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**Bulletin No.32**

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1845

# *Morphology and Recharge Potential of Certain Playa Lakes of the Edwards Plateau of Texas*

## JAMES ROY POOL

*"Creative thinking is more important than elaborate equipment--"*

Frank Carney, Ph.D.
Professor of Geology
Baylor University
1929-1934

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The training of a geologist in a university covers but a few years; his education continues throughout his active life. The purposes of training geologists at Baylor University are to provide a sound basis of understanding and to foster a truly geological point of view, both of which are essential for continued professional growth. The staff considers geology to be unique among sciences since it is primarily a field science. All geologic research including that done in laboratories must be firmly supported by field observations. The student is encouraged to develop an inquiring objective attitude and to examine critically all geological concepts and principles. The development of a mature and professional attitude toward geology and geological research is a principal concern of the department.

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BAYLOR GEOLOGICAL STUDIES

BULLETIN NO. 32

# Morphology and Recharge Potential of Certain Playa Lakes of the Edwards Plateau of Texas

James Roy Pool

BAYLOR UNIVERSITY
Department of Geology
Waco, Texas
Spring, 1977

# *Baylor Geological Studies*

The Baylor Geological Studies Bulletin is published semi-annually, Spring and Fall, by the Department of Geology at Baylor University. The Bulletin is specifically dedicated to the dissemination of geologic knowledge for the benefit of the people of Texas. The publication is designed to present the results of both pure and applied research which will ultimately be important in the economic and cultural growth of the State.

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# CONTENTS

*Page*

Abstract ........ 5

Introduction ........ 5

- Location ........ 6
- Climate ........ 6
- Geologic Framework ........ 6
- Acknowledgments ........ 12

Factors influencing formation and modification of the lakes ........ 12

- Lineaments ........ 12
- Deflation ........ 13
- Solution ........ 13
- End-current and wave erosion ........ 14

The four largest lake basins of the Plateau ........ 17

- The Big Lake basin ........ 17
- The Midkiff Lakes ........ 17
- Lake Lomax ........ 17

Recharge through the lakes ........ 17

- Natural recharge ........ 17
- Artificial recharge ........ 18

Summary and conclusions ........ 18

References ........ 18

Index ........ 20

# ILLUSTRATIONS

FIGURE *Page*

1. The Edwards Plateau, showing location of the eight river basins .......... 6
2. Index map showing described localities .................................. 7
3. Average annual precipitation, 1931-1960 .................................. 6
4. Structural lineaments, northern part of study area .................... 8-9
5. Structural lineaments, southern part of study area .................. 10-11
6. Azimuth of structural lineaments in the eight basins .................... 12
7. Examples of lake basins possibly elongated along lineaments by solution, west-central part of the North Concho basin .............. 13
8. Examples of lakes in the two northernmost river basins ................ 13
9. Average annual precipitation versus ratio of relief to area for selected lakes on the Edwards Plateau ........................... 14
10. Examples of lakes with playas possibly shaped by end current erosion and/or wave action ........................................ 14
11. Azimuth of long axis of 144 selected lake basins ...................... 14
12. Azimuth of long axis of playas of 144 selected lake basins .............. 15
13. Climate at San Angelo, Texas ......................................... 15
14. Lakes showing evidence of end-current erosion by northwest winds, Middle Concho River basin ................................ 15
15. Direction toward steepest bank of lakes in the eight river basins ........ 15
16. Locations of lakes with a distinct steeper bank on one side .............. 16

# *Morphology and Recharge Potential of Certain Playa Lakes of the Edwards Plateau of Texas*

James Roy Pool

## ABSTRACT

Most playa lake basins on the Edwards Plateau of Texas are located in the following river basins: North Concho, Middle Concho, South Concho, San Saba, North Llano, South Llano, Frio, and Nueces.

The average playa lake basin on the Plateau drains an area of about one square mile, and has about 15 feet of topographic relief. Most of the average size and larger lake basins formed mainly by solution of the Cretaceous limestone that forms the Plateau surface; however, formation or modification of the basins by collapse of the limestone does not appear to be common.

Smaller lake basins are most abundant on the northwestern part of the Plateau where the soil is thicker (as much as ten feet thick in Glasscock County) than soils on the upland areas in the southern part of the Plateau. These smaller lake basins normally have drainage areas from approximately ten to 40 acres and five to ten feet of relief. Most smaller lake basins in the thick soil areas were probably formed by a combination of soil deflation and/or solution of gypsum from the soil by infiltrating ground water.

Some smaller lake basins and many average size basins (especially those in the northwestern part of the Plateau) are elongate north-south to northeast-southwest. The Plateau (especially its southeastern part) has an abundance of north-south oriented lineaments. However, the lake basins are not normally associated with the lineaments, and the north-south to northeast-southwest elongation of the basins does not appear to be due to preferential solution along the lineaments, but to deflation and end-current erosion (most of which occurred within the last 5,000 years).

Alteration of the lake basins by end-current and wave erosion (waves washing against their windward shores) is active during May when the prevailing wind, at its maximum strength, blows toward the northwest. Most rainfall occurs in May; thus lake basins that are normally dry most of the year contain some water. The development, by wave erosion, of a steeper bank (into the limestone) on the northwest side of some lake basins is evidence that precipitation and wind patterns on the Plateau have been relatively constant for a considerable time.

A few of the larger lake basins have shapes indicative of modification by end-current erosion by winds blowing from the northwest. The four largest lake basins of the Plateau apparently formed in response to special localized causes.

Recharge through the lake basins is limited by impermeable clay present in most of the basins. The possibilities for artificial recharge, using shallow wells which pierce the impermeable lake basin bottoms, is most promising in the west-central part of the North Concho River basin.

## INTRODUCTION*

### PURPOSE AND SCOPE

This investigation is a reconnaissance of the morphological features of the playa lake basins in eight river basins on the Edwards Plateau (hereafter referred to as "the Plateau") of Texas, with particular attention to the function of the lake basins as sites of ground water recharge.

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*A thesis submitted in partial fulfillment of the requirements for the M.S. degree in Geology, Baylor University, 1976.

## LOCATION

The Edwards Plateau is located in the west-central part of Texas. The eight river basins examined for this study are the Plateau parts of the North, Middle, and South Concho; San Saba; North and South Llano; Frio; and Nueces Rivers (Fig. 1). Most of the playa lake basins on the Plateau are located in or near these eight river basins (Fig. 2).

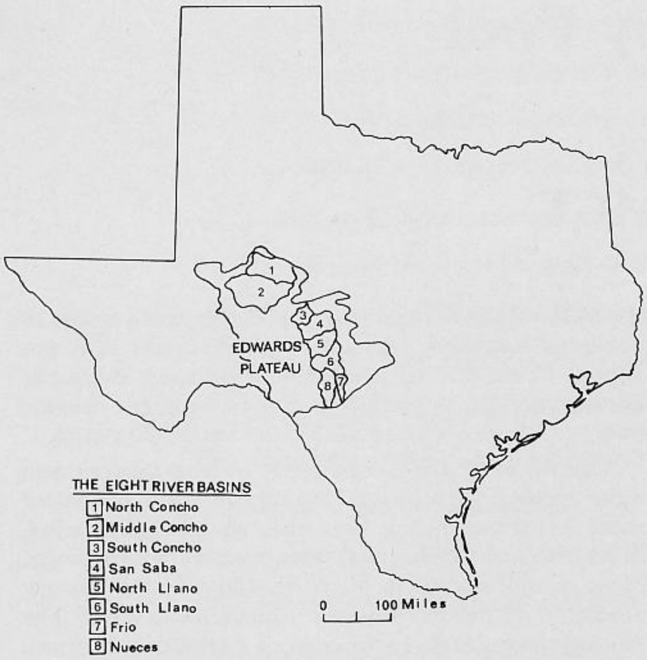


Fig. 1. The Edwards Plateau, showing location of the eight river basins.

## CLIMATE

The Plateau is arid in the northwest where the average annual precipitation is about 14 inches. Precipitation increases in an east-southeasterly direction to about 28 inches in the southeastern part. San Angelo, located near, but outside, the northeast edge of the central part, receives about 19 inches of precipitation each year (Fig. 3).

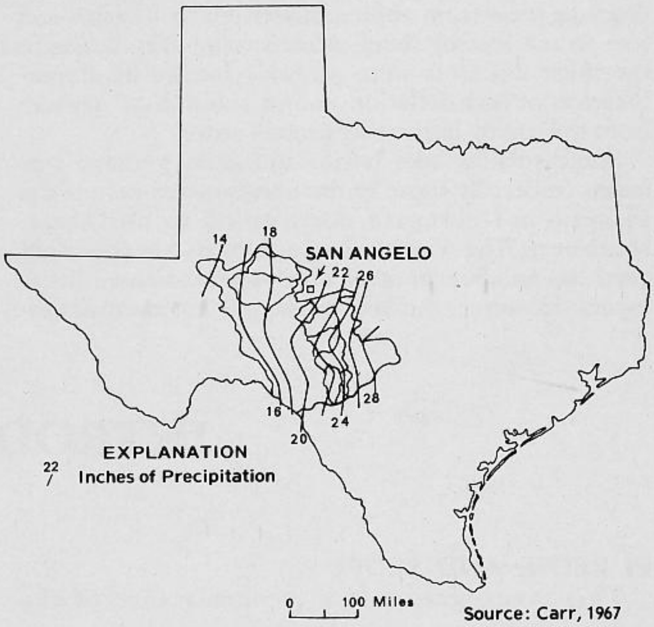
## GEOLOGIC FRAMEWORK

The Edwards Plateau is formed of Lower Cretaceous limestone, marl, and dolomite, with a thin basal interval of shale and sand.

The undissected surface of the Plateau in the North and Middle Concho basins has a southeasterly slope of a few feet per mile. In the more deeply dissected southern six river basins, however, the strata slope gently toward the locations of the two buried valleys which flank a buried north-south trending Pre-Cretaceous topographic high in the central part of the Plateau (Cartwright, 1932, p. 699). Many north-south lineaments are located at the site of the Pre-Cretaceous topographic high (Figs. 4, 5), but most of the lake basins are not associated with the major lineament traces. This fact suggests that the lineaments on the Plateau possibly resulted from deep-seated tectonic movements which occurred after the basins were established and have not resulted from differential compaction of the Cretaceous strata as suggested by Cartwright (1932, p. 700). However, the lakes could also have developed in later-eroded clastic material and been subsequently superimposed onto the limestone terrain.

In the southern part of the study area the surface of the undissected part of the Plateau is marked by irregular interconnecting, broad and shallow swales that—except near the edges of the upland area—drain to small clay-floored lake basins. Most of these lake basins, and indeed most of the lakes on the Plateau, drain an area of about one square mile and have about 15 feet of topographic relief. The swales and their associated basins act as accumulation sites for weathering products from the surrounding slightly higher areas. Both the basins and swales are formed in limestone, suggesting that they are solution features. Most of the basins and swales are not developed along or parallel to lineaments, nor do they have extensive radial and tangential fracture patterns, as would be expected with an origin related to collapse. Rather, the swales and basins appear to be products of long-term weathering of the marl and thin-bedded limestone of the Cretaceous Buda and Del Rio Formations which are the uppermost exposed formations in the southern part of the study area (Rose, 1972, p. 49).

In addition, other soils of the upland region are thin, indicating either a low insoluble residue for the limestone or that the soil has been stripped. In the basins the soils are rarely more than ten feet thick, suggesting that soil formation is a very slow process and that the lakes may be very old.



Source: Carr, 1967

Fig. 3. Average annual precipitation, 1931-1960.

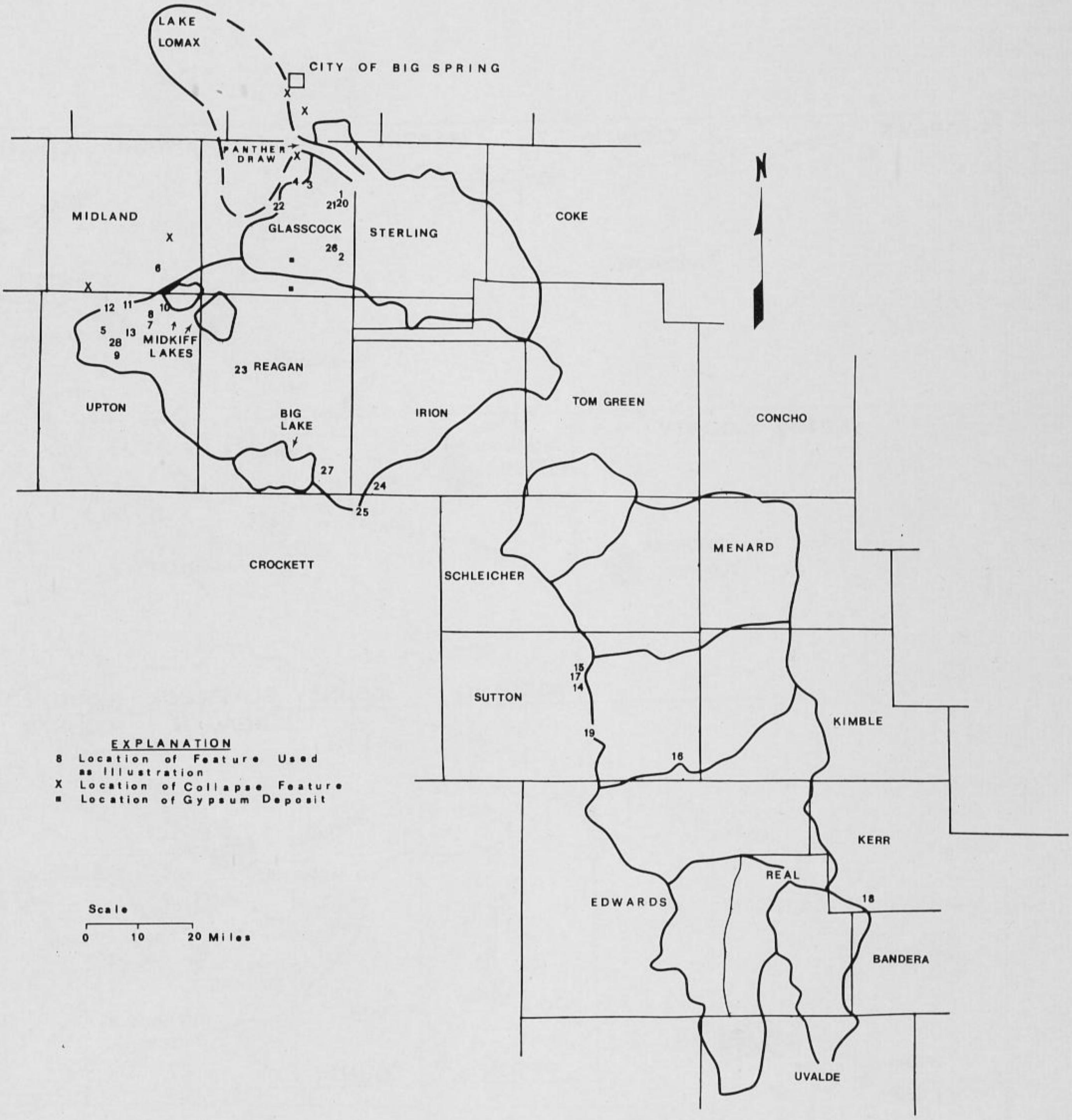


Fig. 2. Index map showing described localities. See explanation for symbols.

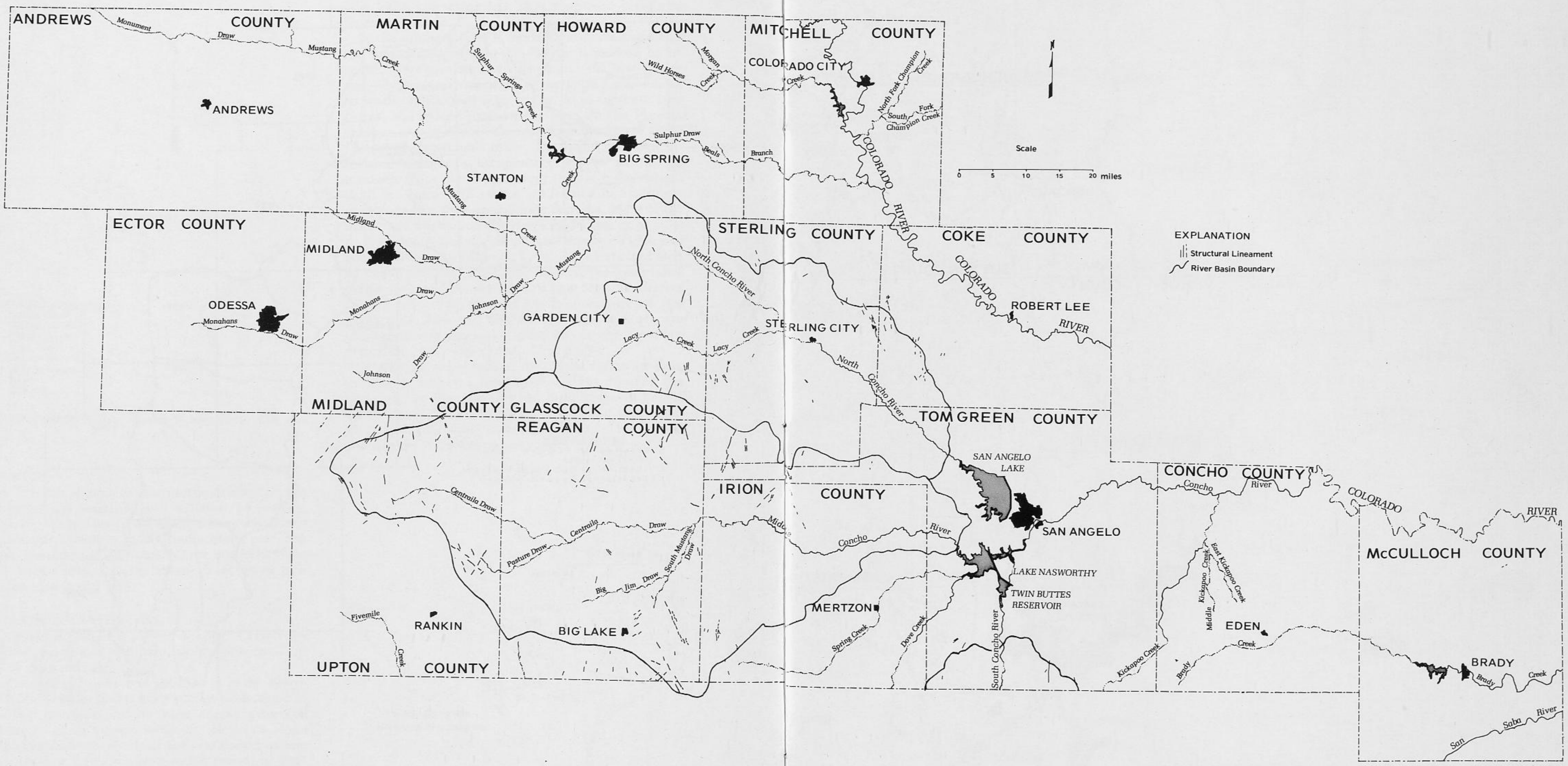


Fig. 4. Structural lineaments, northern part of study area. Lineaments taken from aerial photographs.

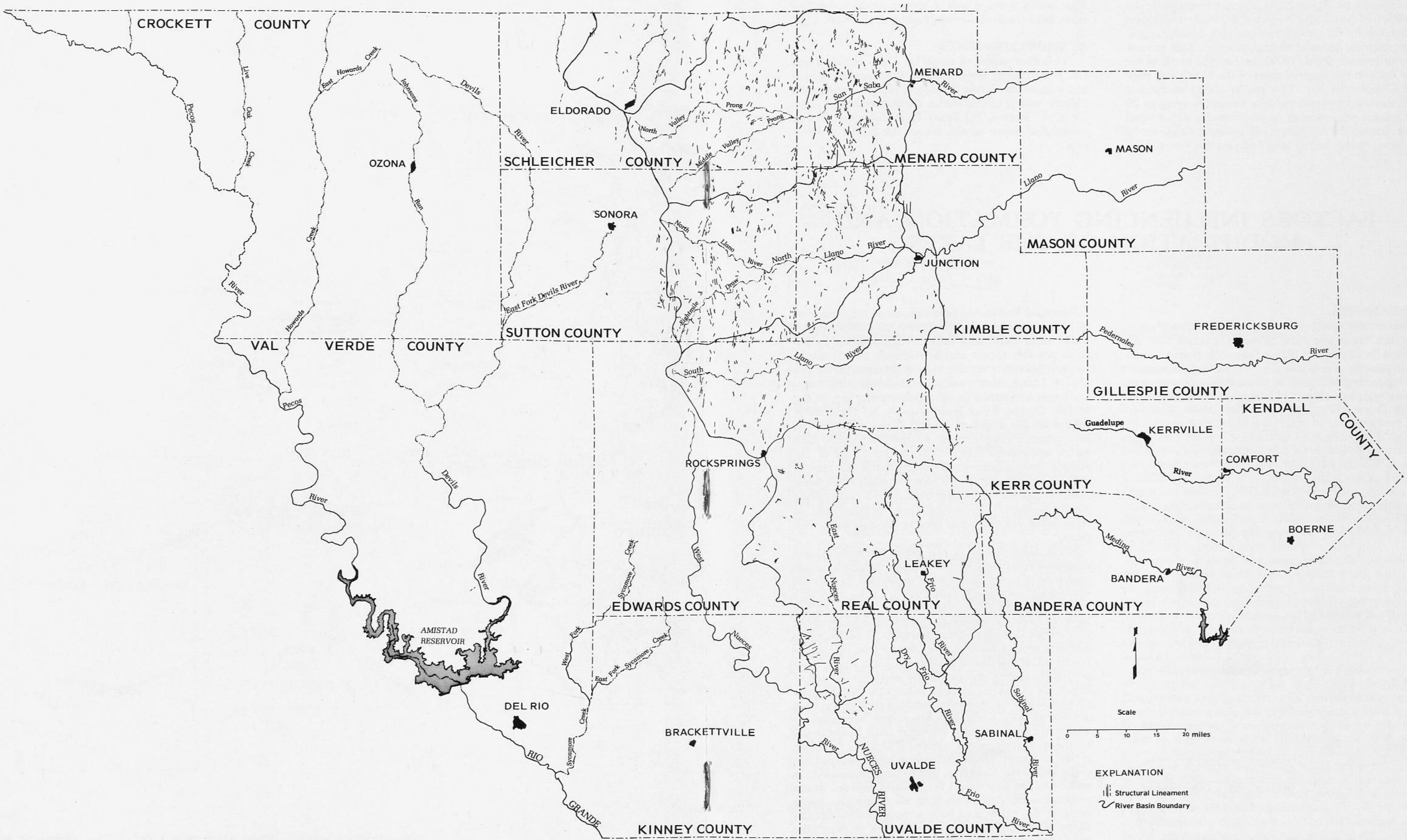


Fig. 5. Structural lineaments, southern part of study area. Lineaments taken from aerial photographs.

In the North Llano basin and northwestward, the undissected part of the Plateau in the eight river basins is masked by silt and clay of possible aeolian origin. This masking deposit, which contains a high percentage of gypsum (Pool, 1971), becomes as much as ten feet thick in the western parts of the North and Middle Concho basins. The silt and clay surface is pockmarked by numerous lake basins (as many as 20 per square mile) ranging in size from numerous small ones, five to ten feet deep and covering about ten to 40 acres, to the largest lake basin on the Plateau, Big Lake, with a drainage area of approximately 130 square miles and a total relief of approximately 300 feet.

**ACKNOWLEDGMENTS**

The author wishes to thank Dr. O. T. Hayward and Dr. Jerry Namy, Baylor University, for supervision and suggestions during the course of this investigation and the writing of this thesis. He also wishes to thank Dr. C. C. Reeves, Jr., Texas Tech University, for his thoughtful review of the manuscript before publication.

# FACTORS INFLUENCING FORMATION AND MODIFICATION OF THE LAKES

## LINEAMENTS

Stereo pair aerial photographs (approximate scale: one inch equals one mile) of the eight basins were examined for lineaments (linear features indicated by soil color change, vegetation, etc.). A five-degree summation azimuth plot (Fig. 6) of lineaments independent of stream segments (Figs. 4, 5) reveals a dominant north-south direction (Pool, 1972a).

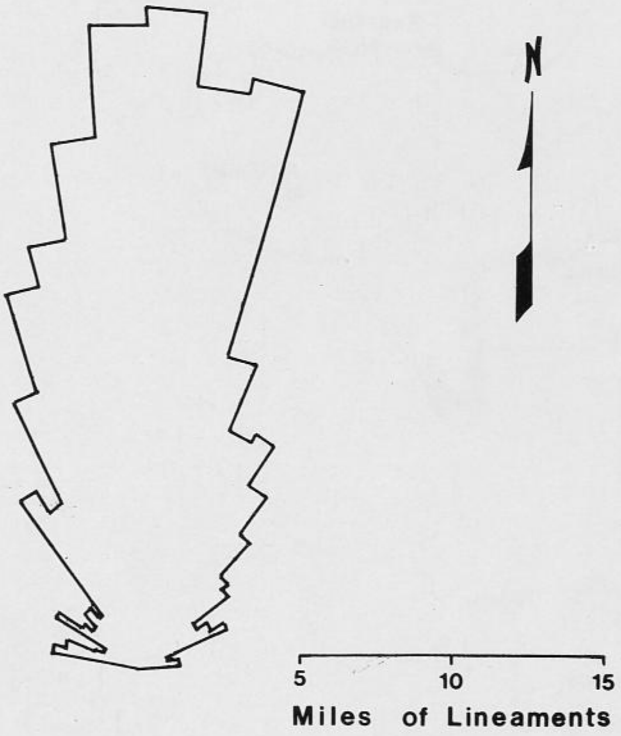


Fig. 6. Azimuth of structural lineaments in the eight basins.

Structural lineaments have influenced the formation of some playa lake basins. This is especially evident where small lake basins have developed along prominent (possibly recent and/or relatively active) north-south lineaments on the southwestern edge of the North Llano River basin, and along northeast-southwest lineaments in the northwestern part of the Middle Concho River basin (Figs. 4, 5). These latter lineaments are discussed later in connection with the formation of Lake Lomax, a large Pleistocene lake which was located just off the northern edge of the Plateau. Several relatively large lake basins also exist in the west-central part of the North Concho River basin that have become elongated, possibly by solution along fractures (Fig. 7). However, aerial photographs of these lakes did not show lineaments associated with them.

Many lake basins in the eight river basins are elongated approximately north-south. Stereoscopic examination of aerial photographs shows that most of the north-south elongated basins are not associated with lineaments. The lineaments on the Plateau are believed to be the surface expression of solution of the Cretaceous limestone along fractures or faults by infiltrating ground water at rates greater than that of unfractured or unfaulted limestone. Thus these lakes probably formed independently of the influence of fractures or faults. It is possible that north-south elongated lake basins in the northern river basins have developed along lineaments which have been covered by aeolian surface debris. However, lake basins in the southern six river basins, where the aeolian (?) deposit is thin or absent, are neither commonly developed nor elongated along numerous north-south lineaments. In addition, the few small lake basins located along prominent lineaments in both the north and south parts of the study area have a more or less circular shape. Therefore the elongated shapes of most lake basins can result from other causes such as deflation,

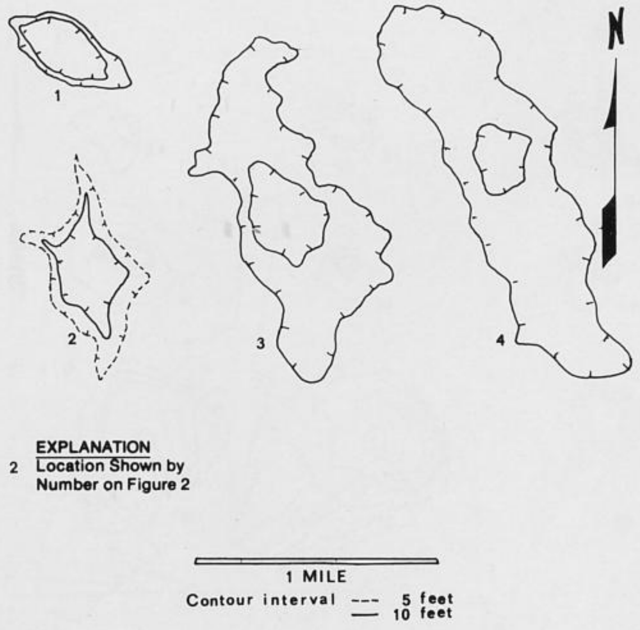


Fig. 7. Examples of lake basins possibly elongated along lineaments by solution, west-central part of the North Concho basin.

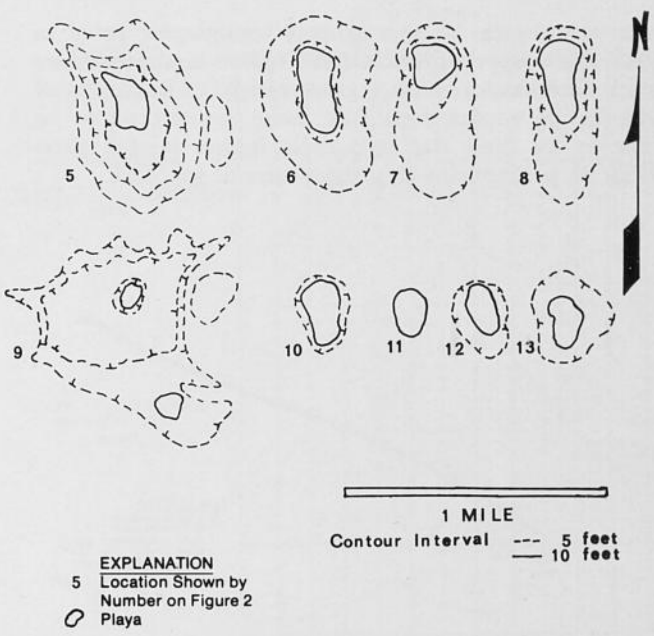


Fig. 8. Examples of lakes, in the two northernmost river basins, possibly formed or modified by deflation.

end-current erosion, and possibly wave erosion instead of preferential solution along lineaments.

## DEFLATION

Lake basins 6, 7, 8, 10, 11, 12, and 13 lie in an area containing relatively thick silt-clay soils in the western part of the Middle Concho River basin (Figs. 2, 8). Because of their location on deep soil and their relatively low relief, these lake basins were probably formed by deflation of the silt and clay soils. Dunes present on the north and northeast sides of some of the deeper lakes in the Middle Concho River basin (i.e., Big Lake, the Midkiff Lakes, and lake No. 28) (Fig. 2) suggest deflation may have caused the elongated shapes of some of these basins. Melton (1940, p. 136) and Reeves (1965, p. 506) found that the deflation-producing prevailing winds on the Southern High Plains (the area immediately north of the Plateau) have blown approximately N 20°E for the last 5,000 years.

The dunes are composed primarily of gypsum with smaller amounts of calcium carbonate, silt, and clay. The dune at Big Lake has a south-facing (wave-cut ?) scarp at its base at the level of the present playa, indicating wetter conditions since formation of the dune.

Lake basins 5 and 9 (Fig. 8) were not field checked, but have what appears on topographic maps to be a low dune on their east-southeast sides. These dunes may have been formed by the S 30°- 90° E winds which were active on the Southern High Plains during the period 5,000 to 25,000 B. P. (Reeves, 1965, p. 506; 1966, p. 288; Reeves and Parry, 1969, p. 353).

## SOLUTION

The thick soil layer at two locations in the northwestern part of the Plateau contains a high percentage of gypsum (Pool, 1971). The presence of gypsum in the soil suggests the possibility of solution by infiltrating ground water as the origin for some of the smaller, more shallow lake basins. That solution of soil gypsum does occur is revealed by concentration in the ground water. On the Plateau portions of Reagan and Glasscock Counties, where the soil is generally thick, the ground water contains 200 to 500 milligrams per liter of sulfate ion (Muller and Couch, 1972; Couch and Muller, 1972). However, sulfate concentrations in ground water in areas where the soil is thin or absent, as in Schleicher, Sterling, and Irion Counties range from 20 to 50 milligrams per liter (Muller and Couch, 1971; Pool, 1972b, 1972c).

Formation of those lake basins on the Plateau which are not located in an area of thick soils, but on Cretaceous limestone bedrock, may have been controlled dominantly by solution processes. In addition, removal of Cretaceous limestone by solution has probably been a factor in the formation of most of the average size and large deep lake basins, including those in thick soil areas.

The disproportionately larger size and greater depth of four of the lake basins has probably resulted from development in response to local conditions (e.g., collapse, increased solution resulting from a local high density of fractures in the limestone, or lateral enlargement by wave erosion and deflation in the deep soil areas of the northern part of the Plateau). Also the location of the four largest lake basins in the northern part of the Plateau indicates that part of the Plateau may have been exposed to weathering for a longer period of time than the southern part.

A comparison of present (1931-1960) average annual precipitation at selected lake basins on the Plateau versus the ratio of approximate topographic relief in feet to the approximate area in square feet drained by each lake basin reveals a great variability in depths of the basins versus their size. Lake basins tend to be deeper for their size in present higher rainfall areas (Fig. 9), perhaps due to greater rates of solution.

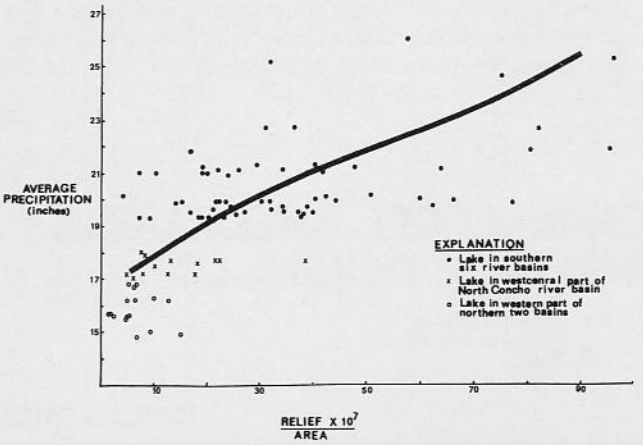


Fig. 9. Average annual precipitation versus ratio of relief to area for selected lakes on the Edwards Plateau.

The implication that present precipitation patterns have influenced development of the lake basins is complicated by possible differences in ages and developmental histories. For example, the thicker soils in the western part of the Middle Concho favor lateral enlargement of basins by both deflation and wave erosion. Another example is the clay-rich soil that forms the bottom of many of the lakes of the Plateau should limit vertical deepening of those lakes by solution or deflation. In addition, some of the lakes in the northern part of the Plateau appear to have developed along lineaments, whereas, the southern part of the Plateau has a much greater density of lineaments, but only a few lakes that are associated with them. Therefore, the conclusion that the present pattern of precipitation has existed long enough to have significantly influenced rates of formation of the lakes by solution could not be substantiated within the limits of this investigation.

## END-CURRENT AND WAVE EROSION

A number of the lake basins on published 7.5 minute topographic maps of the study area show evidence of alteration by end-current erosion and by wave erosion (Fig. 10). End-current erosion causes elongation of a lake basin at right angles to the prevailing wind direction (Rex, 1961). Alteration by wave erosion results from waves washing against the downwind shore of the lake.

The orientation of the long axes of 144 lake basins and their playas, as mapped on 7.5 minute quadrangle maps (Pool, 1972a), is primarily north-south, and secondly east-west to east northeast-west southwest (Figs. 11, 12). The north-south elongations probably result from deflation by south winds (when the basins are dry) and end-current erosion by west winds (when the basins are wet), both acting within the last 5,000 years (Fig. 13) (Reeves and Parry, 1969, p. 354; Reeves, 1965, p. 506). The less prominent east-west elongation may also represent the result of end-current erosion by present prevailing southerly winds.

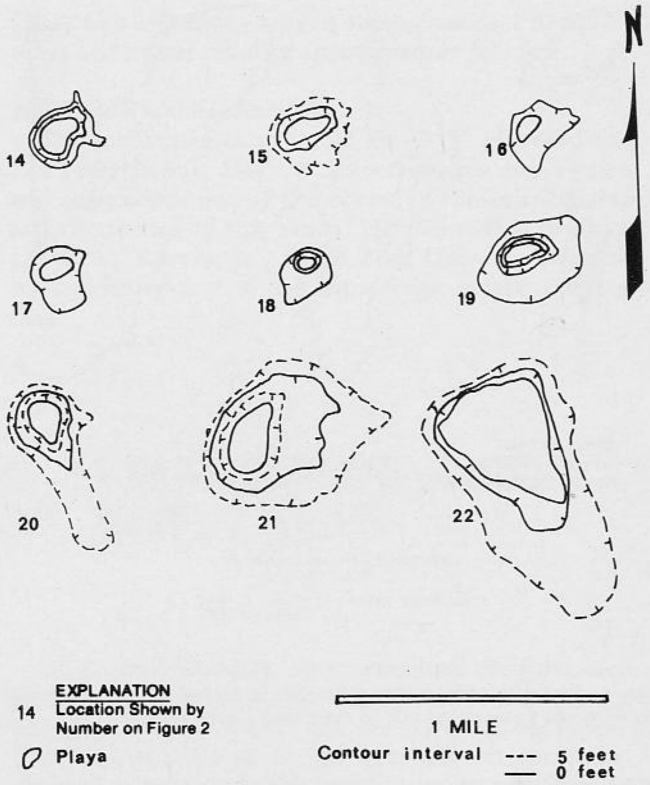


Fig. 10. Examples of lakes with playas possibly shaped by end-current erosion and/or wave action.

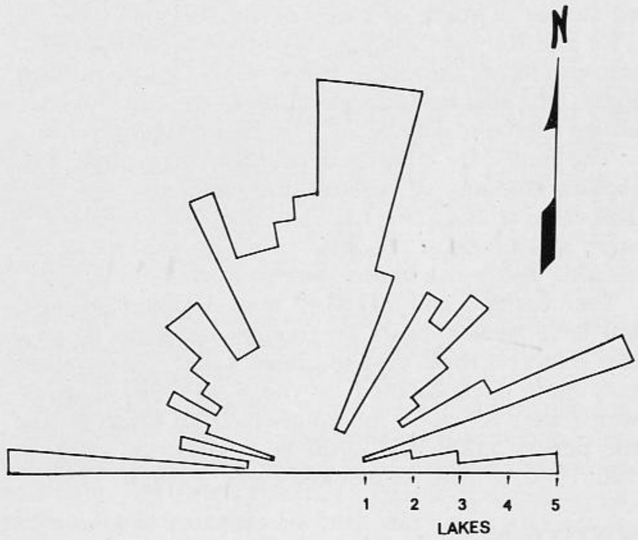


Fig. 11. Azimuth of long axis, 144 selected lake basins.

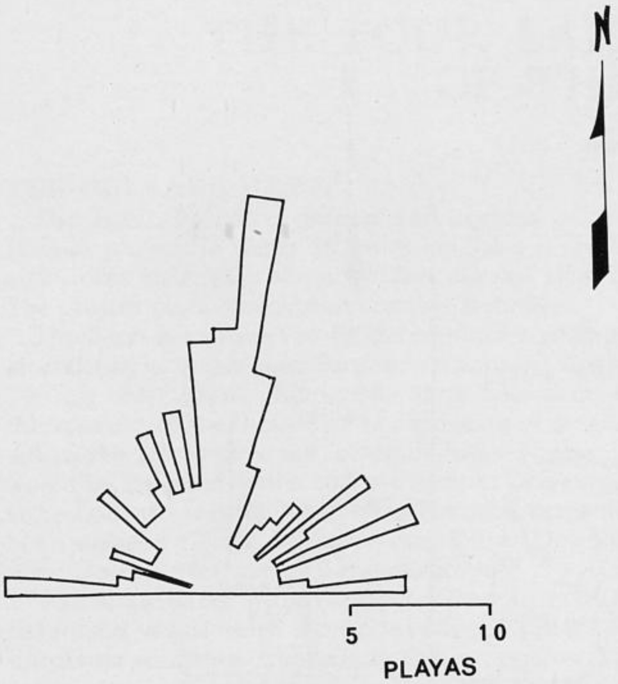
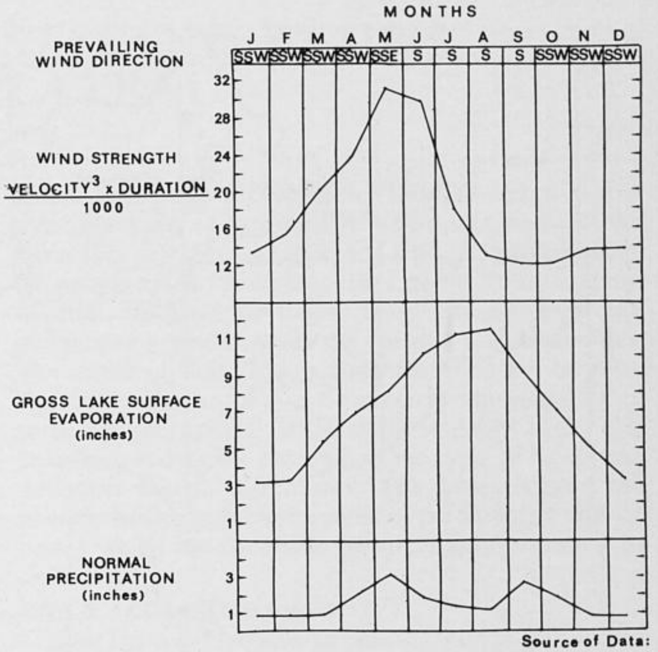


Fig. 12. Azimuth of long axis of playas, 144 selected lake basins.



Source of Data: Orton, 1969, and U. S. Weather Bureau

Fig. 13. Climate at San Angelo, Texas.

Three of the lakes (Fig. 14) show progressive westerly shift of the windward shore with lower lake levels. This may indicate a decrease in annual precipitation in conjunction with a wind shift from northwest to west, prior to 5,000 years B.P.

The strongest evidence for alteration of the lake basins by wave erosion is shown by the teardrop shape and steeper north or northwest banks exhibited by many of the basins (Figs. 10, 13, 15, 16). The steep banks were previously attributed to deflation processes (Pool, 1973).

Figure 13 shows the direction and strength (Price, 1968, p. 106) of the prevailing wind, the gross lake surface evaporation, and the precipitation for the San Angelo area. The strength (velocity cubed multiplied by duration) of the prevailing wind indicates the effec-

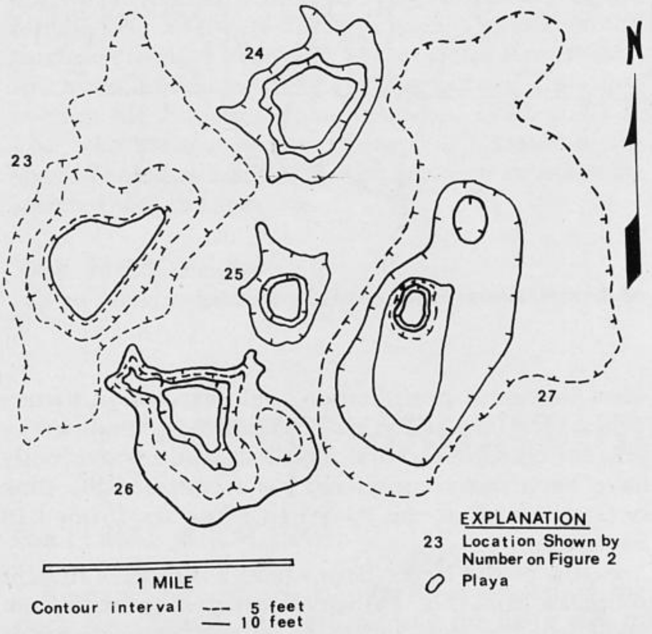


Fig. 14. Lakes showing evidence of end-current erosion by northwest winds, Middle Concho River basin.

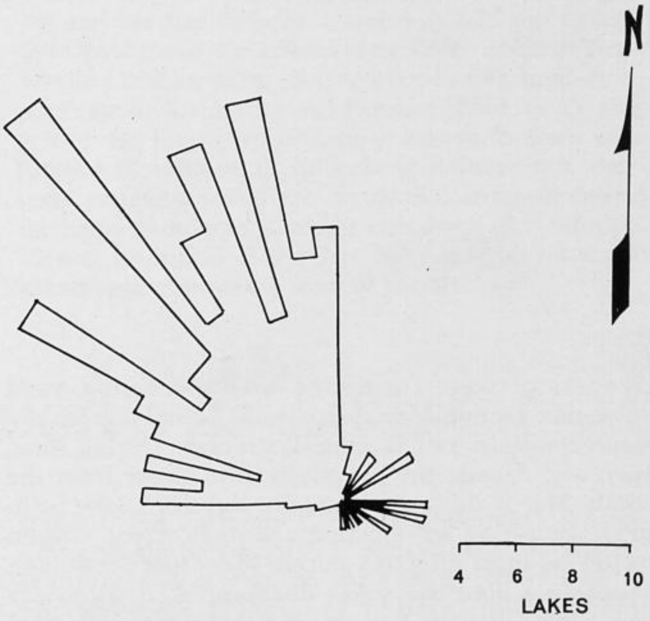


Fig. 15. Direction toward steepest bank of lakes in the eight river basins.

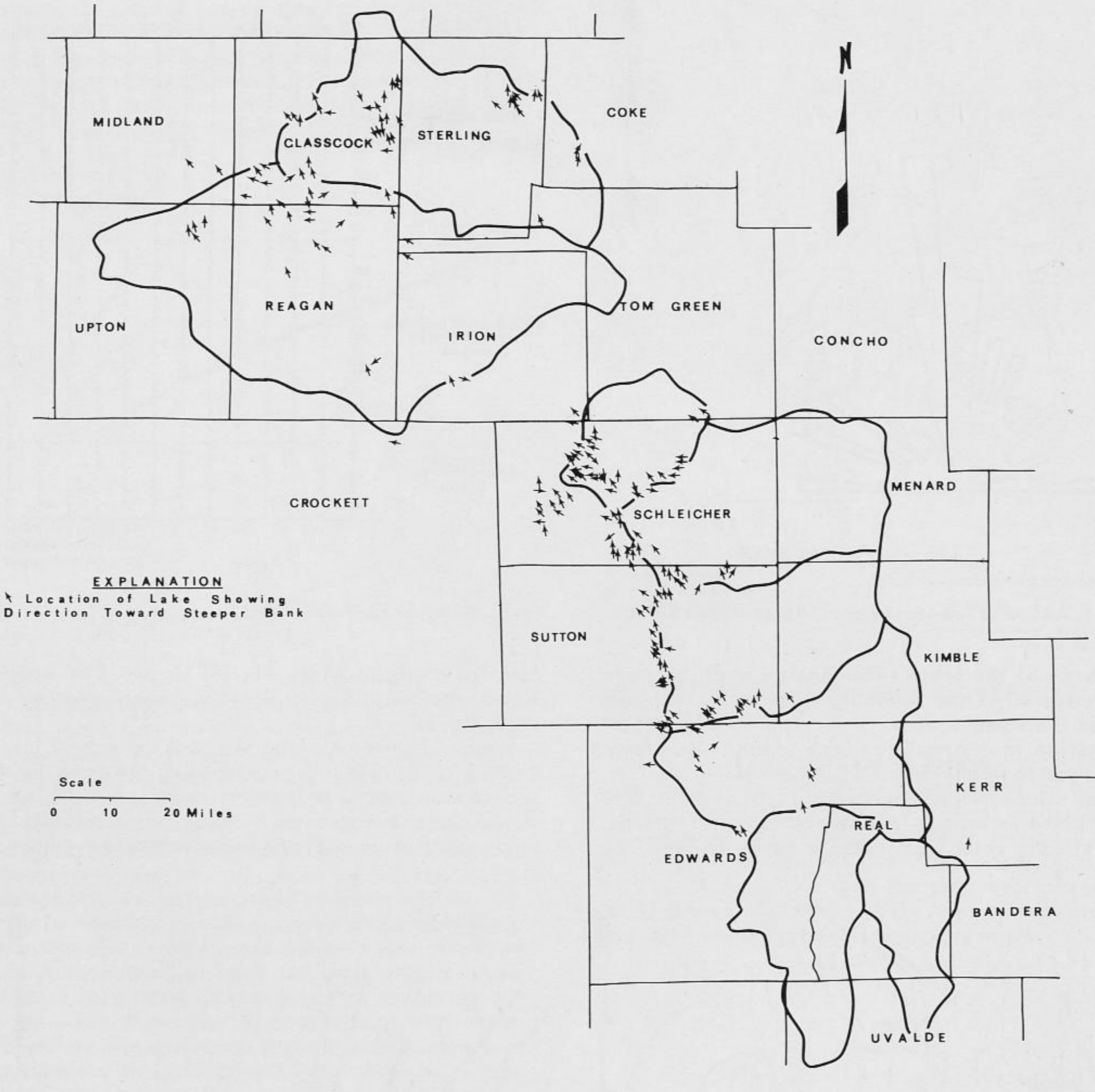


Fig. 16. Locations of lakes with a distinct steeper bank on one side. Arrows point toward steeper banks.

tiveness of wave formation with increasing wind velocities. During May the prevailing wind is from the south-southeast and is at peak strength. During June, July, and August the prevailing wind blows from the south. May is the wettest month; therefore, lake basin modification by wave action and end-current erosion would be most effective during May (south-southeast winds) and until the water disappeared. A secondary wet period usually occurs in September, but wind strength is considerably lower during the fall months. The shapes of the lake basins and the correlation of wind strengths, precipitation, and evaporation patters indicate the lake basins are probably being modified by present climatic factors. These conditions evidently have been fairly consistent for a considerable time because many of the modified lakes are formed in limestone.

A few of the larger basins have a distinctly straight southeast bank (Fig. 14) which may have resulted from end-current erosion produced by northwesterly winds sometime before 5,000 years B.P. (Reeves and Parry, 1969, p. 354).

# THE FOUR LARGEST LAKE BASINS OF THE PLATEAU

## THE BIG LAKE BASIN

The Big Lake basin, largest and deepest on the Plateau proper, is about 19 miles long and seven to eight miles wide, with about 300 feet of relief (Fig. 2). The present playa covers about two square miles.

The basin is surmised to be the result of a sinkhole or collapse in underlying Permian evaporites (Moore, 1967, p. 64). Aerial photographs show lineaments in the area are neither abundant nor radiating or tangential to the relatively small, centrally located playa, as would be expected with a collapse feature. However, a large collapse feature underlying the lake playa has been mapped (D. A. Muller, Texas Water Development Board, 1968, personal communication).

The lake basin apparently formed in a well-developed valley which developed along a prominent northwest-southeast trending lineament system. The valley's original outlet area is covered to an unknown depth by sediments; however, the basin probably drained to the Middle Concho River (to the east) or, less likely, to the Pecos River (to the west). Later the lake had three outlets; they are about 80, 70, and 60 feet, respectively, above the present playa. The most recent and lowest outlet trends through the town of Big Lake, located on the northeast side of the lake. The last permanent drainage antedated the formation of the dunes along the north side of the lake, perhaps during the more arid altithermal ± 5,000 years B.P. The outflow from the lake was apparently captured by the lowest outlet by headward erosion along a northwest-southeast lineament by a tributary of the Middle Concho River. The lake basin is located on the southeast flank of a low (± 30-foot closure) northeast-southwest trending anticline in Cretaceous strata that overlies the Big Lake dome (Hennen, 1929, p. 516). The lake basin may have formed as a result of increased solution associated with fractures or faults associated with the anticline.

## THE MIDKIFF LAKES

Two unnamed lake basins (the lakes are referred to informally in this report as the "Midkiff Lakes"), near the community of Midkiff in the Middle Concho River basin (Fig. 2), drain a combined area of approximately 50 square miles. Maximum relief in the basins is about 80 feet. Both of the basins have several playas and prominent gypsum dunes on the east-northeast sides. The depth of these basins suggests formation by solution and collapse of the Cretaceous limestone or of some deeper material. If the deflated debris is of older lacustrine sediments more than one cycle of filling and deflation would be indicated. The dunes suggest the present basins may be the sites of partially filled older basins which have recently been partially exhumed by deflation.

## LAKE LOMAX

Lake Lomax (Frye and Leonard, 1964, p. 17) was an extensive Pliocene to Pleistocene lake located immediately off the northern edge of the Plateau, on an area of Triassic shale and sand (Fig. 2). Cretaceous and any overlying strata which formerly covered the basin area have been removed by erosion. Outflow from the lake was carried by Panther Valley (Frye and Leonard, 1964, p. 17) from Pliocene to late Pleistocene time, when Beals Creek, which flows through the city of Big Spring, captured the outflow from the lake (Fig. 2).

The collapse features located by an "x" in Figure 2 are on or near the projected trend of a group of prominent northeast-southwest lineaments located in the northwest corner of the Middle Concho River basin (Fig. 4). The three collapse features in Howard County were described by Livingston and Bennett (1944, p. 25) and the two collapse features in Midland County were brought to my attention by D. A. Muller (Texas Water Development Board, 1968, personal communication). Livingston and Bennett (1944, p. 25) suggested that the collapse features known to them were formed by solution of underlying Permian salt. Fractures or faults, which are recognized as lineaments in the aerial photographs, might encourage such solution. Hence, formation of the lake basin may be related to the lineaments.

# RECHARGE THROUGH THE LAKES

## NATURAL RECHARGE

Recharge through the lake basins is limited by the thick clay (Randall soil) which forms the playa area of many of the basins (Wiedenfeld and McAndrew, 1968, p. 27). Some exceptions (lakes whhich recharge quickly) do exist in areas outside the eight river basins studied. For example, C. C. Wiedenfeld (U.S. Soil Conservation Service, 1973, personal communication) reported that "many of the depressions in northwestern Schleicher County and northeast Crockett County are drained rapidly [i.e., within a few hours] into rubble-filled openings in the limestone. These playa lakes are well-vegetated."

An unknown but probably small quantity of recharge through the lake basins in the investigated area may occur during short but relatively frequent rain showers when small amounts of runoff reach the base of the clay soil and enter the limestone of the lake bottoms. The runoff may pass through large, deep (as much as six inches wide and several feet deep) desiccation cracks in the clay soil of the lake bottoms before the cracks swell shut. Significant recharge through those lake basins which have a thick clay soil covering their playas can occur only during infrequent wet periods when the basins catch enough runoff to raise lake levels above the clay strand lines and into contact with relatively permeable limestone outcrops on the sides of some of the basins.

### ARTIFICIAL RECHARGE

Use of the lake basins for artificial recharge appears promising, especially in the northern part of the Plateau.

In the North and Middle Concho River basins the underlying Cretaceous sand is the major aquifer (Mount et al., 1967, p. 70). Artificial recharge in those river basins might be accomplished by using shallow cased wells which pierce the lake bottom clay and extend into underlying Cretaceous limestone and sand. Because of the filtering action of sand, recharge of untreated runoff into the Cretaceous sand aquifer may not cause unacceptable biological pollution provided recharge sites exclude cultivated and livestock areas.

In other parts of the Plateau the major aquifer is Cretaceous limestone, thus the possibility of biological pollution of the ground water by artificial recharge in those areas is much greater because of the limited filtering action. Treatment of the recharge water would probably be advisable in the southern part of the Plateau.

To be economical, lake basins modified for recharge should be relatively large, located in relatively high rainfall areas, and in or near areas needing the extra water supply. Lake basins in the west-central part of the Middle Concho River basin best fit these criteria. These lake basins cover an area of one or more square miles and the average annual precipitation is greater than that of the areas to the west. Recharge in these basins could benefit the irrigated farming in the area. Other large lake basins in the North and Middle Concho River basins (i.e., the Midkiff Lakes, Big Lake, and several other large lakes) have associated gypsum dunes which could cause water quality problems.

# SUMMARY AND CONCLUSIONS

1. The dominant structural lineament (lineament detected without using stream segment alignments) direction in the eight river basins is north-south. A few of the lake basins on the Plateau are located along prominent lineaments, and thus may have been formed by solution caused by infiltration along fractures or faults which are recognized as lineaments in the aerial photographs. However, most Plateau lakes are neither located on nor developed along lineaments, and apparently their formation has not been greatly influenced by increased rates of solution along faults or fractures.
2. Numerous north-south lineaments in the central part of the Plateau, which overlie a north-south oriented Pre-Cretaceous topographic high, may have been caused by differential compaction of Cretaceous strata into Pre-Cretaceous valleys that flank the high. The lineaments appear to post-date the lake basins, particularly in the southern six river basins, because most of the basins are not associated with lineaments. However, it is possible that the lake basins were superimposed onto the limestone terrain from overlying, subsequently eroded sediments.
3. Various playa lake basins in the eight river basins were formed and/or modified by deflation and solution, and were later modified by end-current erosion and wave erosion. Basins formed by deflation are most common in the thicker soil areas located in the northern part of the Plateau. Solution of gypsum by infiltrating ground water in the thick soil may have partly formed some lake basins. Gypsum dunes have formed near a few of the deeper lake basins in the western part of the Middle Concho River basin. The deeper lake basins were formed by solution of underlying Cretaceous limestone, but attendant collapse is not common. However, the four largest basins on the Plateau are undoubtedly the result of solution and large scale collapse.

   The directions of paleo winds on the Southern High Plains (Melton, 1940; Reeves, 1965) and the positions of fringing sand dunes show that many of the lake basins have been altered by deflation.

   The presence of a straight southeast basin shore trending northeast-southwest in a few of the lake basins indicates that the basins were altered by end-current erosion by northwesterly winds.

Present end-current erosion and wave erosion modification of the basins is by south-southeast winds, and is probably most active in the wet, windy month of May, and less active in June, July, and August. The development of steep banks of the lake basins in limestone indicates the wind and precipitation patterns of the Plateau may have been similar to those of the present for perhaps as long as the last 5,000 years.

4. The largest lake basin on the Plateau, Big Lake, appears to be a former externally-draining valley which now contains a relatively small collapsed area.
5. The other two large lake basins on the Plateau, the Midkiff Lakes, appear to be older filled basins which have been partially exhumed by deflation.
6. The Lake Lomax basin and several associated collapse features formed along the projected trend of, and because of, a zone of prominent northeast-southwest trending lineaments.
7. Most recharge through Plateau lake basins probably occurs during infrequent wet periods when lake levels are high enough to allow infiltration through limestone outcrops present along some of the lake shores.
8. Artificial recharge through the lake basins, using shallow wells to pierce the clay playas is feasible in the west-central part of the North Concho River basin where many of the basins cover an area of one or more square miles, the main aquifer is of sandstone, the rainfall is more abundant than in the areas to the west, and a nearby need (irrigation) for additional water exists.

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# INDEX

Anticline 17
Artificial recharge 18
August 16

Big Lake 12, 13, 17, 18
Buda Fm. 6

Calcium carbonate 13
Clay 12, 13, 17, 18
Crockett Co. 17

Deflation 12, 13, 14
Del Rio Fm. 6
Dolomite 6
Dunes 13, 17, 18

East winds 14
End-current erosion 13, 14, 16
Erosion 13, 14, 16
Evaporation 16
Evaporites 17

Faults 12, 17
Fractures 12, 17
Frio R. 6

Glasscock Co. 13
Ground water 12
Gypsum 12, 13, 17, 18

Irion Co. 13

July 16
June 16

Lake Lomax 12
Limestone 6, 12, 13, 17, 18

Marl 6
May 16
Middle Concho R. 6, 12, 13, 14, 17, 18
Midkiff Lakes 13, 17, 18

North Concho R. 6, 12, 18
Northeast winds 16
North Llano R. 6, 12
Nueces R. 6

Pecos R. 17
Permian evaporites 17
Precipitation 6, 14, 15, 16

Randall soil 17
Reagan Co. 13

San Angelo, Tex. 6, 15
Sand 6, 18
San Saba R. 6
Schleicher Co. 13, 17
September 16
Shale 6
Silt 12, 13
Sink hole 17
South Concho R. 6
Southeast wind 17
Southern High Plains 13
South Llano R. 6
South winds 14, 17
Sterling Co. 13
Sulfate 13
Swales 6

Wave erosion 13, 14
West winds 14
Winds 14, 16

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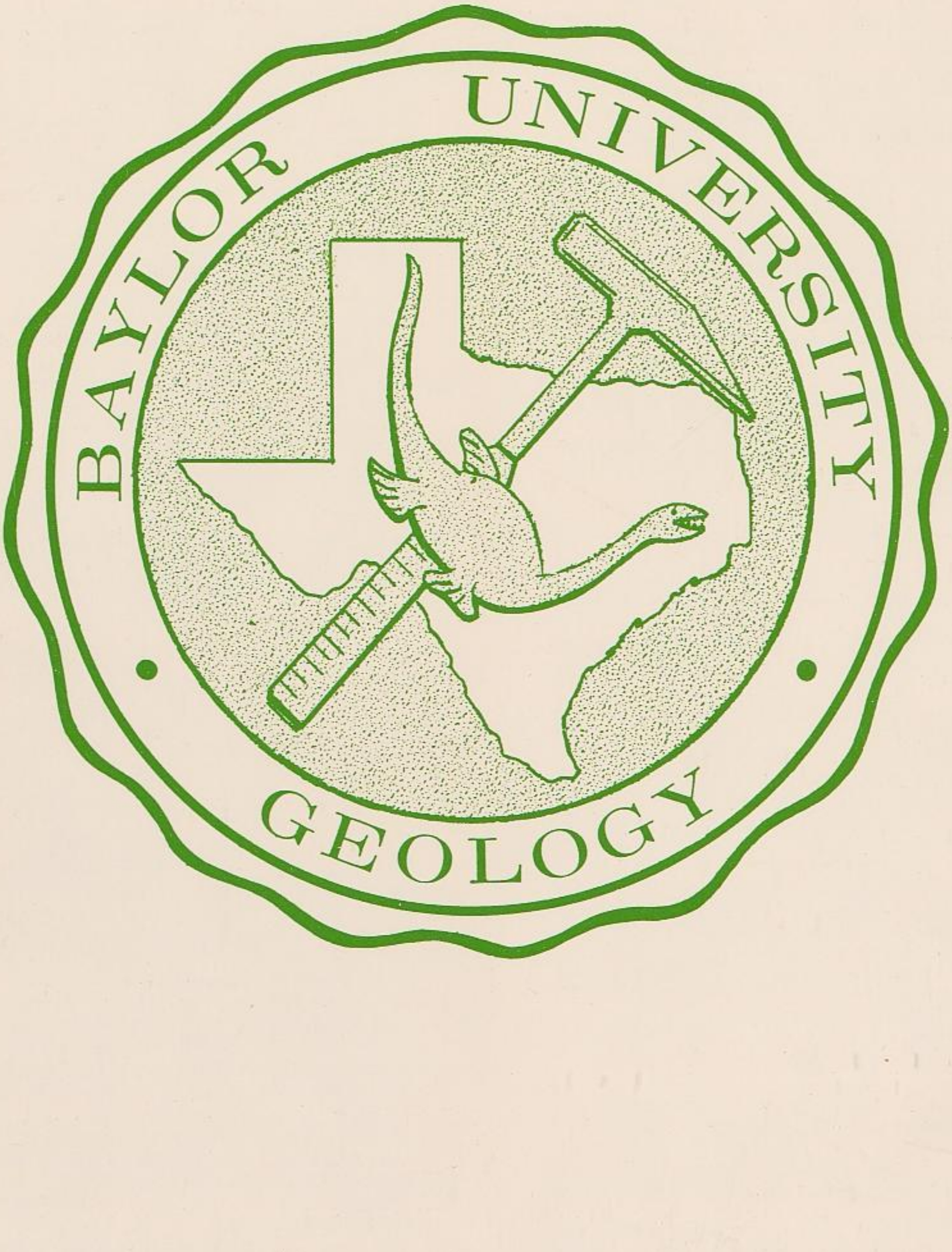
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