LITHOSTRATIGRAPHIC AND DEPOSITIONAL FRAMEWORK, NEAR-SURFACE UPPER PENNSYLVANIAN AND LOWER PERMIAN STRATA, SOUTHERN BRAZOS VALLEY, NORTH-CENTRAL TEXAS

A THESIS SUBMITTED TO THE FACULTY OF

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REQUIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE

BY

MARY J. SEALS

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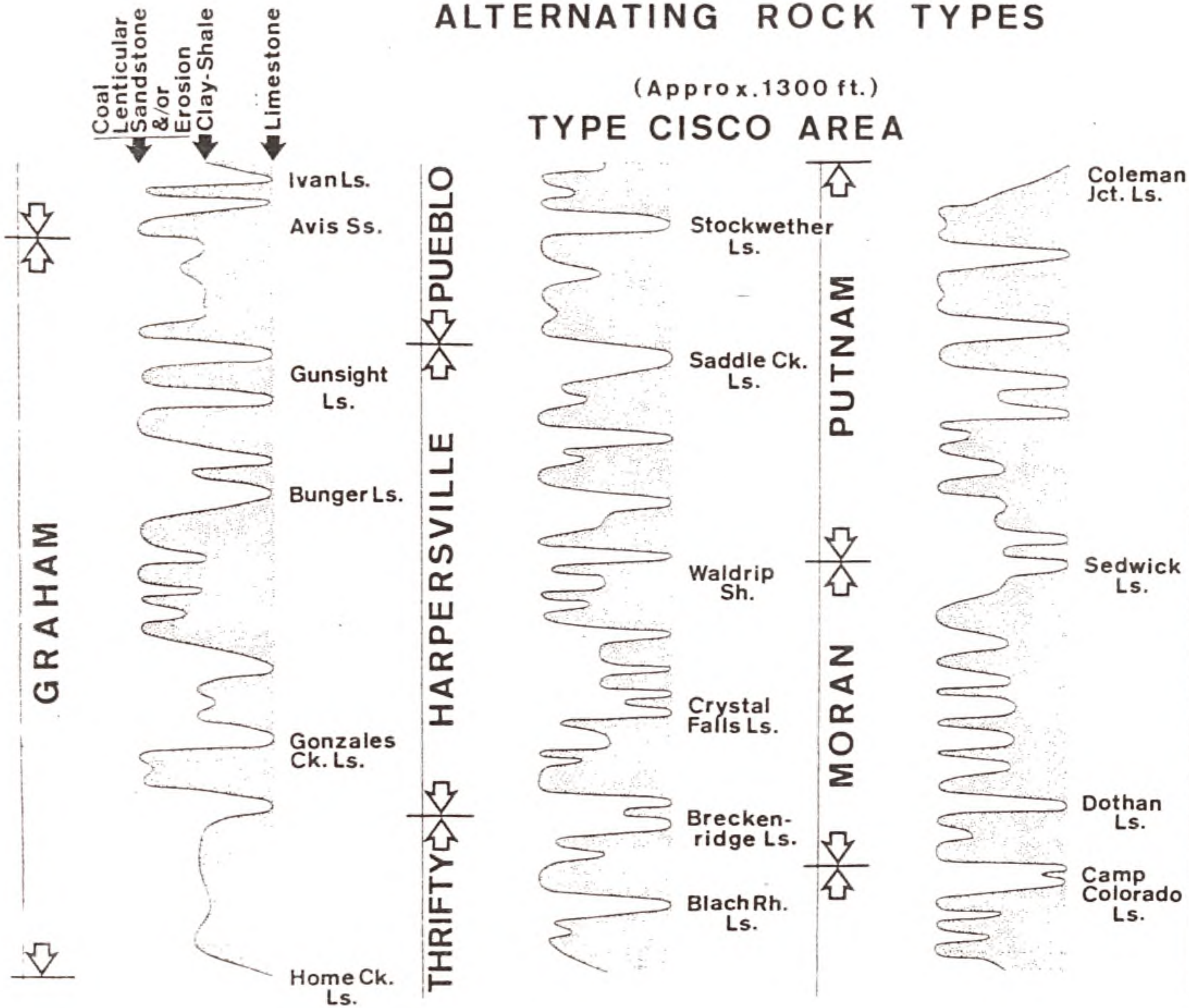
"CYCLIC" DEPOSITION

ALTERNATING ROCK TYPES

(Approx. 1300 ft.)
TYPE CISCO AREA



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ABSTRACT

The purpose of this study was to interpret the depositional framework of the original Cisco Group, Upper Pennsylvanian and Lower Permian, in the shallow subsurface of North-central Texas. Stratigraphic interpretation was based on several subsurface mapping methods --(1) stratigraphic cross sections, (2) isopach maps of limestone-bounded intervals, (3) sandstone percentage maps, (4) structure contour maps, (5) channel sandstone isopach maps, (6) paleotopographic maps, (7) well sample study, and (8) various special maps and cross sections.

Several classifications of the Upper Pennsylvanian and Lower Permian strata have been proposed; however, Plummer and Moore's (1922) classification, although not completely suitable, applies best to the study interval. The problem of the Pennsylvanian-Permian boundary was not a concern of this study.

The strata of the Cisco Group in the study area consist, in order of abundance, of shale, sandstone, limestone, and coal. Rock characteristics and interpretation of depositional environments was of necessity based primarily on electrical responses and geometric distribution.

Little is known about shales within the study area except that they may be highly fossiliferous, commonly carbonaceous, and probably represent transitional environments.

Relatively thin, widespread limestones persist throughout the study interval and represent decrease in clastic influx. The persistent limestones are important in subsurface correlation.

Sandstone deposits can be divided into sheet sandstones of probable marine origin and linear channel-fill sandstone bodies.

Topographic and structural lows were apparently controlled to some degree by differential sand-shale compaction and by compaction of shales underlying massive sandstone bodies. These local compactional features are superimposed on a broad, regional monocline.

Interpretation of channel trend relationships to structure and underlying strata has been an important aspect of this investigation. The dominant orientation of channel trends is in a west-southwest direction, which probably reflects a source area to the east and northeast of the study area. Channels are best developed in structural lows which apparently were also paleotopographic lows.

In non-channel areas differential shale compaction created topographic lows on which a succeeding channel would probably develop. Subsidence due to shale compaction beneath massive sandstone bodies also created topographic lows, which are commonly areas where an upper channel crosses a lower channel. As many as five intersections were observed in a local area.

Continued surface and subsurface research is necessary to describe sufficiently the depositional history of the Cisco Group of North-central Texas. Suggestions for further study include (1) extension of the study downdip and along strike, (2) more dense well control on a larger map scale, (3) mineralogic, petrologic and sedimentary structure studies, and (4) paleotopographic surface and subsurface studies.

INTRODUCTION

Purpose

The primary objectives of this study were to develop the stratigraphic framework and to interpret the depositional history of the original Cisco Group (Home Creek-Coleman Junction interval) of Upper Pennsylvanian and Lower Permian age in the shallow subsurface downdip from classic type areas in the southern Brazos Valley of North-central Texas (fig. 1). Correlation of subsurface stratigraphy with the stratigraphic framework developed at the surface by previous Baylor University investigators was an important aspect of the research.

Location

The area investigated (fig. 1) extends westward into the subsurface from the Home Creek Limestone outcrop in Stephens and Eastland counties to a line ten miles west of the Coleman Junction Limestone outcrop in Shackelford and Callahan counties. The approximate northern and southern boundaries (fig. 1) are respectively six miles north of U. S. Highway 180 and six miles south of U. S. Highway 80.

Procedures

Recognition, mapping, and interpretation of depositional trends within these strata were based on

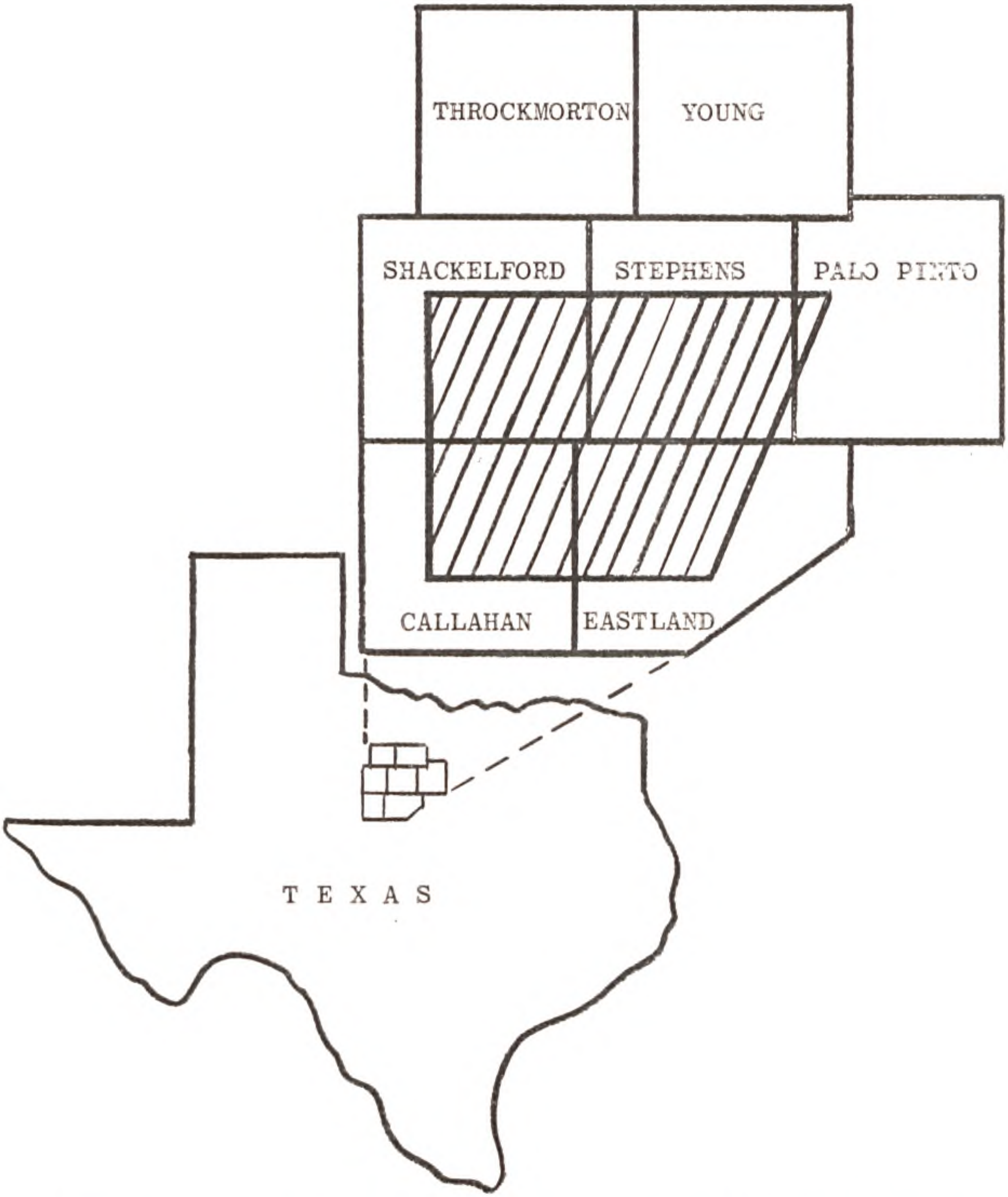

Fig. 1. Index map of thesis area, North-Central Texas.

(1) numerous dip and strike sample and electric log cross sections; (2) structure contour maps on the bases of the Home Creek, Breckenridge, and Sedwick limestones; (3) isopach maps of rocks between key limestone beds; (4) sand percentage maps of selected intervals; (5) isopach maps of individual traceable "channel" sandstone units; (6) paleotopographic maps of major "channel" intervals; (7) various special maps and cross sections; and (8) well sample study.

Previous Work

Many reports have been published on the Upper Pennsylvanian and Lower Permian strata in North-central Texas, but very little literature exists which describes the geology of these strata in the near-by or shallow subsurface.

In 1960 (pp. 168-201) Shankle completed a quantitative study of the depositional environment of the "Flippen" sandstone (pre-Saddle Creek Limestone) from eastern Callahan County to Western Taylor County. Shankle described the areal distribution, the stratigraphic and structural relations, and the environmental character of the "Flippen" sandstone in the subsurface.

Other important publications concerned with subsurface stratigraphy of these strata in Stephens, Eastland, Shackelford, and Callahan counties include cross sections based on electric logs and sample logs (Noland _et al_, 1949a; Noland _et al_, 1949b; Cheney _et al_, 1949; and Morey, 1955) and Abilene Geological Society petroleum field studies (Turner, 1952; Brown, 1954; DeFord, 1956; Russel, 1956; and Wagner, 1956). Many other field studies and cross sections beyond the present study area have been published on these strata by the Abilene Geological Society.

Many pertinent surface stratigraphic, structural, paleontologic, and ground water studies of these rocks have been published. These include Dumble, 1890; Tarr, 1890a,b,c; Cummins, 1890, 1891; Drake, 1917; Plummer, 1919; Adams, 1920, Plummer and Moore, 1922; Moore and Plummer, 1922; Moore, 1929; Cheney, 1929a,b; Roth, 1931; Plummer, 1931; Sellards, 1933; Bullard and Cuyler, 1935; Cheney, 1935; Bradish, 1937; Henbest, 1938; Nickell, 1938; Lee, 1938a,b; Cheney, 1940; Plummer, 1945; Gibson, 1946; Cheney, 1947; Cheney and Eargle, 1951; Cheney and Goss, 1952; Moore and Roth, 1958; Brown, 1959, 1960a,b; Eargle, 1960; Stafford, 1960a,b; Terrier, 1960; Brown, 1962; McGowen, 1964; Bayha, 1964; and Myers, 1965. Surface studies in progress in Stephens, Eastland, Callahan and Shackelford counties by Brown, Waller, and Ray have been consulted during the research.

Acknowledgements

The author appreciates the aid of Dr. L. F. Brown, Jr., Baylor University, who suggested the research, contributed advice, and reviewed the manuscript. The following also contributed to the study: Mr. Real Turmel, Shell Development Company, Abilene, who arranged for the loan of well samples, suggested methods of research, and advised on interpretation of data; Dr. J. W. Dixon, Jr., Baylor University, who gave loyal support; Mr. George Fraser, III, Independent, Abilene, who counseled on subsurface methods; Mr. J. A. Pennington, Electric Log Services, Inc., Dallas, who generously contributed electric well logs necessary for the study; Edgar Tobin Aerial Surveys Company, San Antonio, which supplied the base map; Mr. Earl Harrison, Hardin-Simmons University, who permitted the use of facilities in the Geology Department, and many other persons who have contributed helpful suggestions, kind support, and cooperation. Mrs. Jim Seals drafted the final illustrations.

STRATIGRAPHIC NOMENCLATURE

Stratigraphic units of the Carboniferous rocks of Texas were first subdivided in 1890 by Dumble (pp. lxii-lxix, Pl. III) and Tarr (idem, pp. 201-212). The following year Cummins (1891, pp. 367-375) revised the earlier classifications by renaming and redefining the divisions. Another minor revision of the early classifications was made by Drake in 1893 (pp. 371-429) when he redefined the divisions and named their included beds (table 1).

Exploration for petroleum in Pennsylvanian and Permian strata of North-central Texas stimulated research and indirectly resulted in Plummer and Moore's (1922, pp. 22-23) proposal of a more detailed classification. Their classification (idem, p. 22) consists of four groups -- which are divided into "formations bounded stratigraphically by the most persistent and easily recognized limestones" (table 1).

Sellards (1932, pp. 98-186) summarized Pennsylvanian and Permian rock nomenclature of Texas and slightly modified Plummer and Moore's classification by redefining the Brad Formation (Canyon Group) and by adding and changing the names of a few members (table 1).

The first major revision of Pennsylvanian and

TABLE 1 Classification of Upper Pennsylvanian and Lower Permian Rocks, North-central Texas

DUMBLE (1890) TARR (1890)

Divisions
COLEMAN-ALBANY
WALDRIP-CISCO
?
BROWNWOOD-RANGER

CUMMINS (1891)

Divisions
COLEMAN-ALBANY
CISCO
CANYON

DRAKE (1893)

Divis.	Beds
ALBANY	Coleman Junction
CISCO	Santa Anna Branch
	Bed #18
	Santa Anna
	Horse Creek
	Watts Creek
	Camp Colorado
	Bed #13
	Stockwether
	Camp Creek
	Saddle Creek
	Waldrip
	Chaffin Park's Mt. Lohn
	Speck Mt. Ls.
	Speck Mt. Clay
	Bellerophon
	Trickham
CANYON	Campophyllum
	Bluff Creek
	Home Creek
	Hog Creek

PLUMMER & MOORE (1922)

Gps.	Form.	Members
CISCO	Putnam	Coleman Jct. Ls.
		Sh.& thin Ls.
	Moran	Sedwick Ls.
		Sdy. Sh.
		Dothan Ls.
		Sdy. Sh.
	Pueblo	Camp Colorado Ls.
		Shale
		Eolian Ls.
		Shale
	Harpersville	Saddle Creek Ls.
		Sh.& Ss.
		Belknap Ls.
		Sh.,Ss.,& Coal
		Crystal Falls Ls.
		Shale & Ss.
	Thrifty	Breckenridge Ls.
		Shale
		Blach Ranch Ls.
		Sh.& Ss.
		Ivan Ls.
		Sh., Ss. & Limestone
		Avis Ss.
	Graham	Wayland Sh.
		Gunsight Ls.
		South Bend Sh.
		Bunger Ls.
		Gonzales Ck. Sh.& Ss.
		Jacksboro Ls.
		Finis Sh.
CANYON	Caddo Creek	Home Creek
		Hog Creek Sh.

SELLARDS (1933)

Gps.	Form.	Members
WICHITA	Putnam	Coleman Jct. Ls.
		Santa Anna Branch Sh.
	Moran	Sedwick Ls.
		Sh.& Ss.
		Dothan Ls.
		Sdy. Sh.
CISCO	Pueblo	Camp Colorado Ls.
		Shale
		Stockwether Ls.
		Camp Creek Sh.
	Harpersville	Saddle Creek Ls.
		Sh.& Ss.
		Belknap Ls.
		Sh., Ss., Ls. & Coal
		Crystal Falls Ls.
		Ss.& Sh.
	Thrifty	Breckenridge Ls.
		Shale
		Blach Ranch Ls.
		Sh.& Ss.
		Ivan Ls.
		Sh.& Ss.
		Avis Ss.
	Graham	Wayland Sh.
		Gunsight Ls.
		Necessity Sh.& Ss.
		Bunger Ls.
		Gonzales Ls., Sh.& Ss.
CANYON	Caddo Creek	Home Creek Ls.
		Hog Creek Sh.

CHENEY (1940)

Ser.	Groups	Formations
WOLFCAMP	Putnam	Coleman Jct. Ls.
		Santa Anna Branch Sh.
	Moran	Sedwick
		Horse Ck.
		"Dothan"
	Pueblo	Camp Colorado
		Stockwether
		Saddle Creek
		Waldrip Sh.
?		
CISCO	Thrifty	Obregon
		Chaffin
		Breckenridge
		Speck Mountain
		Ivan
		Avis Ss.
	Graham	Wayland Sh.
		Gunsight
		Post-Bunger cycles 1-7
		Bunger
		North Leon
		Gonzales
CANYON	Caddo Creek	Home Creek Ls.
		Colony Creek Sh.

EARGLE (1960)

Gps.	Form.	Members
WICHITA	NOT STUDIED	
	Pueblo	Camp Colorado Ls.
		Salt Creek Bend Sh.
		Stockwether Ls.
		Coon Mt. Ss.
		Camp Creek Sh.
		Saddle Ck. Ls.
		Waldrip Sh.
CISCO	Thrifty	Chaffin Ls.
		Parks Mt. Ss.
		Breckenridge Ls.
		Speck Mt. Ls.
	Graham	Ivan Ls.
		Wayland Sh.
		Gunsight Ls.
		Bluff Creek Sh.
CANYON	Caddo Creek	Home Ck. Ls.
		Colony Creek Sh.

Permian classification was by Cheney (1940, pp. 81-99) when he modified the earlier rock-stratigraphic classification, resulting in dual time-stratigraphic and rock stratigraphic nomenclature. Cheney elevated the status of the Strawn, Canyon, and Cisco groups to series, making them time-stratigraphic units supposedly equivalent to the Mid-Continent Des Moines, Missouri, and Virgil series (table 1). Plummer and Moore's (1922) Harpersville Formation was eliminated and the Thrifty and Pueblo formations were expanded so that the Texas "series" boundaries would comply with those of the Mid-Continent (Brown, 1959, pp. 2866-2871).

Eargle (1960, Pl 27) modified Cheney's classification to apply to the Pennsylvanian strata of the Colorado River valley (table 1). His classification is not workable in the Brazos River valley outcrop area (Brown, 1960, p. 12; McGowen, 1964, pp. 12-13).

Most geologists, as well as most cross sections and other subsurface publications on the Pennsylvanian and Lower Permian strata of North-central Texas, use Cheney's (1940) modification of Plummer and Moore's (1922) classification. Recent surface stratigraphic work by Baylor geologists (Brown, 1960, 1963; McGowen, 1964; and Brown, Waller, and Ray, in progress) has reestablished the importance of the field oriented classification of Plummer and Moore (1922). The present study is concerned only with rock stratigraphic correlations based on surface data of previous Baylor University studies and extended into the subsurface with electric logs. Individual beds were traced to show their stratigraphic position, distribution, and possible facies relationships. This study is, therefore, not concerned with the problem of the Pennsylvanian-Permian boundary, but rather with reconstruction of a rock-stratigraphic framework in the shallow subsurface rocks of the original Cisco Group (Plummer and Moore, 1922). Delineation of depositional patterns or trends was a primary goal -- not fusulinid time-stratigraphic zonation. As future subsurface and surface studies expand the area of interest, time-rock data will become more important for interregional correlation.

SUBSURFACE MAPPING METHODS

Electric logs, supplemented by radioactivity, sample, and driller's logs, were by necessity the principal stratigraphic tools used in this study. These logging techniques were used to construct a large variety of cross sections and subsurface maps.

The limitations and problems inherent in subsurface interpretation based primarily on electric logs are fully recognized, but these studies are necessary to develop a three-dimensional picture of the depositional framework in North-central Texas. Surface and subsurface studies must be integrated, for both are absolutely necessary in regional stratigraphic research.

Numerous wells have been drilled throughout the study area; however, because of close spacing, lack of penetration through the study interval, or poor logging methods, they were not all used in this study. Most early wells were shallow and produced from the study interval, but no electric logs and only a few reliable driller's logs are available for these wells.

Wells penetrating the section under study (below casing point) were selected to provide optimum areal distribution for stratigraphic control. Wells were chosen to provide at least one control point in each four square miles of map area. Surface casing commonly prevented recording of electric log data for several miles downdip from the outcrop. Therefore, a "no-man's land" or belt of inadequate control extends for several miles downdip from the outcrop of every unit. Adequate control for this shallow or nearsurface area could be obtained by seismology, coring, and/or radioactive logging in cased and old wells. Only about 75 percent of the wells in Shackelford and Callahan counties penetrate the base of the Cisco (Home Creek Limestone) section.

Assuming that a perfect four square mile grid could be achieved, the maximum distance between wells would be 4.25 miles (fig. 2). At that distance between wells, the laws of probability indicate that confidence in finding a linear body 4.25 miles wide is 100%, 2.13 miles wide is 50%, and 1.07 miles wide is 25%. However, the average distance between wells is two miles. At a well distance of two miles (fig. 2), one would have 100% confidence in detecting a two mile wide channel and 50% confidence for a one mile wide channel. With this well scattering, interpretive contouring was necessary in channel and isopach interpretation.

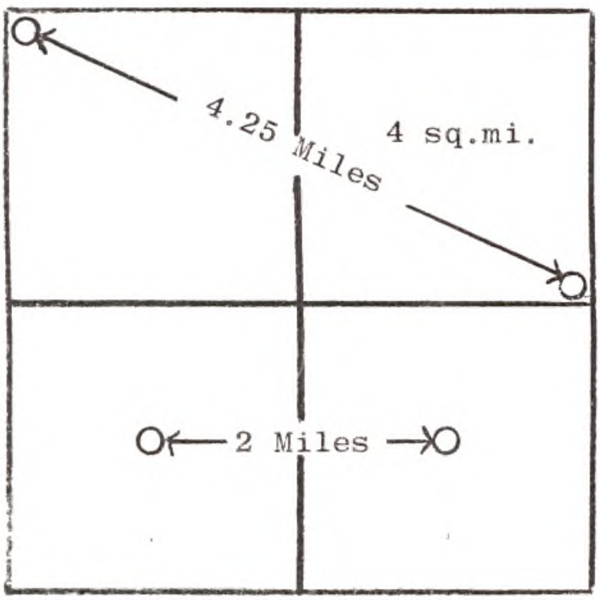

Fig. 2. Diagram illustrating probability of locating linear sandstone bodies of various widths based on one well per each four square mile grid area.

Stratigraphic Cross Sections

Eleven strike and dip stratigraphic cross sections were constructed using electric log correlations; however, only eight cross sections are included in this report (Pls. III-X). Interval thickness and structural interpretations shown on the isopach (Pls. XII-XV) and structure maps (Pls. XXIII-XXV) were not included on the cross sections. Therefore, these cross sections are, in the strictest sense, stratigraphic correlations. Most of the correlations were based on electrical properties of apparently areally persistent limestone rock units. Less persistent rock units such as possible channel sandstones and lenticular limestones were correlated within these limestone-bounded intervals, using sequence, similar electrical properties (resistivity, spontaneous potential, etc.) and areal distribution patterns. The patterns of cut-out or removal of key persistent limestone beds by sand, and rarely by shale, channel bodies help to verify the correlation of these lenticular units.

Structure Contour Maps

Structure contour maps (Pls. XXIII-XXV) were constructed on the bases of the Home Creek, Breckenridge and Sedwick limestones. These maps show the geometry of these limestone beds and aid in interpreting (1) possible structural influence on sandstone distribution, (2) possible development of structure due to shale compaction, and (3) contemporaneous and post-depositional deformation. In addition structure maps supply information necessary to remove regional dip in constructing profiles and interpreting depositional slope. The Breckenridge and Sedwick Limestone structure maps were contoured at intervals of 50 feet, whereas the Home Creek Limestone structure map was contoured at intervals of 20 feet to show greater detail. Elevation data on the outcrop of these limestones were not available.

Isopach Maps of Limestone-bounded Intervals

Isopach or thickness maps were constructed for the intervals between the bases of the Home Creek-Bunger limestones, Bunger-Gunsight limestones, Bunger-Breckenridge limestones, Blach Ranch-Breckenridge limestones, Breckenridge-Crystal Falls limestones, Breckenridge-Stockwether limestones, Stockwether-Camp Colorado limestones, Stockwether-Sedwick limestones, and Sedwick-Coleman Junction limestones (Pls. XII-XVI, XXXVII-XL). Isopach maps supply data for (1) comparing sandstone percentage to interval thickness, (2) demonstrating differential subsidence or deposition, (3) comparing the relationship of possible shale compaction to sandstone thickness, (4) determining degree of contemporaneous deformation, and (5) relating depositional and structural factors which may influence channel sandstone distribution.

Sandstone Percentage Maps

Sand percentage maps (Pls. XVII-XXII) were constructed for the intervals between the bases of the Home Creek-Bunger limestones, Bunger-Breckenridge limestones, Breckenridge-Stockwether limestones, Stockwether-Camp Colorado limestone, Stockwether-Sedwick limestones, and Sedwick-Coleman Junction limestones, to demonstrate possible structural and depositional relationships.

Numerous sandstone beds which occur in the study area are not sufficiently persistent nor thick to trace individually in the subsurface. Therefore, sandstone percentage maps are useful for studying large intervals which contain several non-persistent sandstone beds.

A comparison of sand percentage maps (Pls. XVII-XXII) with isopach maps between key limestones (Pls. XII-XVI) and structure contour maps of marker limestones (Pls. XXIII-XXV) shows the relation of sand distribution and thickness to structure and interval thickness. Sandstone percentage maps may also reveal source direction for clastic deposition.

Channel Sandstone Isopach Maps

Isopach or thickness maps (Pls. XXVI-XXXIV) of selected channel sandstones were constructed to compare areal distribution and thickness. The zero contour on the sandstone isopach maps actually represents a thickness less than 5 feet, which is the minimum thickness that can be detected on the electric logs.

Overlying channels commonly cut into underlying channels with similar electrical properties. When this occurs, the base of the upper channel cannot be determined. Therefore, to be consistent, the base of the sand section is considered the base of both the upper and lower channels. Arbitrarily a minimum of 15 feet of shale between sandstones was used to "differentiate" separate channel sandstone bodies.

Paleotopographic Maps

Paleotopographic maps (Pls. XXXV-XXXVI) were constructed at the bases of the post-Blach Ranch sandstone and post-Saddle Creek sandstone to illustrate the original topography into which these channel sandstone were deposited. These maps are essentially isopach maps of the interval between the uncomformable base of channel sandstones and the base of the next overlying conformable limestone. The mapped intervals include the post-Blach Ranch sandstone-Breckenridge Limestone interval, and the post-Saddle Creek sandstone-Stockwether Limestone interval. The limestones are assumed to have been relatively horizontal when deposited and thus serve as a datum for paleotopographic mapping. Shale compaction could possibly affect the accuracy of these maps.

Normally, boundaries of "valleys" on the paleotopographic map coincide with the zero (5 feet) isopach of channel sandstone thickness maps. "Valleys" are not necessarily filled by sandstone and, therefore, a paleotopographic map is necessary to demonstrate erosional channels preceding sandstone deposition.

Paleogradients could possibly be determined for channels by subtracting the regional structure of the overlying limestone from the gradient shown on the paleotopographic map.

Well Sample Study

Few well samples and no well cores are available for the area of study; therefore, most depositional interpretations were by necessity based on maps and sections constructed with electric logs and close correlation with previous studies. Samples examined in this study were supplied by Shell Development Company, Abilene.

STRATIGRAPHY

For detailed surface descriptions and derivation of North-central Texas Pennsylvanian and Permian stratigraphic nomenclature, the reader is referred to sections in this report on previous work (pp. 3-5), stratigraphic nomenclature (pp. 6-9, table 1) and references.

Selected subsurface intervals (Pl. I) are informally used in this study for convenience of discussion and mapping -- they are not revisions of the nomenclature. The intervals are bounded by the bases of easily recognized, relatively persistent limestones (Pl. I). Intervals are discussed using members of generally recognized Cisco formations (or groups of some workers). However, formal member and formation terminology is not followed in the discussions since surface delineated formation names (Pl. I; table 1) do not necessarily coincide with the more convenient subsurface intervals.

Paleontology is omitted from stratigraphic discussions since assemblages and their distribution cannot easily be extended and traced in the subsurface.

Subsurface Interval Number 1

Subsurface interval number 1 includes strata from the base of the Home Creek Limestone to the base of the Bunger Limestone. Formations which are partially represented in this interval are the Caddo Creek Formation, the uppermost formation of the Canyon Group, and the Graham Formation, the lowermost formation of the Cisco Group (Pl. I; table 1). Interval thickening (Pl. XII) is commonly accompanied by high sandstone percentage (Pl. XVII).

Home Creek Limestone.--The present usage of the name "Home Creek" Limestone was proposed by Plummer and Moore (1922, p. 117) for the uppermost unit of the Caddo Creek Formation, Canyon Group (table 1).

On the outcrop in Stephens County, Waller (personal communication, 1965) described the Home Creek Limestone as two limestone layers separated by five to twenty-two feet of calcareous clay. The lower bed is a light gray, irregularly bedded limestone from seven to twelve feet thick. The upper bed, ranging from six to twenty-six feet in thickness on the outcrop, is a dark blue, irregularly bedded limestone, which is commonly nodular in the upper five feet. The shale section which separates the two limestone beds thickens northward and locally contains massive, cross-bedded channel sandstone lentils which commonly cut into the underlying limestone bed (Loury, 1962, p. 142).

In the subsurface the Home Creek Limestone is relatively easy to recognize by its stratigraphic position above a shale and sandstone section in the uppermost Canyon Group and below a relatively thick shale section in the lowermost Cisco Group. The Home Creek Limestone thickens erratically in the area from 10 to 140 feet (Pl. XI) with maximum thickening in central Shackelford and Callahan counties.

Electrical curves on well logs indicate that the Home Creek Limestone is relatively porous (Pl. I, III-X). The lower bed in the subsurface abruptly splits, pinches-out or thickens. The upper bed is relatively constant in thickness from eight to ten feet and is, therefore, easily traced when present (Pl. III-X).

Finis Shale and Sandstone.-- The Finis Shale and Sandstone, named by Plummer and Moore (1922, p. 127), extends from the Home Creek Limestone to the base of a limestone designated the Gonzales Limestone (Pl. I, table 1). In the subsurface this unit varies in thickness from 110 (Well No. 40) to 220 feet (Well No. 89) and consists of interbedded sandy shales and sandstones. Thick highly porous channel sandstones commonly occur near the top of this unit (Pls. III-X).

Gonzales Limestone.--The Gonzales Limestone was named by Ross (1921, p. 307) for exposures on Gonzales Creek in Stephens County (Pl. I). At the type locality Waller (personal communication, 1965) described the Gonzales Limestone as an upper limestone bed about 2.9 feet thick separated from an underlying siltstone 2.1 feet thick by a silty limestone about 2.9 feet thick.

The Gonzales Limestone has erratic distribution in the subsurface and, therefore, is difficult to trace laterally (Pls. III-X). When present, this unit consists of one to five limestone beds with a total thickness of 10 to 50 feet.

Gonzales Creek Shale.--The Gonzales Creek Shale (and sandstone and limestone) was named by Plummer and Moore (1922, p. 128) for the creek in Eastland County (Pl. I; table 1). On the outcrop this unit consists of irregularly bedded lenticular sandstones, highly fossiliferous and calcareous sandstones, sandy or carbonaceous shales, two limestone lentils and several coal beds (Waller, personal communication, 1965). Waller (idem) postulated that a large lenticular sand body below the Bunger Limestone is an offshore bar; this unit was not recognized in the subsurface.

In the subsurface the Gonzales Creek Shale varies in thickness from 70 (Well Nos. 57, 221) to 180 feet (Well No. 161), and normally consists of a high percentage of sandstone (Pls. I, III-X). A thick channel sandstone, which has a maximum thickness of 170 feet (Well Nos. 65, 175), commonly occurs at the base of the unit and normally cuts through the Gonzales Limestone lentil into the underlying Finis channel sandstone and shale. When the sandstone in the Finis Member is eroded, the base of the Gonzales Creek channel is impossible to delineate since the two sandstones have identical electric properties (Pls. I, III-X).

A limestone about 30 to 40 feet below the Bunger Limestone has electrical properties similar to those of the Bunger. Correlation of these two limestones from the surface into the subsurface has been difficult. The writer is not certain which limestone is Bunger in the subsurface. However, the upper limestone has been designated the Bunger Limestone on the basis of the interval between the bed and the overlying Gunsight Limestone. Both beds grade laterally (based on electric log properties) from highly resistive limestone (Pl. IV, Well No. 50) to porous, poorly resistive sandy limestone or limy sandstone (Pl. IV, Well No. 198) and both are commonly removed by sandstone channeling (Pl. VIII, Well No. 8). Both beds rarely occur together as highly resistive limestones as indicated by the electrical curves on logs.

Subsurface Interval Number 2

Subsurface interval number 2 is comprised of strata between the base of the Bunger Limestone of the Graham Formation and the base of the Breckenridge Limestone, the Uppermost member of the Thrifty Formation (Pl. I; table 1). Interval thickening (Pl. XIII) is commonly accompanied by high sandstone percentage (Pl. XVIII).

Bunger Limestone.--The Bunger Limestone, which overlies the Gonzales Creek Shale and Sandstone, was named by Plummer and Moore (1922, p. 129) for a small town in southern Young County (Pl. I; table 1).

On the outcrop in Stephens County the Bunger Limestone is a dark gray dense limestone which caps a low escarpment (Waller, personal communication, 1965). In the subsurface the Bunger Limestone is an electrically resistive, relatively widespread limestone which grades laterally into sandy limestone or limy sandstone and is normally about 10 feet thick. The limestone is commonly replaced by sandstone-filled channels (Pls. VIII-X).

South Bend Shale.--Plummer and Moore (1922, p. 129) named the South Bend Shale for South Bend in Young County (Pl. I; table 1). This unit extends from the top of the Bunger Limestone to the base of the lower Gunsight limestone (Pl. I). On the outcrop the South Bend Shale consists of 50 to 100 feet of interbedded sandy shales, lenticular sandstones, thin dense limestones, and coals (Waller, personal communication, 1965).

In the subsurface the South Bend Shale varies in thickness from 50 (Well No. 57) to 130 feet (Well Nos. 89, 80). The most mappable unit in the South Bend Shale is a channel sandstone about 35 feet above the Bunger Limestone which commonly cuts the Bunger and rests on the underlying shale (Pls. VIII-X, XXVI). Other sandstone and limestone lentils are present in this section but were not traced in the subsurface.

Gunsight Limestone.-- The Gunsight Limestone was originally called the Campophyllum (coral) bed by Drake (1893, p. 401). It was later named "Gunsight" by Plummer and Moore (1922, p. 130) after the town of Gunsight in Stephens County (Pl. I; table 1).

The Gunsight Limestone on the surface consists of two limestone beds separated by 20 to 30 feet of shale and sandstone. At the type locality (Waller, personal communication, 1965) in Stephens County the lower bed is a light colored limestone containing abundant Caninia (=Campophyllum) remains. The upper bed is a uniformly thin, dense limestone (idem).

The upper and lower Gunsight limestone beds are difficult to differentiate in the subsurface. Perhaps this problem is a result of removal of one or both limestones by sandstone or shale-filled channels. When both limestones are present, the lower bed is thinner and less electrically resistive than the upper bed (Pls. IV-X; Well Nos. 188, 78, 80, 82). The stratigraphic position of the Gunsight Limestone below the Wayland Shale and Avis Sandstone makes this limestone a good stratigraphic marker for subsurface studies, even though it is commonly removed by channelling (Pl. IV-X).

Wayland Shale.--Plummer and Moore (1922, p. 130) named the Wayland Shale for exposures at Wayland, Stephens County (table 1). The Wayland Shale extends from the upper Gunsight limestone bed to the base of the Avis Sandstone (Pl. I). Because its upper boundary is the base of a widespread, massive, irregularly thickening channel sandstone, the Wayland Shale varies in thickness from 36 to 110 feet on the surface (Waller, personal communication, 1965) and from 15 to 120 feet in the subsurface (Pls. IV-X).

On the outcrop Waller (personal communication, 1965) reported that the Wayland Shale contains a "black shale fossil" zone at its base. Waller (idem) postulated that this zone, which cuts into the upper Gunsight limestone bed and sometimes into the lower Gunsight limestone bed, was deposited in a marine channel environment. These marine shale-filled channels could not be traced in the subsurface except where they removed the Gunsight Limestone (Pl. IX, Well No. 159).

Some sand lenses occur in the Wayland Shale, but none are sufficiently extensive to trace in the subsurface. Limestone lentils appear near the upper part of the Wayland Shale when the Avis Sandstone is very thin or absent (Pl. X, Well Nos. 145, 150). Perhaps these limestone beds were widespread prior to Avis erosion and deposition.

Avis Sandstone.--The Avis Sandstone, which occurs 10 to 25 feet below the Ivan Limestone, was named by Plummer and Moore (1922, p. 154) for Avis in Jack County (Pl. I; table 1). This widespread sandstone ranges from 0 to 110 feet thick (Pls. IV-X, XXVII). In the subsurface as well as on the surface (Waller, personal communication, 1965), the base of the Avis Sandstone is difficult to delineate since the channel cuts into sand lentils in the Wayland Shale. The Avis Sandstone is probably locally replaced in the subsurface by post-Ivan channels as suggested by the absence of Ivan Limestone in these areas (Pl. IV, Well Nos. 198, 211).

Ivan Limestone.--The Ivan Limestone, which Plummer and Moore (1922, p. 154) named for exposures near Ivan in Stephens County, normally consists of two limestone beds in the subsurface (Pl. I; table 1). Waller (personal communication, 1965) reported only one persistent "Ivan" limestone in the type area near Ivan, but a lithologically similar limestone lentil occurs three to eight feet above the Ivan limestone southeast of Breckenridge.

In the subsurface the lower limestone bed of the Ivan Limestone is more persistent and more electrically resistive than the upper bed. The two limestone beds commonly appear to merge into one limestone unit with a maximum thickness of 30 feet (Well Nos. 57, 161, 230). The limestones are commonly replaced by shale or sandstone channels (Pl. IV, Well Nos. 198, 211).

Blach Ranch Limestone.--The Blach Ranch Limestone probably equivalent to the Speck Mountain Limestone of the Colorado River valley, was named by Plummer and Moore (1922, pp. 154-155) for exposures near the "Blach" Brothers Ranch east of Breckenridge in Stephens County (Pl. I; table 1). Brown (1960, pp. 14-17) described the Blach Ranch Limestone on the outcrop in Stephens County as a uniform persistent unit composed of two thin limestones -- a lower hard, medium gray, fossiliferous limestone, and an upper moderately hard, olive gray fossiliferous limestone --separated by about one foot of shale.

The Blach Ranch Limestone crops out along a narrow band from the Cretaceous overlap in Eastland County across the area of study except for a small area in Central Stephens County (Pl. XXVIII) where the limestone was removed by channelling (Brown and Waller, personal communication, 1965).

In the subsurface the Blach Ranch Limestone is separated from the Ivan Limestone by a section from 15 (Well No. 228) to 50 feet thick (Well Nos. 221, 228) composed of shale, thin limestone lentils and channel sandstones (Pls. I, IV-X). Above the Blach Ranch Limestone and separating it from the Breckenridge Limestone occurs 15 (Well No. 228) to 50 feet (Well Nos. 80, 89, 161) of interbedded sandstone and shale beds with one thin limestone lentil (Pls. I, IV-X). The Blach Ranch Limestone is widespread in the subsurface except where removed by channel sandstone (Pls. I, IV-X).

Subsurface Interval Number 3

The strata which comprise subsurface interval number 3 lie between the bases of the Breckenridge and Stockwether limestones (Pl. I). The formations represented in this interval include the upper limestone bed of the Thrifty Formation, the total Harpersville Formation, and the lower one-third of the Pueblo Formation (Pl. I; table 1). High sandstone percentage in the interval (Pl. XIX) is commonly accompanied by greater thickening of the interval (Pl. XIV).

Breckenridge Limestone.--Plummer and Moore (1922, p. 155) named the Breckenridge Limestone for the county seat of Stephens County (Pl. I; table 1). At the type locality Brown (1960, pp. 18-20) described the Breckenridge Limestone as three limestone beds -- a lower hard, massive, fusulinid-bearing limestone layer about 2 feet thick; a middle hard, thin, wavy-bedded limestone layer about 3 feet thick; and an upper, poorly bedded limestone and marl section about 2 feet thick. McGowen (1964, p. 17) reported that only the lower massive limestone bed occurs in southwestern Stephens County.

The Breckenridge Limestone of the subsurface normally consists of two limestone units separated by a shale bed approximately three feet thick. The lower unit is remarkably more electrically resistive and thicker than the upper unit (Pl. I). The Breckenridge Limestone commonly overlies a channel sandstone and in turn is commonly overlain or removed by another sandstone (Pls. IV-X, XXIX). The Breckenridge Limestone averages about 15 feet in thickness, but it thickens to 40 feet in some areas (Pl. IX, Well No. 163).

Because of its high electrical resistivity, relative persistence and position in the secion, the Breckenridge Limestone is a good subsurface stratigraphic datum (Pls. IV-X).

Quinn Clay.--Plummer et al (1949, pp. 5-6) proposed the name Quinn clay for the clay section between the Crystal Falls Limestone and "upper Breckenridge limestone." Brown (1960, pp. 21-23) described the Quinn Clay on the surface in northern Stephens County as 30 to 50 feet of clay containing several thin sandstone lentils, a limestone lentil and a sandstone channel deposit.

In the subsurface the Quinn Clay varies in thickness from 40 to 60 feet. The lower 20 feet are commonly channel sandstone (Pls. IV-X, XXIX) which overlies or removes the Breckenridge Limestone. About 35 feet above the Breckenridge Limestone occurs a thin relatively widespread limestone lentil which helps differentiate the upper Quinn sheet sandstone facies from the underlying channel sandstone facies which cuts the Breckenridge Limestone. The upper 15 feet of the Quinn clay consists of interbedded shale and sandstone (Pls. I, IV-X).

Crystal Falls Limestone.--Plummer and Moore (1922, p. 162) named the Crystal Falls Limestone lentil for

Crystal Falls in Stephens County. Brown (1960, pp. 23-26) described the Crystal Falls Limestone at the type locality as a unit 25 feet thick, consisting of (1) a lower limestone-shale-limestone interval from 1.5 to 3.5 feet thick ("Lower Crystal Falls" limestone); (2) a shale unit (Curry Clay," Plummer et al, 1949, p. 17) about 20 feet thick containing limestone concretions and a thin coat seam; and (3) an upper hard massive limestone unit ("Upper Crystal Falls" limestone) about 5 feet thick. A similar sequence of strata occurs in the subsurface except where the "Upper Crystal Falls" limestone has been removed by sandstone channeling (Pl. VII, Well No. 152). The lower unit is easy to recognize in the subsurface because of its stratigraphic position and electrical resistivity (Pls. I, IV-X). When both limestones are present, the Crystal Falls Limestone varies in thickness from 30 (Well No. 82) to 50 feet (Well No. 172).

Waldrip Shale.--Above the Crystal Falls Limestone occurs a series of interbedded sandstones, shales, limestones, and coals which are collectively called the Waldrip Shale (Pl. I; table 1). McGowen (1964, pp. 40-93, Pl. IV) divided the Waldrip Shale into three informal units, bounded by the Crystal Falls Limestone, "limestone bed 3," "limestone bed 5," and Saddle Creek Limestone. McGowen's informal Waldrip "limestone beds 1-6" (1964, pp. 40,93, Pls. I, IV) do not coincide with common stratigraphic nomenclature of the Colorado River valley, i.e. Waldrip limestone beds 1, 2, and 3. Because the Waldrip limestones and sandstones are commonly thin and difficult to delineate in the subsurface, correlation of the sandstone and limestone lentils was not attempted (Pls. IV-X). Of this section Waldrip "limestone bed 5" (defined by McGowen, 1964, pp. 60-64, Pl. I), which is underlain by a thin widespread coal, is the most persistent and easily recognized limestone in the subsurface, but it is commonly removed by channelling, which reduces its usefulness as a stratigraphic marker (Pls. IV-X).

Erratically distributed sandstone-filled channels, some of which are petroleum reservoirs, are abundant throughout the Waldrip Shale. Among these channel sandstones are the following: (1) "Lake Cisco" sandstone (informal surface terminology) which immediately overlies or cuts into the Crystal Falls Limestone and occurs predominately in Callahan and north-western Eastland counties (Pl. XXX); (2) "Lower and Upper Cook" sandstones, outstanding producing zones in North-central Shackelford County, which occur above Waldrip "limestone bed 1" (defined by McGowen, 1964, p. 41); (3) "Flippen" sandstone, described by Shankle (1960, pp. 168-201) in Callahan and Taylor counties, which underlies the Waldrip "limestone bed 5" (McGowen, 1964, pp. 60-64); and (4) "Bluff Creek" sandstone, which lies between Waldrip "limestone bed 5" (idem) and the Saddle Creek Limestone.

Saddle Creek Limestone.--The Saddle Creek Limestone was named by Drake (1893, p. 416) for a creek in McCulloch County (Pl. I; table 1). On the outcrop in the study area the Saddle Creek Limestone is normally comprised of two beds -- a lower nodular limestone about 1 foot thick which grades laterally into calcareous sandstone, and an upper more dense limestone about 2 feet thick which also grades into calcareous sandstone (McGowen, 1964, pp. 93-98).

The Saddle Creek Limestone is erratically distributed in the subsurface as a result of post-depositional channelling (Pls. I, IV-X, XXXI) and it varies in thickness from 5-25 feet when present. The Saddle

Creek Limestone varies from a single distinctive electrically resistive limestone (Pl. X, Well No. 245) to two thin porous calcareous sandstones or sandy limestones separated by a shale bed (Pl. X, Well No. 243). Because the Saddle Creek Limestone varies extensively in thickness and lithology and is commonly removed by overlying channels, it is not a good subsurface stratigraphic marker in the study area.

Camp Creek Shale.--The Camp Creek Shale is comprised of strata above the Saddle Creek Limestone and below the Stockwether Limestone (Pl. I; table 1). McGowen (1964, pp. 120-129) described this unit as predominately clay containing three widespread sandstone beds and several less persistent sandstone and limestone lentils. In the subsurface this unit ranges from 20 feet (Pl. VI, Well No. 188) where partially removed by post-Stockwether channelling to 175 feet (Well No. 175) where deep Camp Creek channels cut into the Waldrip Shale. The shale member has a normal thickness of 60 feet.

Two major channel intervals are recognized in the Camp Creek Shale of the subsurface. The lowermost channel immediately overlies the Saddle Creek Limestone and commonly cuts the limestone to rest on underlying Waldrip Shale (Pl. I, IV-X, XXXI). The base of the lower Camp Creek sandstone unit is difficult to delineate since the channel cuts into older channel sands of the Waldrip Shale which have similar electrical properties (Pl. IX, Well No. 154).

Another channel sandstone occurs 20 to 30 feet above the lowermost Camp Creek sandstone, but it is not as widespread nor as thick as the underlying sandstone. The shale section below and above the second major sandstone contains several sandstone lentils which are not sufficiently thick nor well distributed to trace laterally in the subsurface.

Five to fifteen feet below the Stockwether Limestone occurs a relatively persistent sheet sandstone about five feet thick. This sandstone is rarely cut by post-Stockwether channels (Pl. VI, Well No. 146).

Subsurface Interval Number 4

Subsurface interval number 4 includes strata between the base of the Stockwether Limestone of the Pueblo Formation and the base of the Sedwick Limestone of the Moran Formation (Pl. I; table 1). Interval thickness and sandstone percentage are illustrated on Plates XV and XX respectively.

Stockwether Limestone.--The Stockwether Limestone was named by Drake (1893, p. 417) for the Stockwether ranch, Coleman County. At the surface in the study area the Stockwether Limestone, which is extensively eroded, consists of one or two fossiliferous irregularly bedded limestones about one to three feet thick (McGowen, 1964, pp. 129-135).

In the subsurface the Stockwether Limestone is a dense, electrically resistive, non-porous limestone less than ten feet thick (Pl. I). This limestone grades laterally into sandy limestone or limy sandstone (Pl. X, Well No. 253). Although the Stockwether Limestone is extensively eroded on the surface (McGowen, 1964, pp. 130-131), it is uniformly thick in the subsurface and is only rarely removed by post-depositional erosion (Pl. VI, Well No. 188).

Because of its wide lateral distribution and relatively constant thickness, the Stockwether Limestone is a good stratigraphic datum in the subsurface of the study area (Pl. I, IV-X).

Salt Creek Bend Shale.--Bullard and Cuyler (1935, p. 245) named the strata between the Stockwether Limestone and the Camp Colorado Limestone the Salt

Creek Bend Shale (Pl. I). This unit on the surface consists of 40 to 100 feet of variegated shale with interbedded siltstone, sandstone and local lenticular limestone conglomerate (McGowen, 1964, pp. 135-170).

The Salt Creek Bend Shale of the subsurface, which varies from 60 to 160 (Pl. VI, Well No. 188) feet in thickness, has a normal thickness of 90 feet and averages about 50 percent shale and 50 percent sandstone (Pls. V-X). Although McGowen (1964, pp. 135-170) observed five major sandstone beds in the Salt Creek Bend Shale, only two were traceable in the subsurface. There is, of course, the possiblity that the two traceable beds in the subsurface are actually multiple channels, each comprised of two or more of McGowen's (idem) channels and sandstone lentils.

The lowermost channel in the subsurface Salt Creek Bend Shale occurs approximately 30 feet above the Stockwether Limestone and locally removes that limestone and cuts into the Camp Creek Shale below (Pl. VI, Well No. 146). When the channel cuts into sandstone, its base cannot be delineated since the two sandstones have similar electrical properties.

The second major channel in this section lies about 10 to 20 feet below the Camp Colorado Limestone and has a maximum thickness of 150 feet (Pl. VI, Well No. 188). This channel deposit is not as widespread as the lower channel sandstone and is commonly a series of interbedded thin sand and shale beds (Pls. V-X).

Minor sandstone channels occur in the upper 20 feet of the Salt Creek Bend Shale. They are thin, erratically distributed, and because of these characteristics, were not traced laterally in the subsurface (Pls. V-X).

Camp Colorado Limestone.-- The Camp Colorado Limestone (Pl. I; table 1) was named by Drake (1893, p. 418) in the Colorado River valley and the nomenclature was extended into the Brazos River valley by Plummer and Moore (1922, p. 172). This limestone, which is the uppermost unit of the Pueblo Formation (Pl. I; table 1), normally crops out as two limestone beds separated by 10 to 25 feet of shale (McGowen, 1964, pp. 170-175). On the surface and in the subsurface, the Camp Colorado Limestone thickens southward (Pls. VI-X). In the subsurface of Shackelford County, the Camp Colorado Limestone normally consists of only one electrically resistive limestone bed and rarely an associated, less resistive overlying limestone bed (Pls. VI-VIII). In Callahan County the Camp Colorado Limestone thickens to 60 feet (Well Nos. 215, 221) and apparently splits into five or six thin limestone beds (Pls. VI-VII, X).

Unnamed Shale and Sandstone No. 1.--Above the Camp Colorado Limestone occurs 35 to 65 feet of interbedded shale, channel sandstone, and limestone lentils (Pls. I, VI-X). In the subsurface the only mappable unit is a channel sandstone near the top of the section (Pls. VI-X, XXXIII). This channel sandstone is cut by another channel complex overlying the Dothan Limestone as indicated by the absence of the Dothan when the overlying channel is present. J. R. Ray (personal communication, 1965) suggested that the absence of some of the Dothan Limestone on the surface may be due to erratic deposition of the limestone on an irregularly eroded surface of the earlier channel. When both channels are present in the subsurface, the Dothan Limestone normally is present, which aids in differentiating the two channel sandstones (Pls. VI-X).

Dothan Limestone.--Plummer and Moore (1922, pp. 177-178) applied the name "Dothan" to a limestone occurring 60 feet above the Camp Colorado Limestone. On the outcrop this unit is described as gray, dense, fossiliferous limestone (Ray, personal communication, 1965).

In the subsurface the Dothan Limestone is a porous limestone normally 10 feet thick, commonly underlain and overlain by sandstone channels (Pls. VI-X). The Dothan Limestone is not a good subsurface stratigraphic datum because of it low electrical resistivity values, but when distinguishable, it aids in separating the overlying and underlying channel sandstones (Pls. VI-X).

Unnamed Shale and Sandstone No. 2.--Overlying the Dothan Limestone is 30 (Well No. 230) to 60 feet (Well No. 82) of interbedded sandstone, shale and limestone lentils (Pl. I). Immediately above the Dothan Limestone occurs a channel sandstone which has been traced laterally in the subsurface (Pl. XXXIV). This channel locally cuts the Dothan Limestone and the upper part of the underlying shale and sand.

Other beds in this unnamed unit cannot be traced laterally in the subsurface because they are not sufficiently thick nor persistent laterally (Pls. I, VI-X).

Unnamed Limestone.-- Eighty to one hundred-twenty feet above the Camp Colorado Limestone occurs a relatively persistent limestone from 8 to 20 feet thick, which may be the "Gouldbusk" Limestone of some workers (Pl. I). Because of its high electrical resistivity, this limestone can be more easily traced in the subsurface than the underlying Dothan Limestone (Pls. I, VI-X).

Unnamed Shale No. 3.--From 100 to 125 feet above the Camp Colorado Limestone occurs 20 to 55 feet of shale containing a few sandstone and limestone lentils (Pls. I, VI-X). None of the units in this section are sufficiently extensive to map laterally in the subsurface.

Subsurface Interval Number 5

The strata included in subsurface interval number 5 occurs between the base of the Sedwick Limestone, the uppermost unit in the Moran Formation, and the top of the Coleman Junction Limestone, the uppermost unit in the Putnam Formation (Pl. I; table 1). Interval thickness and sandstone percentage are illustrated on Plates XVI and XXI respectively.

Sedwick Limestone.--The Sedwick Limestone was named by Plummer and Moore (1922, p. 179) for Sedwick in Shackelford County (Pl. I; table 1). On the surface this unit consists of a series of interbedded brown fossiliferous limestones, shales, limestone conglomerates, and sandstones (Ray, personal communication, 1965). The lower bed varies from a sandstone to a sandy limestone and it is overlain by three to five limestone beds which are commonly cut by limestone conglomerate-filled channels (idem).

In the subsurface the Sedwick Limestone normally consists of two limestone beds separated by 15 to 40 feet of interbedded sandstone, limestone, and shale beds (Pls. I, IV-X). The upper limestone bed is commonly removed by channelling, but the lower bed is relatively persistent. The persistence and high electrical resistivity of the lower limestone bed, the distinctive limestone-shale-limestone sequence, and the stratigraphic position between thick shale units make the Sedwick Limestone an excellent subsurface stratigraphic marker (Pls. I, VI-X).

Santa Anna Branch Shale.--Plummer and Moore (1922, p. 184) extended Drake's (1893, p. 419) Santa Anna Branch "bed" of the Colorado River valley into the Brazos River valley (Pl. I; table 1). Ray (personal communication, 1965) divided the Santa Anna Branch Shale on the surface into two units based on lithology. The lower unit consists of gray and red shales and lenticular sandstones. The upper unit is comprised of a series of interbedded limestones, sandstones, and shales locally cut by sandstone-filled channels (idem).

The Santa Anna Branch Shale of the subsurface consists predominately of clay with two major traceable channel sandstones and several thin, non-persistent sandstone and limestone lentils (Pls. I, VI-X).

Overlying the Sedwick Limestone, and sometimes removing the upper limestone bed, occurs a relatively thin persistent sandstone channel (Pl.). Another mappable channel sandstone occurs about 30 feet below the Coleman Junction Limestone (Pl.).

Coleman Junction Limestone.--The Coleman Junction Limestone (Pl. I; table 1) was named in the Colorado River valley by Drake (1893, p. 421) and the name was extended into the Brazos River valley by Plummer and Moore (1922, p. 184).

In the subsurface the Coleman Junction Limestone normally consists of three or four limestone beds with a total thickness of 30 to 50 feet (Well No. 225). The second bed from the base, which is thickest and highest in electrical resistivity, can be easily traced (Pls. I, VI-X). The Coleman Junction Limestone grades vertically into porous sandy limestone and is commonly replaced by overlying channels. Its position between two relatively thick shale sections makes the Coleman Junction Limestone an excellent subsurface stratigraphic datum in the study area (Pls. I, VI-X).

CHANNEL SANDSTONE UNITS

Sandstone bodies within the Cisco Group can be divided into two major types based on relative thickness and lateral extent. One type is the sheet sandstone, commonly well-bedded and ripple-marked, which rarely exceeds 10 feet in thickness and has a broad, rather extensive lateral distribution. The other type is the "channel" sandstone which varies in thickness from 10 to 20 feet and is distributed as a series of linear bodies. Emphasis in this report is given to the thicker channel-fill sandstones.

In this study a channel-fill deposit is defined as a linear sedimentary body composed of sandstone and rarely shale or limestone conglomerate. The channel-fill deposit, where observed at the surface, normally has a lens-shaped cross section, an unconformable basal contact, and a remarkable variability in thickness within short distances (Brown, 1960a,b, 1962; McGowen, 1964; Brown, Waller, and Ray, 1965). In the subsurface, however, only the linear nature of the channel-fill deposit can be delineated; erosional contacts and other sedimentary features can naturally be observed only where the deposit crops out at the surface. Shale-filled channels can best be traced in the subsurface where underlying limestones have been removed. Only sandstone-filled channels are considered in this study because of the difficulty and possible error involved in delineating the distribution of shale-filled channels with normal subsurface methods. Limestone conglomerate-filled channels observed on the surface (Ray, personal communication, 1965) probably cannot be differentiated on electrical logs from other limestones in the subsurface.

Many sandstone-filled channels occur in the Cisco Group, but only a selected few were traced and described in this subsurface study (Pls. XXVI-XXIV) because of (1) restricted lateral distribution of many channel deposits, (2) absence of key marker limestone beds near the stratigraphic position of the channel, and/or (3) insufficient well density in many problem areas.

As previously discussed in the section on subsurface mapping methods (pp. 10-17), confidence in detecting a channel two miles wide is 50 percent when well spacing is four miles and 100 percent when the spacing is two miles. This confidence interval is related to the detection of a channel deposit only, and not necessarily to determination of channel width or detailed distribution patterns. Therefore, considerable interpretation was essential in delineating and contouring these channel-fill sandstones. Subsurface channel trends were closely correlated with surface trends to aid interpretation. With more dense well control, channel dimensions may change and meanderings may become more or less pronounced.

These linear sandstone features are commonly "stacked" and unless a persistent limestone or coal bed is present between the two channel sandstone bodies, they are difficult to differentiate and correlate.

Post-Bunger--Pre-Gunsight Channel Sandstone

About 25 feet below the Gunsight Limestone (Pls. I, III-X, XXVI) occurs a channel sandstone which varies in thickness from 0 to 70 feet and rarely cuts the underlying Bunger Limestone. The predominant distribution pattern (Pl. XXVI; fig. 3) of this sandstone suggests a southwestward trending system of delta distributaries. The "distributaries" vary in width from 2.5 to 6 miles and are commonly lobate near the apparent distal points. There is no joining of main distributaries except in eastern Shackelford County where minor distribu-

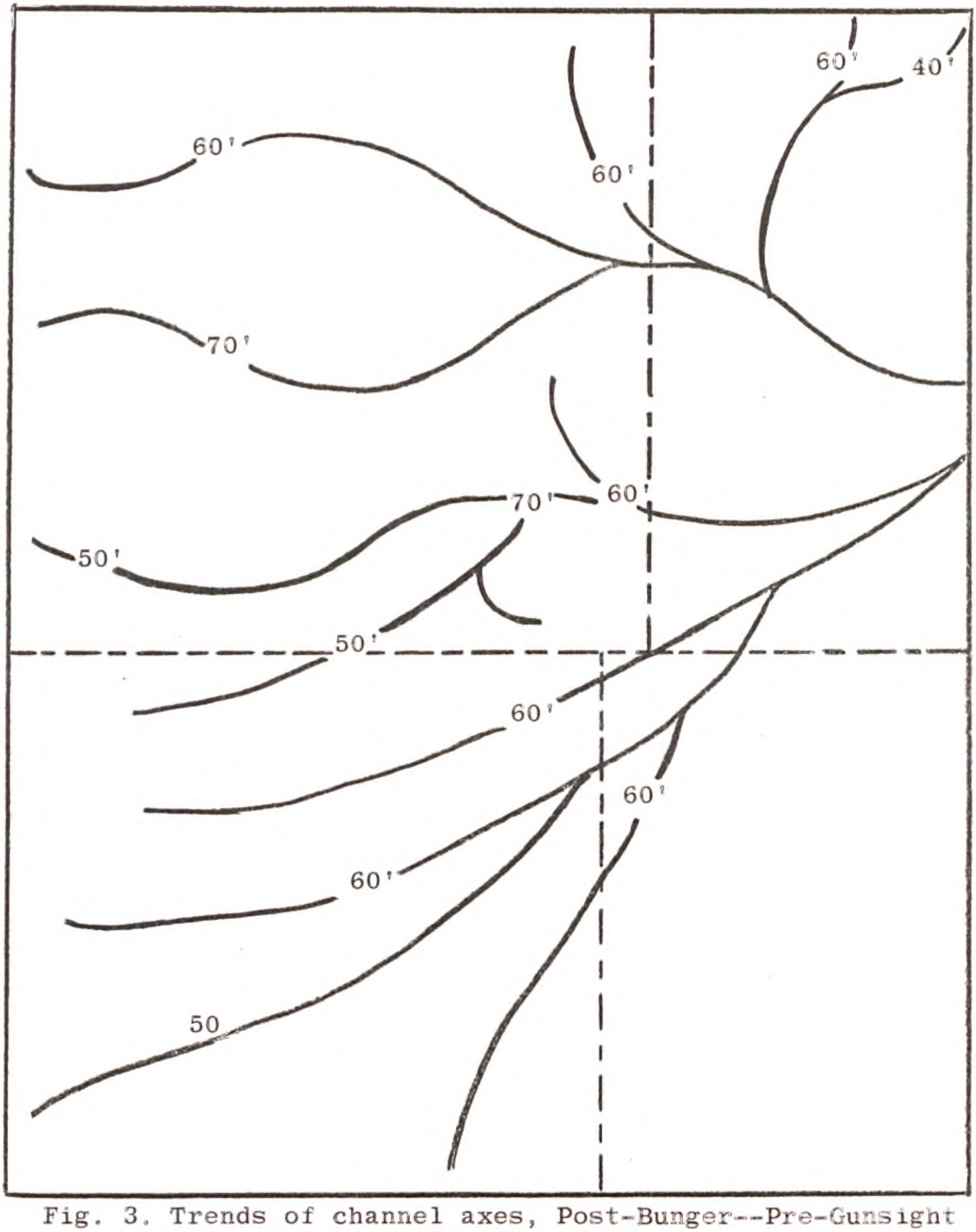

Fig. 3. Trends of channel axes, Post-Bunger--Pre-Gunsight channel-fill sandstone. See Pl. XXVI.

taries are shared. Distributaries branch from an outcrop locality in central Stephens County mapped by Waller (personal communication, 1965) and spread westward and southwestward into Shackelford and Callahan counties. All the distributary channels reach 50 feet in thickness and most are locally 60 to 70 feet thick. Channel sands thicken within the lobes of the distributaries. The extent of the distributaries outside the study area is unknown.

Avis Sandstone

The Avis Sandstone overlies the Wayland Shale and occurs 10 to 25 feet below the Ivan Limestone (Pls. I, III-X; table 1). The Avis Sandstone distribution pattern (Pls. XXVII; fig. 4) suggests a complex of braided stream channels with several tributaries. Thickness of the sandstone varies from 0 to 110 feet in west-central Shackelford County. The distribution pattern of this channel system is typified by areas or "islands," where sandstone is thin or absent.

All "tributaries" of the Avis Sandstone system coalesce within the study area except the southernmost tributary. A westward channel trend is more dominant in the Avis Sandstone system than the southwestward trend common to other Cisco channel complexes. Channel

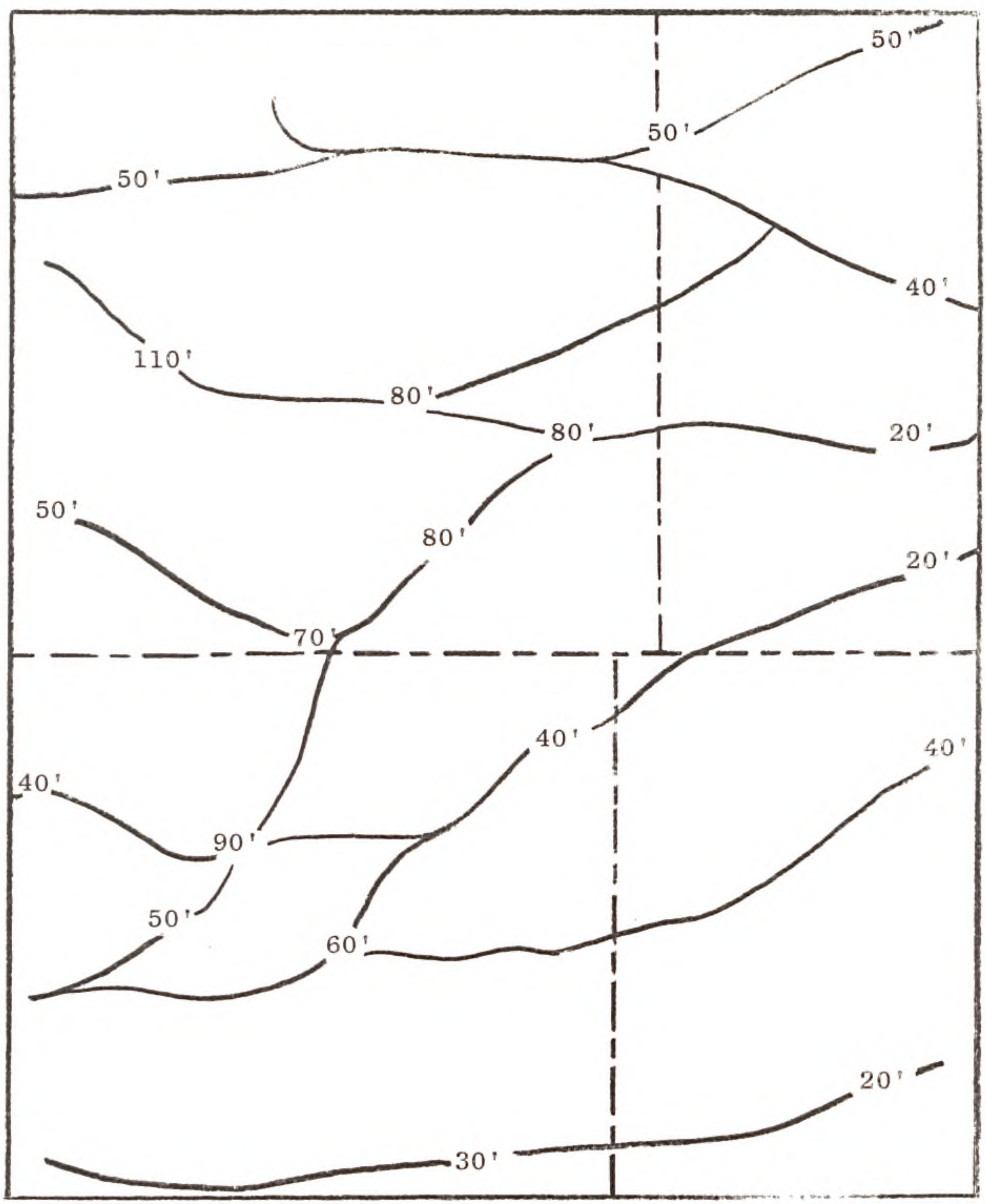

Fig. 4. Trends of channel axes, Avis Sandstone. See Pl. XXVII.

width varies from two to six miles; widest areas occur where channels coalesce. The extent of this channel system is unknown outside the study area.

Post-Blach Ranch--Pre-Breckenridge Channel Sandstone

Five to twenty feet below the Breckenridge Limestone occurs a relatively thin channel sandstone which commonly removes the underlying Blach Ranch Limestone when the sandstone thickness exceeds 30 feet (Pls. I, III-X, XXVII). The distribution pattern (Pls. XXVII; fig. 5) suggests that this sandstone was deposited in a southwestward trending deltaic complex. The "distributaries" branch from two outcrop localities in central Stephens County and extend into Shackelford, Callahan, and northwestern Eastland counties. The deposit is commonly 20 feet or less in thickness with isolated areas up to 50 or 60 feet thick. Channel width is commonly two to four miles with maximum width of seven miles coinciding with thickest sand accumulation.

The paleotopographic surface on which this sandstone complex was deposited is reflected in both an isopach map (Pl. XXV) of the sandstone and an isopach map of the interval between the base of the sand and the overlying Breckenridge Limestone. Both

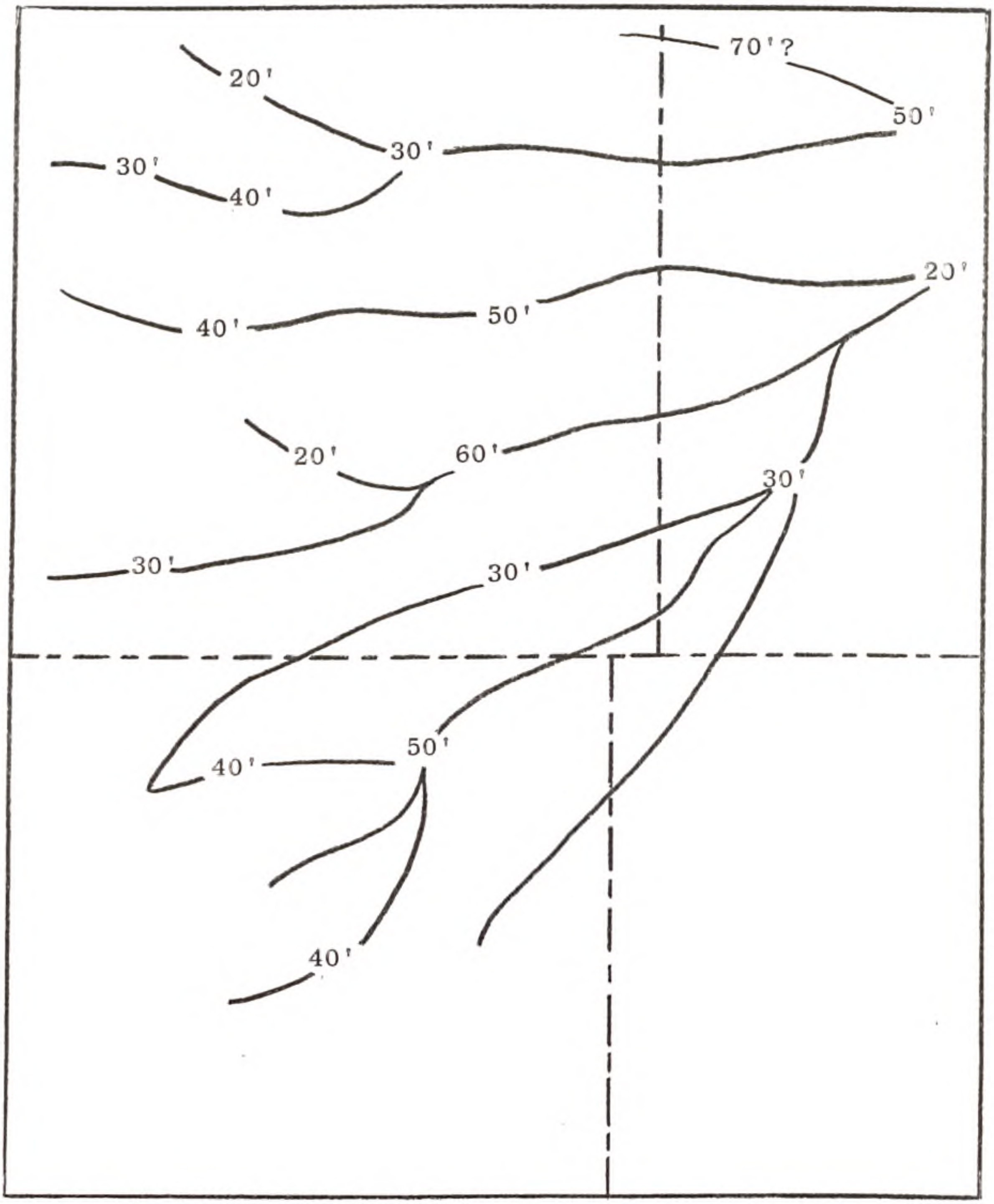

Fig. 5. Trends of channel axes, Post-Blach Ranch--Pre-Breckenridge channel-fill sandstone. See Pl. XXVIII.

maps show a remarkable similarity in outline and "valleys" on the limestone-sandstone (paleotopographic) interval map (Pl. XXXV) are normally accompanied by equal or near-equal thicknesses of sand on the sandstone isopach map (Pl. XXVIII). This suggests that "valleys" were almost, if not completely, filled with sandstone before marine inundation climaxed by deposition of the Breckenridge Limestone.

The post-Blach Ranch channel sandstone commonly coincides with structural lows on the Blach Ranch Limestone and by structural highs on the Breckenridge Limestone as indicated by a structure map of the Breckenridge Limestone (Pl. XXIV) and an isopach map of the Blach Ranch-Breckenridge interval (Pl. XXXVIII).

Post-Breckenridge--Pre-Crystal Falls Channel Sandstone

Plate XXIX illustrates the thickness and areal distribution of the channel sandstone which occurs between the Breckenridge Limestone and the overlying limestone lentil below the Crystal Falls Limestone. This channel sandstone was mapped by McGowen (1965, Pl. VII) in four outcrop areas of southwestern Stephens County. At section 10, McGowen (1964, pp. 238-240) described the mineralogy of this channel deposit as approximately 80% quartz, 15% clay and 5% hematite.

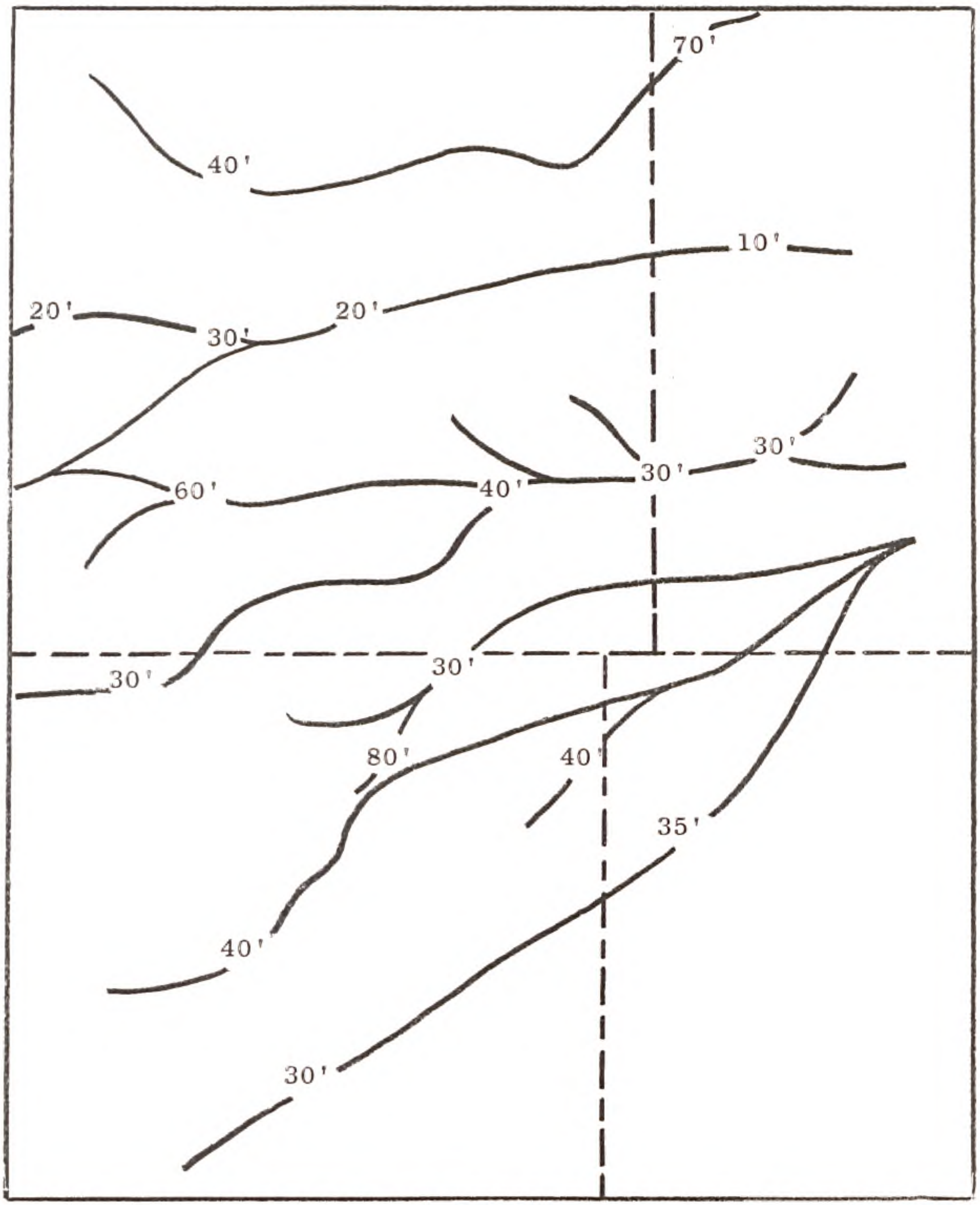

Fig. 6. Trends of channel axes, Post-Breckenridge--Pre-Crystal Falls channel-fill sandstone. See Pl. XXIX.

At section 13 (idem), which is near the top of the channel, the deposit consists of about 75% quartz, 24% clay, 1% chert and a trace of heavy minerals. McGowen (idem, p. 240) proposed that the post-Breckenridge sandstone was deposited in a subaqueous scour and that finer sand and clay at the top of the deposit possibly indicated an approach to baselevel with decrease of stream gradient.

In the subsurface the post-Breckenridge channel sandstone (Pls. I, III-X, XXIX; fig. 6) varies from 0 to 80 feet in thickness and appears to have been deposited in a deltaic environment as indicated by its down-current branching pattern. Perhaps the "distributaries" observed at the surface and in the subsurface originally coalesced updip from the present outcrop. The post-Breckenridge sandstone extends into the subsurface from several outcrop areas and branches into relatively straight distributaries with few minor "fingers." The southernmost and northernmost distributaries do not have minor branches. Distributaries coalesce in west-central Shackelford County and northeastern Callahan County. These junctions probably resulted from relatively rapid shifting of the channel, which now occurs at a similar stratigraphic position throughout the area. This channel sandstone normally coincides with structural lows and is commonly accompanied by isopach thicks between the Breckenridge and Crystal Falls limestones. The extent of this channel deposit outside the study area has not been determined.

Post-Crystal Falls Channel Sandstone

The post-Crystal sandstone (Pls. I, XXX; fig. 7) which probably occurs between McGowen's (1964, Pl. I) Waldrip "limestone beds 2 and 5" extends into the subsurface from a widespread conglomeratic outcrop in northwestern Eastland County. The outcrop material consists of sandy conglomerate with shale lenses and has a maximum thickness of about 40 feet. The channel deposit on the outcrop is in contact with the normal non-channel section of the Waldrip Shale Member (Brown, 1965, personal communication).

The "Lake Cisco" sandstone (Pl. XXX; fig. 7), as it is informally called on the surface, has a maximum subsurface thickness of 50 feet with the thickest accumulations in lobes near the distal ends of the "distributaries." Minor branches extend from the distributaries but have no thick lobe accumulations.

The most noticeable characteristic of the "Lake

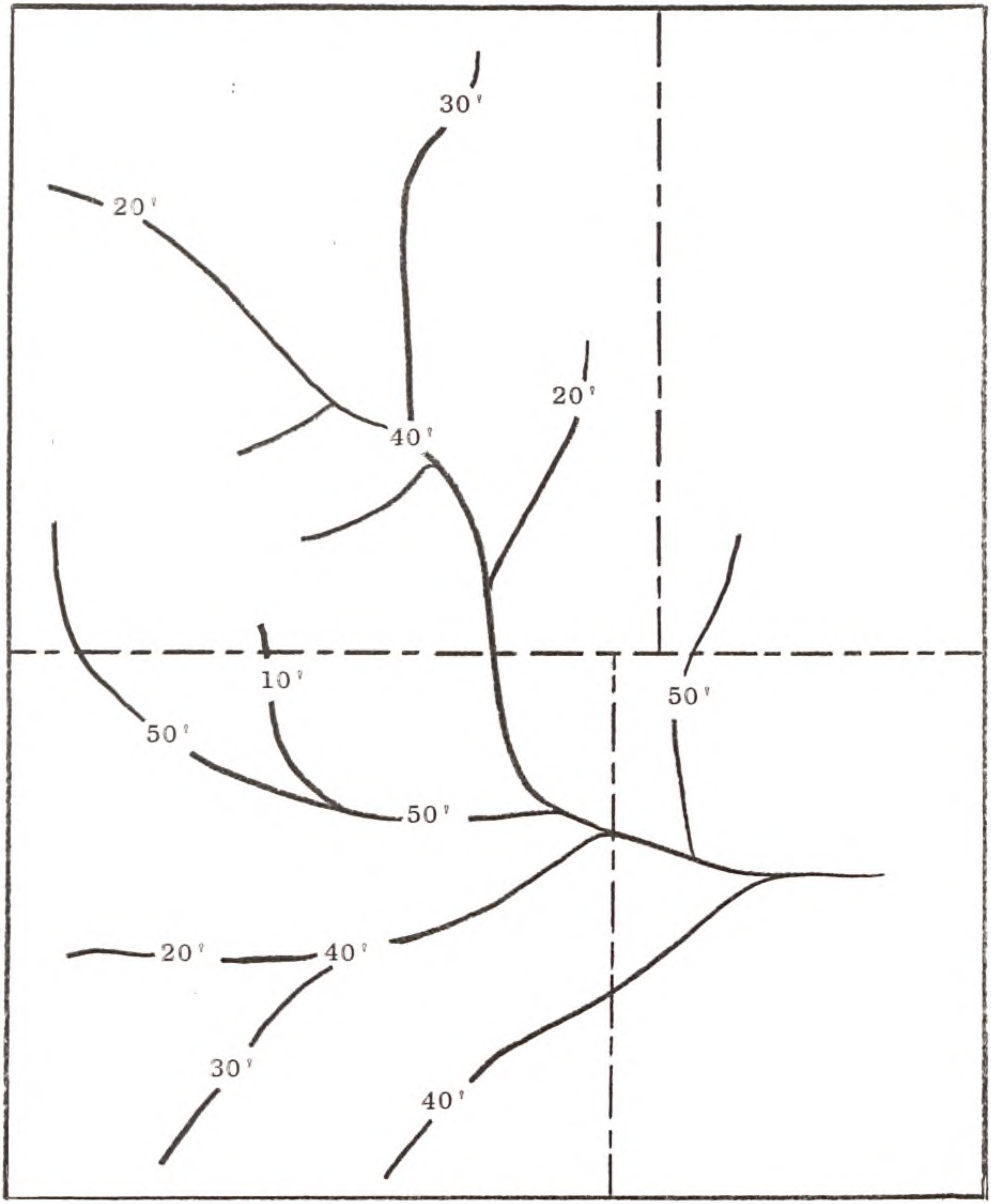

Fig. 7. Trends of channel axes, Post-Crystal Falls--Pre-Saddle Creek channel-fill sandstone. See Pl. XXX.

Cisco" sandstone, which differs from those of the other channel sandstones described in this report, is the marked change of depositional direction from the normal southwest to the northwest. The distributaries branch from a common outcrop area and do not coalesce downdip. The two northernmost branches in north-central Shackelford County may possibly be distributaries of another system originating in northern Stephens or Young County. Most of the distributaries terminate westward in Callahan County, but the southern and northern distributaries extend beyond the map area.

Post-Saddle Creek--Pre-Stockwether Channel Sandstone

Above the Saddle Creek Limestone and commonly removing it, occurs a channel sandstone which varies in thickness from 0 to 110 feet (Pls. I, IV-X, XXXI). This channel (Pl. XXXI; fig. 8) branches from at least three outcrop areas and coalesces downdip in several localities.

McGowen (1964, p. 253; Pl. VII) mapped two outcrop areas of the post-Saddle Creek channel sandstone in southwestern Stephens County and observed a marked westward decrease in grain size. He noticed that "both channel outcrops appeared to become narrower

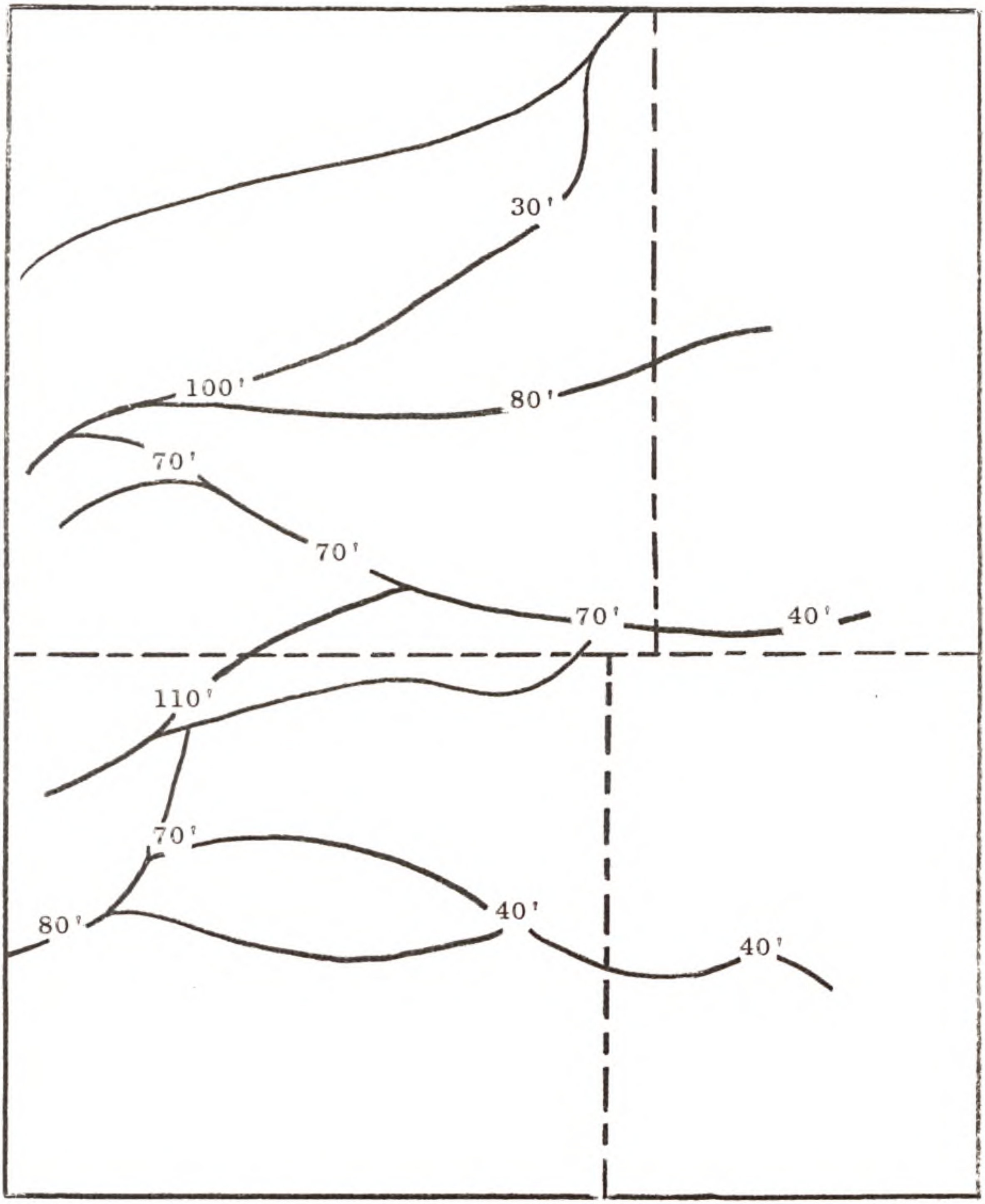

Fig. 8. Trends of channel axes, Post-Saddle Creek--Pre-Stockwether channel-fill sandstone. See Pl. XXXI.

downdip, which may indicate that downcutting was maximum eastward, and the subaqueous scour occurred where the channels are narrowest" (*idem*, p. 254). McGowen (*idem*, p. 255) also observed that the narrower southern channel in Stephens County cuts through the nodular, shelly, and algal facies of the Saddle Creek Limestone and that the wider northern channel is most narrow in the sandy *Osagia* facies, broadens in the calcareous sand facies, and is widest where it cuts the sand facies of the Saddle Creek. McGowen (*idem*) stated that these characteristics indicate the close relationship of the width of the stream valley and the type of material it cuts. Channel widths and limestone facies are highly interpretive in the subsurface and comparisons and associations are, therefore, not valid. However, by studying these phenomena on the surface perhaps a better understanding of the subsurface can develop.

The distribution pattern of the post-Saddle Creek sandstone (Pl. XXXI; fig. 8) suggests a complex braided stream system which thins downdip to the southwest with the coalescence of tributaries in central Shackelford and Callahan counties. The extent of this system outside the study area is unknown and the outcrop area of the northernmost tributaries is postulated as northern Stephens or Young County. The lack of sand in southern Callahan County is especially notable.

A comparison of the sandstone isopach map (Pl. XXXI) and the paleotopographic map at the base of the post-Saddle Creek sandstone (Pl. XXXVI) indicates that the "valleys" cut by the streams were not completely filled with sandstone (fig. 9). The shale which completes the filling may have been deposited before or during marine inundation which followed sandstone deposition. Perhaps the main channel shifted before complete filling by sandstone, allowing shale filling in the old valley.

"Valleys" on the paleotopographic surface reached a depth of 175 feet. "Valley walls" less than 60 feet below the Stockwether Limestone could not be delineated, since no sandstone nor other lithologic change occurs at that interval to mark the possible erosional surface (fig. 9).

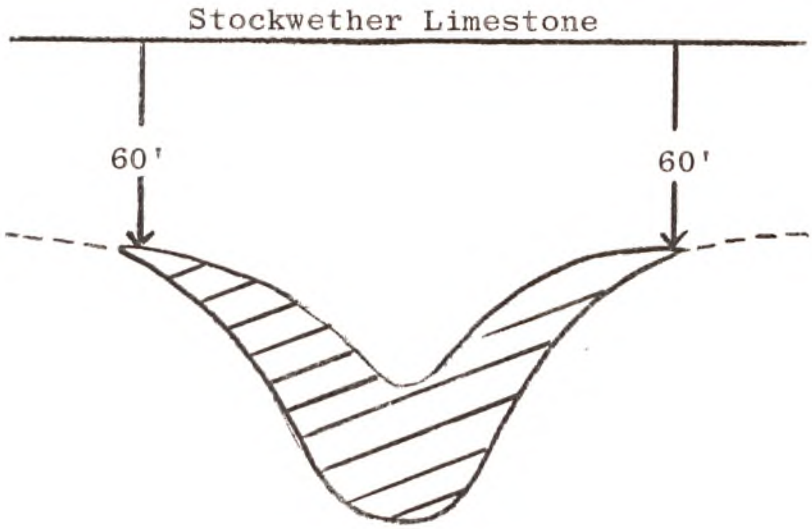

Fig. 9. Relationship between channel-fill sandstone and paleotopographic (erosional) surface, Post-Saddle Creek--Pre-Stockwether channel deposit.

Thick deposits shown on the sandstone isopach map (Pl. XXXI; fig. 8) may represent multiple channels where post-Saddle Creek channels cut through the limestone and into underlying channel sandstones.

Post-Stockwether--Pre-Camp Colorado Channel Sandstone

The lowermost of the two channel sandstones which occur between the Stockwether and Camp Colorado limestones in the subsurface (Pls. I, IV-X, XXXII) has a distribution pattern which resembles a relatively

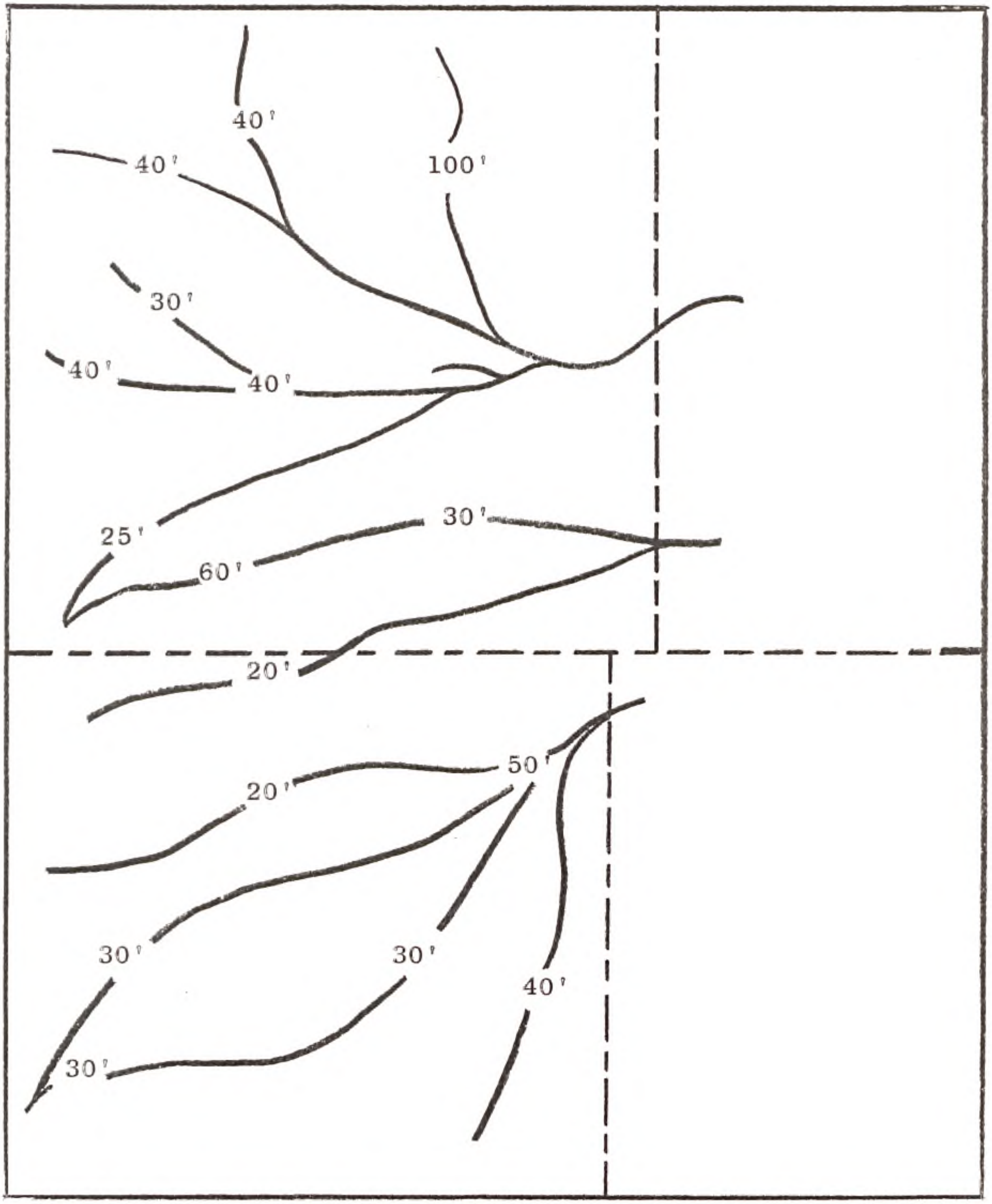

Fig. 10. Trends of channel axes, Post-Stockwether--Pre-Camp Colorado channel-fill sandstone. See Pl. XXXII.

thin delta distributary complex. The uppermost channel sandstone in this interval was not mapped in the subsurface.

McGowen (1964, pp. 261-262) described the sandstone, which was mapped in the subsurface, as the lowermost of five sandstones occurring in the Stockwether-Camp Colorado interval. Only two sandstone bodies were observed in the subsurface; however, they may represent multiple channels composed of several of McGowen's (idem) channels in the Stockwether-Camp Colorado interval. Northwest of Eolian in west-central Stephens County, McGowen (idem) described the outcrop as a relatively broad, shallow channel area. On the outcrop in southern Stephens County, Brown (personal communication, 1965) described this channel deposit as occurring lower in the section and commonly replacing the Stockwether Limestone.

This channel complex (Pl. XXXII; fig. 10) branches from three outcrop areas in western Stephens and Eastland counties and extends into the subsurface in a predominately southwestern direction. Most "distributaries" in this complex are slightly meandering. Only the major distributaries in central Shackelford County have minor distributaries. Convergence of the channels occurs in south-central Shackelford and west-central Callahan counties. The extent of this sandstone complex outside the study area is unknown.

The lower post-Stockwether channel sandstone (Pl. XXXII; fig. 10) varies in thickness from 0 to 50 feet and in width from two to seven miles. The maximum width occurs in eastern Callahan County where a major channel bifurcates. The channel rarely removes the Stockwether Limestone in the subsurface. Although a paleotopographic map was not drawn at the base of this sandstone, the "valleys" appear to be relatively well filled with sandstone as compared to the poorly filled post-Saddle Creek "valleys."

Post-Camp Colorado--Pre-Dothan Channel Sandstone

Between the Camp Colorado and Dothan limestones is a channel complex which does not exceed 30 feet in thickness (Pls. I, XXXIII; fig. 11).

On the outcrop, Ray (personal communication, 1965) has mapped six channelled areas at this stratigraphic level. The distribution pattern (Pl. XXXIII; fig. 11) in the subsurface suggests a complex of braided stream channels which probably coalesced updip beyond the present outcrop and may possibly branch downdip into a westward trending delta complex.

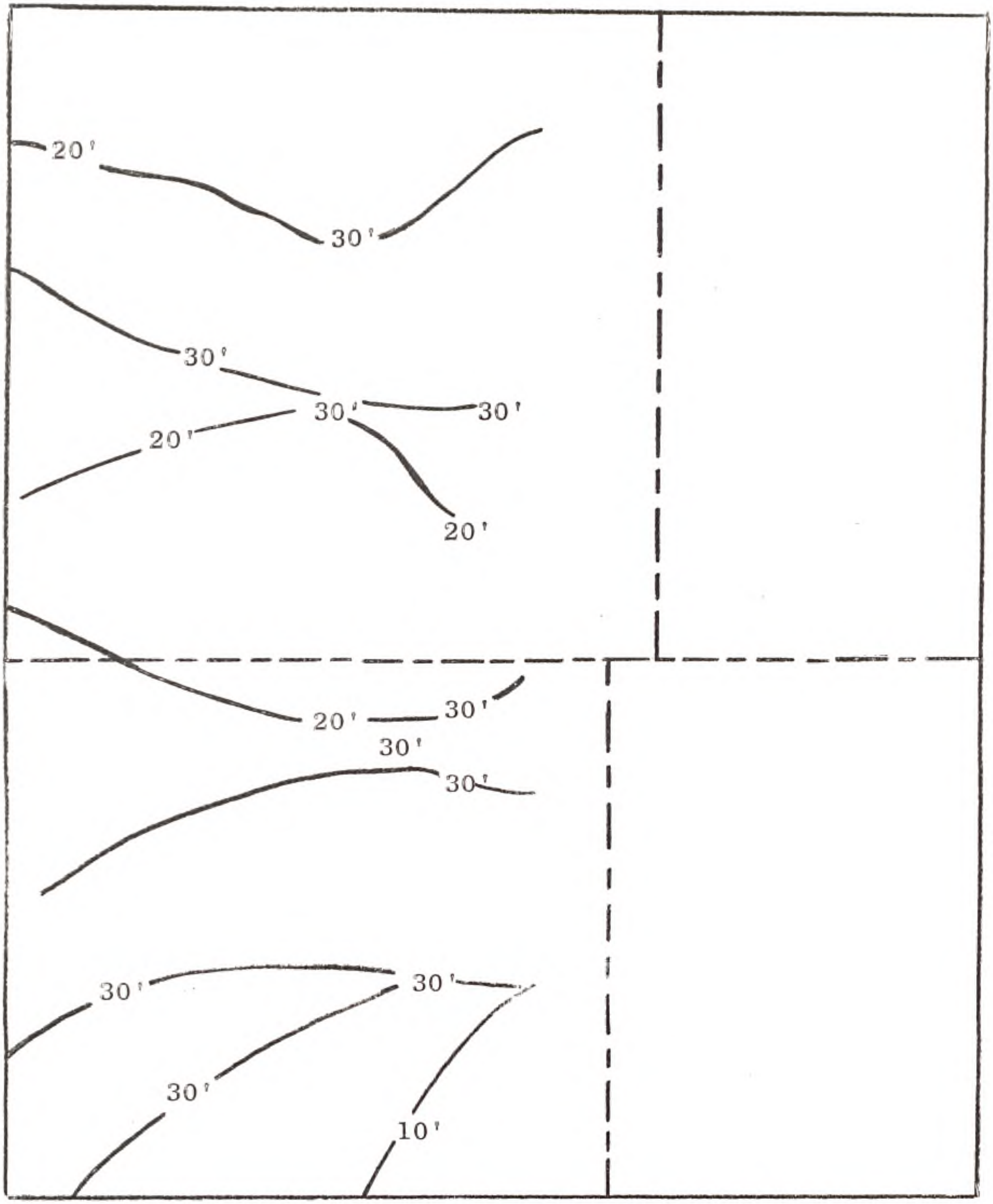

Fig. 11. Trends of channel axes, Post-Camp Colorado--Pre-Dothan channel-fill sandstone. See Pl. XXXIII.

The limits of the study area are not sufficiently broad to allow proper delineation of this unit.

Post-Dothan--Pre-Sedwick Channel Sandstone

Plate XXXIV illustrates the distribution and thickness of a sandstone channel complex which occurs below the Sedwick Limestone and has an upper boundary approximately 30 feet above the Dothan Limestone. Three outcrop areas were mapped by Ray (personal communication, 1965) in Shackelford, Eastland, and Callahan counties. The two most northern channel outcrops (Pl. XXXIV; fig. 12) branch into the subsurface as several "distributaries," whereas, the southern channels do not branch. In Shackelford County the sand reaches a maximum thickness of 40 feet where the northernmost distributary splits into five branches. In east-central Callahan County the channel is 50 feet thick where it cuts through the Dothan Limestone and into underlying channel sandstone.

Additional study downdip from the western boundary of the present area will be necessary to determine depositional patterns for channels in the upper part of the section under investigation.

DEPOSITIONAL FRAMEWORK

Interpretation of the depositional framework of the strata of the Cisco Group of North-central Texas is based on possible interrelationships between rock type and distribution, source direction, tectonics, and paleotopography. Most of these factors are illustrated individually on a variety of highly subjective maps (Pls. XI-XLIV) and cross sections (Pls. III-X) which are based on interpretation of electrical logs. The well distribution used in this investigation necessitated considerable interpretive contouring which increases the subjectivity of all maps and cross sections. Although stratigraphic interpretation must relie heavily upon many variables, various approaches and parameters must be utilized and measured if a three-dimensional picture of the depositional framework is to be developed.

Conclusions reached in this study are empirical since they are based on limited observation provided by electrical logs and on comparison of the study area with depositional and stratigraphic models developed in earlier surface and subsurface studies. Studies similar to the present investigation include research in the Illinois basin (Potter, 1963, pp. 1-92; Friedman, 1960, pp. 1-59),

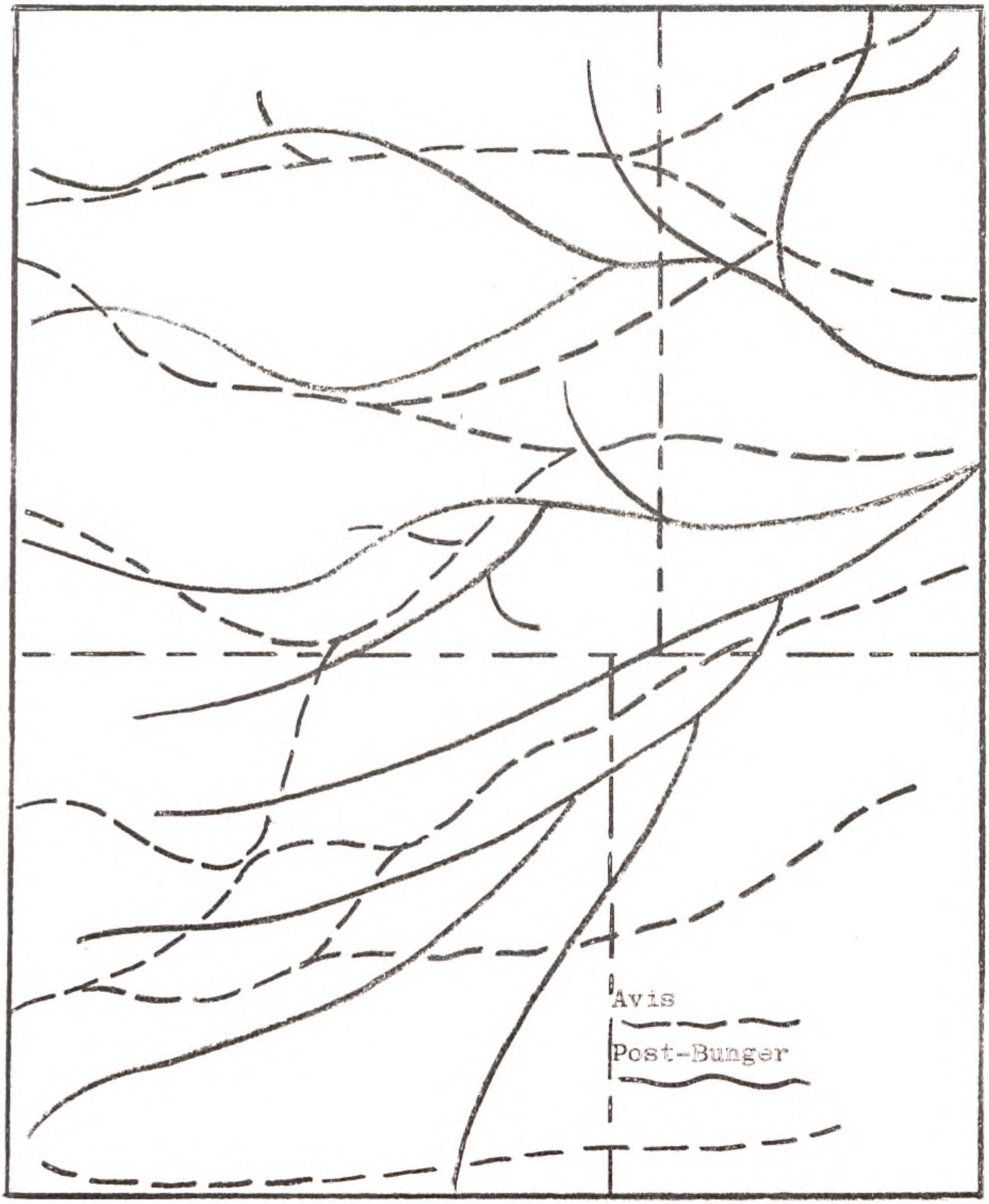

Fig. 13. Areal relationship of distribution patterns of adjacent channel systems, Post-Bunger, Avis channels. See Pls. XXVI-XXVII.

Appalachian basin (Pepper et al, 1954, pp. 1-111), Rio Grande River delta (Nanz, 1954, pp. 96-117), and Mississippi River delta (Fisk et al, 1954, pp. 76-99; Fisk, 1961, pp. 29-52; Coleman and Gagliano, 1964, pp. 67-80). With continued research involving additional well control, more varied mapping methods and continued comparison with modern and ancient sedimentary models, perhaps the depositional framework of the study interval can be described with more confidence and accuracy.

Plummer and Moore (1922, pp. 121-190) were the first to theorize on the depositional environment of the Cisco Group of North-central Texas. Their generalized interpretations (idem) remain relatively valid.

Lee (1938a, pp. 11-90) was apparently the first geologist to recognize channel deposition in the Cisco Group. Lee (idem) related channel scour and deposition to major withdrawals of the sea and reelevation of the Ouachita Mountains from which channel-fill sediments were derived. He described the depositional history of the Cisco Group in greater detail than Plummer and Moore (1922, pp. 121-190) by including the depositional character of each formation as related to sea-level oscillations, diastrophism, and degree of erosion.

Subsequent pertinent studies of depositional environments

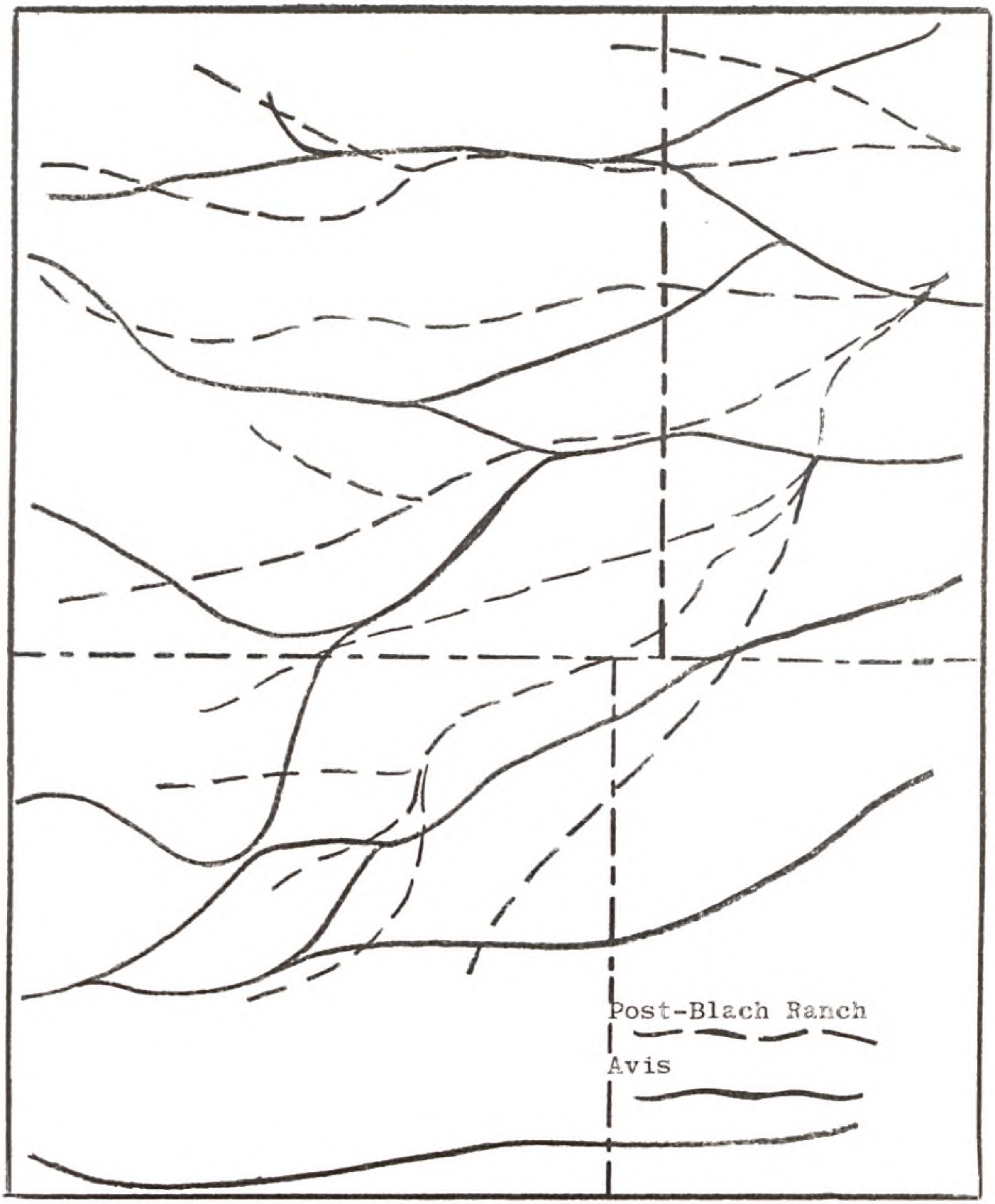

Fig. 14. Areal relationship of distribution patterns of adjacent channel systems, Avis, Post-Blach Ranch channels. See Pls. XXVII-XXVIII.

include a structural study by Cheney and Goss (1952, pp. 2237-2265), a channel distribution and environmental study by Shankle (1960, pp. 168-201), an interpretation of depositional topography and cyclic deposition in West-central Texas by Jackson (1964, pp. 317-328), and a detailed study of the stratigraphy and depositional history of the Harpersville and Pueblo formations in Stephens County by McGowen (1964, pp. 1-440).

General Framework

The strata of the Cisco Group described in this report were probably deposited in a variety of shallow near-shore environments. Deposition was undoubedly influenced by irregular emergence and submergence along the strand-line and the influx of clastic sediments across a broad, relatively featureless coastal plain and adjacent shelf.

The variety and sequence of rock types indicate fluctuating shorelines and possibly slight changes in water depth. Rock types which comprise the Cisco Group strata, in order of abundance, are shale and clay, sand-stone, limestone, and coal. The vertical sequence of shale, sandstone and limestone in the Cisco Group is relatively cyclic; however, a generalization for repetitive order which could be applied throughout the Cisco section is impractical (Pl. I; frontispiece).

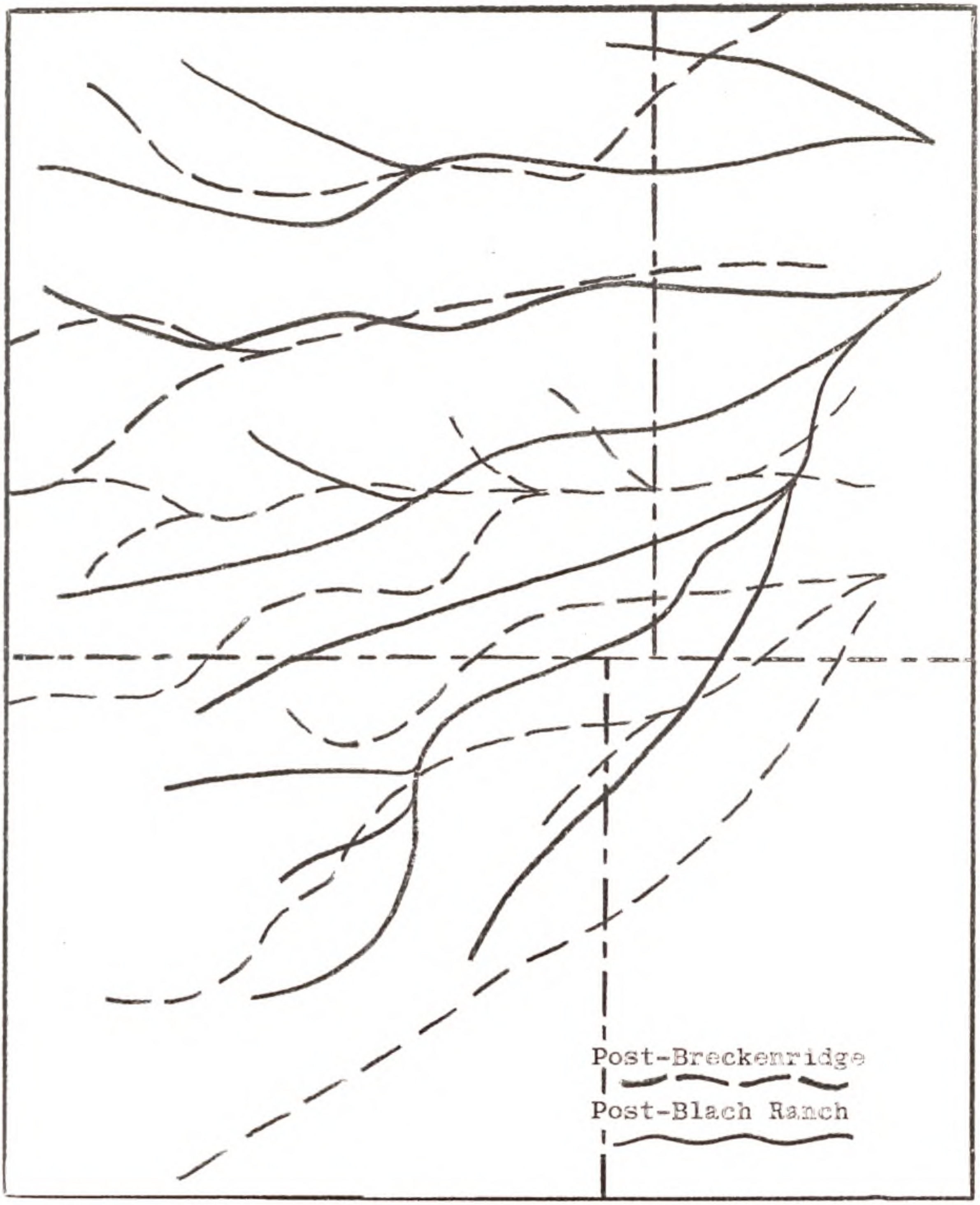

Fig. 15. Areal relationship of distribution patterns of adjacent channel systems, Post-Blach Ranch, Post-Breckenridge channels. See Pls. XXVIII-XXIX.

Generally, limestones probably indicate maximum marine conditions; sandstone and coal beds may indicate progradation during maximum coarse clastic influx; and fossiliferous shales, clays, and limestone lentils are characteristic of transitional environments. These empirical generalizations as to environment are not intended to imply that sediment types were necessarily deposited in bands paralleling strand line. Cisco rocks are, rather, characterized by abrupt vertical and lateral variations, which are evidence of fluctuating, irregular depositional conditions. Shorelines with a similar variety of local environments are presently developing in Recent sedimentary basins.

The study interval thickens westward and northwestward in the study area as indicated on cross sections (Pls. III-X) and isopach maps (Pls. XII-XXI, XXXVII-XL) of limestone-bounded intervals. The interval between the Home Creek and Bunger Limestone (subsurface interval number 1, Pls. I, XXIII), for example, thickens across the area from 280 to 420 feet. All other intervals (subsurface intervals numbers 2-5) display similar isopach patterns. However, local variations of thickness partially obscure the westward pattern of regional thickening on the isopach maps. Cheney (1952, p. 2263) suggested that westward thickening

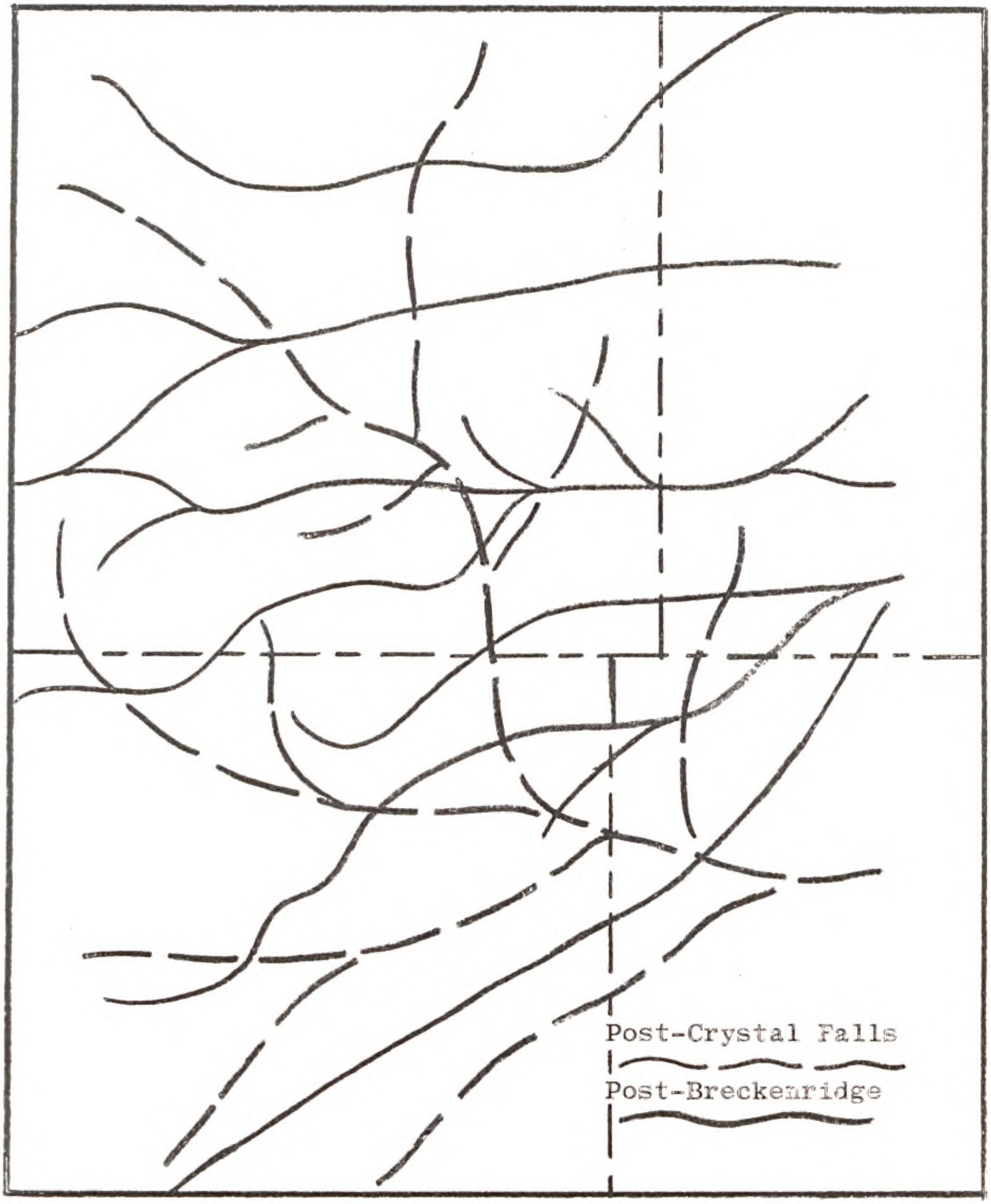

Fig. 16. Areal relationship of distribution patterns of adjacent channel systems, Post-Breckenridge, Post-Crystal Falls channels. See Pls. XXIX-XXX.

of the lower Cisco beds (subsurface interval number 1) is associated with epeirogenic uplift in the Ouachita tectonic belt and that spasmodic uplift continued throughout Cisco deposition.

Limestone deposits thicken in the extreme western and southern sections of the study area, whereas sandstone accumulation is greatest in central and eastern areas (Pls. III-X, XVII-XXII).

The predominant orientation of coarse clastic deposition is west-southwestward (Pls. XVII-XXII, XXVI-XXXIV), about 60 degrees from apparent regional marine northeast-southwest depositional strike. The relatively constant direction of coarse clastic deposition reflects the possibility of a northeastern and eastern source area and a relatively stable depositional slope. During deposition of the Cisco rocks, only one major change in direction of clastic transport was noted in the area. The "Lake Cisco" channel system (post-Crystal Falls) probably transported sediment northwestward, rather than in the normal westward to southwestward direction (Pl. XXX).

Structure

Local structure in the study interval is apparently related to differential compaction of shales and linear

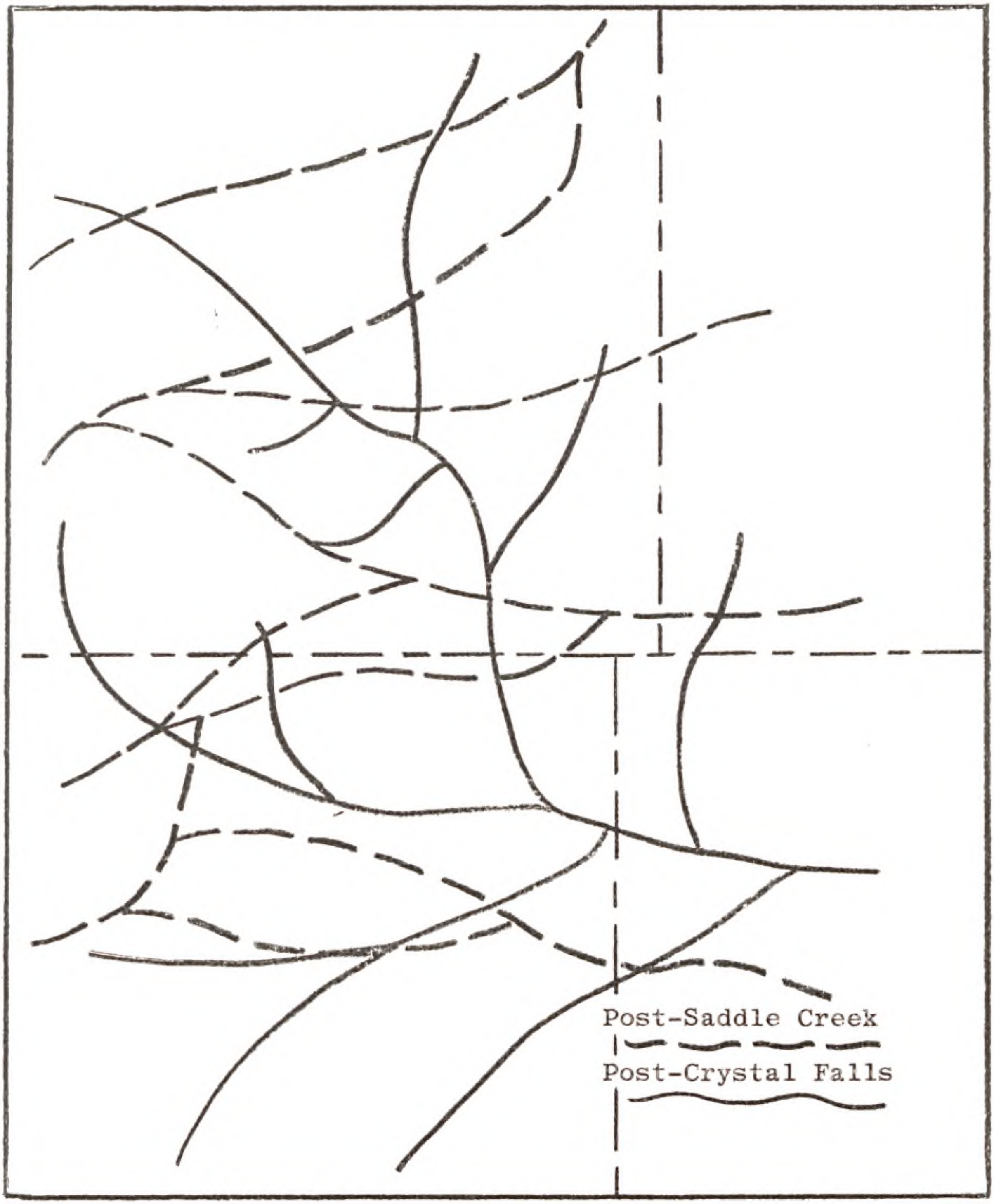

Fig. 17. Areal relationship of distribution patterns of adjacent channel systems, Post-Crystal Falls, Post-Saddle Creek channels. See Pls. XXX-XXXI.

sandstone bodies and to abnormal shale compaction beneath massive channel-fill sandstones. In Cisco rocks, this important, but local compactional structure is superimposed and in part controlled by gentle structural (tectonic) relief on a gently dipping northwestward monocline. Apparently some contemporaneous structural activity occurred as indicated by the westward thickening of the shale intervals.

Several factors which influence differential compaction are (1) composition of the sediment, particularly size, mineralogy, and shapes of grains; (2) properties and influence of interstitial water; (3) temperature and pressure related to depth of burial; and (4) time required for sediments to reach equilibrium after burial (Weller, 1959, pp. 273-310).

Although the compressibility of limestone is unknown, limestone compaction is of little significance in the study interval. Limestone beds of the Cisco Group, which are widespread and relatively constant in thickness, display little evidence of differential compaction although petrographic studies may demonstrate minor diagenetic changes.

Compaction in sands, which results from rearrangement of relatively spherical rigid grains, is not as great as compaction in flat, plate-like clay particles. The high

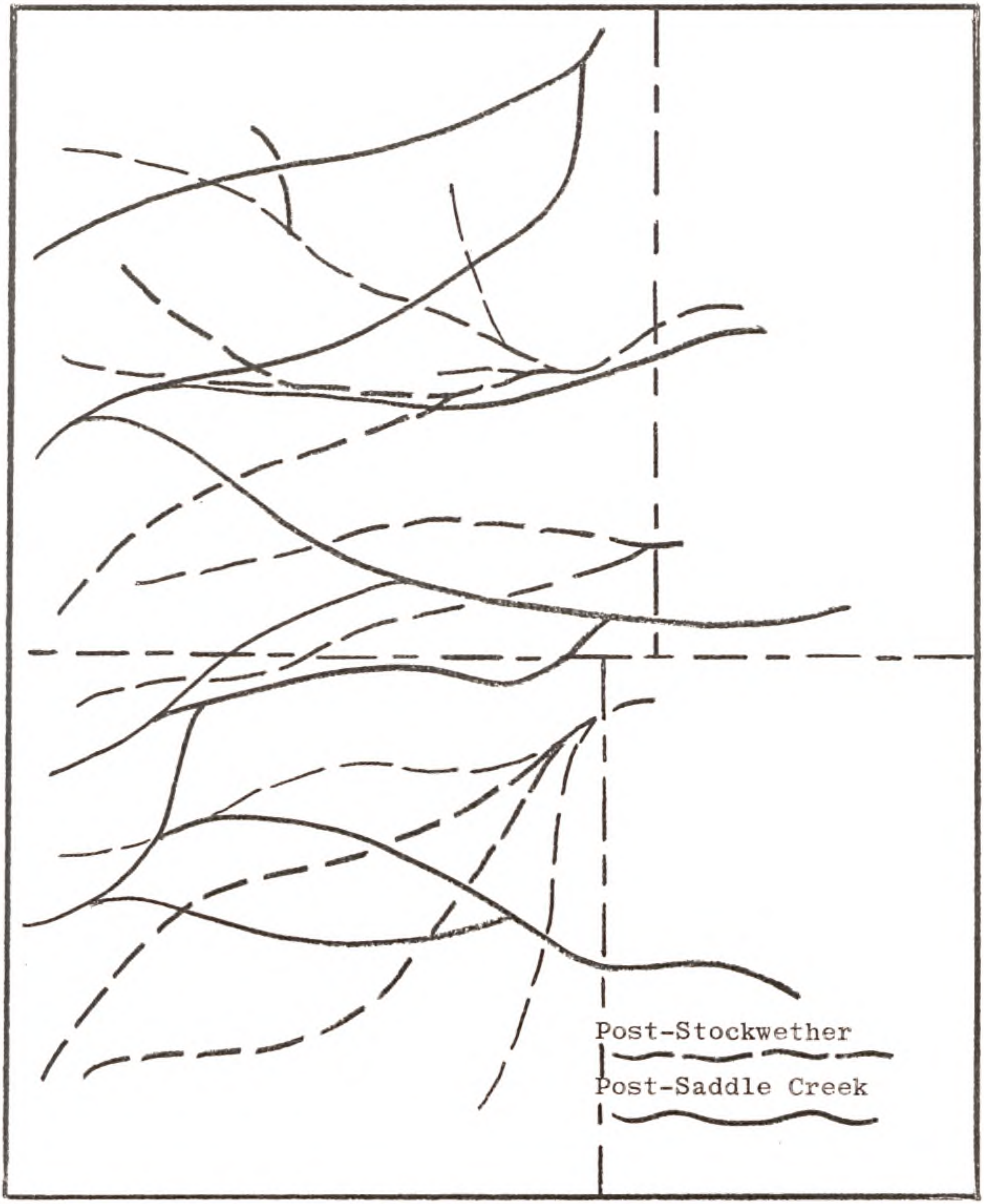

Fig. 18. Areal relationship of distribution patterns of adjacent channel systems, Post-Saddle Creek, Post-Stockwether channels. See Pls. XXXI-XXXII.

degree of compaction in shales is the result of several factors that include (1) release of interstitial water; (2) rearrangement of grains and closer packing; and (3) deformation of clay minerals until porosity is eliminated (idem).

Mueller and Wanless (1957, p. 86) emphasized that caution must be exercised when drawing conclusions concerning channel sandstone compaction relative to shale compaction based on sandstone percentage maps. They note (idem) that (1) channel sandstones vary in coarseness and amount of interstitial clay which influences compactibility; and (2) where 20 to 80 feet of shale may have accumulated prior to channel scour, the lower layers of shale probably were already partially compacted before erosional stages commenced.

If compaction of shales began soon after deposition, some topographic relief resulting from the differential compaction would have developed by the end of shale deposition. If an overlying limestone were deposited over a topographic high, thinning of the limestone might be expected. It was impossible in the subsurface to detect subtle changes in thickness in the relatively thin Cisco limestones. However, the relationship between paleotopographic surfaces and deposition should be investigated

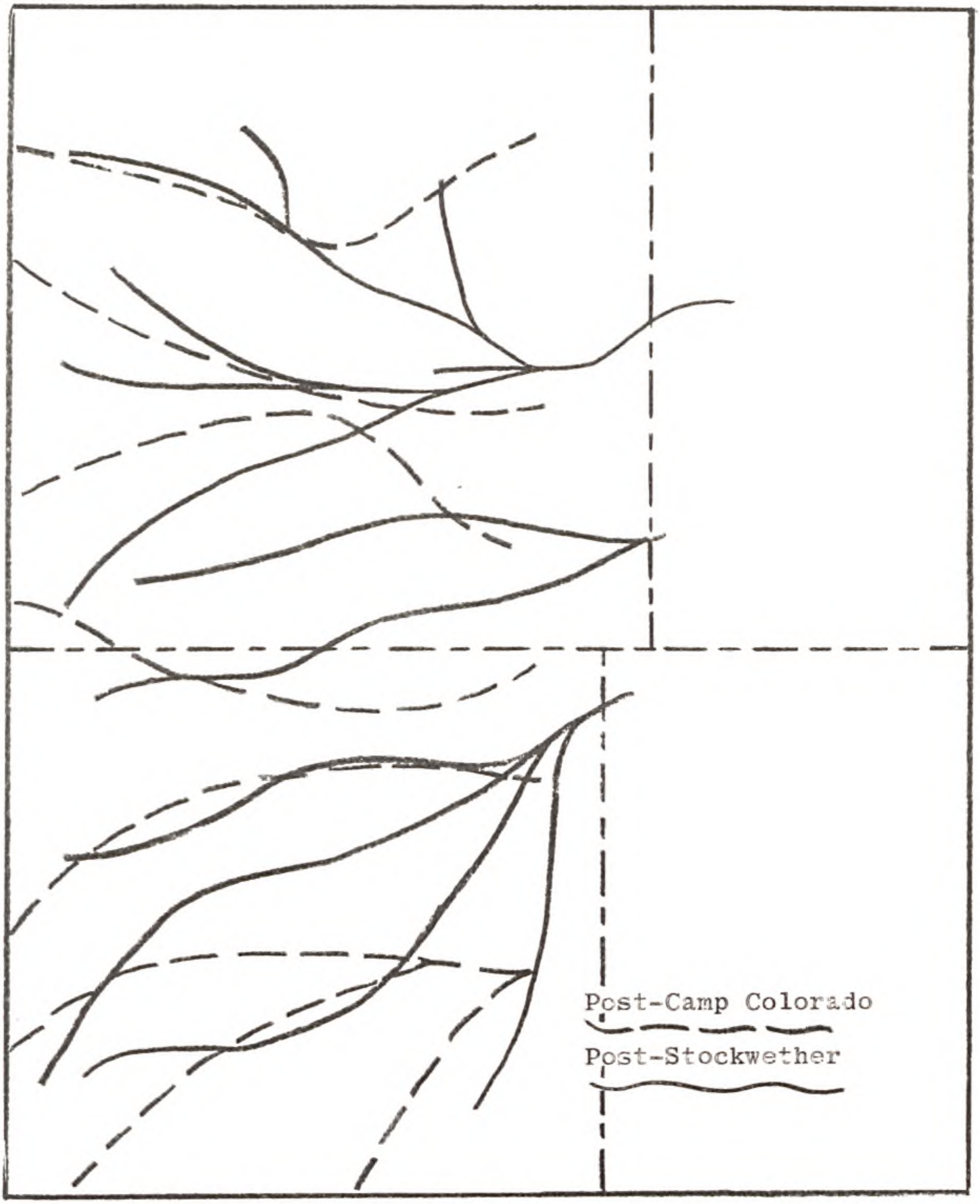

Fig. 19. Areal relationship of distribution patterns of adjacent channel systems, Post-Stockwether, Post-Camp Colorado channels. See Pls. XXXII-XXXIII.

throughly at the surface.

In order to estimate the degree of structure resulting from shale compaction, a series of profiles were drawn along a single line at several stratigraphic levels (Pls. XLII-XLIII). The intervals were bounded by persistent marker limestone beds which were assumed to be relatively horizontal when deposited. Compaction was undoubtedly greatest in areas of thickest shale accumulation.

Maximum thicknesses on isopach maps (Pls. XXXVII-XL) of selected intervals between successive limestones commonly coincide with maximum percentages of sandstone on sandstone percentage maps (Pls. XVIII-XXII) and with maximum thicknesses of channel-fill sandstone on channel isopach maps (Pls. XXVI, XXVIII-XXIX, XXXII). The relationship between thick isopach intervals and high sand percentage or thick channel-fill sandstone probably is the result of sand deposition in topographically low areas, which resulted from tectonic effects and/or differential compaction. Both tectonic and differential compaction undoubtedly affected channel-fill sandstone accumulation.

This close relationship between isopach thickness and sandstone thickness is not as evident when considering larger intervals because primary sand/shale ratios are distorted to a greater degree by the compaction of thicker shale units.

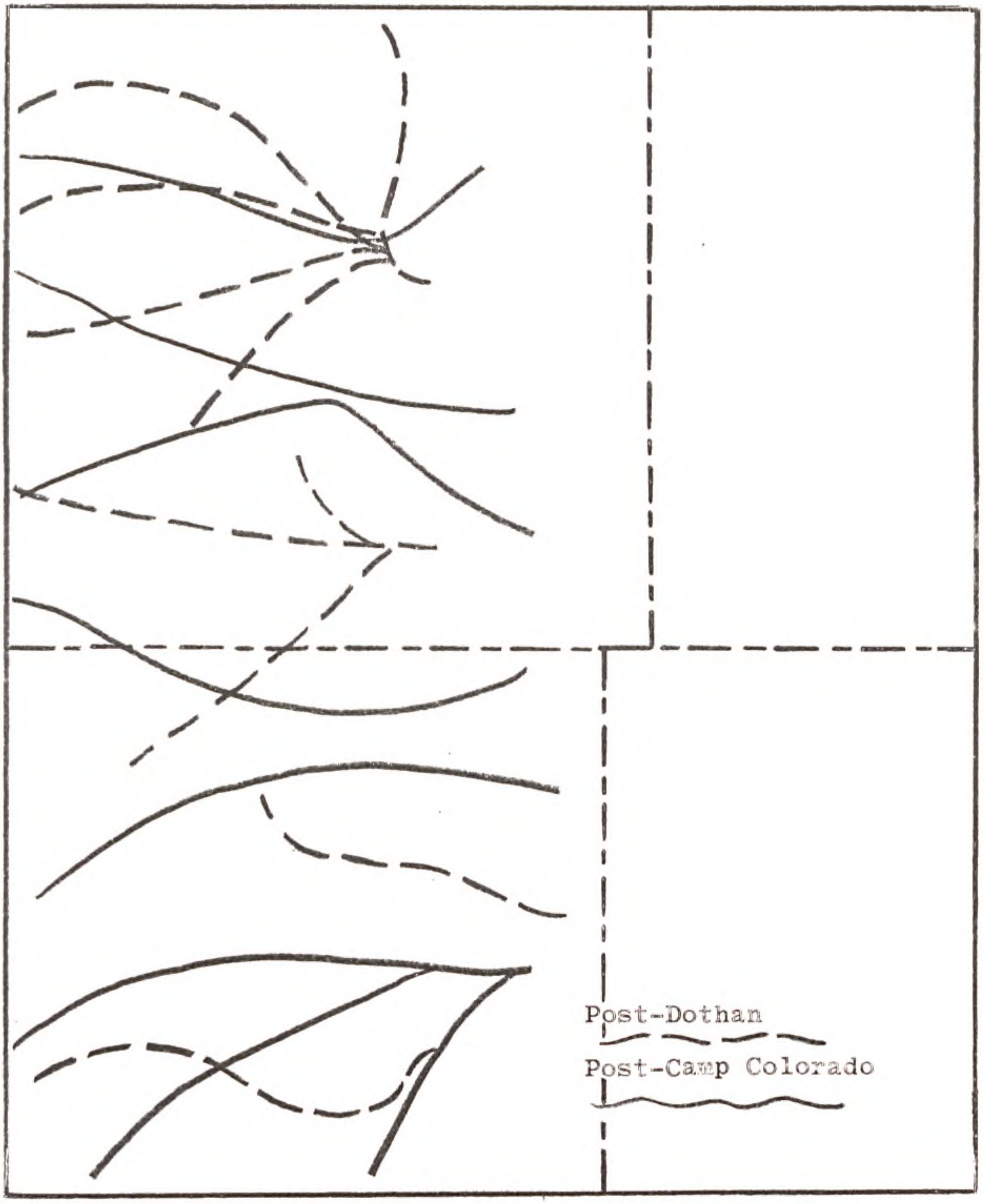

Fig. 20. Areal relationship of distribution patterns of adjacent channel systems, Post-Camp Colorado, Post-Dothan channels. See Pls. XXXIII-XXXIV.

Where subsidence of a channel-fill sandstone body due to compaction of underlying shales is greater than compaction in the interchannel areas, structural and topographic lows are formed, which coincide with maximum sandstone accumulation. Because channels will naturally develop in topographic lows, maximum sandstone accumulation within a channel complex commonly coincides with structural depressions. Several successive channels are commonly "stacked" in the study area and the composite weight of these channel-fill bodies may have caused sufficient subsidence to develop local topographic lows. Regional tectonics may have provided primary tectonic lows or synclines in which drainage was initially established in the area.

Perhaps some structural development of the rocks in the Cisco Group can to some degree be related to strata of the underlying Canyon Group which are characterized by thick limestones and fine calcareous clays, with only minor lenses of sandstone. Differential build-up of the Home Creek Limestone (Pls. XI, XXIII), possibly affected depositional topography and shale compaction in the overlying Graham Formation, since the distribution of several lower Graham channel sandstones below the Bunger Limestone coincide with thin areas contoured on the Home Creek Limestone isopach map (Pl. XI).

Many structural and channel trends which occur in the Graham Formation also occur in younger formations of the Cisco Group as evidenced by comparison of structure profiles (Pls. XLII-XLIII) across the area. Differential compaction of interchannel shales and channel-fill sandstones, coupled with subsidence of the massive channel bodies by compaction of underlying shales, and superimposed on pre-existing structure and topography, resulted in the myriad channel patterns observed in the study.

Limestone Deposition

Only the lateral distribution, thickness and relative porosity of the limestone beds could be observed since the present study is restricted to electric log interpretations. Incorporation of surface data with subsurface distribution provide some interpretation of carbonate depositional environments. Volumetrically, limestone is insignificant in the Cisco Group; however, the apparent persistence and characteristic electrical properties of these units are of great importance in correlation.

Several relatively thin limestone beds of wide lateral extent and persistence occur throughout the Cisco Group (Pls. I, III-X). The wide distribution of these limestones suggests relatively uniform depositional topography. Petrographic studies (McGowen, 1964, pp. 176-238, 428-440;

Waller and Ray, 1965, personal communication) of these carbonate rocks at the outcrop point to varied local environments, but lateral persistence of the limestones is exceptional when compared with other rock types.

Limestone deposition does not necessarily indicate distance from shore or depth of water, for limestone deposition was probably more closely controlled by favorable conditions for lime-secreting organisms and a decrease in the influx of terrigenous clastic sediments. Slight fluctuations in water depth would have had some effect on carbonate deposition, but minor topographic features, sources of clastics, turbidity, and currents were probably more important environmental factors. Carbonates apparently developed during rare periods when clastic sediment influx was minimum in the local area.

Possible litho-facies changes of the limestones in the subsurface were not mapped. Several limestones, such as the Bunger, North Leon (?), and Saddle Creek limestones, however, apparently grade to sandy limestone or limy sandstone as indicated by low resistivity and moderate porosity interpreted from electric logs. The significance of these changes can not be determined without additional samples and cores.

Shale Deposition

Shales of the Cisco Group represent a variety of environments; however, without a vast supply of well samples for clay mineralogic and paleontologic studies, these environments must be interpreted primarily on the basis of geometry and relationship to adjacent sandstones and limestones. Possible shale-filled channels can be postulated where underlying limestones are locally absent, but these channel-types were not traced in the present study. Intensive surface studies on mud rocks must be completed before any interpretation can be attempted in the subsurface. Perhaps radioactivity logs, coupled with microfossil and clay mineral studies of well samples, will lead to some understanding of subsurface shale environments--but only after an adequate framework has been established and tested at the surface.

Sheet Sandstone Bodies

Sandstone deposits of the Cisco Group can be divided into two major types based on geometry--sheet and linear sandstone bodies. Sheet sandstone bodies, which commonly overlie channel sandstone units or occur in cross section as thin sandstone lentils in shale sections, have irregular widespread distribution patterns and a relatively constant thickness of about 10 feet. Environmentally these deposits, when overlying channel-fill deposits, possibly represent a decrease in coarse clastic influx and a transition from the predominantly sandstone channel-fill sequence to a more normal marine deposition. In some cases the sheet sandstone bodies may be the result of destruction and redoposition of the upper layers of channel deposits by subsequent marine inundation.

On the outcrop sheet sands are characterized by ripple-marks and marine fossil fragments. Waller (1965, personal communication) and McGowen (1964, pp. 251) reported Lebenspuren occurring in the sheet sands at the top of the Avis Sandstone and above sandstone bed IPhD of the upper Harpersville Formation.

Linear Sandstone Bodies

General features.--Linear sandstone bodies, characterized by great variability in thickness and elongate distribution patterns, comprise the majority of sandstone deposits of the Cisco Group.

Rich (1923, pp. 110-112) divided "shoestring" or linear sandstone bodies on the basis of their possible origin, such as (1) shore beaches and bars; (2) off-shore bars; (3) ordinary river channesl; (4) delta distributary channels; and (5) tidal channels. Based on the criteria which Rich (<u>idem</u>) established for recognition of these deposits, only linear sandstone deposition characteristic of ordinary river channels, delta distributary channels and/or tidal channels are possibly recognizable in the subsurface study area.

Waller (personal communication, 1965) postulated on the basis of stratigraphic relationships, that a sandstone body (IPgE and IPgF) which occurs at the surface in the Gonzales Creek Member is possibly a bar deposit. McGowen (1964, Pl. VII) postulated that an offshore bar (sandstone IPhF) occurs at the surface in the upper section of the Harpersville Formation. McGowen (<u>idem</u>) based this interpretation on the apparent lineation of the sandstone body parallel to depositional strike. Perhaps similar deposits do exist in the subsurface of the study area but were not recognized because of well control and interpretive contouring. It should be emphasized, however, that in the present study the only criteria available to suggest an origin of the linear sandstones are thickness, areal distribution and position within a paleotopographic valley. It is certainly possible that the many channel systems contoured could, in part, contain many bar-like deposits which were not recognized with present control and detail. Bar deposits oriented perpendicular to the Cisco strandline would be particularly difficult to delineate. The agreement between subsurface and surface data, however, strengthens the argument that the linear sandstone bodies are predominantly part of some sort of channel systems.

Potter (1962b, pp. 2-8) separated elongate bodies on the basis of areal extent rather than possible origin. The most commonly occurring distribution pattern described by Potter (idem) is "dendroid" which branches updip and/or downdip and has a variable width of 100 feet to 3 miles. A dendritic pattern may characterize a variety of environments, such as fluvial, deltaic, and tidal environments. The second most abundantly occurring pattern is the "belt" (idem) which ranges in width from 3 to 35 miles, contains areas of little or no permeable sand, has weakly meandering outlines, and may include tributaries and/or distributaries. The third, and least abundant, type of linear sandstone distribution pattern according to Potter (idem) are isolated lenses or "pods" which may be the result of partial channel filling by mud and silt or possibly deposition in a predominantly marine environment. In the present study the dominant distribution pattern of linear bodies is dendroid. Belts possibly characterize some phases of channel deposition in the study interval, for example, the Avis Sandstone and post-Saddle Creek sandstone deposits.

These possible belt trends may have resulted from channel-shifting or multiple channelling of dendroid type channels.

Interpretive contouring with the present well control obscures many details of channel patterns. Most minor tributaries are probably included within the limits of the main channel contours and are, therefore, obscured. Since the purpose of the present study has been to delineate, at a reasonable scale, the general subsurface lithostratigraphic framework, detailed studies of channel segments was not feasible. Many shallow wells penetrate some of the channel bodies, but for this report, wells were selected which provided maximum control for the entire Cisco section.

Sanders (1957, pp. 198-201) emphasized the importance of considering the type of sediment-fill as well as the channel pattern in any attempt to interpret precise origins of channels. He (idem) described the origin of the channel in which the Pleasantview Sandstone of West-central Illinois occurs, as either of tidal or fluvial origin. The sediments filling the channel may also have originated in either a fluvial or tidal environment (idem). With these possibilities, Sanders (idem) listed four combinations of sediment fill and channel origins: (1) tidal channels with littoral marine filling, perhaps indicating subsidence but no particular changes in geography; (2) tidal channels with fluvial filling, indicating marine regression between cutting and filling; (3) fluvial channels with fluvial filling, indicating a change in the stream regimen from cutting to filling; and (4) fluvial channels with littoral marine filling, indicating marine transgression.

Similar environments to those Sanders (idem) described may have existed during erosion and filling of the channels of the Cisco Group. However, until detailed mineralogic and sedimentary structure studies are completed on these deposits, depositional environments must be interpreted on the geometry of the system.

The westward branching or distributary patterns of the post-Bunger--pre-Gunsight, post-Blach Ranch--pre-Breckenridge, post-Breckenridge--pre-Crystal Falls, post-Stockwether--pre-Camp Colorado, post-Camp Colorado--pre-"Dothan" and post-"Dothan"--pre-Sedwick channels (Pls. XXVI, XXVIII-XXX, XXXII-XXXIV) suggest deltaic environments. The distribution patterns of the Avis Sandstone (Pl. XXVII; figs. 4, 13-14) and the post-Saddle Creek--pre-Stockwether channel sandstone (Pl. XXXI; figs. 8, 17-18) could be characteristic of either tidal or fluvial channels, produced by rapid lateral shifting of channel distributaries. Surface studies by McGowen and Waller (1965, personal communication) do not support the interpretation of a tidal origin since only unidirectional sedimentary structures have been observed.

Near the distal areas of several channel distributaries (Pls. XXVI, XXVIII-XXX, XXXII-XXXIV) in the study interval, the channel-fill deposits thicken and appear to become lobate. These lobes possibly may be similar to "bar-finger" sands of the Mississippi River delta described by Fisk (1954, pp. 76-99; 1961, pp. 29-52). Fisk (*idem*) observed that as the sediments carried by the Mississippi River reached the sea, the most active deposition occurred close to the mouths of the distributaries and created bulges on the front of the delta platform. Fisk (*idem*) also noticed that effects from great "bulge" accumulation in the Southwest Pass affects bottom contours to a depth of 240 feet.

Direction of channel scour can be interpreted with reasonable assurance, but channel gradient remains difficult to reconstruct since compaction between an overlying limestone datum and the channel-fill deposit may distort the isopach pattern which reflects the paleovalley. Until paleotopographic maps are carefully constructed at the bases of several channels, a study of stream gradients and their environmental significance within the study interval will be impractical.

Channel distribution.--In the study interval channel-fill deposits normally occur in synclinal areas (Pls. XLII-XLIV). Since channel systems will naturally develop in topographically low areas, a relationship between synclines and paleotopographic low areas apparently existed. Therefore, channel deposits commonly occur in synclines which were also low areas on the paleotopographic surface. As successive channel systems developed during the Cisco, each pattern was, to some degree, apparently controlled by differential shale-sand compaction related to the preceding underlying channel system. Shale compaction in non-channel areas was generally greater than sandstone compaction or subsidence of channel-fill sandstone due to excessive weight. Thus, paleotopographic compactional lows, which commonly formed between channel distributaries, provided the route along which the next overlying channel system probably developed. Therefore, succeeding channel systems (separated by a shale and/or limestone interval) have trends that are generally parallel (figs. 13-20), but laterally off-set due to shale compaction. In some areas, however, successive channel-fill sandstones (fig. 13-20) cross each other in local areas where unusually low paleotopographic areas resulted from subsidence beneath abnormally thick channel lobes, bifurcations or convergences in the lowermost of the two successive channels. Some intersections of channels may only be accidental, but comparison of channel isopach maps (Pls. XXVI-XXXIV) and paleotopographic maps (Pls. XXXV-XXXVI) suggests that most intersections are related to unusual accumulation of sandstone in the lower channel, which resulted in subsidence greater than compaction in the thick shales of the interchannel areas. As many as five pairs of successive channel sandstone intersections have been observed in the same local area (Pl. XLI).

Figures 13-20 illustrate the relationship of two successive channel patterns and the relative similarity of channel trends throughout deposition of the Cisco Group. These figures illustrate the roughly parallel but laterally offset nature of successive channels, as well as the less common "overlap, crossing or stacking" of successive sandstone bodies.

Summary.--The predominantly west-southwestward trending channels of the Cisco Group are apparently deltaic in origin as based on geometric distribution. Channel deposits which have a linear pattern occur primarily in structural lows created by differential sand-shale compaction in non-channel areas and increased subsidence of massive sandstone bodies as a result of compaction in underlying shales.

Successive channel trends commonly parallel each other with lateral offset, except in areas of intersection on topographic lows created by massive sandstone subsidence. Compactional features which contribute to channel distribution were superimposed on a regional, gently sloping monocline.

SUGGESTIONS FOR FURTHER STUDY

The present study, complemented by surface studies of other investigators, has only begun to approach an interpretation of the depositional framework of the strata of the Cisco Group in North-central Texas. Much concentrated work and application of varied surface and subsurface methods are needed to solve satisfactorily many more problems in this area. Listed below are several suggestions for further study.

1. The present study illustrates the general depositional framework. Therefore, the next step is to concentrate on thin vertical sections over wider areal extent. Perhaps the characteristics learned from the study of these intervals can be applied to thicker units in order to illustrate more fully the depositional history.

2. Improved correlation between the surface and subsurface, not only of key limestones but of sands and various facies and channel tracts, is needed. An altimeter survey along the outcrop of several key limestones and additional interval thickness data at the surface, coupled with better well control would increase the validity of surface-subsurface

correlations. Control in the "no-man's land," (a strip about two miles wide downdip from the outcrop where subsurface data cannot be recorded on electric logs because of surface well casings) could possibly be obtained by radioactive logging in old water and oil wells, seismic refraction surveys, and selective coring operations.

3. Problem areas in the subsurface which merit more work are in the intervals between the Home Creek-Bunger limestones, Crystal Falls-Saddle Creek limestones, and Sedwick-Coleman Junction limestones. Because few persistent marker limestones are present in these intervals, many correlation problems exist which may never be solved without better well control or corings. Several channel-fill sandstones which were not mapped laterally in the present study occur in these intervals (Pl. I).

4. Present well control in problem areas limits more detailed studies in critical areas, such as along channels. An attempt to obtain all available subsurface data should be undertaken in order to provide maximum information for valid interpretations.

5. Channel-fill sandstones are important oil and ground water reservoirs. Continued study of the

relationships between channel patterns, structure, and other related factors would be both interesting and economically important.

6. Continued study, not only of subsurface samples, but expanded petrography and structure studies in surface rocks, are vital to understanding the depositional framework of the Cisco Group. Sedimentary features must be analyzed at the surface since cores are not available in the subsurface study area. Because of inherent limitations and the limited number of available well samples, depositional and provenance studies of Cisco rocks will be generally restricted to the outcrop. However, such surface sedimentary studies are imperative if an adequate picture of the subsurface is to be developed.

7. Study of shale-filled and limestone conglomerate-filled channels would add much to the present knowledge of the deposition framework of the study interval. Possibly with more dense well control and more radioactivity logs, shale channels could be differentiated by tracing the absence of underlying marker limestones and/or presence of more radioactive material characteristic of these deposits.

8. Paleotopographic maps at the bases of all the channel-fill bodies will be necessary to delineate properly these periods of channel erosion and relate them to overlying and underlying marker limestones. Without these paleotopographic maps, projected vertical profiles are not completely valid.

9. Extensive review of Recent sedimentary models must accompany any interpretation of channel deposition and associated structures.

10. With closer well spacing and greater areal extent, perhaps a statistical review of the data in the study interval could yield information useful in understanding regional patterns of deposition.

11. Study of paleo-stream gradients would be useful in understanding the origin or environmental significance of channels. Gradient studies will be limited, perhaps, because of differential subsidence and compaction.

SUMMARY AND CONCLUSIONS

1. Interpretation of the depositional framework of the strata of the Cisco Group of North-central Texas was the primary purpose of this study.
2. Conclusions reached in this study are empirical since they are based on interpretation of electrical logs which were selected to give maximum vertical and lateral control within a four square mile grid. The stratigraphy developed was compared to Recent models, as well as ancient models based on studies in other areas.
3. Rock type and distribution, source direction, tectonics, and paleotopography were illustrated on several subjective subsurface maps and cross sections. Interrelationships between these factors were the basis for environmental interpretations.
4. Several classifications of the Upper Pennsylvanian and Lower Permian strata have been proposed; however, Plummer and Moore's (1922) classification, although not completely suitable, applies best to the study area.
5. The Pennsylvanian--Permian boundary problem was not a concern of this study.

6. The strata of the Cisco Group consists of a highly variable sequence of shale, sandstone, limestone, and coal. Limestones are normally thin, persistent beds which provide a datum for subsurface correlation. Shales are highly fossiliferous, carbonaceous, and probably represent transitional environments. Sandstones can be divided into two groups based on geometry--sheet and linear sandstone bodies.
7. Sheet sandstones have irregular widespread distribution patterns and relatively constant thickness of about 10 feet. These deposits possibly represent a decrease in coarse clastic influx and a transition from predominantly channel-fill sandstones to more normal marine deposition. In some cases these tabular bodies may have resulted from destruction and redeposition of the upper layers of channel deposits by subsequent marine inundation.
8. Linear sandstone bodies, characterized by great variability in thickness and elongate distribution patterns, comprise the majority of sandstone deposits of the Cisco Group. Based on geometric distribution, most linear sandstone bodies were probably sedimentary fills in deltaic distributaries. Some channel-fill sandstones may have been of tidal origin; how-

ever, present field evidence by Waller and McGowen does not support a tidal origin.

9. Many details of channel distribution are masked by interpretive contouring with the present well control and horizontal scale.
10. Local structure in the study interval is apparently related to differential sand-shale compaction and to abnormal shale compaction beneath channel-fill sandstones. These important, but local, compactional structures were superimposed and in part controlled by structural relief on a gently dipping northwestward monocline.
11. Channel-fill deposits commonly occur in structural lows. Apparently most structural lows were also paleotopographic lows which controlled channel distribution.
12. The relative similarity of channel trends may partly be attributed to structural and topographic influence. Differential sand-shale compaction created structural and topographic lows in predominantly shale, non-channel areas. Overlying channel systems commonly developed in these paleotopographic lows and are off-set but parallel to the underlying systems. Rare intersections of successive channel systems occur in probable paleotopographic lows apparently created

by abnormal subsidence beneath unusually massive sandstone bodies in the lobe, bifurcation and convergence areas of the underlying channel system.

13. Future studies in the area should include paleo-topographic maps of channel systems; greater detailed mapping based on denser well control; more intensive study of the relationship between compaction, tectonic structure and channel pattern; extension of the study area to provide more regional pictures, including detailed channel studies many miles downdip; and closer correlation with presently developing environmental interpretation on the out-crop.

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APPENDIX I

Subsurface Control[1]

Well No.	Description
1.	Jones & Stasney, Dawson & Conway #G-2, Shackelford Co., ETRR Sur., Sec. 173.
2.	Wilcox Investment Co., J. T. Morris #1, Shackelford Co., ETRR Sur., Sec. 166.
3.	G. R. Whitney Oil Account, Chloe A. Nail #8, Shackelford Co., ETRR Sur., Sec. 138, GL: 1796.
4.	Marshall R. Young, Cook III #A-30, Shackelford Co., ETRR Sur., Sec. 111, GL: 1828.
5.	Marshall R. Young, Cook 89-A #7, Shackelford Co., ETRR Sur., Sec. 89, GL: 1799.
6.	Marshall R. Young, Cook 61-A #72, Shackelford Co., ETRR Sur., Sec. 61, GL: 1739.
7.	A. V. Jones & Son, Matthews #B-1, Shackelford Co., ETRR Sur., Sec. 55.
8.	Phillips Petroleum Co., Hews #D-1, Shackelford Co., ETRR Sur., Sec. 32, GL: 1609.
9.	Warren Wright, Clausell-Long #1, Shackelford Co., TE&L Sur., Sec. 576, GL: 1430.
10.	Connally & Jackson, Bernstein #1, Shackelford Co., TE&L Sur., Sec. 531.
11.	Twin Oil Corp., L. A. Sanders #A-1, Shackelford Co., TE&L Sur., Sec. 594, GL: 1321.
12.	Texas Crude Oil, W. H. Green #1, Shackelford Co., TE&L Sur., Sec. 812, GL: 1325.
13.	G. F. McQueen et al, C. C. Gillean #1, Shackelford Co. TE&L Sur., Sec. 1530, GL: 1234.
14.	Oxford Drilling Co., Russell #1, Stephens Co., TE&L Sur., Sec. 1534, GL: 1188.
15.	Cherry & Kidd, Waller #1, Stephens Co., TE&L Sur., Sec. 1521, GL: 1206.
16.	McElroy Ranch Co., W. H. Green #1, Stephens Co., TE&L Sur., Sec. 1513, GL: 1201.

[1]Refer to Plates

17. McElroy Ranch Co., W. H. Green, #D-1, Stephens Co., TE&L Sur., Sec. 1505, GL: 1199.
18. McElroy Ranch Co., Barker et al #1, Stephens Co., T&PRR Sur., Sec. 3, GL: 1270.
19. Texaco, Inc., G. H. Mitchell #1, Stephens Co., TE&L Sur., Sec. 1292, GL: 1185.
20. Orion A. Daniels et al, Blach Estate #1, Stephens Co., TE&L Sur., Sec. 1283, GL: 1143.
21. Renwar Oil Corp., Sam Ball #1, Stephens Co., TE&L Sur., Sec. 1264, GL: 1124.
22. J. W. Hastings, Hamil #1, Stephens Co., IAL Sur., Sec. 6, GL: 1245.
23. Gulf Oil Corp., J. M. Ward #C-33, Stephens Co., TE&L Sur., Sec. 1226, GL: 1152.
24. Gulf Oil Corp., J. M. Ward #C-34, Stephens Co., TE&L Sur., Sec. 1238, GL: 1171.
25. Olsan Bros., Inc. & Leo Vesenmeir, Jr., S. P. Robertson #1, Stephens Co., TE&L Sur., Sec. 1356.
26. Birdwell-Hoffman, J. H. Caton #1, Stephens Co., T&PRR Sur., Blk. 5, Sec. 5, GL: 1340.
27. McElroy Ranch Co., Mary Kendrick #1, Stephens Co., TE&L Sur., Sec. 1358, GL: 1300.
28. Woodson Oil Co., J. P. Stewart #1, Stephens Co., TE&L Sur., Sec. 1345, GL: 1297.
29. Woodson Oil Co., Cooper #1, Stephens Co., TE&L Sur., Sec. 1313, GL: 1139.
30. Texaco, Inc., A. M. Moon #2, Stephens Co., TE&L Sur., Sec. 1307, GL: 1170.
31. Texaco, Inc., Walker #B-1, Stephens Co., TE&L Sur., Sec. 1332, GL: 1149.
32. Texoma Production Co., O. R. Cooper #2, Stephens Co., TE&L Sur., Sec. 1336, GL: 1169.
33. Texoma Production Co., Odessa Smith #1, Stephens Co., SPRR Sur., Blk. 3, Sec. 5, GL: 1223.
34. J. E. Connally, R. N. Richarson #1, Stephens Co., SPRR Sur., Sec. 8, GL: 1212.

35. Forrest and Cotton, Burnsides #1, Stephens Co., T&PRR Sur., Blk. 5, Sec. 14, GL: 1258.
36. Texas & Pacific Coal & Oil Co., W. L. Tullos #12, Stephens Co., T&PRR Sur., Blk. 5, Sec. 20, GL: 1362.
37. Roy H. Smith Drilling Co., Z. W. Sutphen #1, Stephens Co., T&PRR Sur., Blk. 5, Sec. 51.
38. Texo Oil Co., McMeen #1, Stephens Co., T&PRR Sur., Blk. 5, Sec. 47.
39. Ada Oil Co., Winston #1, Stephens Co., T&PRR Sur., Blk. 5, Sec. 41, GL: 1379.
40. F. Kirk Johnson, Blanche Winston #1, Stephens Co., T&PRR Sur., Blk. 5, Sec. 39, GL: 1365.
41. Texas Pacific Coal & Oil Co., A. S. Veale #C-11, Stephens Co., TE&L Sur., Sec. 1419, GL: 1250.
42. Commonwealth Oil Co. et al, R. T. Sweeney #1, Stephens Co., TE&L Sur., Sec. 1409, GL: 1318.
43. Pauley-Bond et al, Freeman-Williams #1, Stephens Co., T&PRR Sur., Blk. 5, Sec. 32, GL: 1267.
44. Texaco, Inc., H. E. Wilson #5, Stephens Co., TE&L Sur., Sec. 2100, GL: 1324.
45. Magellan Co., A. N. Sullivan #1, Stephens Co., TE&L Sur., Sec. 2066, GL: 1323.
46. R. W. R. Oil Co., George Neil #1, Stephens Co., TE&L Sur., Sec. 2095, GL: 1389.
47. Texaco, Inc., J. W. Parks #A-76, Stephens Co., TE&L Sur., Sec. 3360, GL: 1287.
48. Texaco, Inc., W. M. Houston #5, Stephens Co., TE&L Sur., Sec. 2090, GL: 1354.
49. Paul & William Moss, W. M Cox #1, Stephens Co., TE&L Sur., Sec. 2067.
50. Texaco, Inc. J. W. Parks #A-75, Stephens Co., TE&L Sur., Sec. 3366, GL: 1295.
51. Texaco, Inc., J. W. Parks #A-74, Stephens Co., TE&L Sur., Sec. 3365, GL: 1320.
52. Texaco, Inc., N. J. Brooks #10, Stephens Co., TE&L Sur., Sec. 3390, GL: 1278.
53. S. D. Johnson et al, C. Hart #1, Stephens Co., TE&L Sur., Sec. 3384.
54. Texaco, Inc., O. Tomlin #1, Stephens Co., BAL Sur., Sec. 87, GL: 1210.

55. Woodley Petroleum Co., Fred Tomlin #A-1, Stephens Co., T&PRR Sur. Blk. 8, Sec. 39, GL: 1228.
56. Wittmer-Knight & Ewing, Charles H. Clark, et al #1, Stephens Co., BAL Sur., Sec. 85, GL: 1245.
57. Magnolia Petroleum Co., C. A. Curry #1, Stephens Co., LAL Sur., Sec. 17, GL: 1268.
58. Texaco, Inc., J. F. Brown #9, Stephens Co., T&PRR Sur., Blk. 8, Sec. 18, GL: 1268.
59. Texaco, Inc., A. J. Jones #1, Stephens Co., T&PRR Sur., Blk. 8, Sec. 13, GL: 1196.
60. Shell Oil Co., O. Tomlin #1, Stephens Co., BAL Sur., Sec. 70, GL: 1246.
61. Rhodes & Lewis, George #2, Stephens Co., BAL Sur., Sec. 56.
62. McElroy Ranch Co., J. H. Sedwick #1, Shackelford Co., BAL Sur., Sec. 54, GL: 1319.
63. Kadane-Griffith Oil Co., Davis #B-1, Stephens Co., T&PRR Sur., Blk. 8, Sec. 9, GL: 1280.
64. Harry Beaumont, Offutt #1, Shackelford Co., TE&L Sur., Sec. 1541, GL: 1208.
65. Taxman Oil Co., Mary Harbaugh #1, Shackelford Co., TE&L Sur., Sec. 1563, GL: 1257.
66. H. F. Pettigrew, T. E. Moore #1, Shackelford Co., TE&L Sur., Sec. 1560, GL: 1270.
67. Roark, Hooker, Roark, Jones, Stasney & S. B. Roberts, Lynch #1, Shackelford Co., BAL Sur., Sec. 9, GL: 1322.
68. Roark, Hooker, Jones & Stasney, R. S. Burchard #1, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 6, GL: 1280.
69. Allied Oil - Fox & Fox, Sanders #B-1, Shackelford Co., TE&L Sur., Sec. 590, GL: 1347.
70. Wilson Exploration Co., Simpson #1, Shackelford Co., BAL Sur., Sec. 13, GL: 1325.
71. Burt C. Johnston, Leach #1, Shackelford Co., BAL Sur., Sec. 15, GL: 1406.

72. Carl Bagwell, Trustee & Parker Petroleum Co., Inc., Hooker Trust #B-28, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 17, GL: 1566.

73. W. K. Wood et al, Matthews Estate #1, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 8, GL: 1481.

74. Tannehill Petroleum Corp., Matthews #C-26, Shackelford Co., ETRR Sur., Sec. 58, GL: 1566.

75. J. R. Christie, Jeter #36, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 15.

76. H. F. Pettigrew, Newell #B-1, Shackelford Co., ETRR Sur., Sec. 87, GL: 1732.

77. Marshall R. Young, Dell Newell Sec. 1, #1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 1, GL:1763.

78. Great Expectations Oil Corp., Dell Newell #S-1, Shackelford Co., ETRR Sur., Sec. 114, GL: 1832.

79. G. B. Cree et al, Mrs. Dell Newell #22-42, Shackelford Co., ETRR Sur., Sec. 142, GL: 1814.

80. John H. DeFord, Trustee, Mrs. Dell Newell #1, Shackelford Co., ETRR Sur., Sec. 168.

81. S & S Drilling Service, Inc., Mrs. Dell Newell #2, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 4, GL: 1837.

82. G. E. Kadane & Sons, Merrick Davis #I-1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 21, GL: 1937.

83. J. W. King, Jr et al, Merrick Davis #1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 18, GL: 1810.

84. Continental Oil Co., L. J. Ackers #I-23, Shackelford Co., T&PRR Sur., Blk. 13, Sec. 23, GL: 1817.

85. Victory Oil Co. & Bell-Dumont, Juliet Grimes #1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 31, GL: 1793.

86. Woodson Oil Co., Davis-Morton #1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 33, GL: 1735.

87. Phillips Petroleum Co., Roark #1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 45, GL: 1747.

88. Humphrey Marshall, Merrick Davis #1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 25.

89. Harry Lewis, Jr., F. B. Cloud #1, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 38, GL: 1613.

90. H. P. Key et al, W. H. Green #1, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 47, GL: 1672.

91. Intex Oil Co., Elliott #1, Shackelford Co., LAL Sur., Sec. 19, GL: 1392.

92. Roark, Hooker & Roark, J. H. & R. B. Elliott #1, Shackelford Co., LAL Sur., Sec. 11, GL: 1445.

93. Omitted

94. SoRelle & SoRelle, Flippen #B-4, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 41.

95. Kendrick Oil Co., Martin #1, Shackelford Co., BAL Sur., Sec. 37.

96. M. J. Mitchell, Robinson #1, Shackelford Co., BAL Sur., Sec. 42.

97. M. J. Mitchell, W. H. Green #1, Shackelford Co., BAL Sur., Sec. 34, GL: 1354.

98. Wayne Petroleum Co., W. H. Green Estate #1, Shackelford Co., BOA Sur., Sec. 1.

99. Henry Homes, Jr., A. E. Koenig #1, Shackelford Co., LAL Sur., Sec. 68, GL: 1348.

100. Phillips Petroleum Co., Pan Ace #1, Shackelford Co., LAL Sur., Sec. 16, GL: 1351.

101. M. J. Mitchell, S. J. Pritchard #1, Shackelford Co., BOA Sur., Sec. 44, GL: 1389.

102. Harry Beaumont, J. H. Elliott #1, Shackelford Co., BOA Sur., Sec. 22, GL: 1292.

103. Roeser & Pendleton Inc., Davis Parrish #1, Shackelford Co., BOA Sur., Sec. 3, GL: 1292.

104. Charles H. Osmond, W. H. Green #1, Shackelford Co., BAL Sur., Sec. 29, GL: 1308.

105. Woodson Oil Co., Lummus-Cottle-Elliott Unit #1, Shackelford Co., BOA Sur., Sec. 5, GL: 1358.

106. W. L. Meadows, Jr., Grover Morris #1, Shackelford Co., BOA Sur., Sec. 40, GL: 1334.
107. The Ibex Co., Compt #1, Stephens Co., BAL Sur., Sec. 58, GL: 1293.
108. Gilchrist Drilling Co., Tomlin #1, Stephens Co., BAL Sur., Sec. 74, GL: 1262.
109. Texaco, Inc., C. Whitfield #1, Stephens Co., BOA Sur., Sec. 35, GL: 1286.
110. Deeprock Oil Corp., F. M. Tomlin #1, Stephens Co., BOA Sur., Sec. 31, GL: 1221.
111. Fred M. Manning, Inc., W. T. Moore et al #A-3, Stephens Co., TE&L Sur., Sec. 2255.
112. Dekalb Agricultural Association, Inc., Ima Higgins #2, Stephens Co., TE&L Sur., Sec. 2257, GL: 1256.
113. Sinclair Prairie, E. S. Curry #1, Stephens Co., TE&L Sur., Sec. 2264, GL: 1270.
114. Texas Pacific Coal & Oil Co., Harold Singleton #1, Stephens Co., TE&L Sur., Sec. 2032, GL: 1253.
115. Don Choate & Russell Maguire, Lauderdale #1, Stephens Co., TE&L Sur., Sec. 2963, GL 1313.
116. Henderson Drilling Co., Curry Estate #1, Stephens Co., TE&L Sur., Sec. 2035.
117. Connally & Jackson, Plumb Heirs #1, Stephens Co., T&PRR Sur., Blk. 7, Sec. 16.
118. Connally & Jackson, E. C. Head et al #1, Stephens Co., T&PRR Sur., Blk. 7, Sec. 15, GL: 1302.
119. W. H. Green et al, M. C. Lauderdale #1, Stephens Co., T&PRR Sur., Blk. 6, Sec. 58, GL: 1360.
120. Fenix & Scisson & Cannon Drilling Co., Fambrough #1, Stephens Co., T&PRR Sur., Blk. 6, Sec. 12, GL: 1325.
121. James B. Dunnigan, J. Black #1, Stephens Co., T&PRR Sur., Blk. 6, Sec. 15, GL: 1890.
122. A. E. Elliott, Sam Harris Estate #1, Stephens Co., T&PRR Sur., Blk. 6, Sec. 37, GL: 1384.

123. Haesemeyer & Rice, E. M. Newman #1, Stephens Co., T&PRR Sur., Blk. 6, Sec. 62, GL: 1375.
124. Gulf Oil Corp., Maggie Harris et al #2, Stephens Co., T&PRR Sur., Blk. 6, Sec. 54, GL: 1440.
125. Gilchrist Drilling Co., J. D. Gray #1, Stephens Co., T&PRR Sur., Blk. 6, Sec. 18.
126. Two Square "D" Oil Co., Pearl D. Guest #1, Stephens Co., T&PRR Sur., Blk. 6, Sec. 30, GL: 1480.
127. E. C. Johnston Co., Mary Edith Marrs #1, Stephens Co., T&PRR Sur., Blk. 6, Sec. 89, GL: 1614.
128. Cannon Drilling Co., E. A. Hancock #1, Stephens Co., T&NORR Sur., Blk. 8, Sec. 7, GL: 1508.
129. Royalty Corporation of America et al, Garner #1, Stephens Co., T&PRR Sur., Blk. 6, Sec. 83, GL: 1355.
130. Connally & Jackson, Alex Fambro #1, Stephens Co., T&PRR Sur., Blk. 7, Sec. 28, GL: 1367.
131. Fletcher Oil & Gas Drilling Co., Tomlinson #1, Stephens Co., SPRR Sur., Sec. 446, GL: 1397.
132. Woodley Petroleum Co., G. W. Thorpe #4, Stephens Co., SPRR Sur., Sec. 456, GL: 1390.
133. A. J. Slagter, Jr., F. Thorp #1, Stephens Co., G. Click Sur. #50, GL: 1358.
134. J. E. Connally Oil Co., Lillie Adams #1, Stephens Co., T&PRR Sur., Blk. 7, Sec. 49, GL: 1315.
135. Prairie Oil & Gas, Tucker #1, Stephens Co., T&PRR Sur., Blk. 7, Sec. 21, GL: 1415.
136. L. A. Thomson, Bernie McCrea #1, Stephens Co., John Stephenson Sur., Sec. 385, GL: 1320.
137. Delta Oil Co. of Delaware, Bernie McCrea #C-1, Stephens Co., SPRR Sur., Sec. 371.
138. Lone Star Production Co., Carrie E. Tipton #1, Stephens Co., TE&L Sur., Sec. #A-857, GL: 1284.
139. Connally & Jackson, J. M Rush #1, Stephens Co., T&PRR Sur., Blk. 7, Sec. 25.

140. Fred M. Manning, Inc., Henry Compton #1, Stephens Co., T&PRR Sur., Blk. 7, Sec. 35.
141. Woodley Petroleum Co., C. J. O'Conner #1, Stephens Co., T&PRR Sur., Blk. 7, Sec. 53. GL: 1382.
142. Sorrells Oil Co., Ross Elliott #1, Stephens Co., T&PRR Sur., Blk. 7, Sec. 37, GL: 1389.
143. J. H. DeFord, Trustee, W. S. Bynum #1, Shackelford Co., UIL Sur., Sec. 92, GL: 1405.
144. Omitted
145. Monsanto Chemical Co., Oma #1, Shackelford Co., BOA Sur., Sec. 46, GL: 1320.
146. Honolulu Oil Co., Pool #1, Shackelford Co., UIL Sur., Sec. 35, GL: 1330.
147. Panhandle Oil Corp. & Champion Winkler Oil Corp., Midkiff #1, Shackelford Co., UIL Sur., Sec. 66, GL: 1340.
148. Panhandle Oil Corp. Spencer #1, Shackelford, Co., UIL Sur., Sec. 113, GL: 1408.
149. Jack's Oil Wells, Inc., O. L. Hubbard #1, Shackelford Co., UIL Sur., Sec. 74.
150. Bolin Oil Co. & J. K. Wadley, W. L. English #1, Shackelford Co., UIL Sur., Sec. 28.
151. J. J. Eisner, Snyder Estate #1, Shackelford Co., LAL Sur., Sec. 34, GL: 1507.
152. Taxman Oil Co. & D. L. Rose, C. B. Snyder #1, Shackelford Co., LAL Sur., Sec. 29, GL: 1411.
153. Creslenn Oil Co., Snyder #1, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 66, GL: 1507.
154. Don L. Choate, C. B. Snyder, Jr. #1, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 65, GL: 1479.
155. P. T. Fullwood, Trustee, J. L. Snyder #1, Shackelford Co., LAL Sur., Sec. 66, GL: 1441.
156. Humble Oil & Refining Co., Green #C-1, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 55, GL: 1542.
157. M. E. Body, A. E. Dyer, Trustee #1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 73, GL: 1605.

158. Gilchrist Drilling Co., Dyer #2, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 63, GL: 1523.
159. Fogelson & Ingleright, H. A. Lones #2, Shackelford Co., T&PRR Sur., Blk. 11, Sec. 64, GL: 1507.
160. Humble Oil & Refining Co., Will H. Green #E-1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 70. GL: 1867.
161. Standard Oil of Kansas, W. H. Green #1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 68, GL: 1802.
162. Apache Drilling Co., Walker-Buckler #1, Shackelford Co., T&PRR Sur., Blk. 13, Sec. 62, GL: 1956.
163. Sojourner Drilling Co., Ltd., Alice Walker #1, Shackelford Co., T&PRR Sur., Blk, 13, Sec. 74, GL: 1906.
164. Starr Oil & Gas Co., J. B. Windham #1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 80.
165. Black Drilling Co., Windham #A-1, Shackelford Co., T&PRR Sur., Blk. 12, Sec. 88, GL: 1796.
166. Bridwell Oil Co., Idi R. Webb #A-1, Callahan Co., T&PRR Sur., Blk. 12, Sec. 91, GL: 1939.
167. L. A. Hedrick, J. T. Windham #1, Callahan Co., ETRR Sur., Sec. 10, GL: 1862.
168. West Central Drilling Co., J L. Dugan #1, Callahan Co., BBB&C Sur., Sec. 71, GL: 1885.
169. W. D. Evans, Katie Dugan #2, Callahan Co., BBB&C Sur., Sec. 72.
170. Constantine, Perkins, & St. John & Lunsford Drilling Co., Hugh W. Ross et al #1, Callahan Co., BBB&C Sur., Sec. 86, GL: 1946.
171. Metaco Oil Co., Claude Osborn #1, Callahan Co., BBB&C Sur., Sec. 96, GL: 1883.
172. Stroube Central, et al, McDonald #1, Callahan Co., BBB&C Sur., Sec. 101, GL: 1828.
173. Womer & Tilton, Ralph Snyder #1, Callahan Co., BBB&C Sur., Sec. 117, GL: 1659.

174. Otto Oil Co., Ltd. & M. L. Kinnebrew, Mrs. E. M. Harris #1, Callahan Co., BBB&C Sur., Sec. 114, GL: 1677.
175. Magnolia Petroleum Co., Dyer Trust #1, Callahan Co., ETRR Sur., Sec. 22, GL: 1729.
176. Intex Oil Co., Elma Jackson #1-96, Callahan Co., T&PRR Sur., Blk. 12, Sec. 96, GL: 1530.
177. Neaves Petroleum Development Co., I. N. Jackson #A-1, Callahan Co., ETRR Sur., Sec. 16.
178. Neaves Petroleum Development Co., C. B. Snyder #B-1, Callahan Co., BBB&C Sur., Sec. 141.
179. John H. Wilson, C. B. Snyder #1, Callahan Co., BBB&C Sur., Sec. 142, GL: 1727.
180. Bruce Connally, Inc. et al, N. M. George #1, Callahan Co., BOA Sur., Sec. 63.
181. Craig & Wittmer, Morris Snyder #B-1, Callahan Co., BOA Sur., Sec. 58, GL: 1531.
182. Fain & McGaha, C. B. Snyder #4, Callahan Co., T&NO Sur., Sec. 6, GL: 1754.
183. Rhodes Drilling Co., J. W. Kennedy #1, Callahan Co., LAL Sur., Sec. 51, GL: 1944.
184. A. V. Jones & Son & L. H. Hill, Blanton #1, Callahan Co., LAL Sur., Sec. 53, GL: 1501.
185. Fain & McGaha, B. A. & Ray Elliott #1, Callahan Co., LAL Sur., Sec. 54 & 55, GL: 1431.
186. Paramount Oil Inc., H. D. Hart #3, Callahan Co., LAL Sur., Sec. 61, GL: 1477.
187. Fowler Farm Oil Corp., Fred Hart #1, Callahan Co., D&DA Sur., Sec. 7, GL: 1439.
188. H. G. Henson, Blankenship #1, Callahan Co., TE&L Sur., Sec. 2040, GL: 1478.
189. Gly, Inc., Cottle #1, Callahan Co., UIL Sur., Sec. 126, GL: 1403.
190. McElroy Ranch Co., Emma Cottle #1, Callahan Co., TE&L Sur., Sec. 2048, GL: 1493.

191. John Fidel, Emma Cottle #1, Callahan Co., TE&L Sur., Sec. 3196.
192. R. K. Stoker, Yarbrough #1, Callahan Co., TE&L Sur., Sec. 3194, GL: 1561.
193. McElroy Ranch, W. G. Jones #81, Callahan Co., TE&L Sur., Sec. 3161, GL: 1478.
194. G. A. Bloomquist, E. C. McClelland #2, Eastland Co., SPRR Sur., Sec. 466, GL: 1562.
195. Vern W. Bailey, Dan Hamilton Estate #3, Eastland Co., SPRR Sur., Sec. 462, GL: 1479.
196. Lone Star Production Co., G. P. Mitcham #E-1, Eastland Co., SPRR Sur., Sec. 491, GL: 1652.
197. Johnson Oil & Supply, G. P. Mitcham #1, Eastland Co., SPRR Sur., Sec. 469, GL: 1524.
198. Midway Oil Co., W. H. Grove Estate #1, Eastland Co., SPRR Sur., Sec. 473, GL: 1475.
199. Lone Star Production Co., C. J. Kleiner #C-1, Eastland Co., H&TC RR Sur., Blk. 4, Sec. 71, GL: 1458.
200. W. M. Jarrel, Exal Continental Nat'l Bank #1, Eastland Co., H&TC RR Sur., Blk. 4, Sec. 55, GL: 1560.
201. Sheets & Walton Drilling Co., G. T. Parrack #C-1, Eastland Co., H&TC RR Sur., Blk. 4, Sec. 18, GL: 1639.
202. Harding Bros., Poteet #1, Eastland Co., H&TC RR Sur., Blk 4, Sec. 9, GL: 1555.
203. Nueve Operating Co., Courtney #18, Eastland Co., H&TC RR Sur., Blk. 4, Sec. 41, GL: 1578.
204. McElroy Ranch Co., M. E. Robinson #1, Eastland Co., H&TC RR Sur., Blk 3, Sec. 5.
205. Greenbrier Oil Co., Mary Stansell #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 43, GL: 1620.
206. Gulf Oil Corp., G. P. Fee #A-3, Eastland Co., H&TC RR Sur., Blk. 4, Sec. 77, GL: 1604.
207. Bankline Oil Co. et al, G. P. Fee #B-1, Eastland Co., H&TC RR Sur., Blk. 4, Sec. 65, GL: 1579.

207. Bankline Oil Co. et al, G. P. Fee #B-1, Eastland Co., H&TC RR Sur., Blk. 4, Sec. 65, GL: 1579.

208. Benson-Montin, E. B. Hayes #1, Eastland Co., SPRR Sur., Sec. 498, GL: 1577.

209. J. E. Connally et al, Sam Baugh #1, Eastland Co., City of Cisco, City Blk. 139, GL: 1676.

210. Connally & Jackson, Walker Estate #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 87.

211. Bankline Oil Co., Albert Hanson #2, Eastland Co., SPRR Sur., Sec. 501, GL: 1608.

212. Russell Cobb, Jr., Etta Camp #1, Eastland Co., TE&L Sur., Sec. 3183, GL: 1646.

213. W. G. Arnot, Dennison #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 107, GL: 1726.

214. W. W. Lechner, Clifford Estate #1, Callahan Co., TE&L Sur., Sec. 3153, GL: 1535.

215. McElroy Ranch Co., W. A. Ramsey #1, Callahan Co., TE&L Sur., Sec. 2276, GL: 1622.

216. Harrison & Norwood, Roxie Ogle #1, Callahan Co., TE&L Sur., Sec. 2974, GL: 1477.

217. Woodley Petroleum Co., First State Bank of Abilene #1, Callahan Co., TE&L Sur., Sec. 2978, GL: 1559.

218. G. Jack Carter, Williams #1, Callahan Co., SPRR Sur., Blk. 5, Sec. 301, GL; 1652.

219. J. G. Thompson, Guy Houston #1, Callahan Co., SPRR Sur., Sec. 309, GL: 1670.

220. J. W. King, Jr. & John DeFord, Trustee, Arthur Beasley #1, Callahan Co., D&DA Sur., Sec. 25, GL: 1590.

221. J. W. King, Jr. et al, N. L. Finley #1, Callahan Co., D&DA Sur., Sec. 13, GL: 1533.

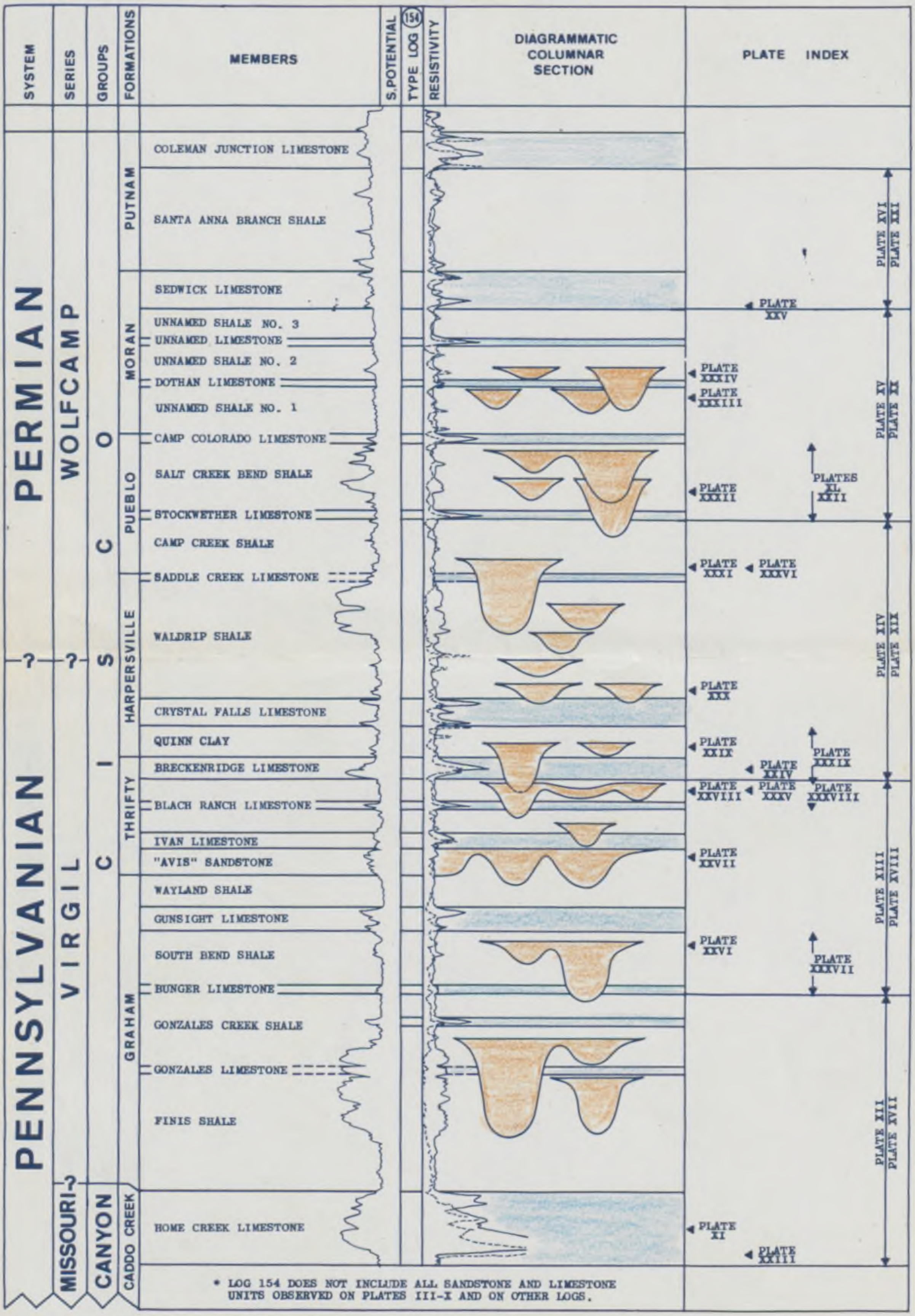
222. Lord & Ream Production Co., Earl Burke #1, Callahan Co., D&DA Sur., Sec. 16, GL: 1531.

223. Woodley Petroleum Co., P. G. Hatchett #32, Callahan Co., D&DA Sur., Sec. 20, GL: 1578.

224. Miami Operating Co., Inc., N. L. Finley #2, Callahan Co., BOA Sur., Sec. 72, GL: 1515.
225. C. R. Craig, Lula Snyder #1, Callahan Co., BBB&C Sur., Sec. 144, GL: 1588.
226. Fulwiler, Watkins, Fraley, Hutchinson #2, Callahan Co., BBB&C Sur., Sec. 136.
227. Brannon & Murray, Dyer #1, Callahan Co., BBB&C Sur., Sec. 135, GL: 1601.
228. Fisher & Stoker, M. L. Gilliand Fee #1, Callahan Co., BBB&C Sur., Sec. 131, GL: 1797.
229. Arkansas Fuel Oil Co., Griggs #1, Callahan Co., BBB&C Sur., Sec. 107, GL: 1769.
230. B. H. Freeland et al, Ross #1, Callahan Co., BBB&C Sur., Sec. 110, GL: 1780.
231. Warren & E. C. Johnston Co., Hugh Ross #X-4, Callahan Co., BBB&C Sur., Sec. 94, GL: 1910.
232. Paul M. Hicks, Latimer #1, Callahan Co., BBB&C Sur., Sec. 93, GL: 1932.
233. West Central Drilling Co., D. E. Allen #1, Callahan Co., BBB&C Sur., Sec. 81, GL: 1973.
234. Castle, Castle & Winfrey, Hoyt Rogers #1, Callahan Co., BBB&C Sur., Sec. 64, GL: 1983.
235. L. A. Hedrick, Jackson #1, Callahan Co., James O. Young Sur. #523, GL: 1937.
236. Bridwell Oil Co., M. B. Nichols #1, Callahan Co., L. D. Gibbs Sur., Sec. 34, GL: 1939.
237. L. A. Hedrick, W. B. Phillips #1, Callahan Co., BBB&C Sur., Sec. 10, GL: 1940.
238. W. H. Eckes et al, Harris-Barton #1, Callahan Co., BBB&C Sur., Sec. 8.
239. Mid-Cintinent Petroleum Corp., Brown #B-1, Callahan Co., SPRR Sur., Blk. 2, Sec. 1, GL: 1915.
240. L. A. Hedrick, J. W. Brown #1, Callahan Co., W. H. Jackson Sur. #2, GL: 1901.
241. Ned C. Butler, White & Bauchette #1, Callahan Co., Victoria CSL Sur. #336, GL: 1908.

242. Copaz Oil & Gas Corp., Jones #1, Callahan Co., Victoria CSL Sur. #336, GL: 1956.
243. Oil Well Drilling Co., Ace Hickman #1, Callahan Co., BBB&C Sur., Sec. 149.
244. Geochemical Surveys, Beasley #W-1, Callahan Co., D&DA sur., Sec. 41.
245. Chester A. Imes & The Federal Royalty Co., J. H. Hughes #1, Callahan Co., D&DA Sur., Sec. 47, GL: 1780.
246. Arnold & Olga Barrett et al, Oscar Rose #A-1, Callahan Co., SPRR Co. Sur., Blk. 8, Sec. 7, GL: 1849.
247. Babb-Barbosa Oil Co., W. T. McClure #1, Callahan Co., E. Shipman Sur.
248. Star Oil Co., W. T. McClure #1, Callahan Co., SPRR Sur., Sec. 4, GL: 1840.
249. M. L. Kinnebrew et al, Cora Trantham #1, Callahan Co., SPRR Sur., Blk. 5, Sec. 320.
250. Ungren & Frazier, Lovelady #1, Callahan Co., J. Barton Sur. #6, GL: 1758.
251. L. A. Warren et al, E. R. Battle #1, Callahan Co., BOA Sur., Sec. 20, GL: 1723.
252. Texas Crude Oil Co., Shrader #1, Callahan Co., Matilda Cherry Sur., GL: 1773.
253. Johnson & Warren, I. W. Morgan #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 132, GL: 1686.
254. Low Drilling Co., Townsend #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 100, GL: 1675.
255. Bartlett Oil Co., Cozart #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 101, GL: 1591.
256. K. L. B. Drilling Corp., F. E. Clark #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 82, GL: 1618.
257. Socony Mobil Oil Co., Olga Taylor #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 94, GL: 1703.
258. Oil Associates, Inc., J. R. Bacon #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 50, GL: 1632.
259. Tom Potter, Britton Estate #1, Eastland Co., H&TC RR Sur., Blk. 3, Sec. 41.

PLATE I



REPRESENTATIVE LOG AND DIAGRAMMATIC COLUMNAR SECTION

PLATE II

INDEX MAP FOR CROSS SECTIONS AND PROFILES

PLATE III

Sandstone

Shale

Limestone

Interpretive Position

0 1/2 1 2 3 Miles

APPROXIMATE HORIZONTAL SCALE

STRATIGRAPHIC CROSS SECTION

LINES WERE PROJECTED FROM WELL LOCATIONS TO AN ARBITRARY STRIKE LINE AND, THEREFORE, INDICATED DISTANCES BETWEEN WELLS MAY NOT BE TRUE. SEE PLATE II. STRUCTURAL AND ISOPACH INTERPRETATION BETWEEN WELLS WAS NOT ATTEMPTED ON THIS CORRELATION CROSS SECTION.

MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965

Sandstone

Shale

Limestone

Interpretive Position

0 1/2 1 2 3 Miles

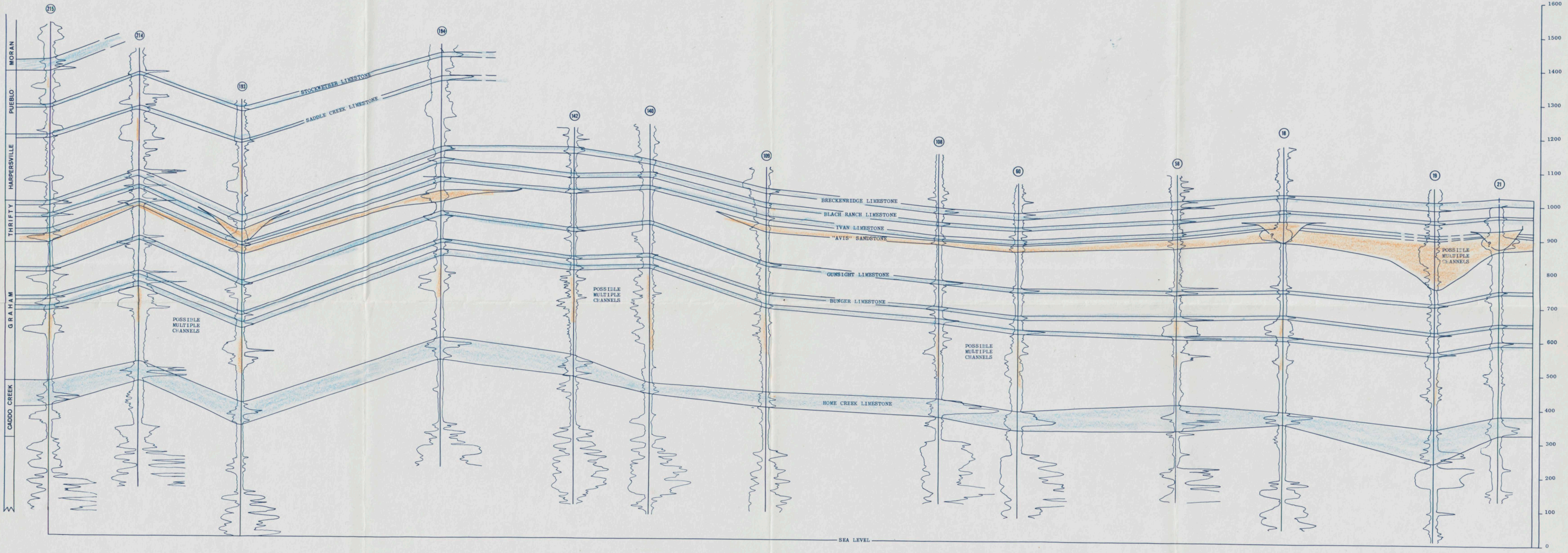
APPROXIMATE HORIZONTAL SCALE

STRATIGRAPHIC CROSS SECTION

LINES WERE PROJECTED FROM WELL LOCATIONS TO AN ARBITRARY STRIKE LINE AND, THEREFORE, INDICATED DISTANCES BETWEEN WELLS MAY NOT BE TRUE. SEE PLATE II. STRUCTURAL AND ISOPACH INTERPRETATION BETWEEN WELLS WAS NOT ATTEMPTED ON THIS CORRELATION CROSS SECTION.

MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965

PLATE V



Sandstone
Shale
Limestone
Interpretive Position

0 1/2 1 2 3
1:48,000
APPROXIMATE HORIZONTAL SCALE

STRATIGRAPHIC CROSS SECTION

LINES WERE PROJECTED FROM WELL LOCATIONS TO AN ARBITRARY STRIKE LINE AND, THEREFORE, INDICATED DISTANCES BETWEEN WELLS MAY NOT BE TRUE. SEE PLATE II. STRUCTURAL AND ISOPACH INTERPRETATION BETWEEN WELLS WAS NOT ATTEMPTED ON THIS CORRELATION CROSS SECTION.

MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965

PLATE VI

Sandstone

Shale

Limestone

Interpretive Position

0 1/2 1 2 3 Miles

1:48000

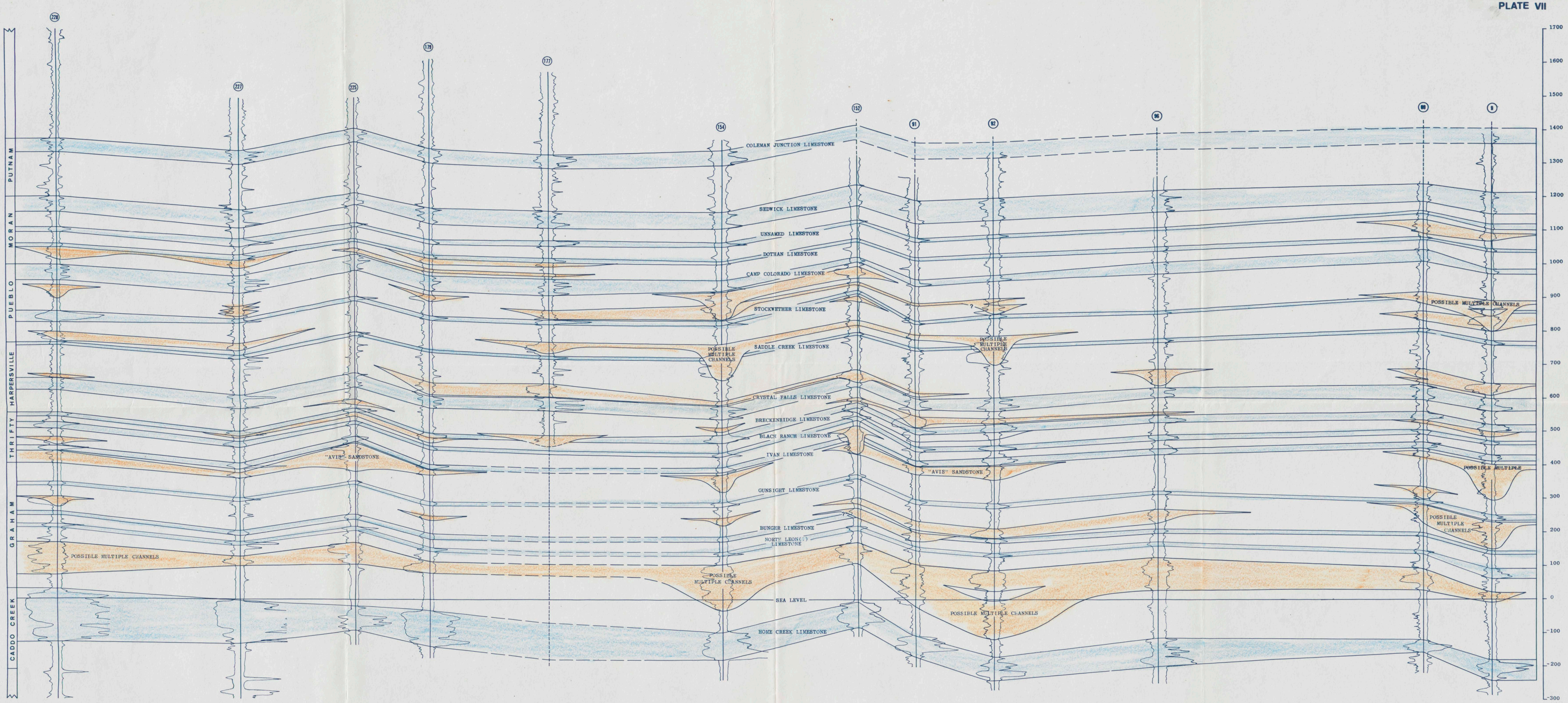
APPROXIMATE HORIZONTAL SCALL

STRATIGRAPHIC CROSS SECTION

LINES WERE PROJECTED FROM WELL LOCATIONS TO AN ARBITRARY DIP LINE AND, THEREFORE, INDICATED DISTANCES BETWEEN WELLS MAY NOT BE TRUE. SEE PLATE II. STRUCTURAL AND ISOPACH INTERPRETATION BETWEEN WELLS WAS NOT ATTEMPTED ON THIS CORRELATION CROSS SECTION.

MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965

PLATE VII



Sandstone
Shale
Limestone
Interpretive Position

0 1/2 1 2 3 Miles

APPROXIMATE HORIZONTAL SCALE

STRATIGRAPHIC CROSS SECTION

LINES WERE PROJECTED FROM WELL LOCATIONS TO AN ARBITRARY STRIKE LINE AND, THEREFORE, INDICATED DISTANCES BETWEEN WELLS MAY NOT BE TRUE. SEE PLATE II. STRUCTURAL AND ISOPACH INTERPRETATION BETWEEN WELLS WAS NOT ATTEMPTED ON THIS CORRELATION CROSS SECTION.

MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965

STRATIGRAPHIC CROSS SECTION

LINES WERE PROJECTED FROM WELL LOCATIONS TO AN ARBITRARY DIP LINE AND, THEREFORE, INDICATED DISTANCES BETWEEN WELLS MAY NOT BE TRUE. SEE PLATE II. STRUCTURAL AND ISOPACH INTERPRETATION BETWEEN WELLS WAS NOT ATTEMPTED ON THIS CORRELATION CROSS SECTION.

MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965

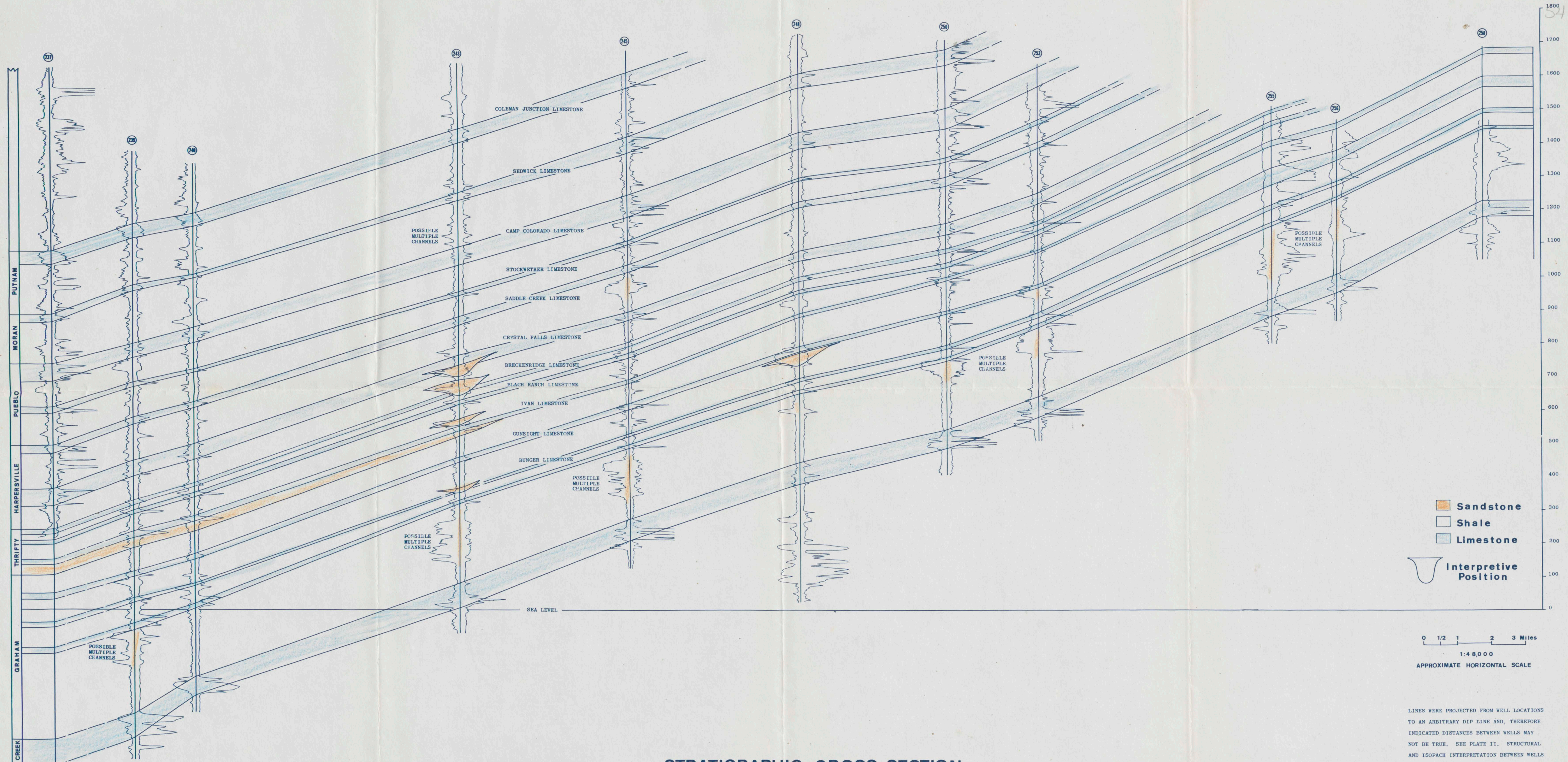
PLATE IX

LINES WERE PROJECTED FROM WELL LOCATIONS TO AN ARBITRARY DIP LINE AND, THEREFORE, INDICATED DISTANCES BETWEEN WELLS MAY NOT BE TRUE. SEE PLATE II. STRUCTURAL AND ISOPACH INTERPRETATION BETWEEN WELLS WAS NOT ATTEMPTED ON THIS CORRELATION CROSS SECTION.

STRATIGRAPHIC CROSS SECTION

MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965

PLATE X



STRATIGRAPHIC CROSS SECTION

LINES WERE PROJECTED FROM WELL LOCATIONS TO AN ARBITRARY DIP LINE AND, THEREFORE INDICATED DISTANCES BETWEEN WELLS MAY NOT BE TRUE. SEE PLATE II. STRUCTURAL AND ISOPACH INTERPRETATION BETWEEN WELLS WAS NOT ATTEMPTED ON THIS CORRELATION CROSS SECTION.

MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965

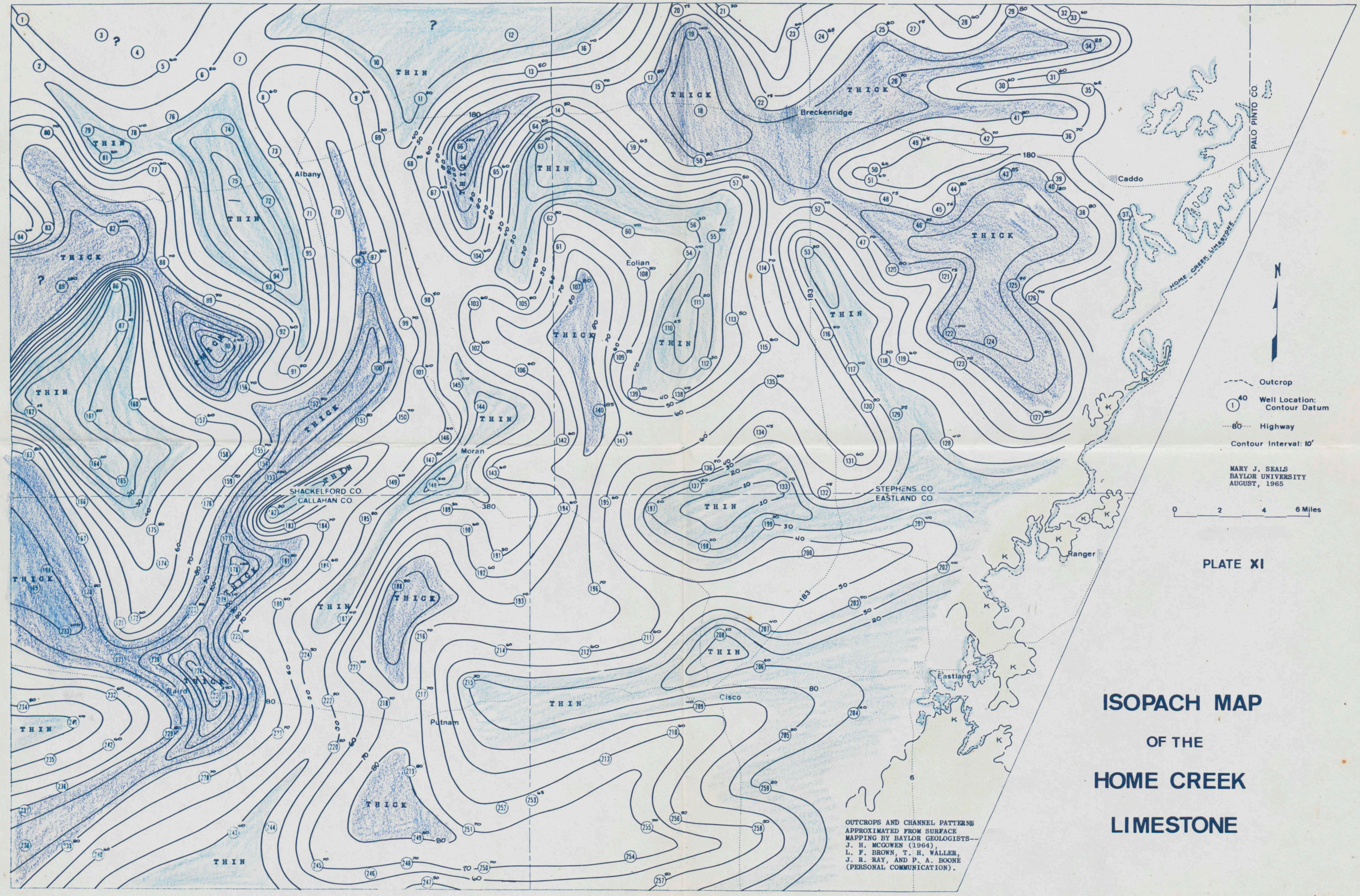


PLATE XI

ISOPACH MAP OF THE HOME CREEK LIMESTONE

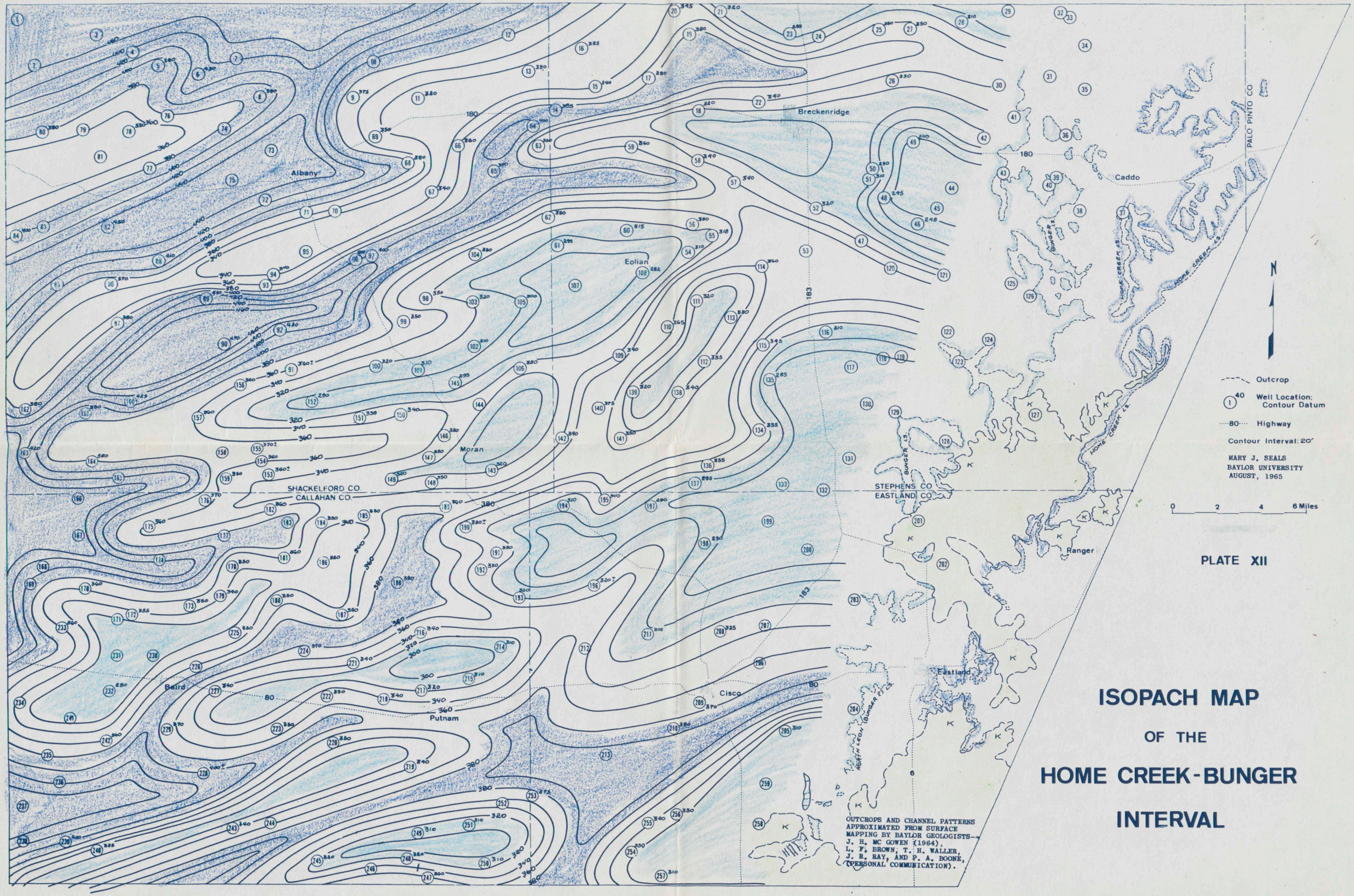
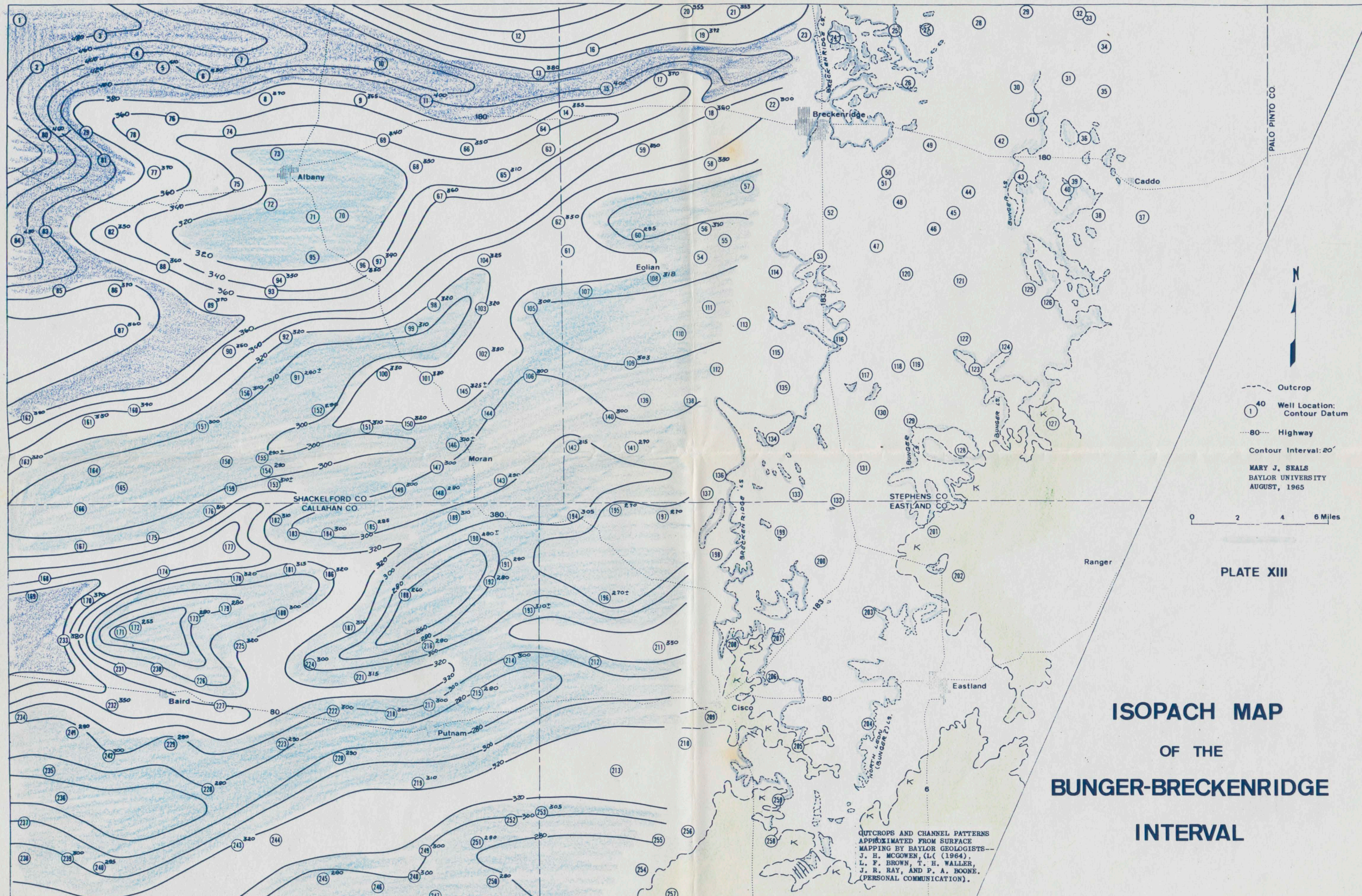
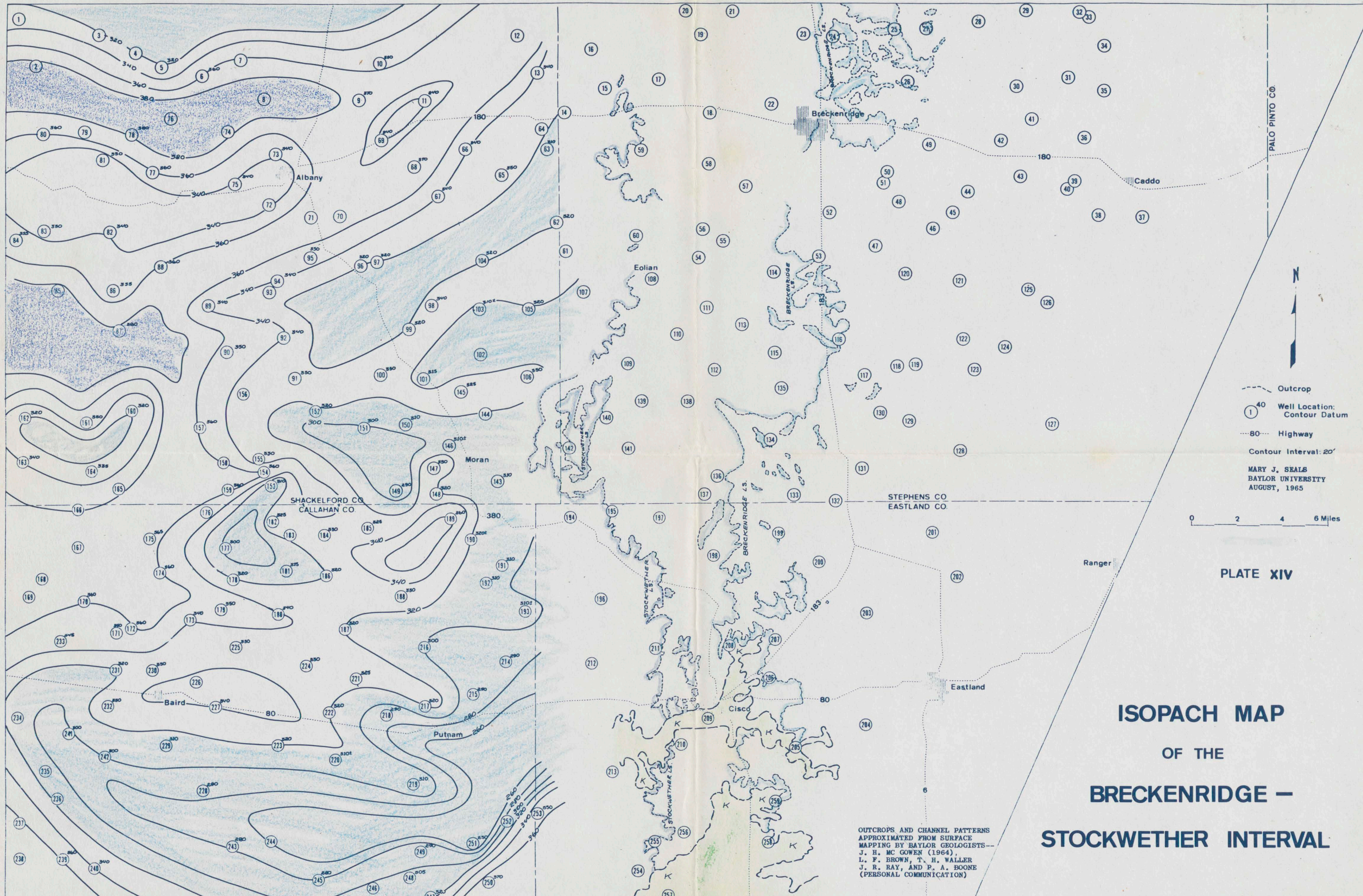


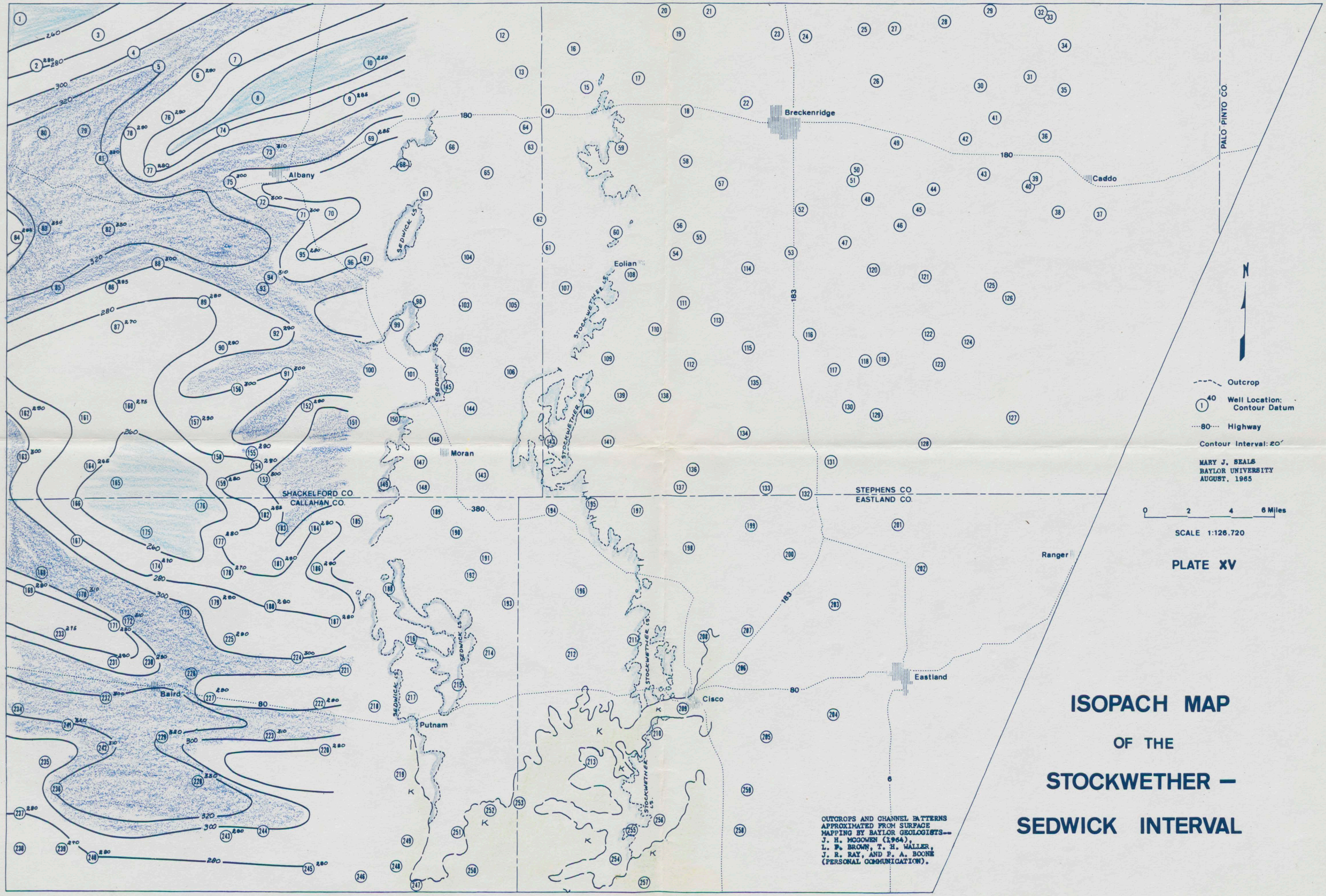
PLATE XII

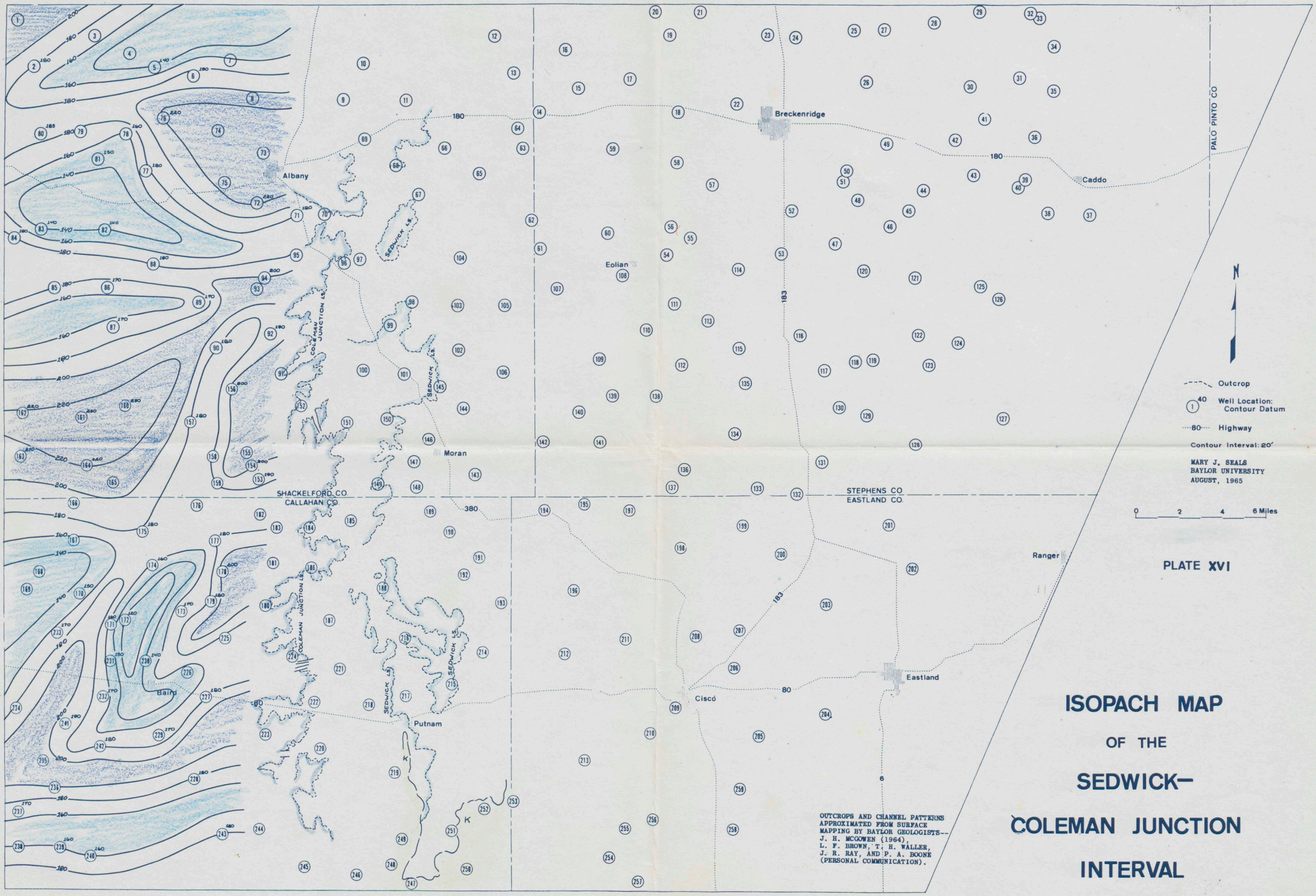
ISOPACH MAP OF THE HOME CREEK-BUNGER INTERVAL

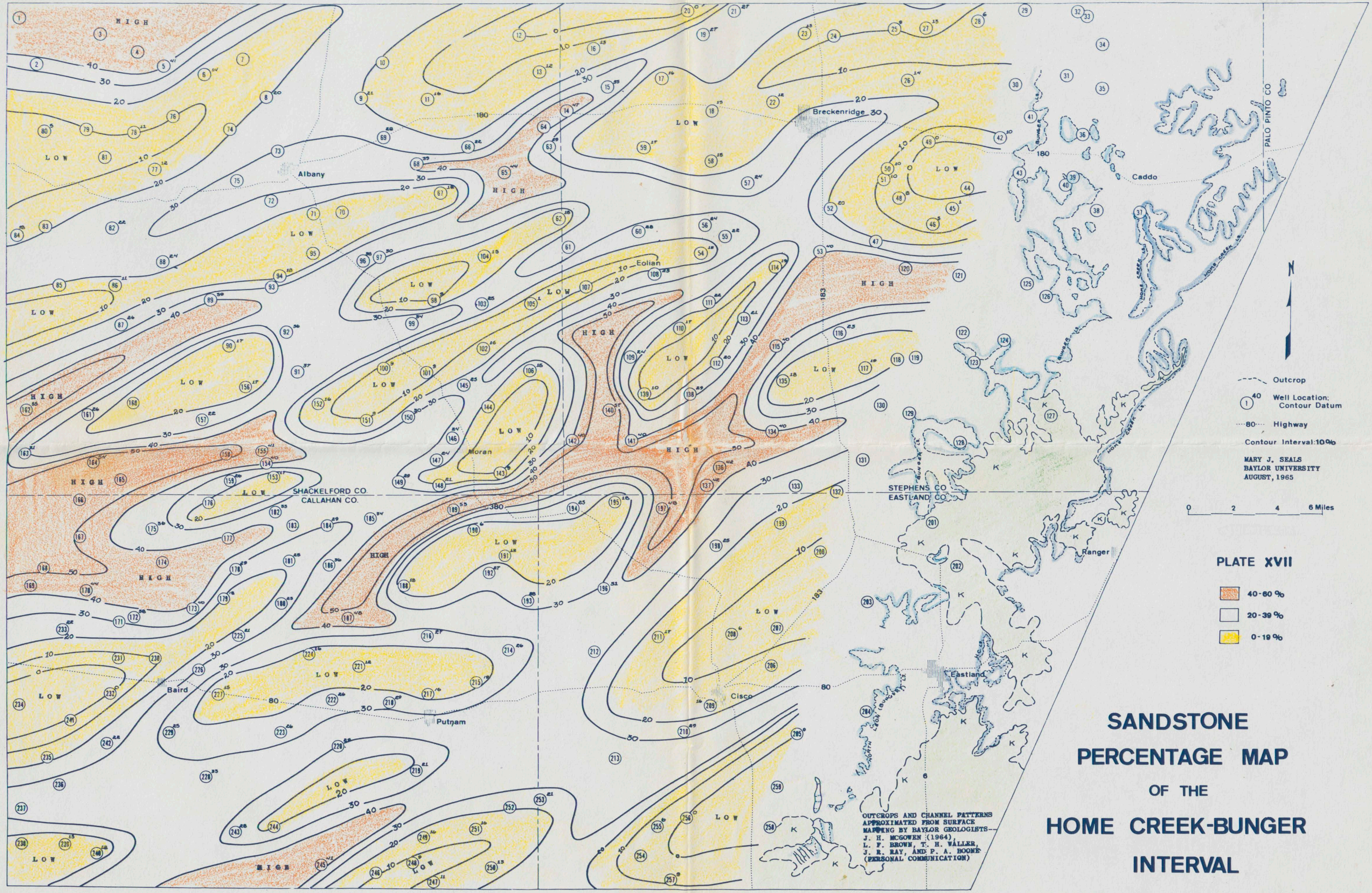


ISOPACH MAP OF THE BUNGER-BRECKENRIDGE INTERVAL


ISOPACH MAP
OF THE
BRECKENRIDGE –
STOCKWETHER INTERVAL
PLATE XIV
Outcrop
Well Location: Contour Datum
Highway
Contour Interval: 20'
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
OUTCROPS AND CHANNEL PATTERNS APPROXIMATED FROM SURFACE MAPPING BY BAYLOR GEOLOGISTS-- J. H. MC GOWEN (1964), L. F. BROWN, T. H. WALLER J. R. RAY, AND P. A. BOONE (PERSONAL COMMUNICATION)
PALO PINTO CO.
STEPHENS CO.
EASTLAND CO.
SHACKELFORD CO.
CALLAHAN CO.
Albany
Breckenridge
Caddo
Eolian
Moran
Ranger
Eastland
Cisco
Baird
Putnam
BRECKENRIDGE LS.
STOCKWETHER LS.


ISOPACH MAP
OF THE
STOCKWETHER —
SEDWICK INTERVAL
PLATE XV
Outcrop
Well Location: Contour Datum
Highway
Contour Interval: 20'
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
SCALE 1:126,720
N
PALO PINTO CO.
STEPHENS CO.
EASTLAND CO.
SHACKELFORD CO.
CALLAHAN CO.
Breckenridge
Albany
Caddo
Eolian
Moran
Ranger
Cisco
Eastland
Baird
Putnam
SEDWICK LS.
STOCKWETHER LS.
OUTCROPS AND CHANNEL PATTERNS
APPROXIMATED FROM SURFACE
MAPPING BY BAYLOR GEOLOGISTS--
J. H. MCGOWEN (1964),
L. F. BROWN, T. H. WALLER,
J. R. RAY, AND F. A. BOONE
(PERSONAL COMMUNICATION).


Albany
Breckenridge
Caddo
Eolian
Moran
Cisco
Eastland
Ranger
Baird
Putnam
PALO PINTO CO
SHACKELFORD CO.
CALLAHAN CO.
STEPHENS CO
EASTLAND CO.
COLEMAN JUNCTION LS.
SEDWICK LS.
180
183
380
80
6
N
Outcrop
Well Location: Contour Datum
Highway
Contour Interval: 20'
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
PLATE XVI
OUTCROPS AND CHANNEL PATTERNS APPROXIMATED FROM SURFACE MAPPING BY BAYLOR GEOLOGISTS-- J. H. MCGOWEN (1964), L. F. BROWN, T. H. WALLER, J. R. RAY, AND P. A. BOONE (PERSONAL COMMUNICATION).
ISOPACH MAP
OF THE
SEDWICK–
COLEMAN JUNCTION
INTERVAL


SANDSTONE PERCENTAGE MAP
OF THE
HOME CREEK-BUNGER
INTERVAL
PLATE XVII
40-60 %
20-39 %
0-19 %
Outcrop
Well Location; Contour Datum
Highway
Contour Interval:10%
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
OUTCROPS AND CHANNEL PATTERNS APPROXIMATED FROM SURFACE MAPPING BY BAYLOR GEOLOGISTS-
J. H. McGOWEN (1964)
L. F. BROWN, T. H. WALLER,
J. R. RAY, AND P. A. BOONE
(PERSONAL COMMUNICATION)
SHACKELFORD CO.
CALLAHAN CO.
STEPHENS CO
EASTLAND CO
PALO PINTO CO
Albany
Breckenridge
Caddo
Eolian
Moran
Baird
Putnam
Cisco
Eastland
Ranger

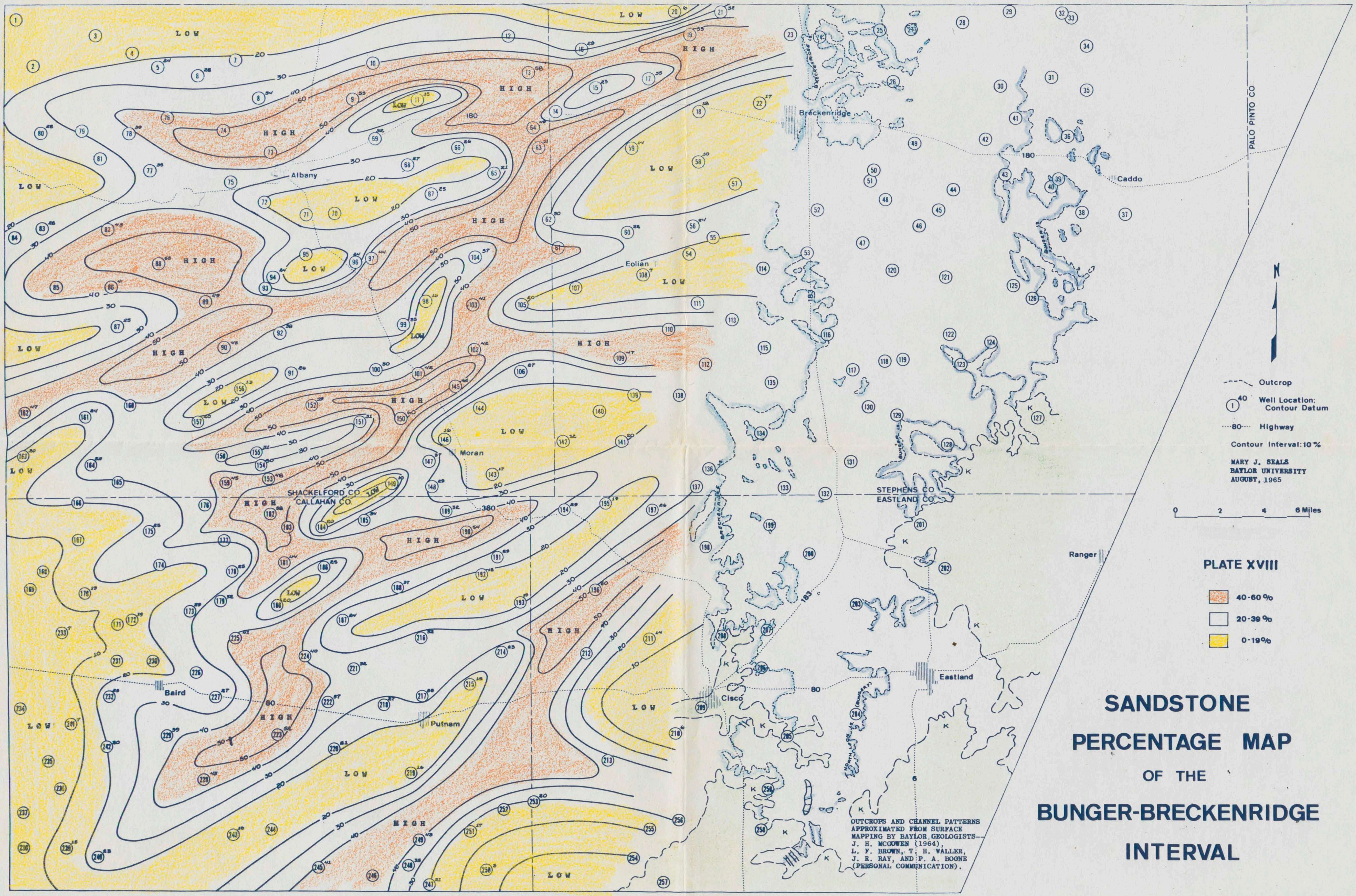
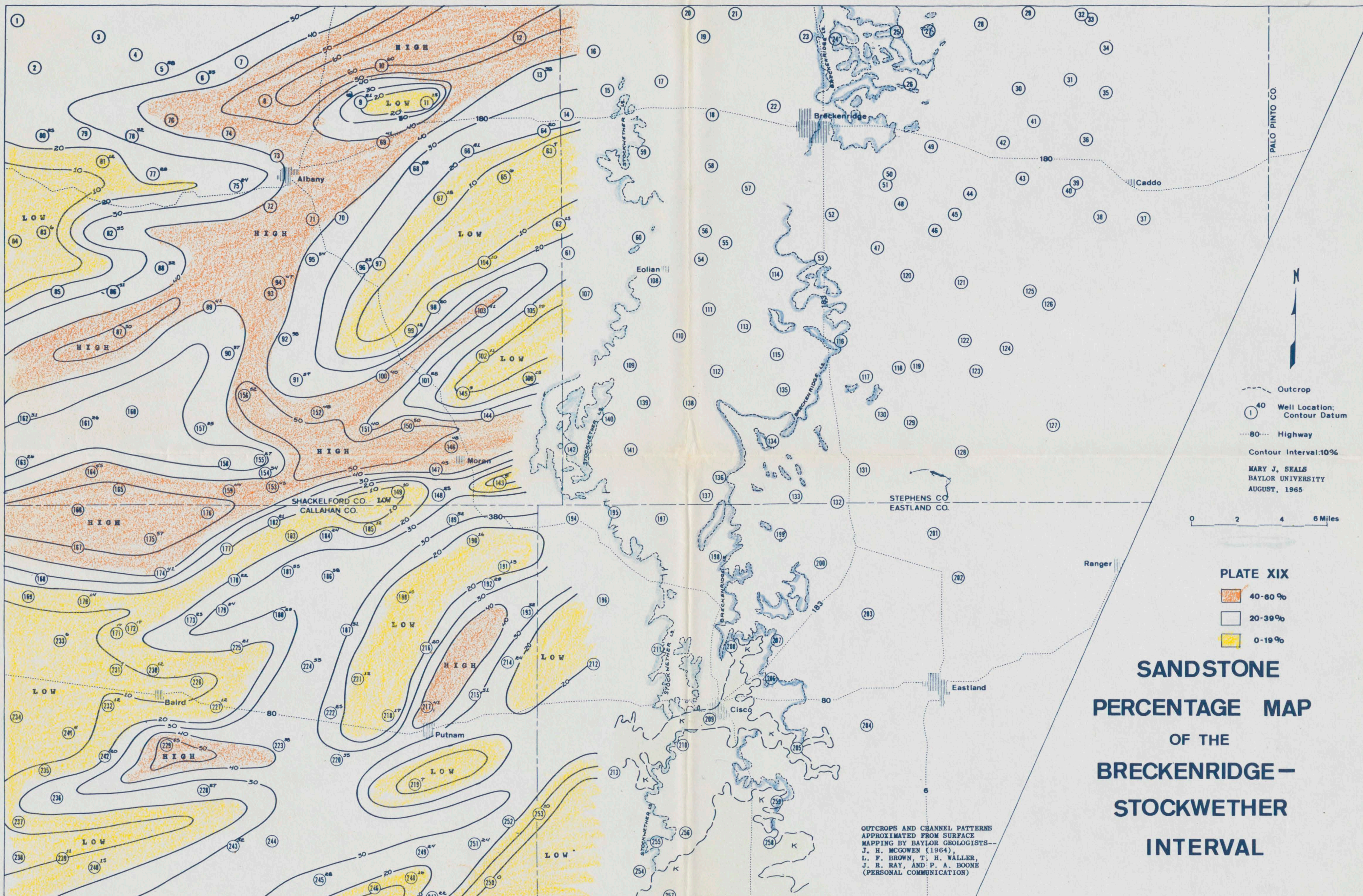
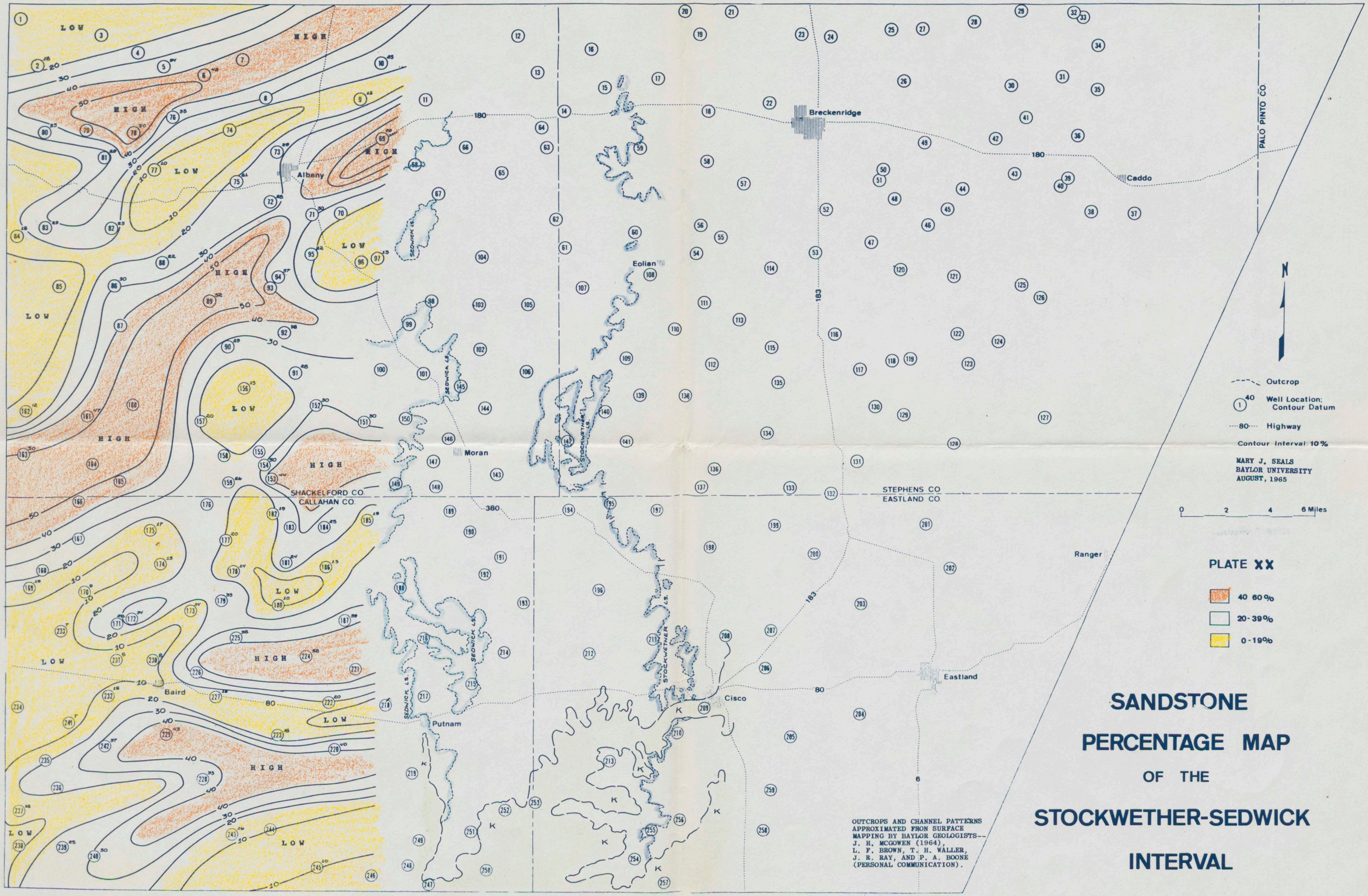


PLATE XVIII
SANDSTONE
PERCENTAGE MAP
OF THE
BUNGER-BRECKENRIDGE
INTERVAL
Outcrop
Well Location: Contour Datum
Highway
Contour Interval: 10%
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
40-60%
20-39%
0-19%
OUTCROPS AND CHANNEL PATTERNS APPROXIMATED FROM SURFACE MAPPING BY BAYLOR GEOLOGISTS—
J. H. MCGOWEN (1964),
L. F. BROWN, T. H. WALLER,
J. R. RAY, AND P. A. BOONE
(PERSONAL COMMUNICATION).
PALO PINTO CO.
SHACKELFORD CO.
CALLAHAN CO.
STEPHENS CO
EASTLAND CO
Breckenridge
Caddo
Albany
Eolian
Moran
Ranger
Baird
Putnam
Cisco
Eastland
HIGH
LOW


SANDSTONE PERCENTAGE MAP OF THE BRECKENRIDGE — STOCKWETHER INTERVAL
PLATE XIX
40-60 %
20-39 %
0-19 %
Outcrop
Well Location; Contour Datum
80 Highway
Contour Interval: 10%
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
N
OUTCROPS AND CHANNEL PATTERNS APPROXIMATED FROM SURFACE MAPPING BY BAYLOR GEOLOGISTS-- J. H. MCGOWEN (1964), L. F. BROWN, T. H. WALLER, J. R. RAY, AND P. A. BOONE (PERSONAL COMMUNICATION)
Albany
Breckenridge
Caddo
Eolian
Moran
Baird
Putnam
Cisco
Eastland
Ranger
SHACKELFORD CO.
CALLAHAN CO.
STEPHENS CO.
EASTLAND CO.
PALO PINTO CO.
HIGH
LOW
BRECKENRIDGE LS.
STOCKWETHER LS.
180
183
380
80
6


SANDSTONE
PERCENTAGE MAP
OF THE
STOCKWETHER-SEDWICK
INTERVAL
PLATE XX
40 60%
20-39%
0-19%
Outcrop
Well Location: Contour Datum
Highway
Contour Interval: 10%
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
N
OUTCROPS AND CHANNEL PATTERNS APPROXIMATED FROM SURFACE MAPPING BY BAYLOR GEOLOGISTS-- J. H. MCGOWEN (1964), L. F. BROWN, T. H. WALLER, J. R. RAY, AND P. A. BOONE (PERSONAL COMMUNICATION).
PALO PINTO CO.
STEPHENS CO
EASTLAND CO.
SHACKELFORD CO.
CALLAHAN CO.
Breckenridge
Caddo
Albany
Eolian
Moran
Ranger
Eastland
Cisco
Baird
Putnam
SEDWICK LS.
STOCKWETHER LS.
HIGH
LOW

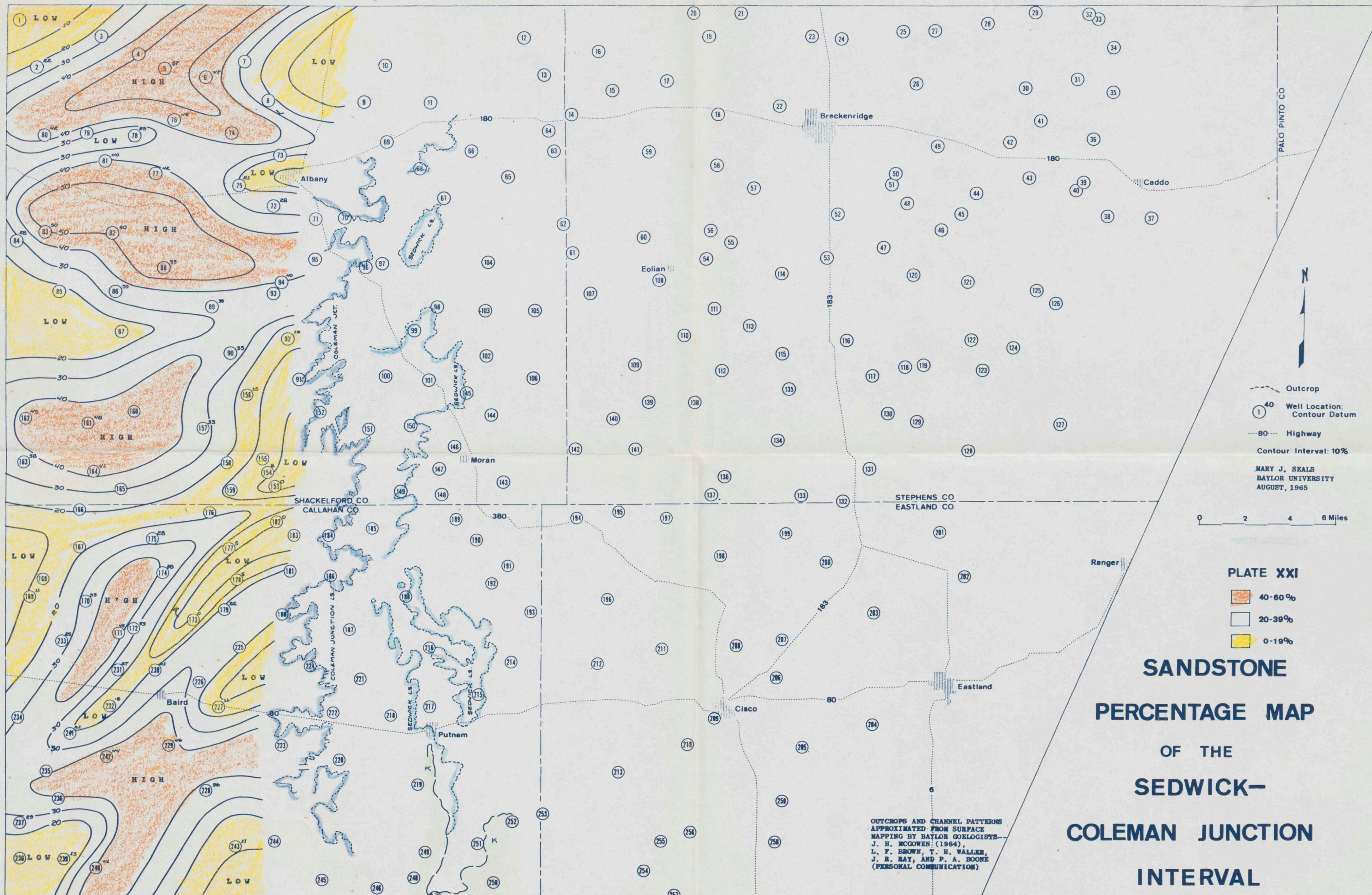


PLATE XXI
40-60 %
20-39%
0-19%
SANDSTONE
PERCENTAGE MAP
OF THE
SEDWICK–
COLEMAN JUNCTION
INTERVAL
Outcrop
Well Location: Contour Datum
Highway
Contour Interval: 10%
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
N
OUTCROPS AND CHANNEL PATTERNS APPROXIMATED FROM SURFACE MAPPING BY BAYLOR GOELOGISTS– J. H. MCGOWEN (1964), L. F. BROWN, T. H. WALLER, J. R. RAY, AND P. A. BOONE (PERSONAL COMMUNICATION)
SHACKELFORD CO
CALLAHAN CO
STEPHENS CO
EASTLAND CO
PALO PINTO CO
Albany
Breckenridge
Caddo
Eolian
Moran
Baird
Putnam
Cisco
Eastland
Ranger
COLEMAN JCT.
COLEMAN JUNCTION LS.
SEDWICK LS.
HIGH
LOW

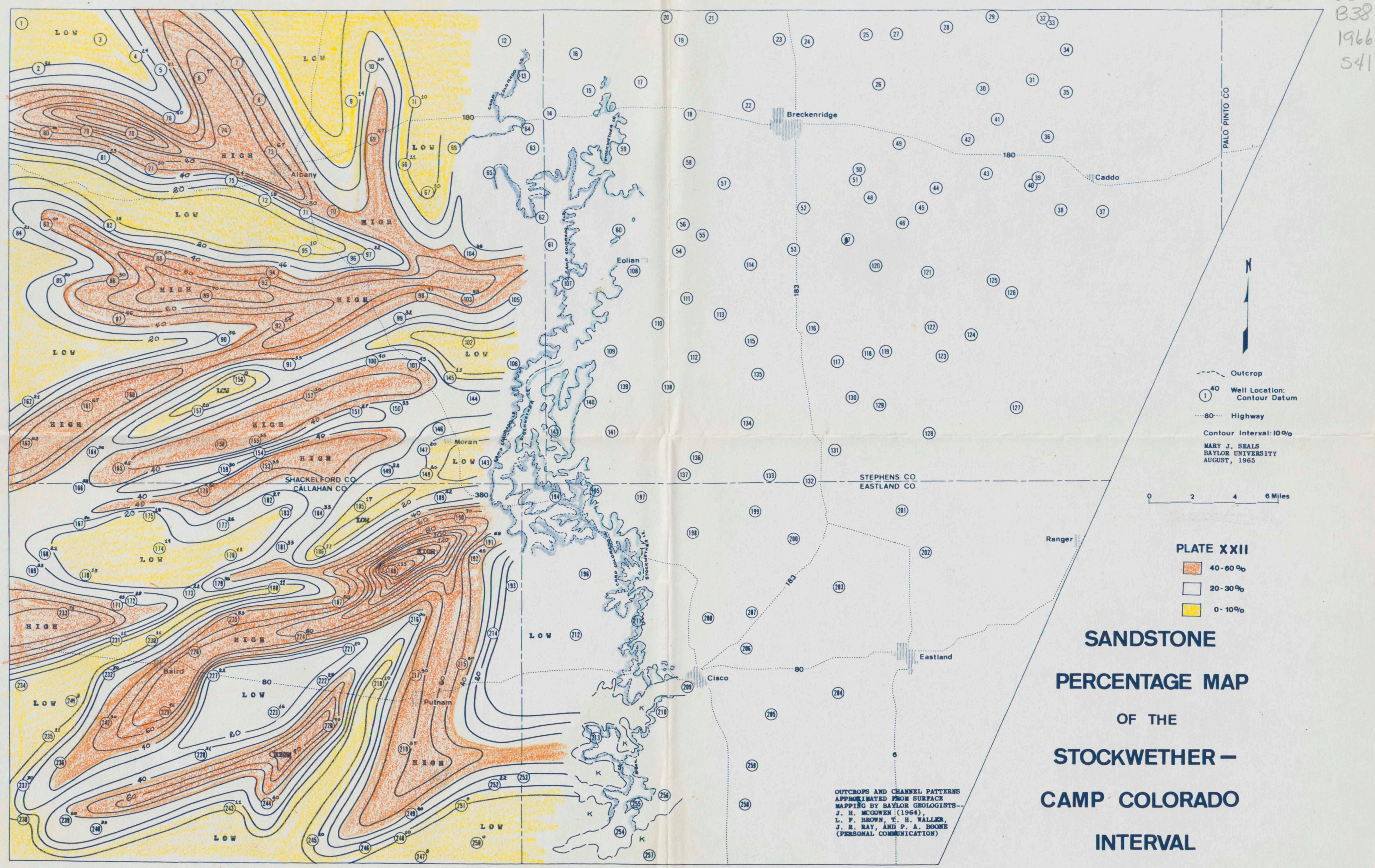
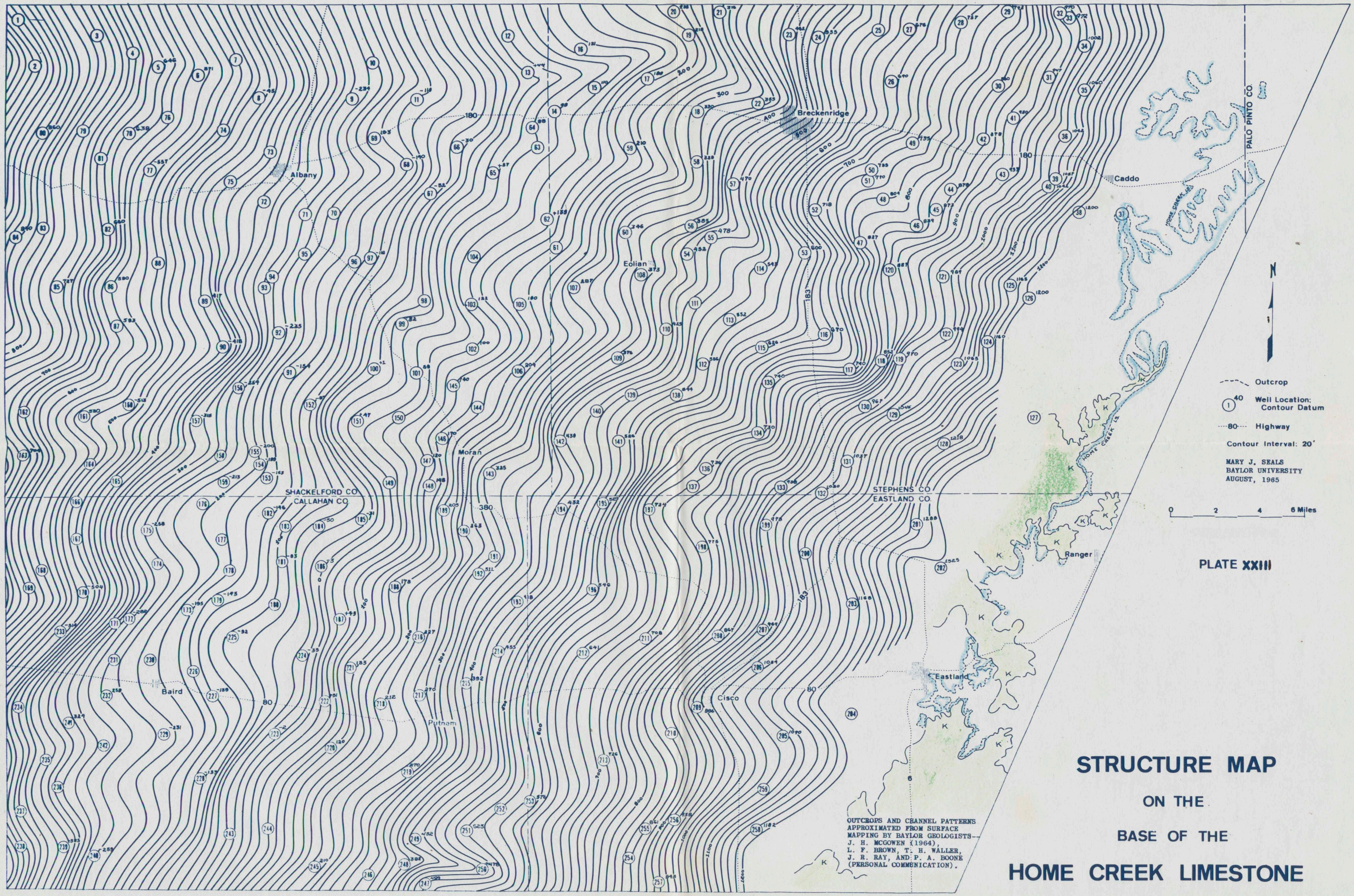
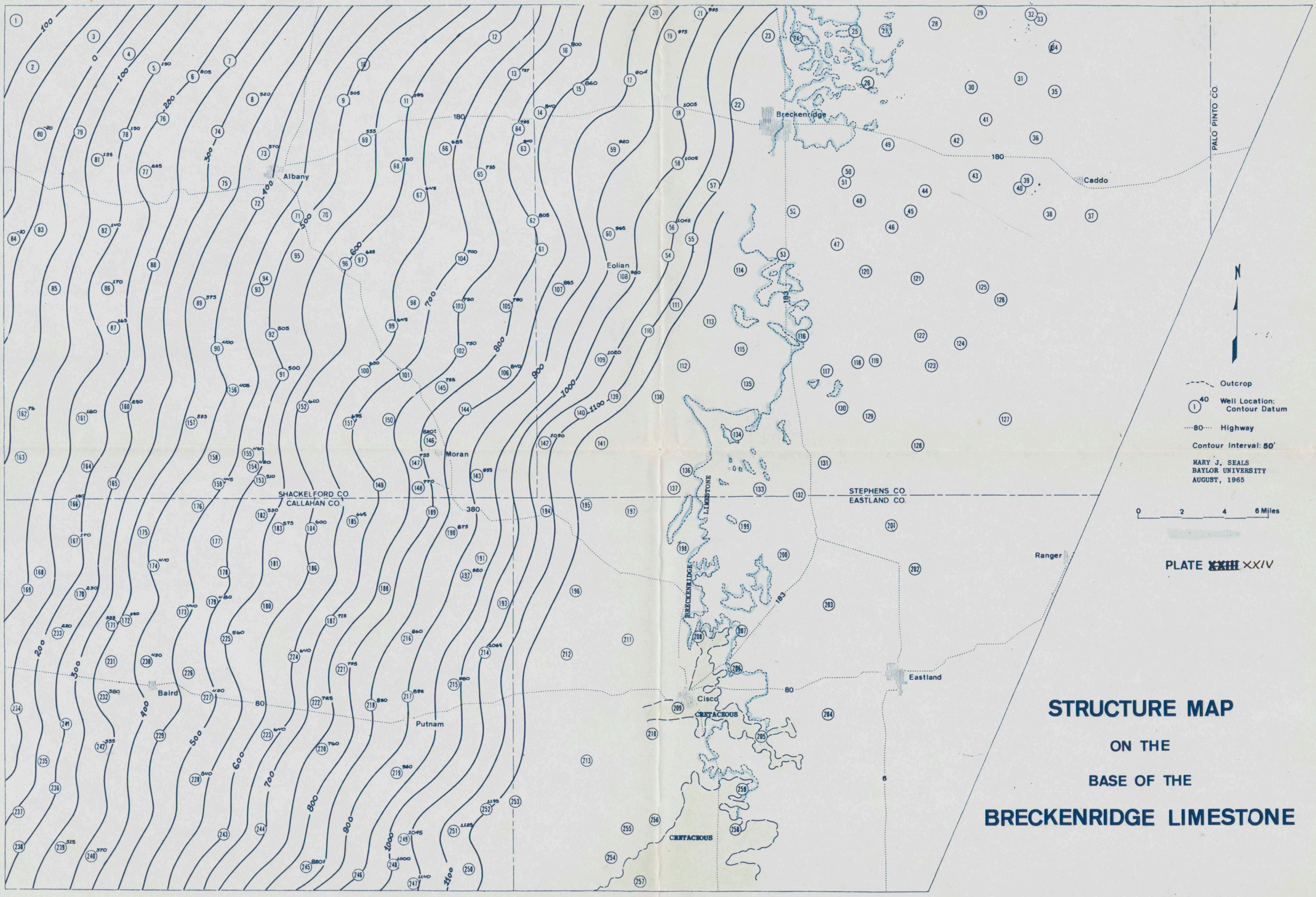
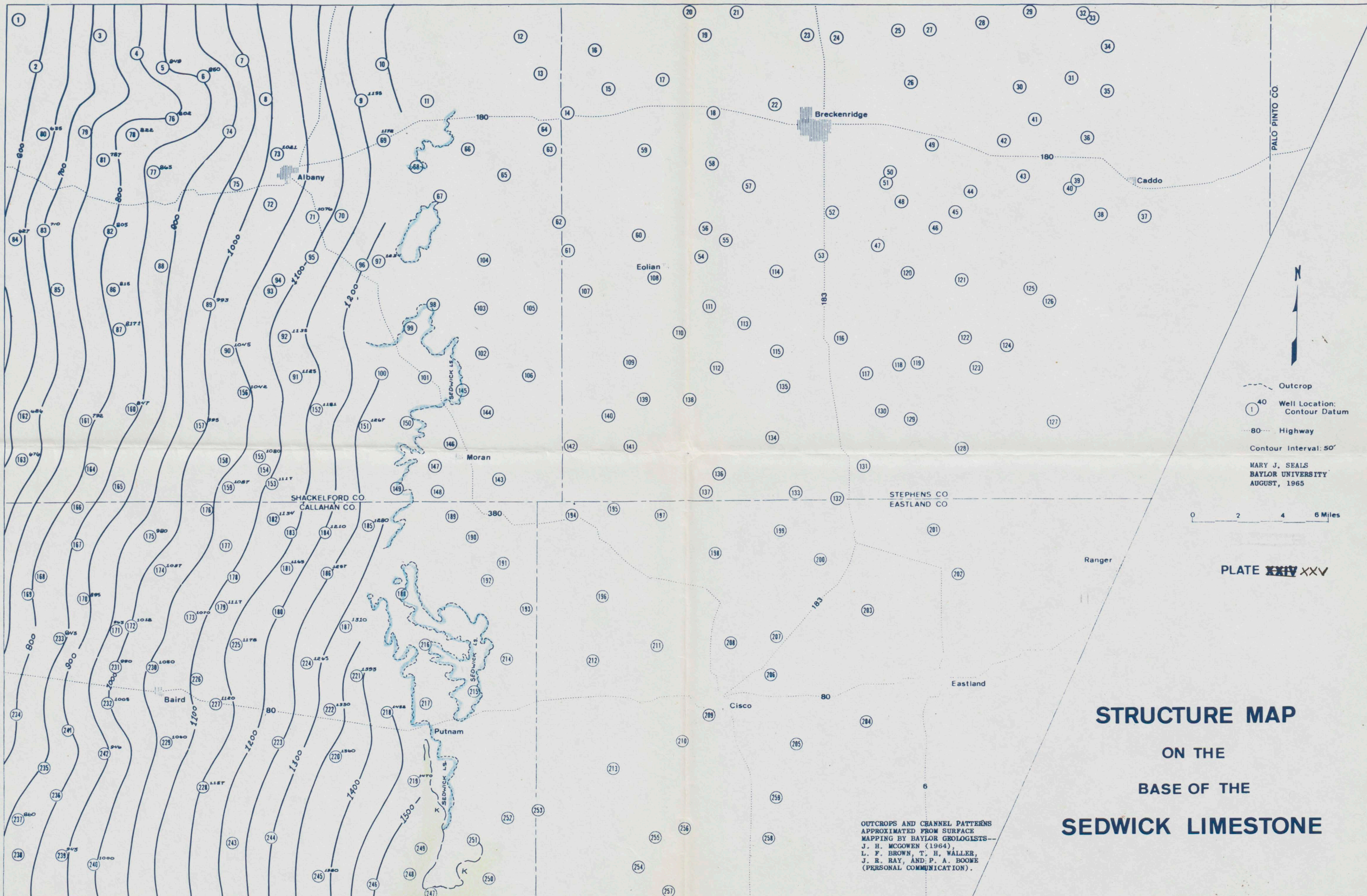


PLATE XXII
40-60%
20-30%
0-10%
SANDSTONE
PERCENTAGE MAP
OF THE
STOCKWETHER –
CAMP COLORADO
INTERVAL
Outcrop
Well Location: Contour Datum
Highway
Contour Interval: 10%
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
N
OUTCROPS AND CHANNEL PATTERNS
APPROXIMATED FROM SURFACE
MAPPING BY BAYLOR GEOLOGISTS--
J. H. MCGOWEN (1964),
L. F. BROWN, T. H. WALLER,
J. R. RAY, AND P. A. BOONE
(PERSONAL COMMUNICATION)
Breckenridge
Caddo
PALO PINTO CO.
Albany
Eolian
Moran
SHACKELFORD CO.
CALLAHAN CO.
STEPHENS CO.
EASTLAND CO.
Ranger
Eastland
Cisco
Baird
Putnam
180
183
380
80
6
HIGH
LOW



STRUCTURE MAP
ON THE
BASE OF THE
HOME CREEK LIMESTONE


STRUCTURE MAP
ON THE
BASE OF THE
BRECKENRIDGE LIMESTONE
PLATE XXIII XXIV
Outcrop
Well Location: Contour Datum
Highway
Contour Interval: 50'
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
N
PALO PINTO CO.
STEPHENS CO
EASTLAND CO.
SHACKELFORD CO.
CALLAHAN CO.
Albany
Breckenridge
Caddo
Eolian
Moran
Baird
Putnam
Cisco
Eastland
Ranger
CRETACEOUS
BRECKENRIDGE LIMESTONE



STRUCTURE MAP
ON THE
BASE OF THE
SEDWICK LIMESTONE

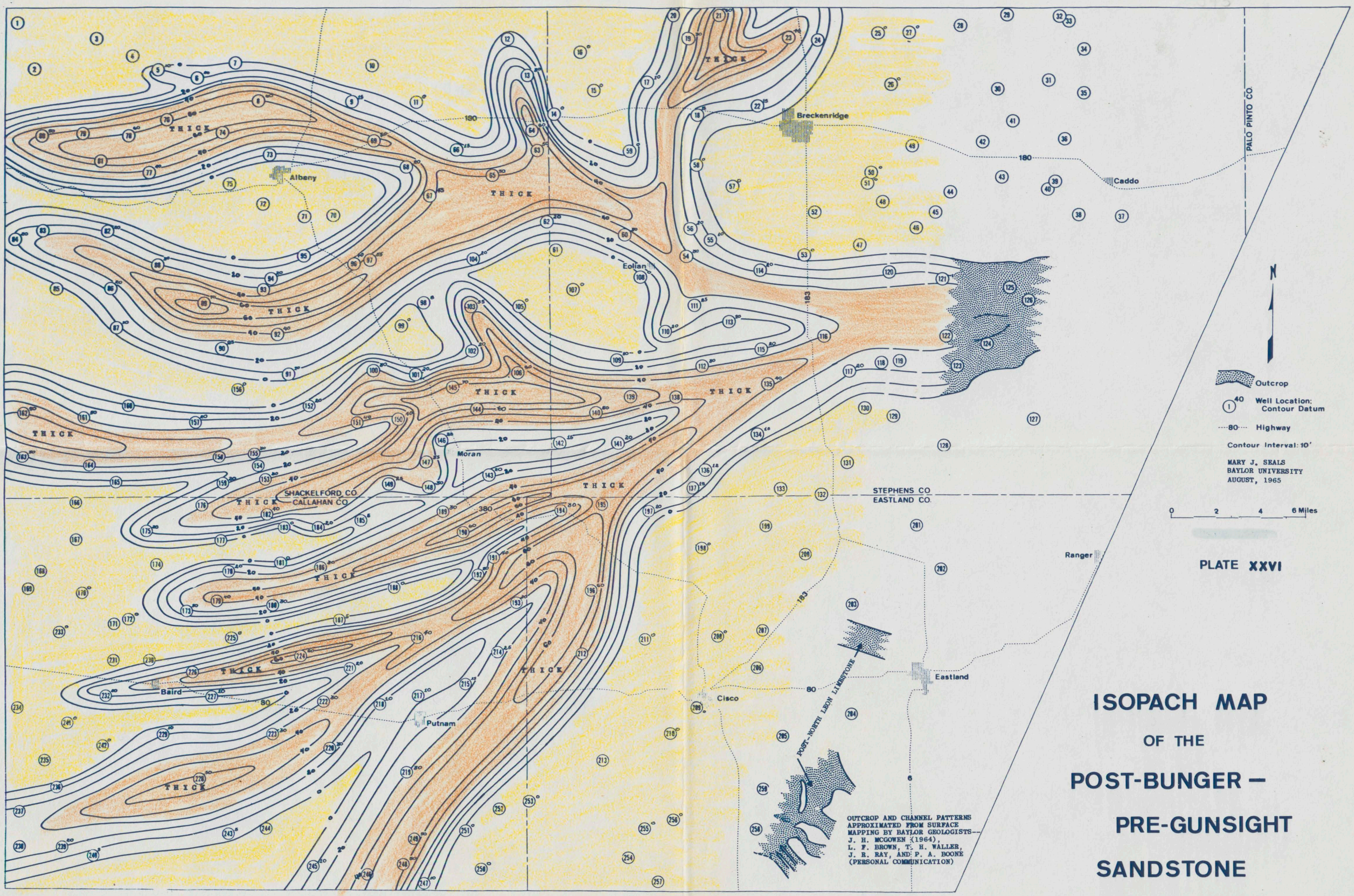
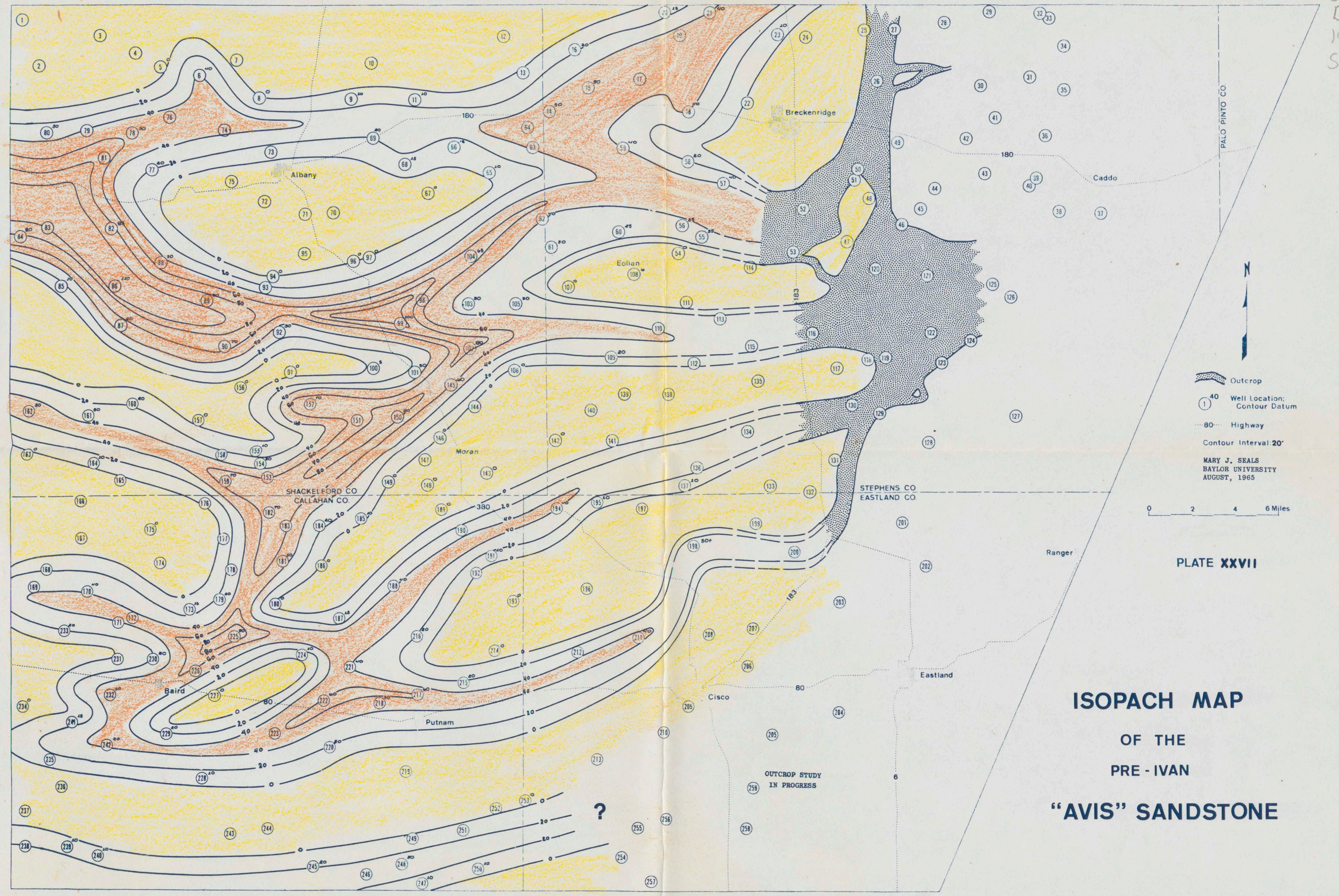


PLATE XXVI

ISOPACH MAP OF THE POST-BUNGER — PRE-GUNSIGHT SANDSTONE


ISOPACH MAP
OF THE
PRE - IVAN
"AVIS" SANDSTONE
PLATE XXVII
Outcrop
Well Location; Contour Datum
Highway
Contour Interval: 20'
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
N
PALO PINTO CO.
STEPHENS CO.
EASTLAND CO.
SHACKELFORD CO.
CALLAHAN CO.
Breckenridge
Caddo
Albany
Eolian
Moran
Ranger
Eastland
Cisco
Baird
Putnam
OUTCROP STUDY
IN PROGRESS
?

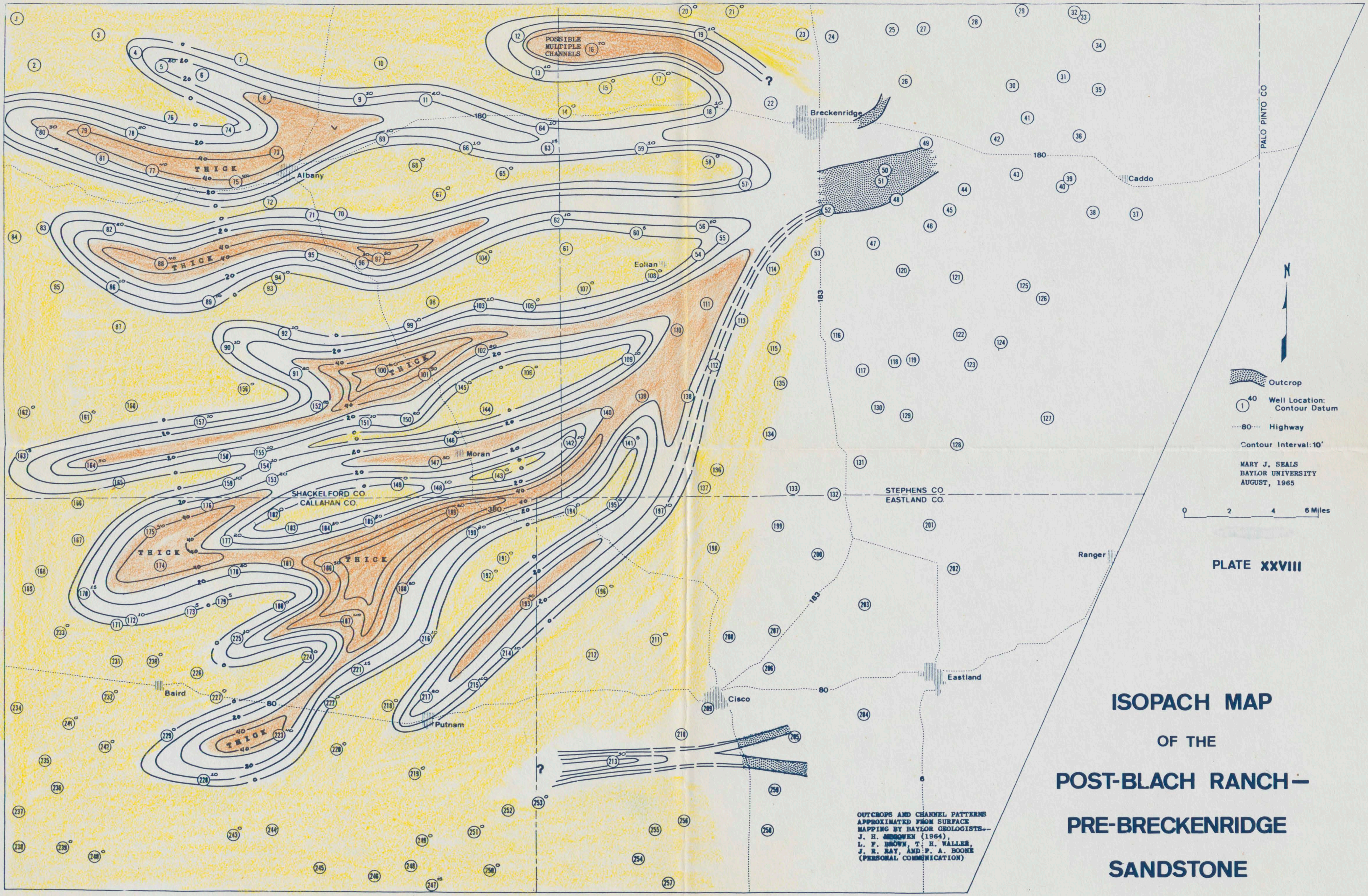
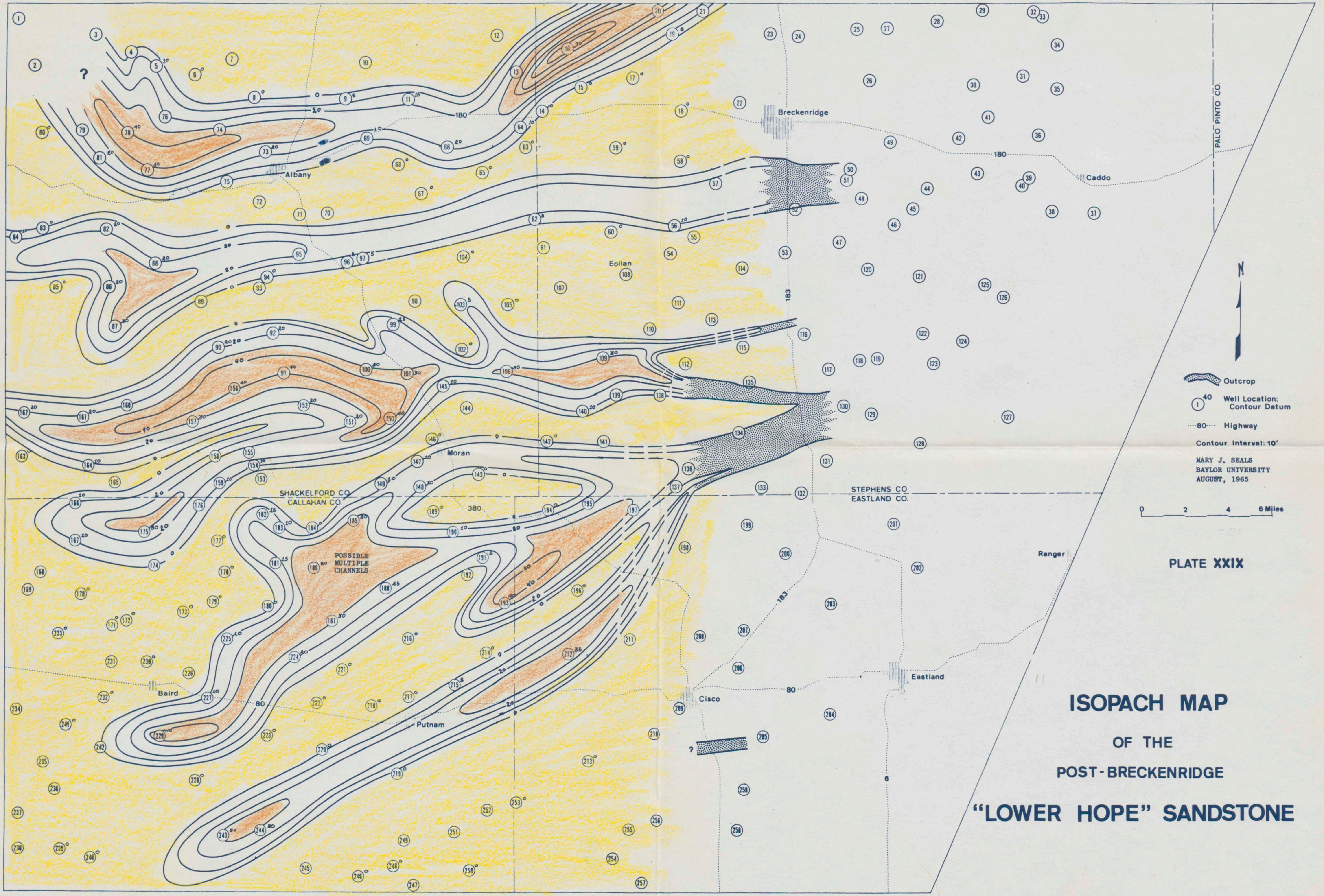
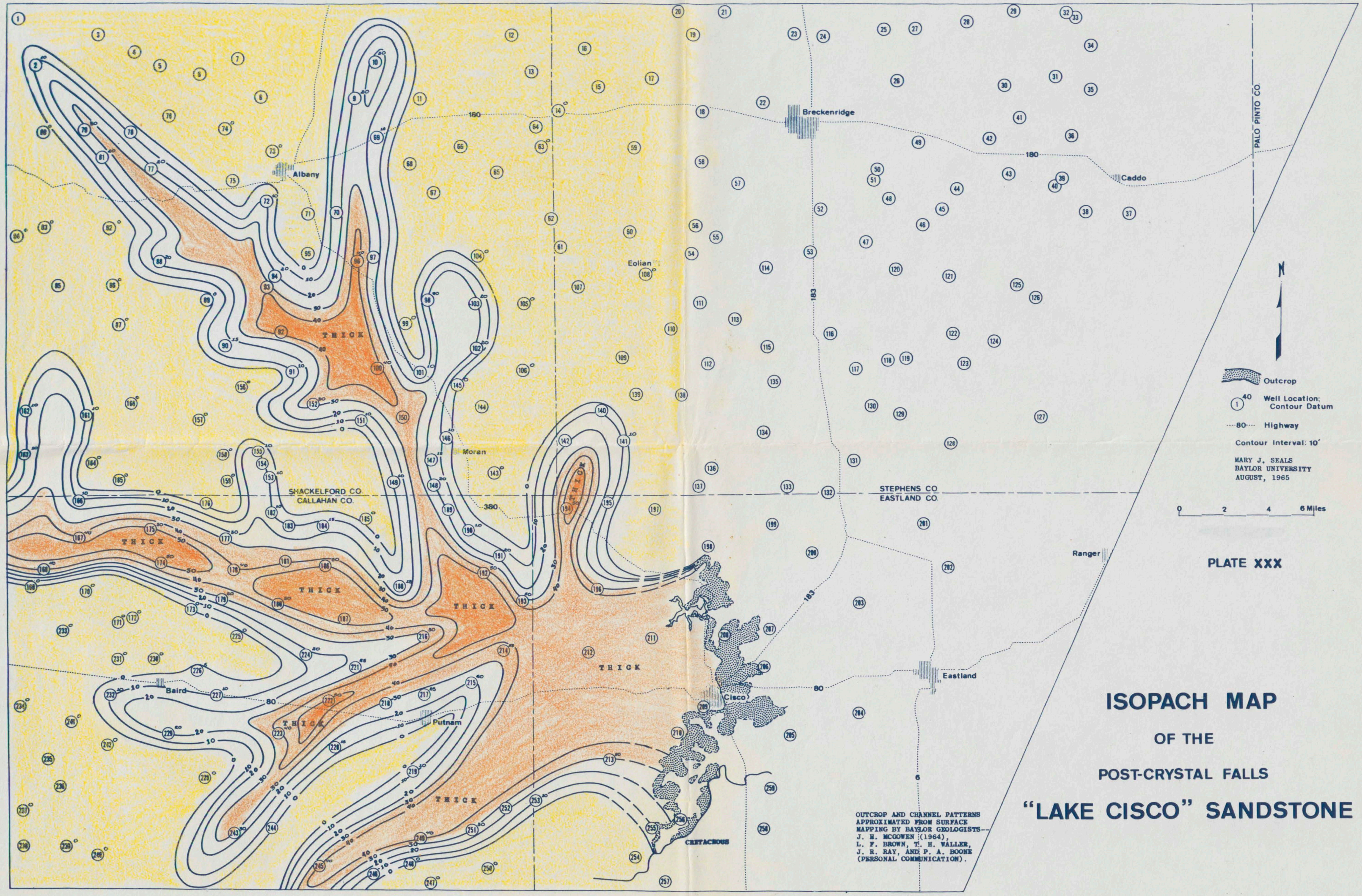


PLATE XXVIII

ISOPACH MAP OF THE POST-BLACH RANCH— PRE-BRECKENRIDGE SANDSTONE


Breckenridge
Albany
Caddo
Eolian
Moran
PALO PINTO CO.
SHACKELFORD CO.
CALLAHAN CO.
STEPHENS CO.
EASTLAND CO.
POSSIBLE MULTIPLE CHANNELS
Ranger
Baird
Putnam
Cisco
Eastland
Outcrop
Well Location; Contour Datum
Highway
Contour Interval: 10'
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
N
PLATE XXIX
ISOPACH MAP
OF THE
POST-BRECKENRIDGE
"LOWER HOPE" SANDSTONE



ISOPACH MAP
OF THE
POST-CRYSTAL FALLS
"LAKE CISCO" SANDSTONE

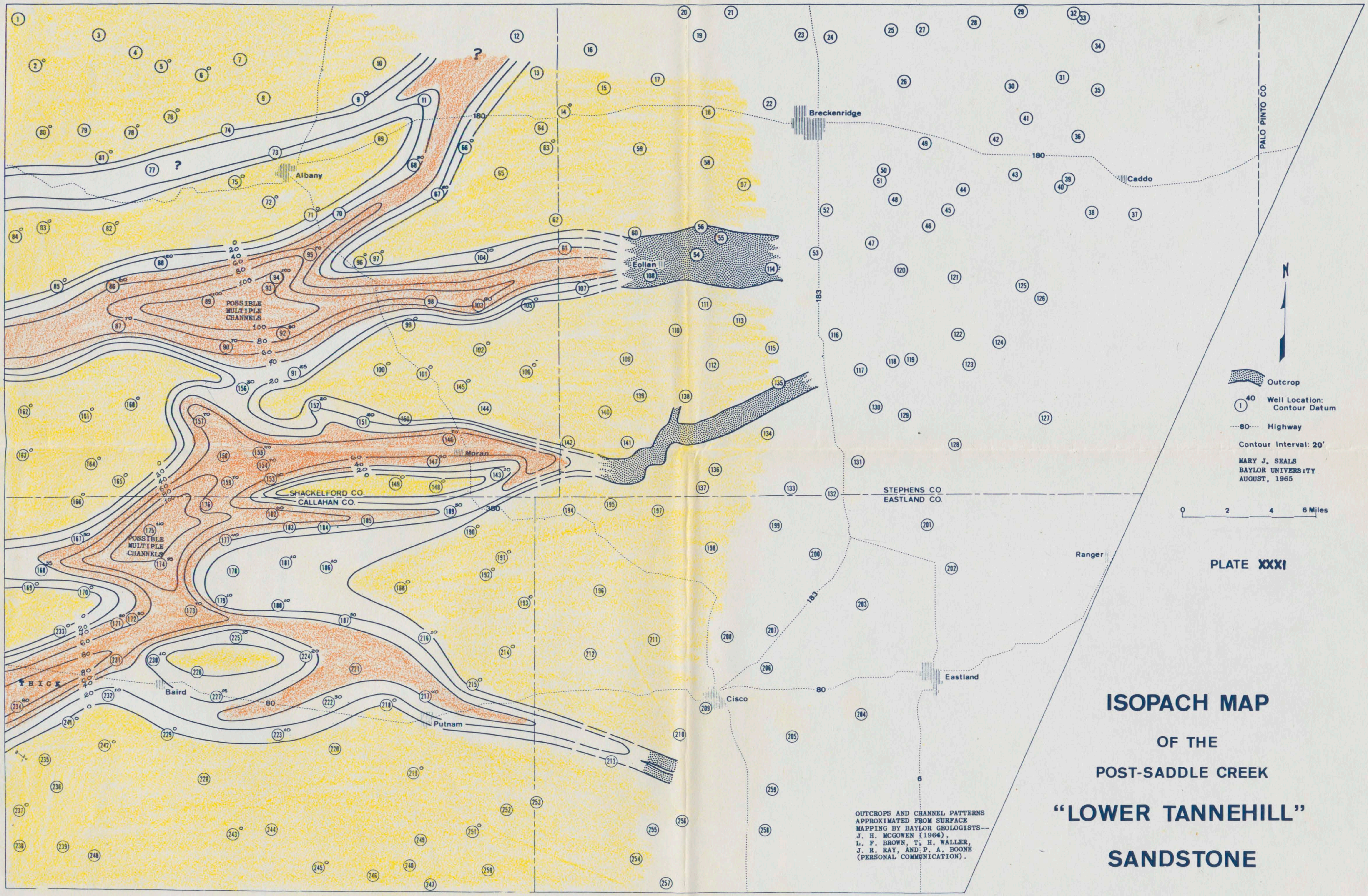


PLATE XXXI

ISOPACH MAP

OF THE

POST-SADDLE CREEK

"LOWER TANNEHILL"

SANDSTONE

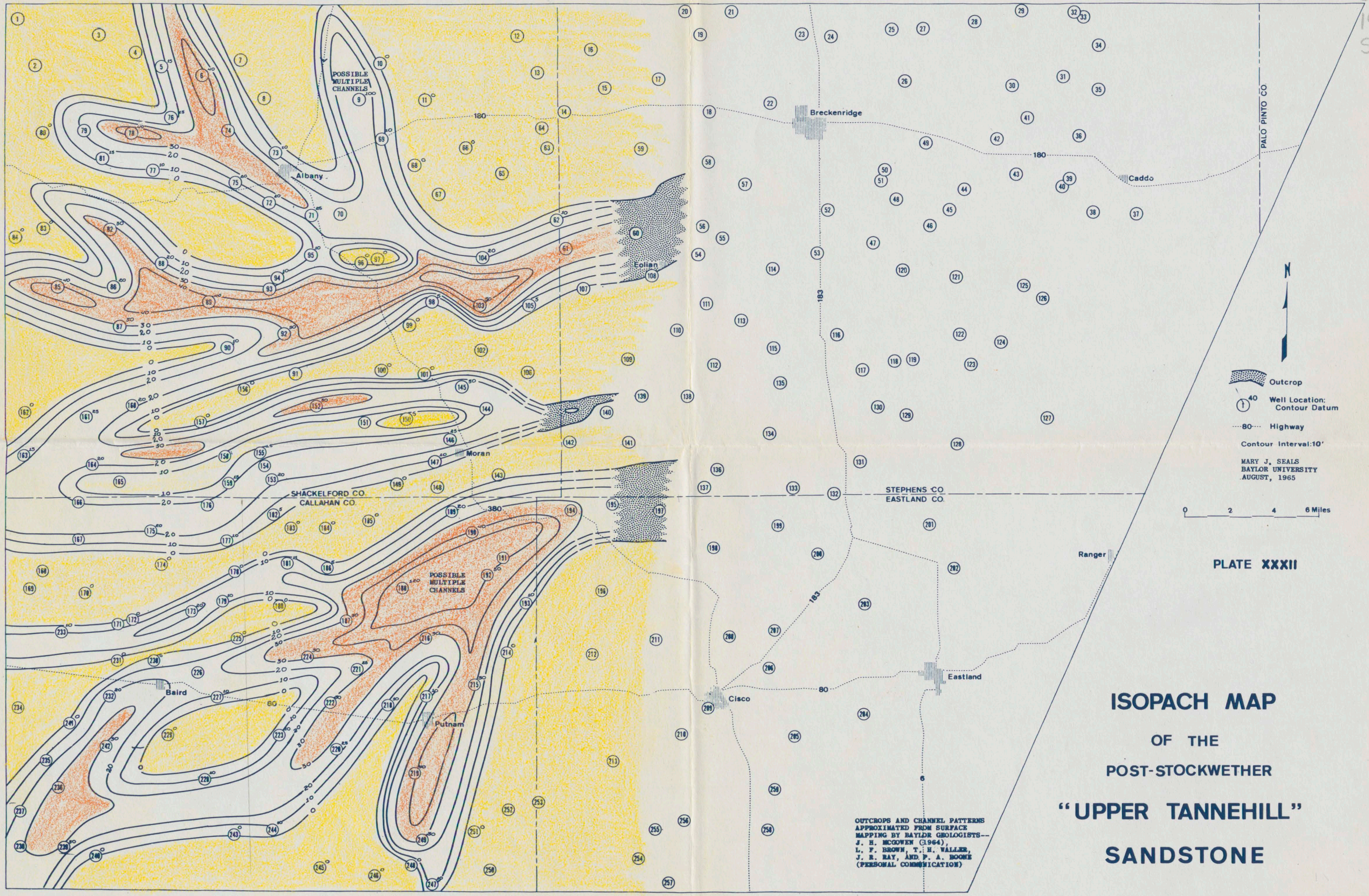


PLATE XXXII

ISOPACH MAP
OF THE
POST-STOCKWETHER
"UPPER TANNEHILL"
SANDSTONE

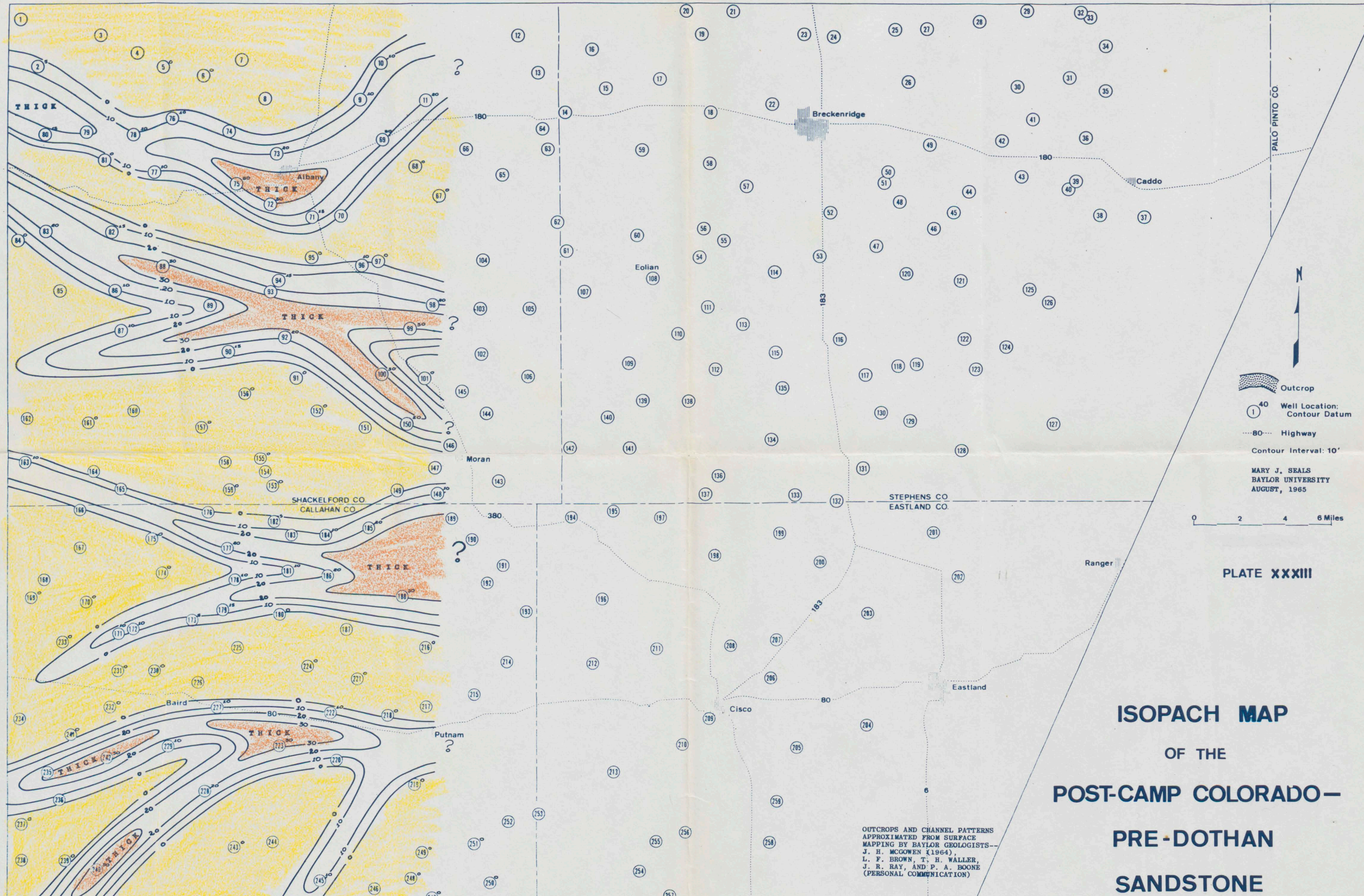


PLATE XXXIII

ISOPACH MAP
OF THE
POST-CAMP COLORADO— PRE-DOTHAN SANDSTONE

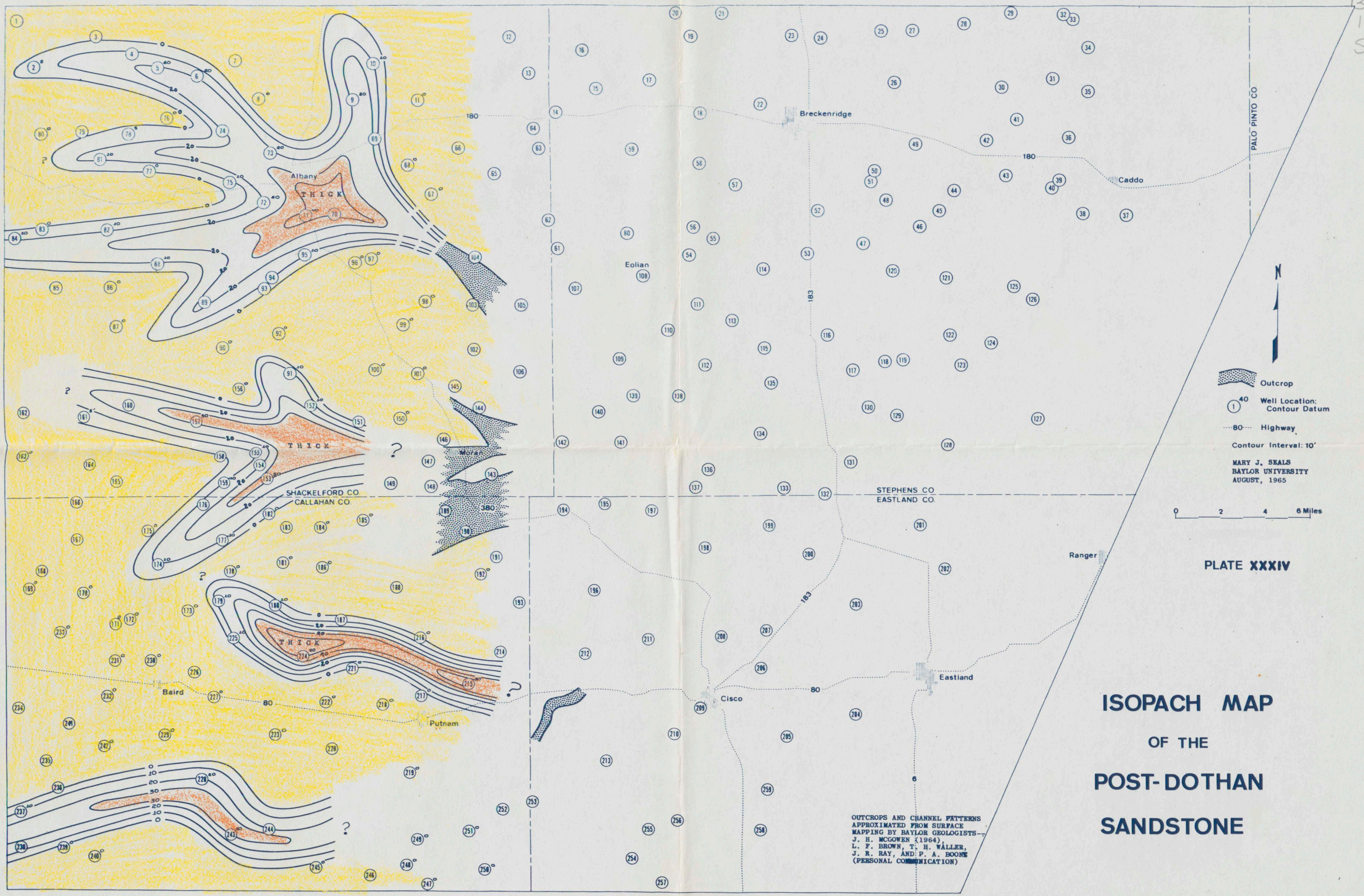
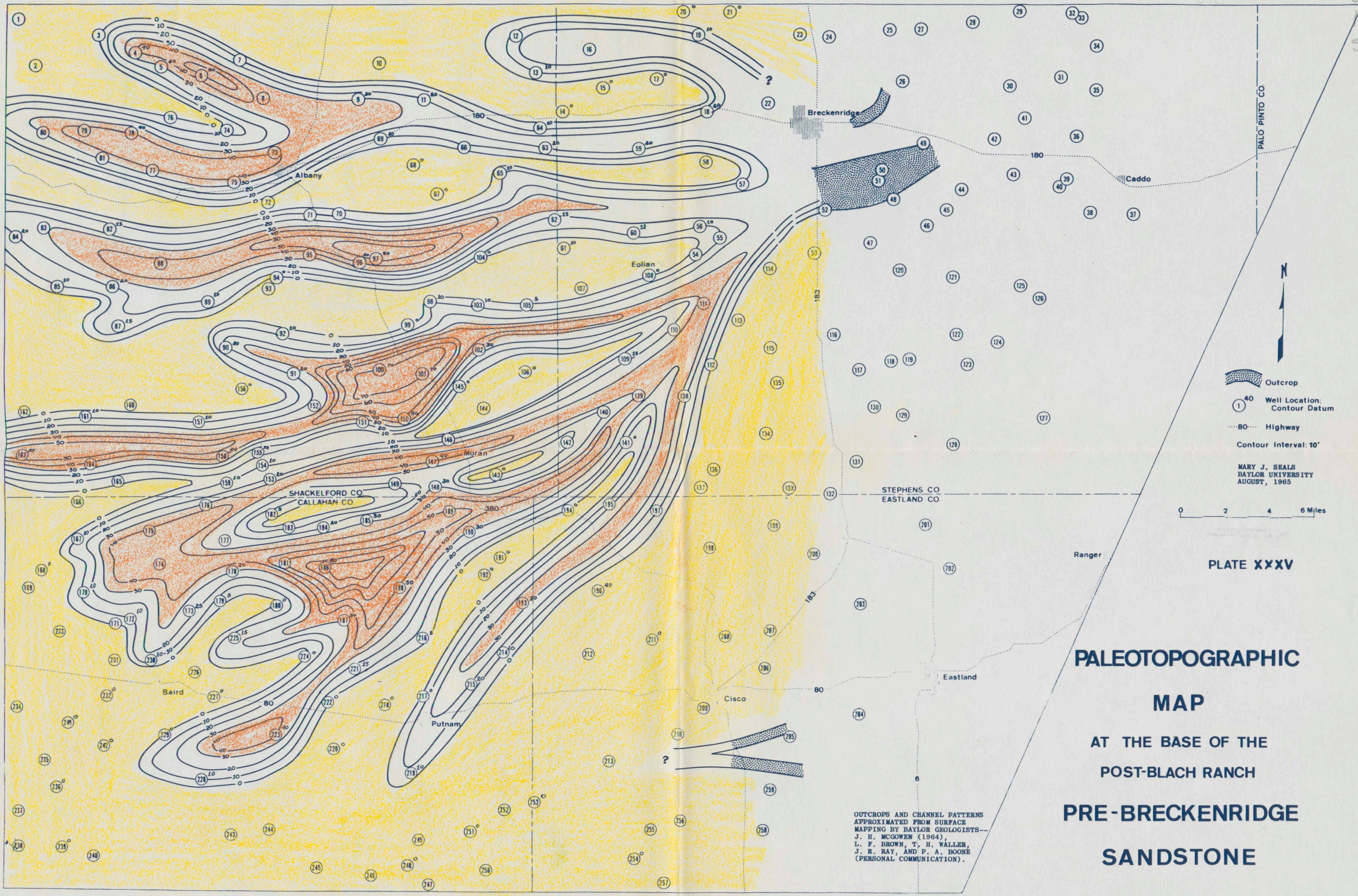


PLATE XXXIV

ISOPACH MAP OF THE POST-DOTHAN SANDSTONE


Breckenridge
Albany
Caddo
Eolian
Moran
Baird
Putnam
Cisco
Eastland
Ranger
SHACKELFORD CO.
CALLAHAN CO.
STEPHENS CO.
EASTLAND CO.
PALO PINTO CO.
Outcrop
Well Location; Contour Datum
Highway
Contour Interval: 10'
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
PLATE XXXV
OUTCROPS AND CHANNEL PATTERNS APPROXIMATED FROM SURFACE MAPPING BY BAYLOR GEOLOGISTS-- J. H. MCGOWEN (1964), L. F. BROWN, T. H. WALLER, J. R. RAY, AND P. A. BOONE (PERSONAL COMMUNICATION).
PALEOTOPOGRAPHIC
MAP
AT THE BASE OF THE
POST-BLACH RANCH
PRE-BRECKENRIDGE
SANDSTONE

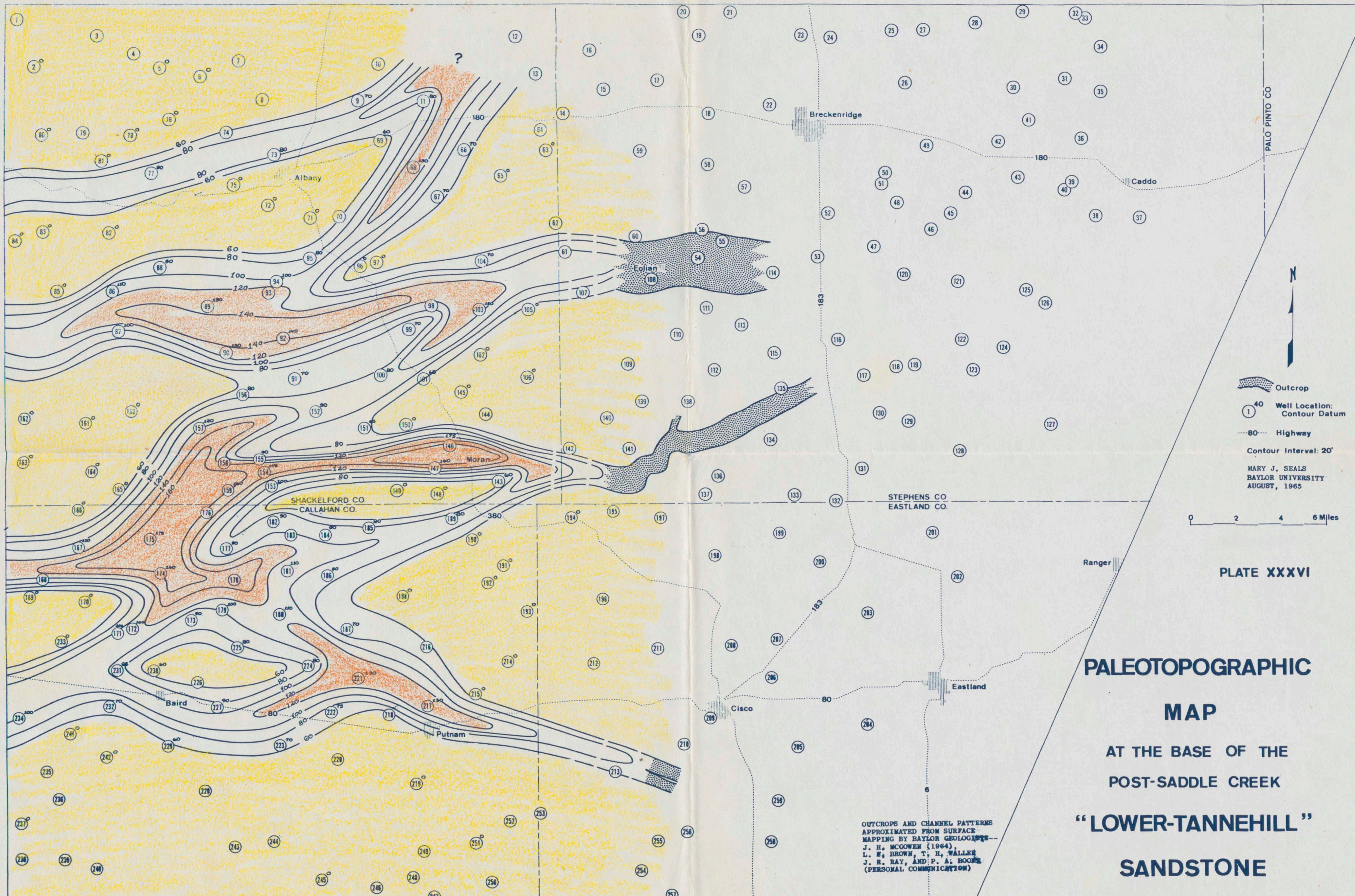
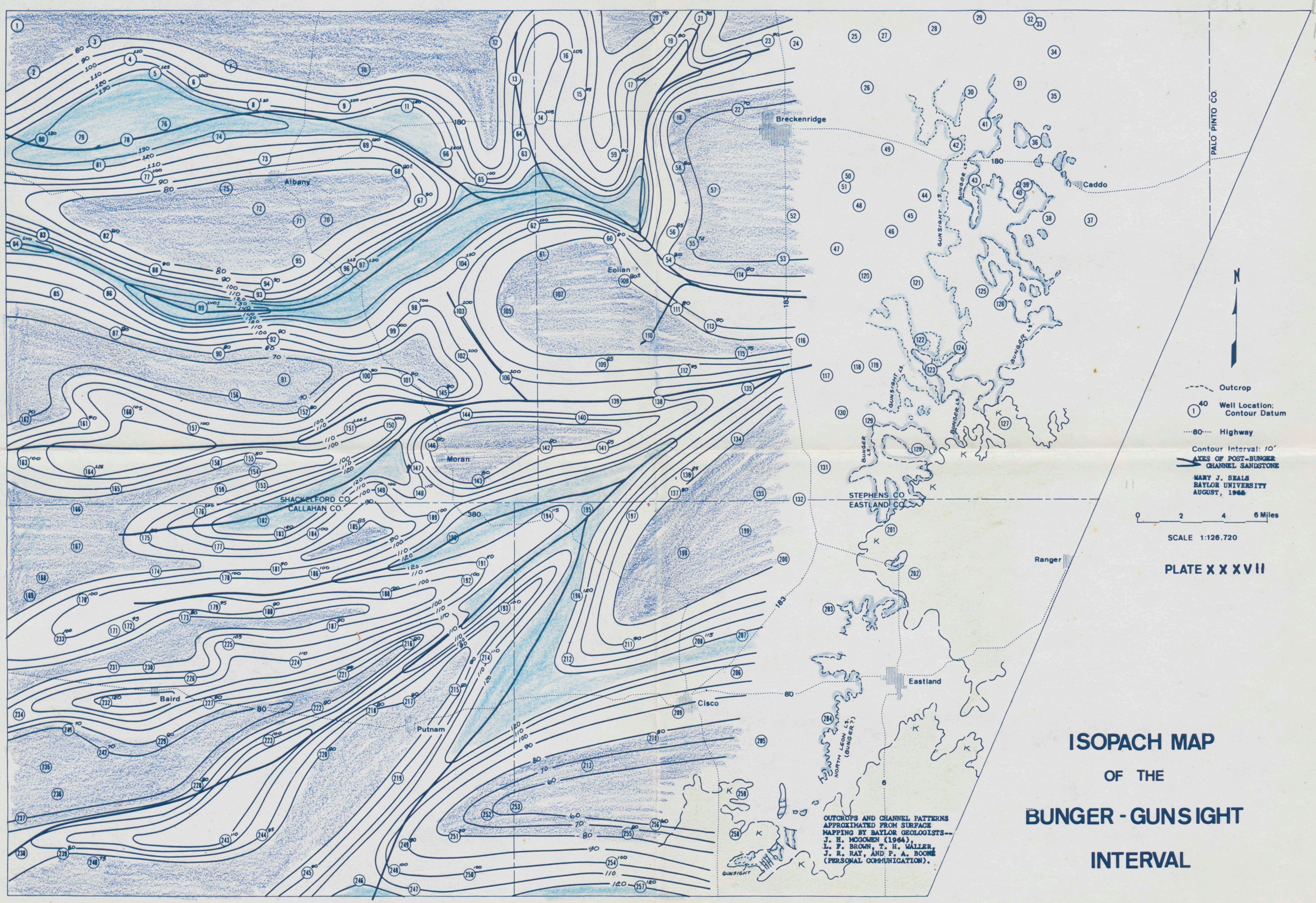


PLATE XXXVI

PALEOTOPOGRAPHIC MAP

AT THE BASE OF THE POST-SADDLE CREEK "LOWER-TANNEHILL" SANDSTONE


Breckenridge
Albany
Eolian
Caddo
Moran
Cisco
Putnam
Baird
Eastland
Ranger
PALO PINTO CO.
SHACKELFORD CO.
CALLAHAN CO.
STEPHENS CO.
EASTLAND CO.
GUNSIGHT LS.
BUNGER LS.
NORTH LEON LS. (BUNGER?)
GUNSIGHT
N
Outcrop
Well Location: Contour Datum
Highway
Contour Interval: 10'
AXES OF POST-BUNGER CHANNEL SANDSTONE
MARY J. SEALS
BAYLOR UNIVERSITY
AUGUST, 1965
0 2 4 6 Miles
SCALE 1:126,720
PLATE XXXVII
OUTCROPS AND CHANNEL PATTERNS APPROXIMATED FROM SURFACE MAPPING BY BAYLOR GEOLOGISTS-- J. H. MCGOWEN (1964), L. F. BROWN, T. H. WALLER, J. R. RAY, AND P. A. BOONE (PERSONAL COMMUNICATION).
ISOPACH MAP
OF THE
BUNGER - GUNSIGHT
INTERVAL

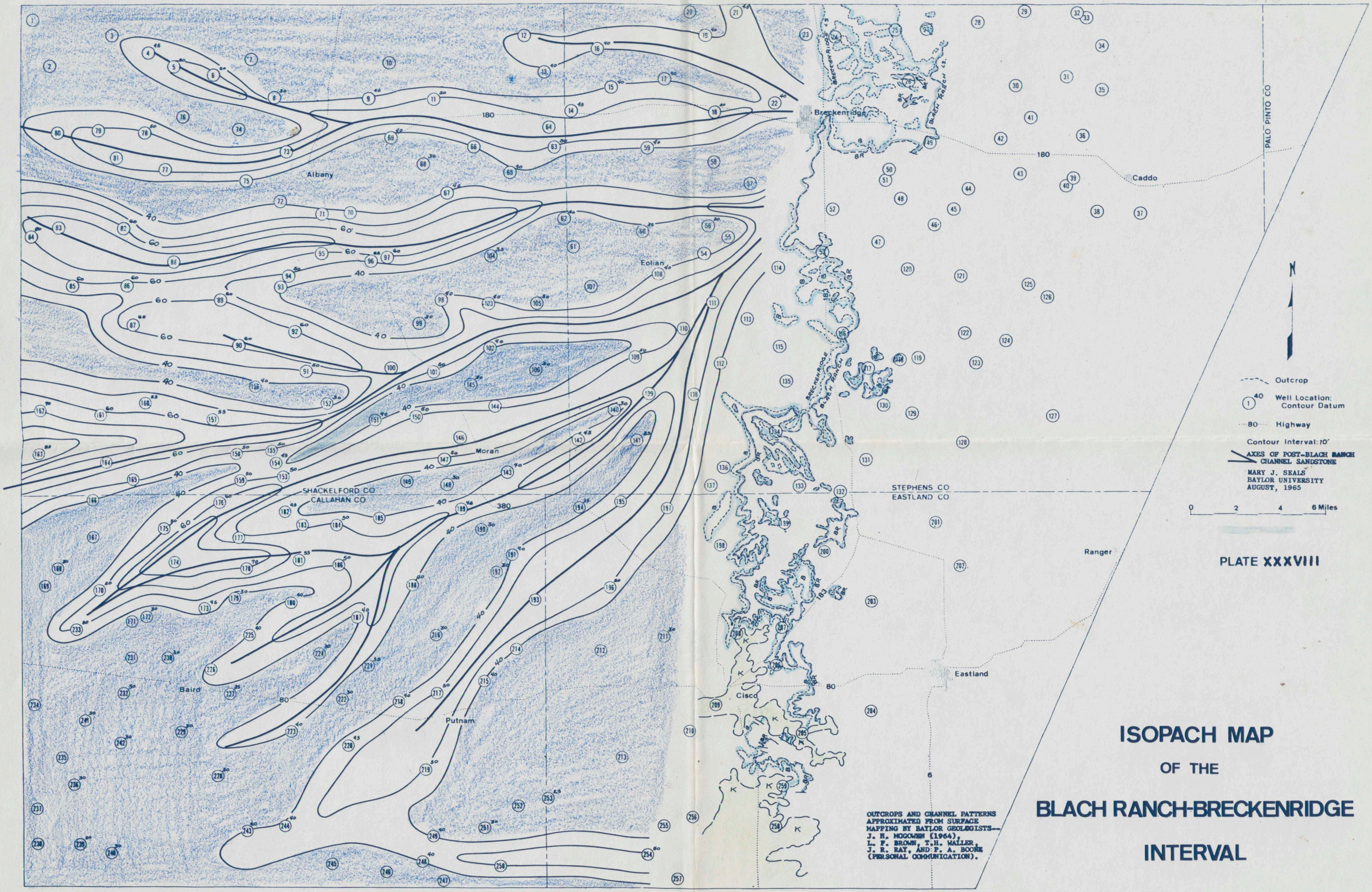
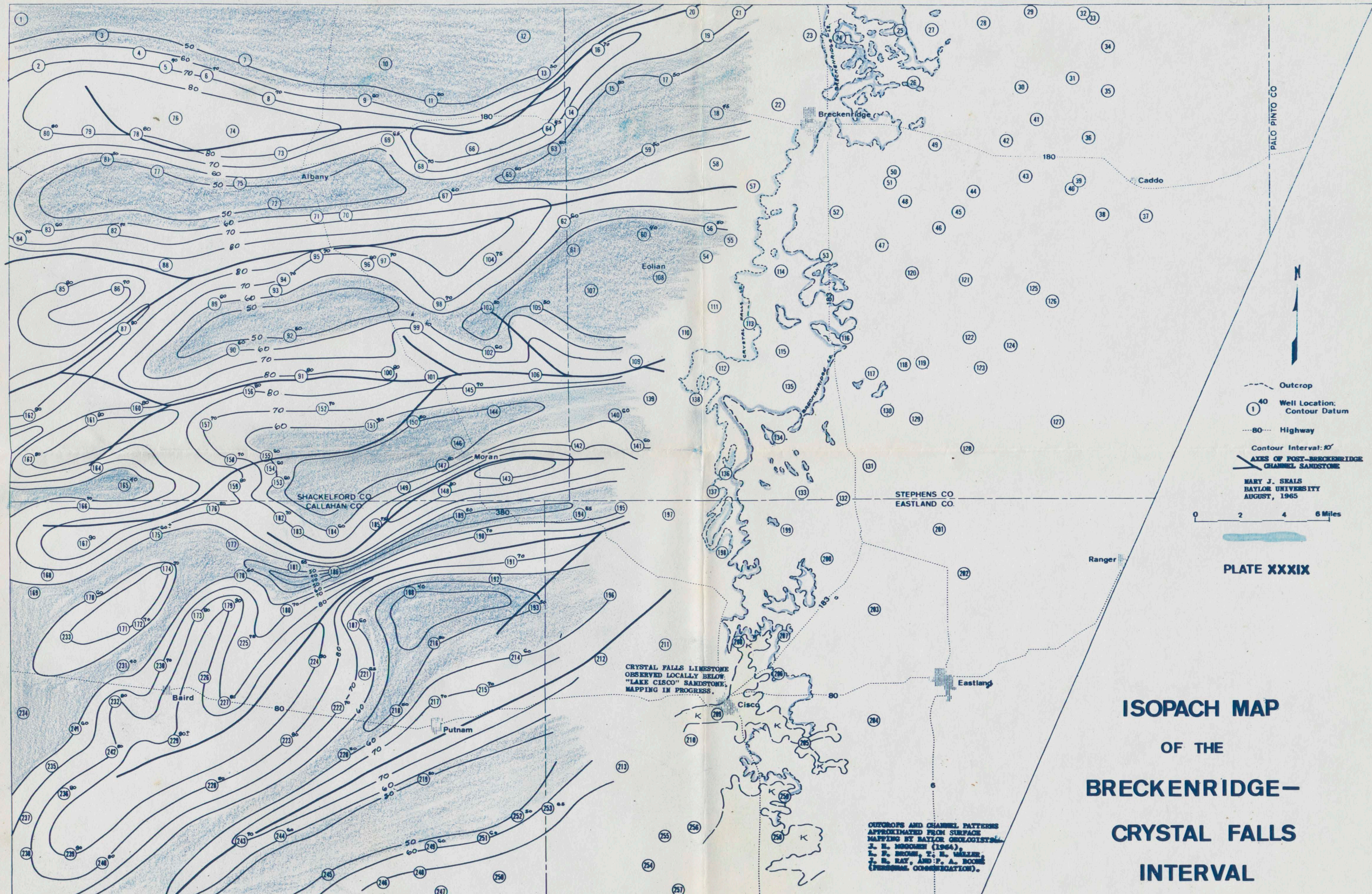
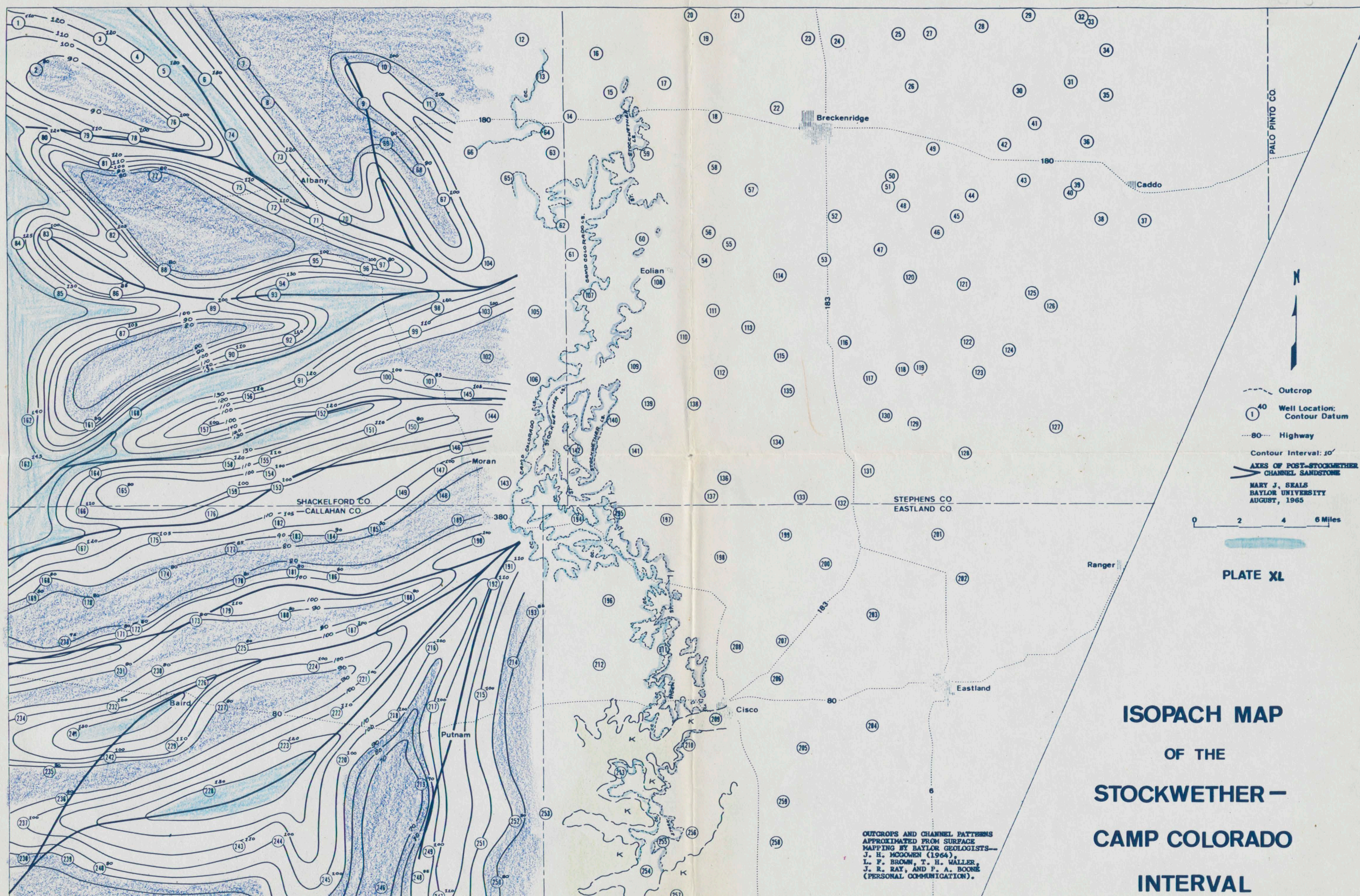


PLATE XXXVIII

ISOPACH MAP OF THE BLACH RANCH-BRECKENRIDGE INTERVAL

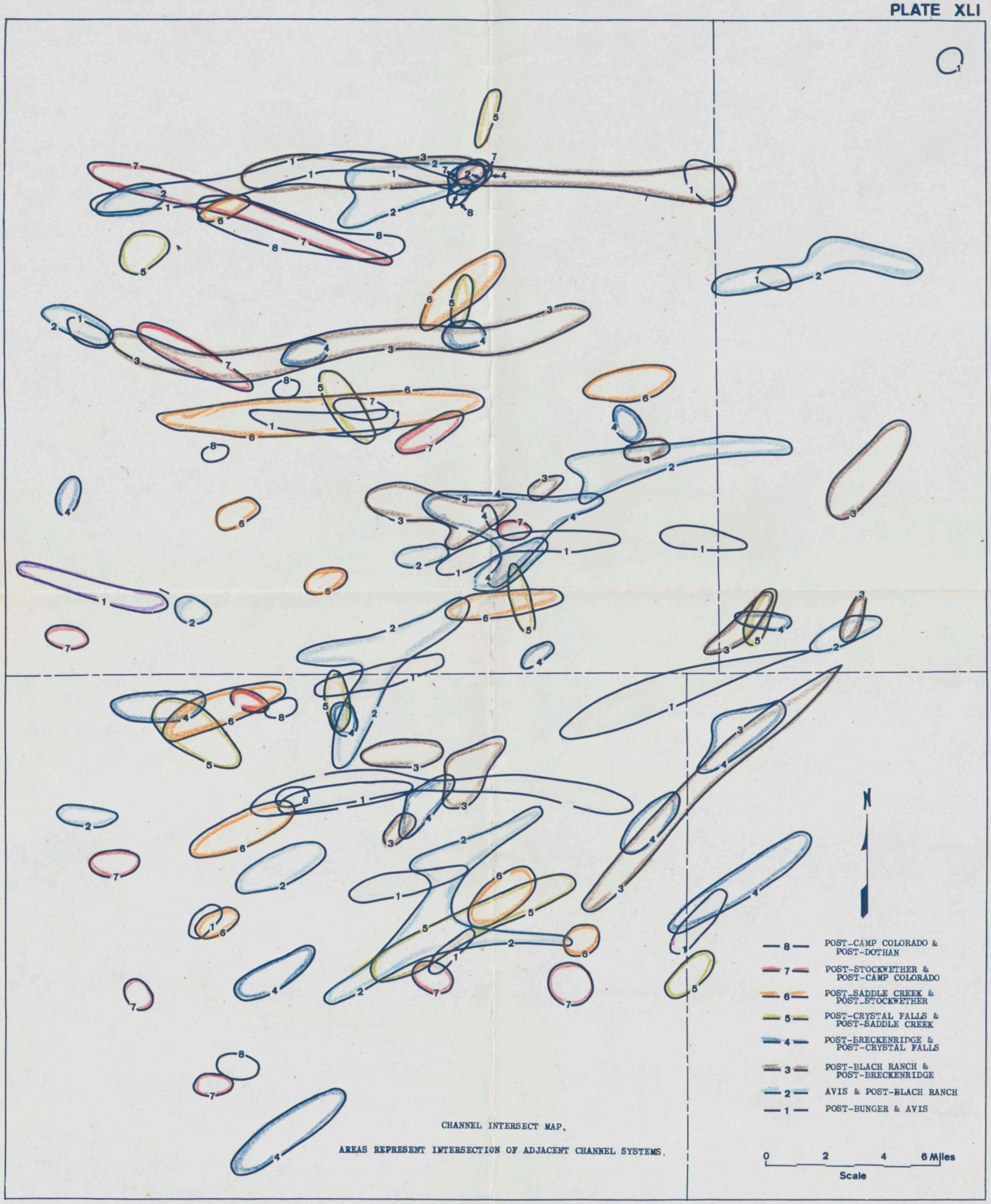


ISOPACH MAP OF THE BRECKENRIDGE–CRYSTAL FALLS INTERVAL



ISOPACH MAP OF THE STOCKWETHER – CAMP COLORADO INTERVAL

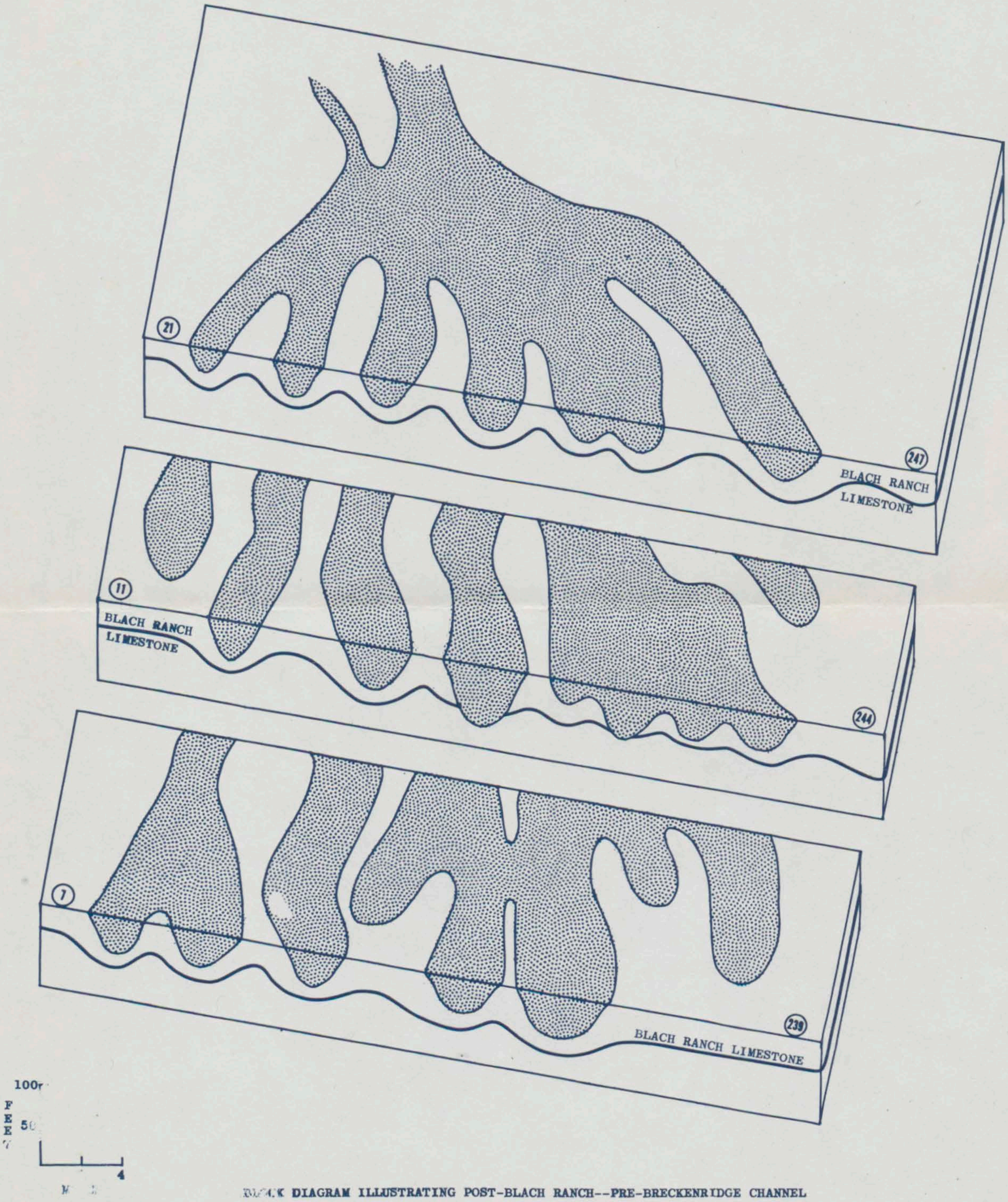
PLATE XLI



CHANNEL INTERSECT MAP.

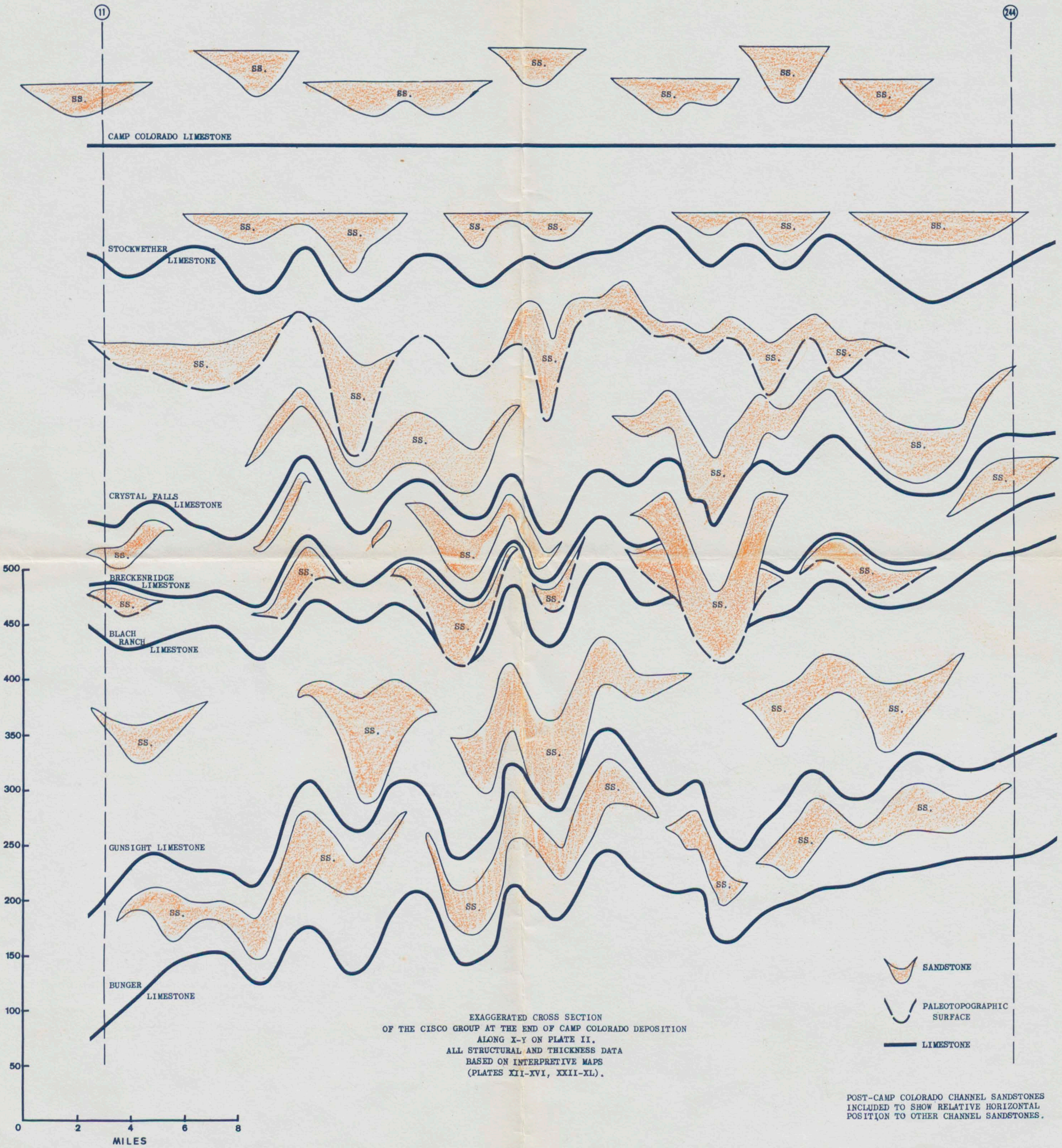
AREAS REPRESENT INTERSECTION OF ADJACENT CHANNEL SYSTEMS.

PLATE XLIV



BLOCK DIAGRAM ILLUSTRATING POST-BLACH RANCH--PRE-BRECKENRIDGE CHANNEL

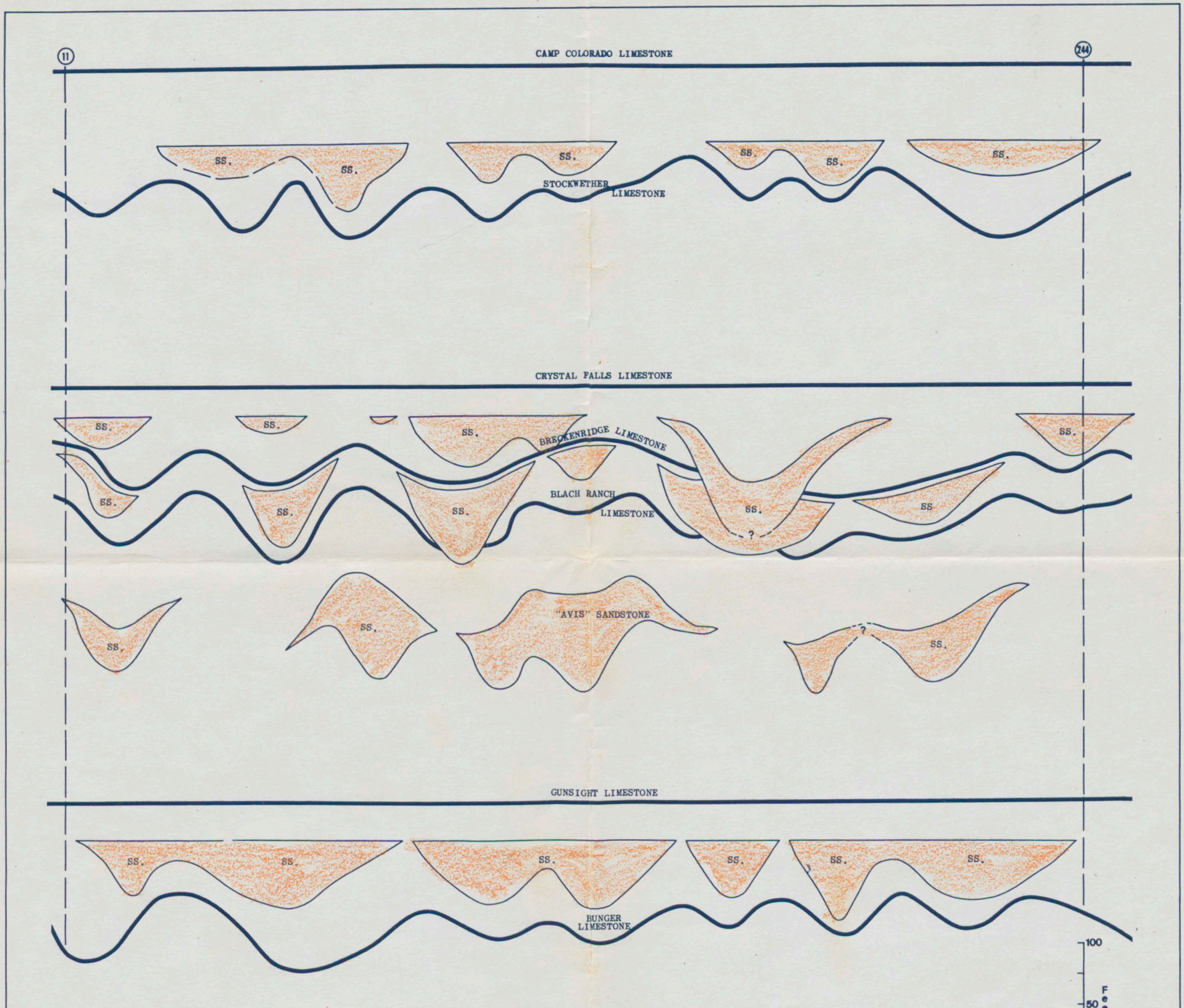
PLATE XLII



EXAGGERATED CROSS SECTION
OF THE CISCO GROUP AT THE END OF CAMP COLORADO DEPOSITION
ALONG X-Y ON PLATE II.
ALL STRUCTURAL AND THICKNESS DATA
BASED ON INTERPRETIVE MAPS
(PLATES XII-XVI, XXII-XL).

POST-CAMP COLORADO CHANNEL SANDSTONES INCLUDED TO SHOW RELATIVE HORIZONTAL POSITION TO OTHER CHANNEL SANDSTONES.

PLATE XLIII



EXAGGERATED CROSS SECTIONS OF SELECTED INTERVALS ALONG LINE X-Y ON PLATE II REPRESENTING CONDITIONS AT THE END OF GUNSIGHT, CRYSTAL FALLS AND CAMP COLORADO DEPOSITION BASED ON INTERPRETIVE MAPS (PLATES XXII, XXVI-XXIX XXXII. XXXVII-XL).