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THE DEMING AXIS
SOUTHEASTERN ARIZONA, NEW MEXICO AND TRANS-PECOS TEXAS

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The Deming axis is a major linear tectonic element extending from southeastern Arizona to Trans-Pecos Texas. The trend of this axis is partially expressed by a chain of five lesser structural units; the Van Horn uplift in western Texas, the Florida and Burro uplifts in southwestern New Mexico, and the Graham and Florence uplifts in southeastern Arizona. The Deming axis seems to have been initiated during Mississippian time, and its presence has had a significant effect on the subsequent sedimentary and structural patterns of this area. These features are illustrated by paleogeographic maps of the Paleozoic and Mesozoic, and paleogeologic maps of outcrop patterns developed during intervals of major tectonism and erosion. The general north-south strike of Tertiary structures and present-day topographic features in this region are deflected to a northwest-southeast trend across the Deming axis, and this is the basis for the concept of the Texas lineament. Lateral continuations of the Deming axis beyond the area of investigation are open to speculation.

An analysis of the regional structure and stratigraphy of southern Arizona and New Mexico, western Texas and northern Sonora and Chihuahua, Mexico, has revealed the presence of a major linear tectonic element which is here termed the Deming axis. This feature can be traced from the vicinity of the town of Florence in south-central Arizona to the area of Van Horn in Trans-Pecos Texas, and has been named from Deming, New Mexico, which is near the center of the area of investigation. The Deming axis seems to have been initially developed during Mississippian time and its presence has had a significant effect on the sedimentary and structural patterns of the late Paleozoic, Mesozoic and Tertiary.

The evolution of the Deming axis can best be observed through the construction of paleogeologic and paleotectonic maps for critical parts of the stratigraphic sequence. The accompanying illustrations are generalized summaries of a series of maps that were prepared, for the most part, from a detailed survey of published and unpublished literature on this region, and an examination of available well control. Some segments have been compiled from field observations. For reference purposes, the trend of the Deming axis is indicated by a dashed line (D—A) extending across each map. A complete documentation of the control data used in assembling these maps would cover several hundred references. The appended bibliography has been selected to substantiate only the structural elements critical to the theme of this short note.

Figure 1 illustrates the regional trend of the Deming axis from south-central Arizona to Trans-Pecos Texas. An extension of this axis to the west of the map area has not been established, as the structural and stratigraphic history of southwestern Arizona is still imperfectly known. An eastward trace is likewise obscure due to the welter of Paleozoic, Mesozoic and Cenozoic structural events of western Texas and northern Mexico. Even along the known trend of the axis the complete understanding of its geologic history awaits the results of additional field work.

As indicated on Figure 1, the Deming axis seems to consist of a chain of five lesser tectonic features: the Van Horn, Florida, Burro, Graham and Florence uplifts. The individuality of these uplifts is only relative, although each seems to have become locally prominent during one or more intervals of geologic time. Structural and stratigraphic descriptions have been published for the Van Horn, Florida, and Burro uplifts (see bibliography). The features herein referred to as the Graham and Florence uplifts are previously undescribed.

The Graham uplift centers around the Precambrian mass of the Pinaleno Mountains and is named for Mt. Graham, the highest peak in the range. Significant local uplift and erosion occurred in the area of this element during the Late Jurassic "Nevadan" and Late Cretaceous to early Tertiary "Laramide" orogenies. The effect of Nevadan deformation has been mapped in the Dos Cabezas and northern Chiricahua Mountains, where Cretaceous sediments overlap eroded Paleozoic rocks and locally rest on Precambrian granite and schist. Renewed uplift and erosion during Laramide time is evidenced by the presence of Late Cretaceous and Tertiary volcanics resting unconformably on Mesozoic, Paleozoic and Precambrian rocks in the Dos Cabezas, Pinaleno, Santa Teresa, Turnbull and Mescal Mountains.

Nevadan and Laramide movement on the Florence uplift can be interpreted from field work in the ranges to the east and south of the city of Florence, Arizona. Nevadan tectonism is recorded by the occurrence of Cretaceous sediments and volcanics unconformably overlying Paleozoic and Precambrian beds in the Black, Santa Catalina, Waterman and Vekol Mountains. Broad uplift and erosion of Laramide age is evidenced in the Superior area, and the Tortilla, Black, Tortolita, Tucson, Silver Bell, Vekol and Silver Reef Mountains where the Cretaceous-Tertiary volcanic suite rests on older rocks of various ages. Sedimentary rock outcrops are rare in the region to the west and northwest of Florence, and the western limit of this uplift cannot be determined.

Separation between the Florence and Graham uplifts, and between the Graham and Burro uplifts, is a matter of conjecture. The proof is hidden beneath the piles of Tertiary volcanics forming the Galiuro and Peloncillo Mountains. Perhaps the best evidence is the mountains themselves, with the volcanic rocks in these ranges being topographically and structurally lower than the Precambrian on Mt. Graham.

Evidence for a Precambrian expression of the Deming axis is inconclusive. A zone of east-west trending Precambrian structures is certainly present in the core area of the Van Horn uplift in Texas. However, through southern New Mexico and Arizona the dominant lineations within Precambrian exposures are northeast-southwest. Probably the Deming axis is not underlain throughout its entire length by a significant basement structural element.

Figure 2 depicts the general paleogeology of early Paleozoic time. This region appears to have been a part

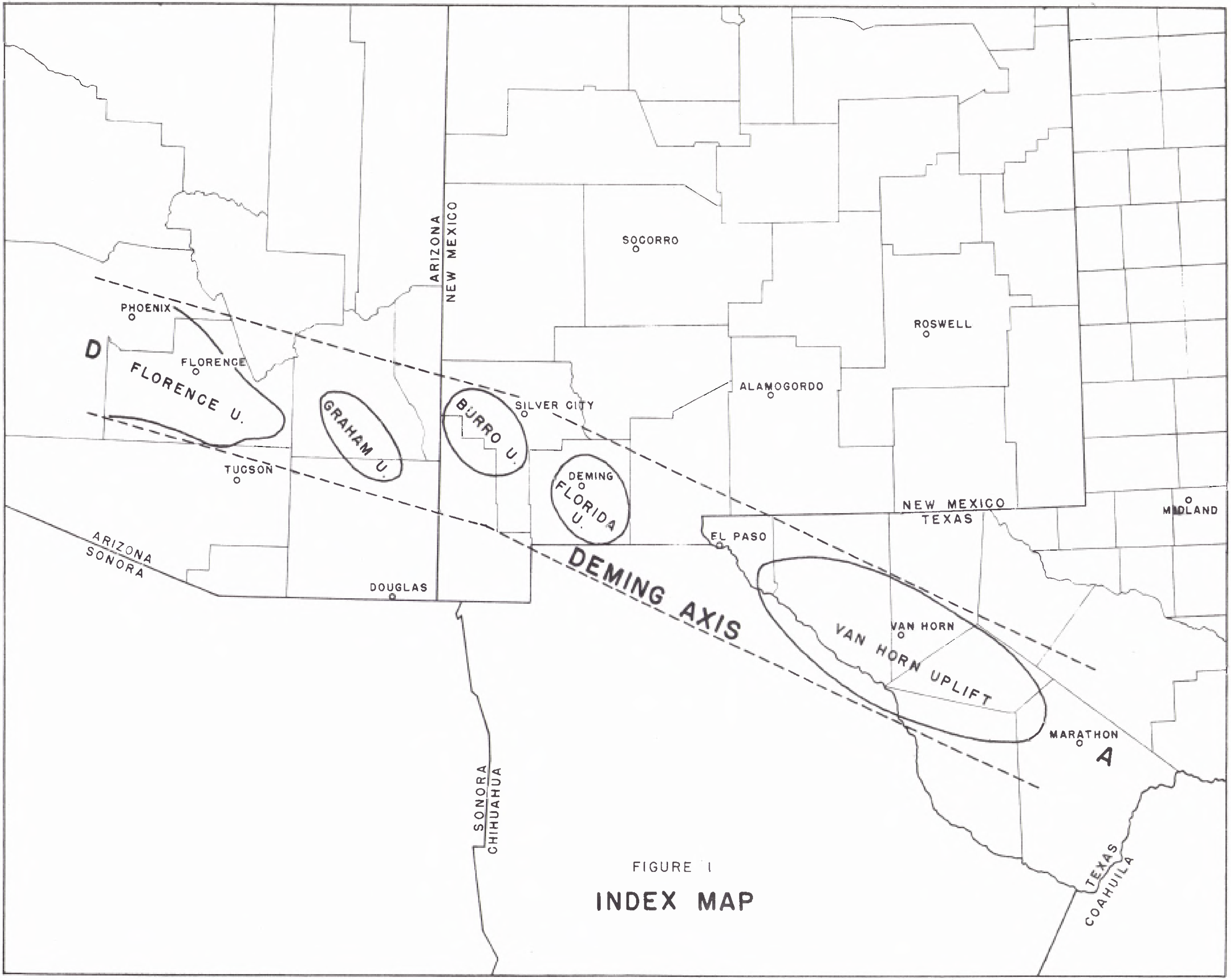

FIGURE 1

INDEX MAP

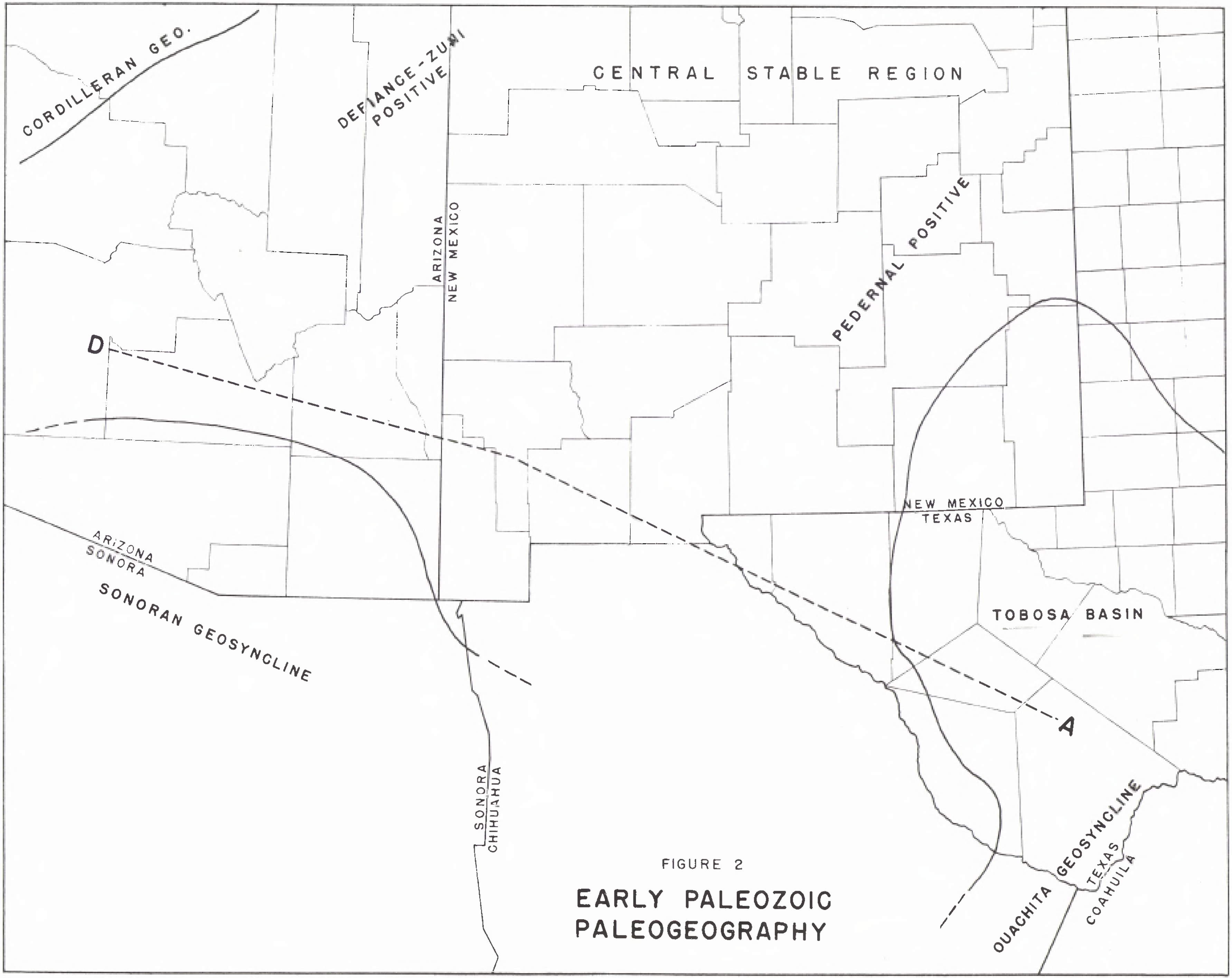

FIGURE 2

EARLY PALEOZOIC PALEOGEOGRAPHY

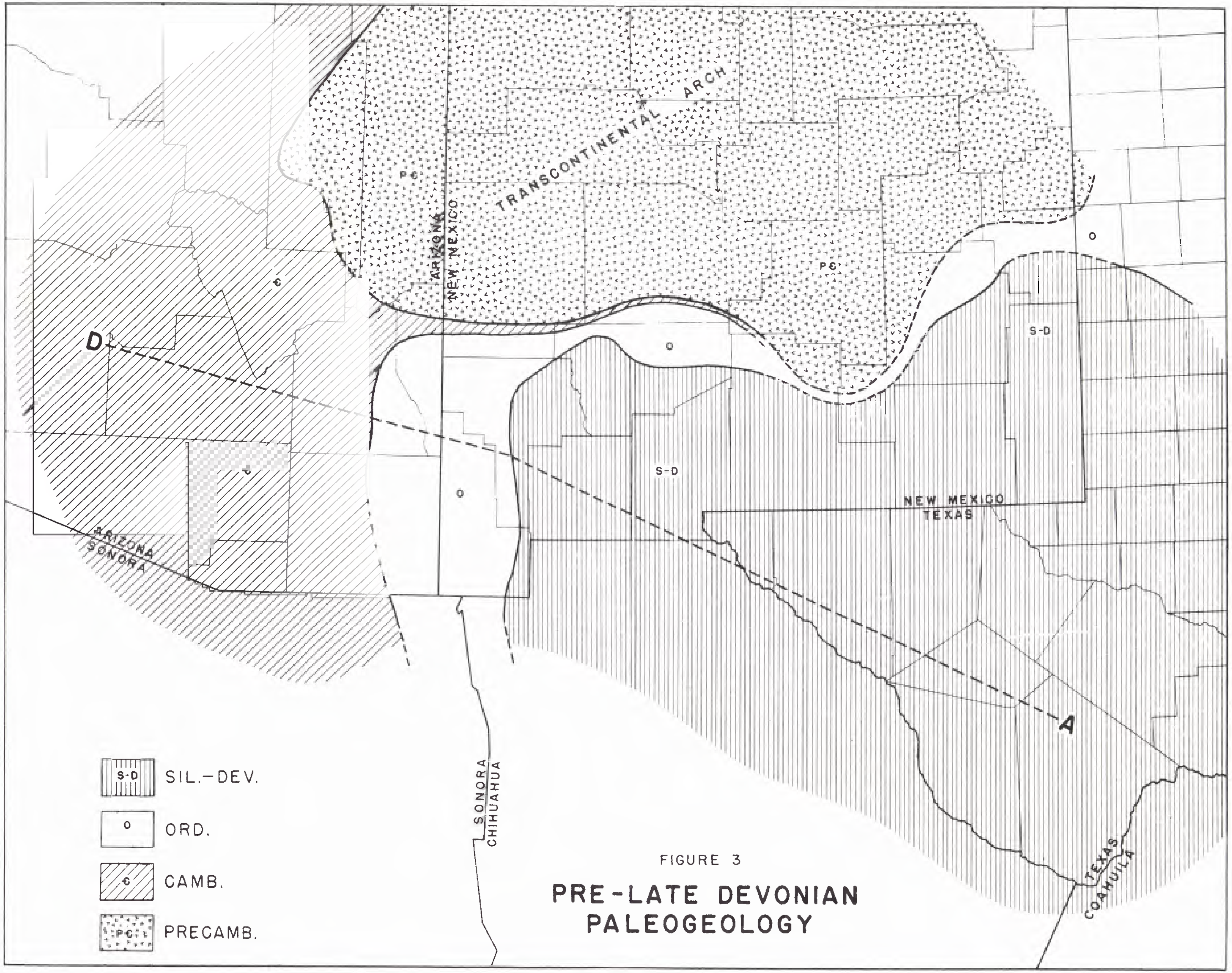

FIGURE 3

PRE-LATE DEVONIAN PALEOGEOLOGY

of the southwestern extension of the Central Stable region of the North-American continent. The Defiance-Zuni and Pedrenal positive areas may have been present as local upwarps on this platform, but this is by no means certain.

Cambrian deposits are thin or absent over most of southern New Mexico and western Texas. However, they thicken to the southwest across Arizona and Sonora towards the Paleozoic Sonoran geosyncline, and to the northwest toward the Cordilleran geosyncline. Cambrian beds also thicken to the southeast across Texas into a seaway possibly coincident with that of the late Paleozoic Ouachita geosyncline. Due to prelate Devonian erosion, the record of Early Ordovician sedimentation is obscure over the northern and western parts of the map area, but strata of this age are present across southern New Mexico and Texas, and thicken southeastward to the site of the Cambrian basin.

The history of later Ordovician, Silurian and Early Devonian sedimentation is likewise unknown through much of southern Arizona and northern Sonora, although beds representing parts of these time intervals are present in central and southern Sonora along the trend of the Sonoran geosyncline.

Another depositional feature of this period is the Tobosa basin, which was centered around the present site of the Central Basin platform of West Texas and southeastern New Mexico. The Tobosa basin seems to have been a persistent structural and depositional sag from Middle Ordovician through Devonian time.

Gaps in the fossil record suggest that during several periods in the early Paleozoic this region was subjected to epeirogenic upwarping, resulting in non-deposition of sediments and mild erosion. The first strong cycle of uplift and erosion occurred in Late Devonian time when the pre-Martin, pre-Percha, pre-Woodford and pre-Chattanooga unconformity was developed throughout the southern United States. During this time the broad Transcontinental arch was raised across northern New Mexico and central Arizona, and early Paleozoic beds were eroded off this arch to the approximate limits shown on Figure 3. Southwestern Arizona was broadly upwarped ("Mazatzal land") and post-Cambrian strata were stripped back to the vicinity of the Arizona-New Mexico boundary. Over most of central and southeastern Arizona Late Devonian beds rest on late Cambrian, with only a slightly discordant contact representing this extensive period of erosion. There is no definite evidence from lithofacies, thickness and structural studies in this region that a significant tectonic element was present along the trend of the Deming axis during early Paleozoic time.

Although separated from the older rocks by a major unconformity, the tectonic patterns of the Late Devonian generally reflect those of earlier Paleozoic. A limestone facies thickens to the southwest across southern Arizona into the Sonoran geosyncline in northwestern Sonora. The dark shale facies of southern New Mexico and western Texas thickens into a sag over-lying the earlier Tobosa basin. Again there is no stratigraphic or structural evidence of the Deming axis having been present during this time interval.

Although the record of Mississippian deposition has been obscured over much of this area by pre-Pennsylvanian epeirogenic upwarp and erosion, enough evidence remains to indicate that a significant change occurred in the regional tectonic framework during this Period. In southeastern Arizona and southwestern New Mexico, the northwest-trending Pedregosa basin began to form, and the alignment of its northeastern margin provides an expression of the tectonic development of the Deming axis (Figure 4). The effect of this axis on sedimentation is revealed by the thick, massively-bedded deposits of Early Mississippian limestone found in the Pedregosa basin which contrast with the thinner, somewhat more clastic, occasionally reef-bearing units found to the north and northeast of the axis. In south-central New Mexico, Kinderhook and Osage rocks are present in the San Andres and Sacramento Mountains, but have not been identified in the Hueco Mountains and Sierro Diablo outcrop areas of Trans-Pecos Texas. This absence is attributed to the initial appearance of the Van Horn uplift on the Deming axis. This uplift was evidently not active in Late Mississippian time, as Chester rocks are present in the outcrops of both Texas and New Mexico.

The second important cycle of uplift and erosion to affect this region occurred prior to Pennsylvanian deposition. Pre-Pennsylvanian paleogeologic mapping (not illustrated) suggests that over much of Arizona and New Mexico this movement was largely epeirogenic in nature. The Defiance-Zuni and Pedernal landmasses were developed at this time. A local, short-lived uplift occurred in the vicinity of the Caballo Mountains in south-central New Mexico; and in southeastern New Mexico and West Texas the Pecos uplift, the foundation of the Central Basin platform, also appeared. The tectonic behaviour of most of Trans-Pecos Texas during this time interval is unknown due to the widespread effects of the succeeding pre-Permian erosion period. The Deming axis does not seem to have played an important role during this interval of structural movement.

At the beginning of Pennsylvanian sedimentation, numerous structural changes occurred in New Mexico and western Texas, resulting in the development of the paleogeographic elements illustrated on Figure 4. During this time the Deming axis began to assume a more significant effect on the structural and sedimentary patterns of this region. The Pennsylvanian record is obscure in the mountain ranges of Trans-Pecos Texas, but the limited amount of data now available suggest that the Van Horn uplift (Diablo platform) may have been mildly positive and provided a separation between the Delaware and Marfa basins. To the northwest there is good evidence from thickness and lithofacies data that the Florida uplift (Florida islands) was developed on the trend of the Deming axis in and around Luna County, New Mexico. The trend of the Deming axis again seems to have provided a flexure controlling a zone of regional facies change for Pennsylvanian sedimentation in southeastern Arizona and southwestern New Mexico. Thick units of relatively clastic-free carbonates accumulated in the Pedregosa basin in contrast to the much more clastic sections deposited in the Central New Mexico basins, and on the flanks of the Defiance-Zuni landmass. The relatively stable Deming axis provided a favorable environment for late Pennsylvanian reef development along the northeastern margin of the Pedregosa basin in New Mexico.

The third significant pulse of Paleozoic orogenic movement in this region occurred prior to, or early in, Permian time. The result of this tectonism is illustrated on the paleogeologic map of Figure 5. Through southeastern Arizona, most of southwestern New Mexico, and in the depositional

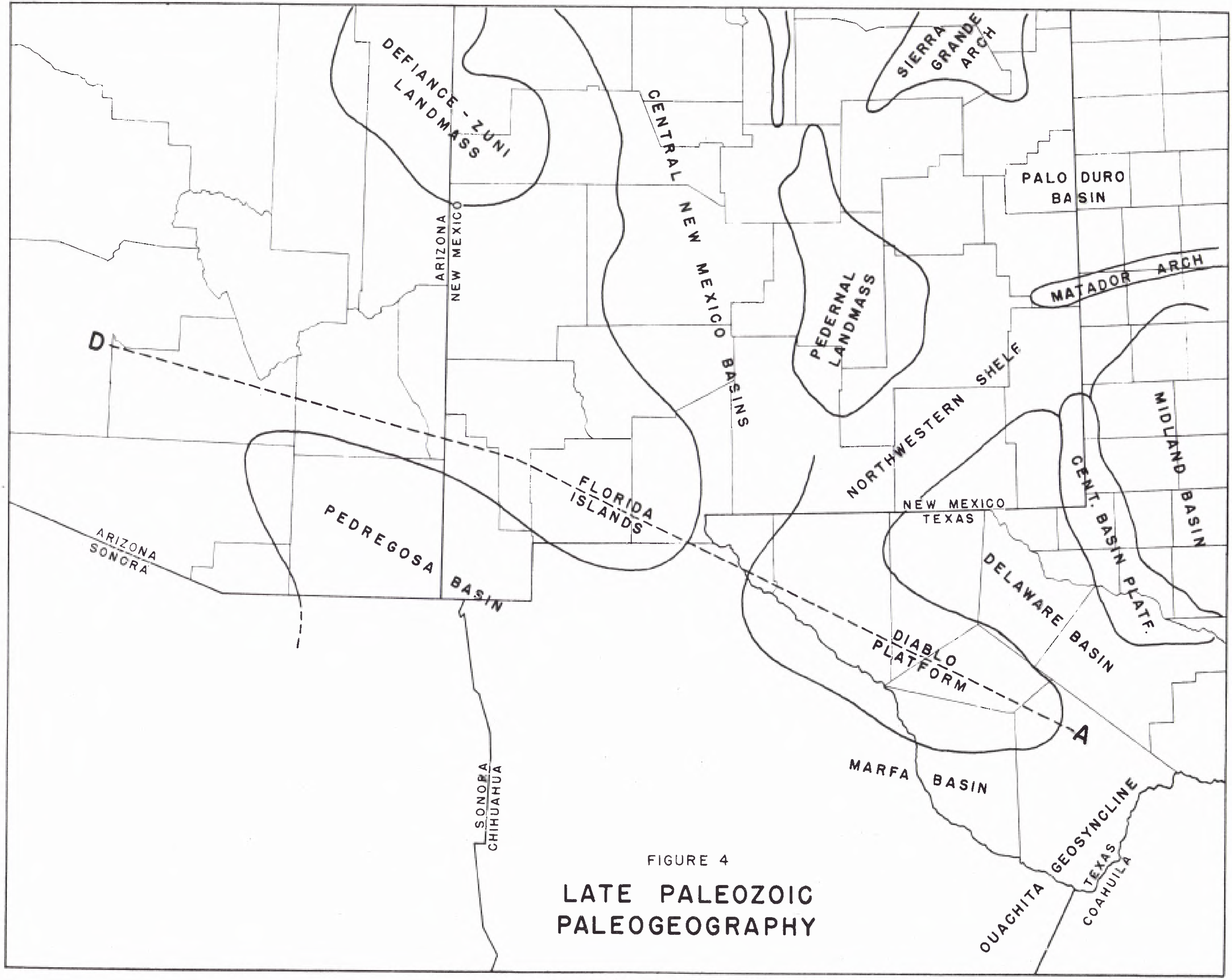

FIGURE 4

LATE PALEOZOIC PALEOGEOGRAPHY

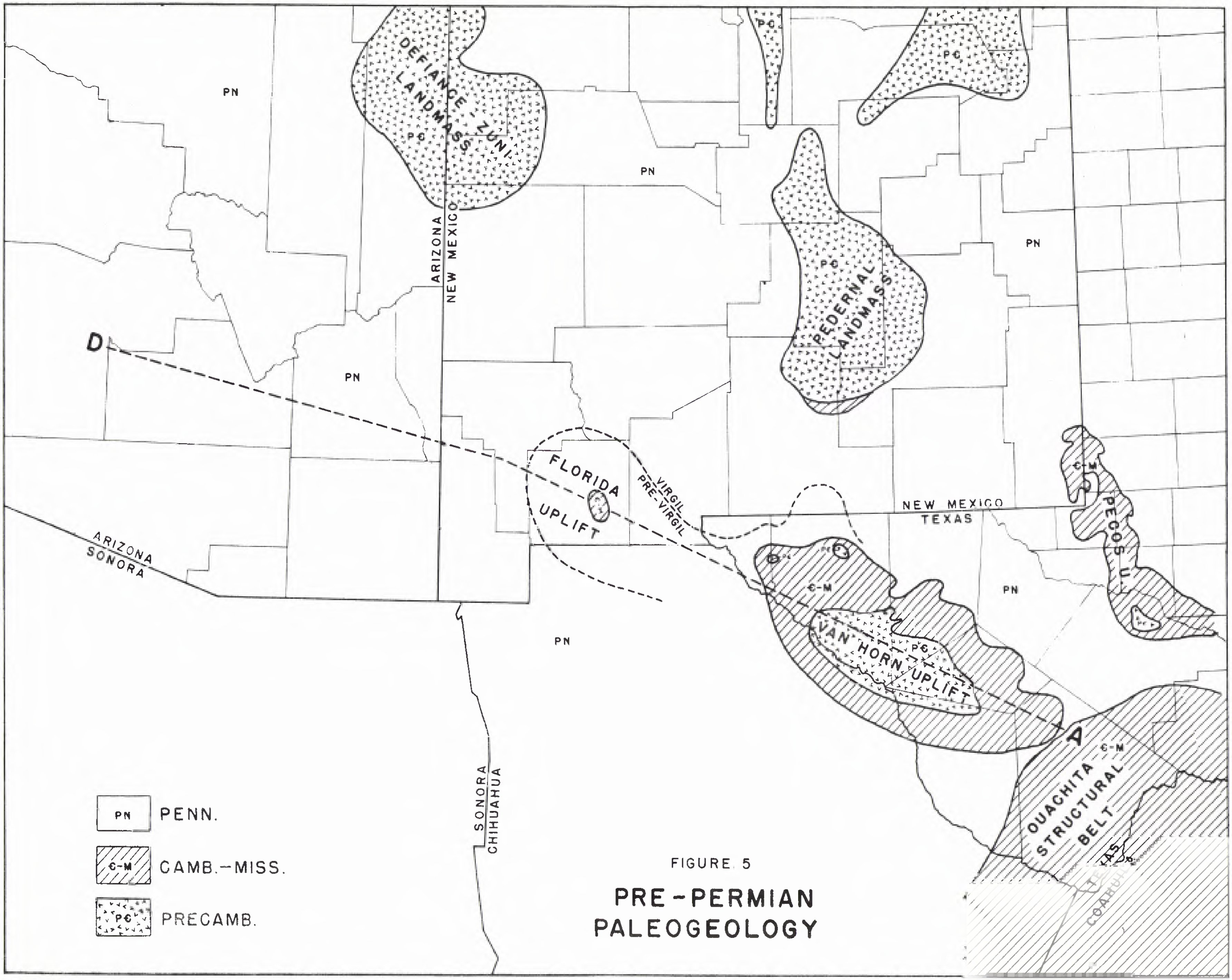

FIGURE 5

PRE-PERMIAN PALEOGEOLOGY

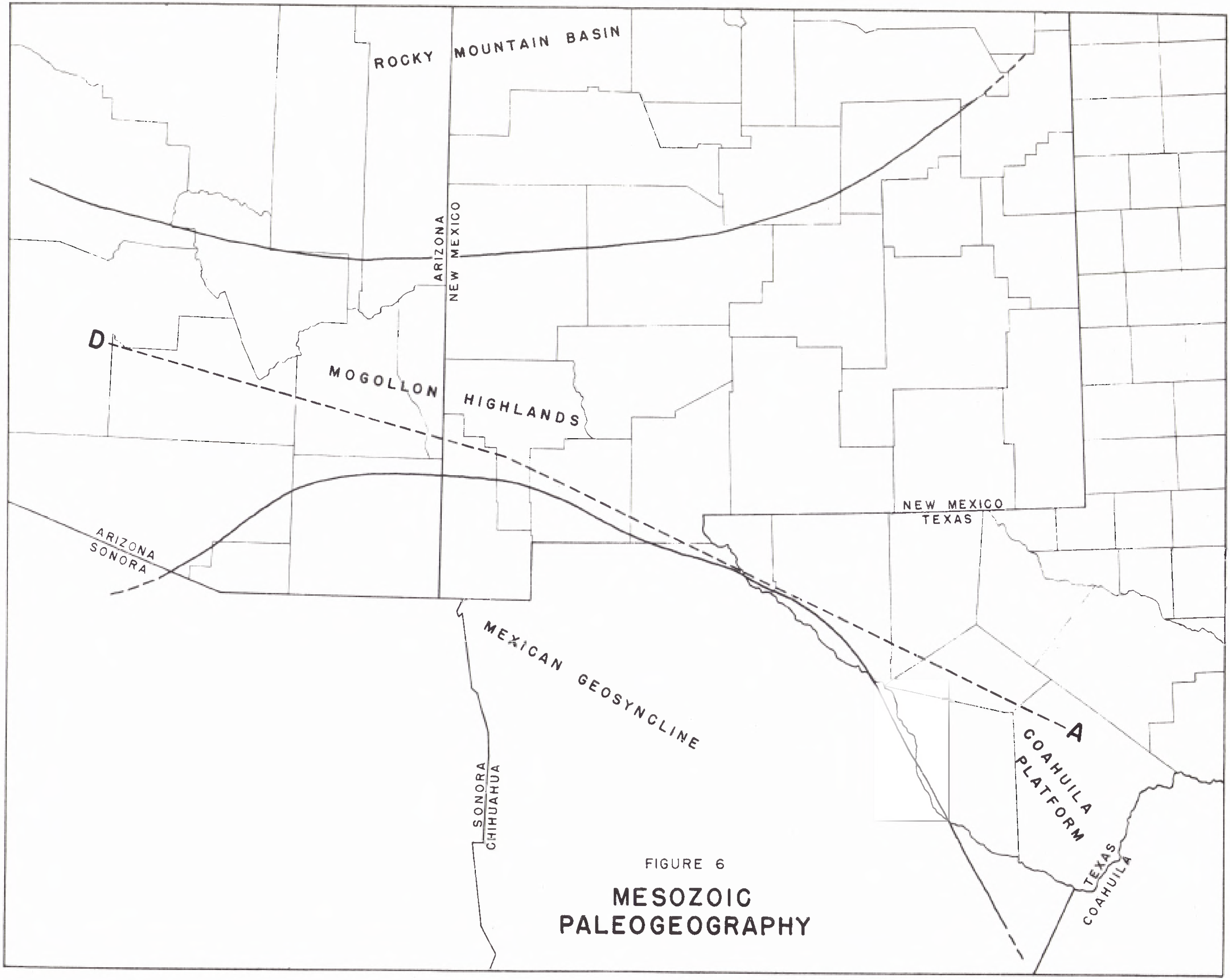

FIGURE 6

MESOZOIC PALEOGEOGRAPHY

basins of southeastern New Mexico and western Texas, there is little evidence for a break in sedimentation between Pennsylvanian and Permian times. However, the complex tectonic elements of the Ouachita structural belt reached their culmination at this time, and subsidiary deformation is recorded on the positive structural features to the northwest of this trend. At the southeastern end of the Deming axis, the area of the Van Horn uplift was upwarped and deeply eroded, with all pre-Permian sediments being stripped off its crest. To the northwest, the deformation was less severe in the area of the Florida uplift. All Pennsylvanian strata were removed in the vicinity of the Florida Mountains, and beds of Virgil age are missing over a somewhat broader region. Similarly, the Pecos uplift was rejuvenated and deeply eroded; however, this tectonism is significantly recorded on the Pedernal landmass only around its southern margin.

During Permian time the region of the Van Horn uplift provided a stable environment (Diablo platform) for extensive reef development, as did the Pecos uplift (Central Basin platform) to the east. To the west the flexure along the trend of the Deming axis continued to provide regional environmental control for Early Permian sedimentation. The Pedregosa basin on the south continued to sink and receive predominately carbonate deposition, again accompanied by reefing in southwestern New Mexico. To the north, the Early Permian is largely represented by an extensive clastic redbed shelf facies. The record of the late Permian is obscured by the effects of extensive post-Paleozoic erosion. However, there is a similarity between Late Permian strata preserved on either side of the axis, suggesting that this feature was not a particularly significant tectonic element during this time.

The regional paleogeography of Mesozoic time (Figure 6) is much simpler than that of the late Paleozoic. The character of the Deming axis was generally positive through this period, and it appears to have acted as an intermittent barrier (Mogollon highlands) between depositional basins to the north and south. Sediments of Triassic and Jurassic age are found on either side of this structural trend. However, the present limits of their occurrence are due to pre-Cretaceous uplift and erosion, and consequently there is some question as to whether or not these widely-separated rock units were once connected over the Deming axis.

The regional effects of the Nevadan orogeny is depicted on the paleogeologic map of Figure 7. In contrast to the late Paleozoic tectonic events, which were more severe along the eastern part of the Deming axis, the Nevadan movements were more strongly expressed toward the west; and the Florence, Graham and Burro uplifts were developed at this time. In each of these areas the Paleozoic rock column was removed, exposing sizeable terrains of Precambrian. To the east, this upwarping resulted in the erosion of only the post-Wolfcamp Permian section, although Precambrian rocks were re-exposed in a small area on the crest of the Van Horn uplift. Just to the south of the Deming axis, a sharp uplift in the vicinity of the Mule Mountains was also eroded to the Precambrian.

The regional control of deposition and structure by the Deming axis was well-expressed during the Cretaceous. During most of Lower Cretaceous time, sedimentation was confined to the Mexican geosyncline lying immediately to the south of the axis. Only during Washita time were appreciable amounts of sediment deposited over the eastern end of the axis in West Texas and southeastern New Mexico. A significant tectonic shift occurred during the Upper Cretaceous, and rocks of this age were probably deposited only in the Rocky Mountain basin encroaching from the north. The few deposits of very Late Cretaceous age found to the south of the Deming axis in Arizona and northern Sonora (Figure 8) may be attributed to local pockets of debris resulting from early Laramide movements.

Marine sedimentation within the area of investigation was terminated by the widespread deformation of the Laramide orogeny. The history of this orogeny is quite complex and it seems to have developed in several stages extending from Late Cretaceous into early Tertiary time. A detailed discussion of this progression of events is beyond the scope of this paper, and reference is made here only to the earliest movement. The result of this period of uplift and erosion is summarized on the paleogeologic map of Figure 8, the title of which may be somewhat misleading. In southeastern Arizona and part of southwestern New Mexico this "pre-Tertiary" map is drawn at the base of the volcanic section, part of which is considered to be late Cretaceous in age. In Trans-Pecos Texas and some areas in New Mexico, where the volcanics are thought to be entirely Tertiary in age, this map more nearly reflects a true pre-Tertiary picture.

As shown on Figure 8, the earliest expression of Laramide movement consisted of the rejuvenation and re-erosion of the tectonic features associated with Deming axis. Upwarping appears to have been more or less regional in nature and preceded the extensive folding, faulting, volcanism and intrusive igneous activity that are usually considered to be characteristic of Laramide time. In Trans-Pecos Texas, a subsidiary fold was developed in the vicinity of the Chinati Mountains south of the main trend of the Van Horn uplift. In addition, there is good evidence that a long, possibly boomerang-shaped, trend was developed to the north of the Deming axis in southwestern New Mexico. This feature, here termed the Hillsboro uplift, can be traced through the Lemitar, Magdalena, San Mateo, Cuchillo, Black and Mimbres ranges where the Cretaceous is absent and Tertiary rocks rest on Paleozoic beds locally as old as Ordovician. The southeast-trending arm of this uplift is quite conjectural, but has been postulated in order to tie in areas of pre-Tertiary erosion in the southern Caballo, Robledo, Tonuco, Dona Ana and (possibly) Organ Mountains.

A study of structures known to have been primarily developed during the Laramide orogenic period has indicated that the persistent Deming axis had a significant effect on the strike trends of these elements. Similarly, this axis was also instrumental in determining the strike directions of the Basin and Range structures developed during the late Tertiary Cascadian orogeny. Figure 9 is a plot of the strikes of major Laramide and Cascadian structures present in the area of investigation. With supplementary reference to the recently-published tectonic maps of the United States and Mexico, it can be seen that the dominant structural grain of this region is north to north-northwest. However, across the Deming axis this grain is sharply deflected to a west-northwest trend. This deflection is also obvious on an examination of the present topographic trends and is the basis for the concept of the Texas lineament (see bibliography). An analysis of lineament recognition and lineament tectonics is also beyond the scope of this paper. However, it is thought that the structural and topographic strike deviations along the Tex-

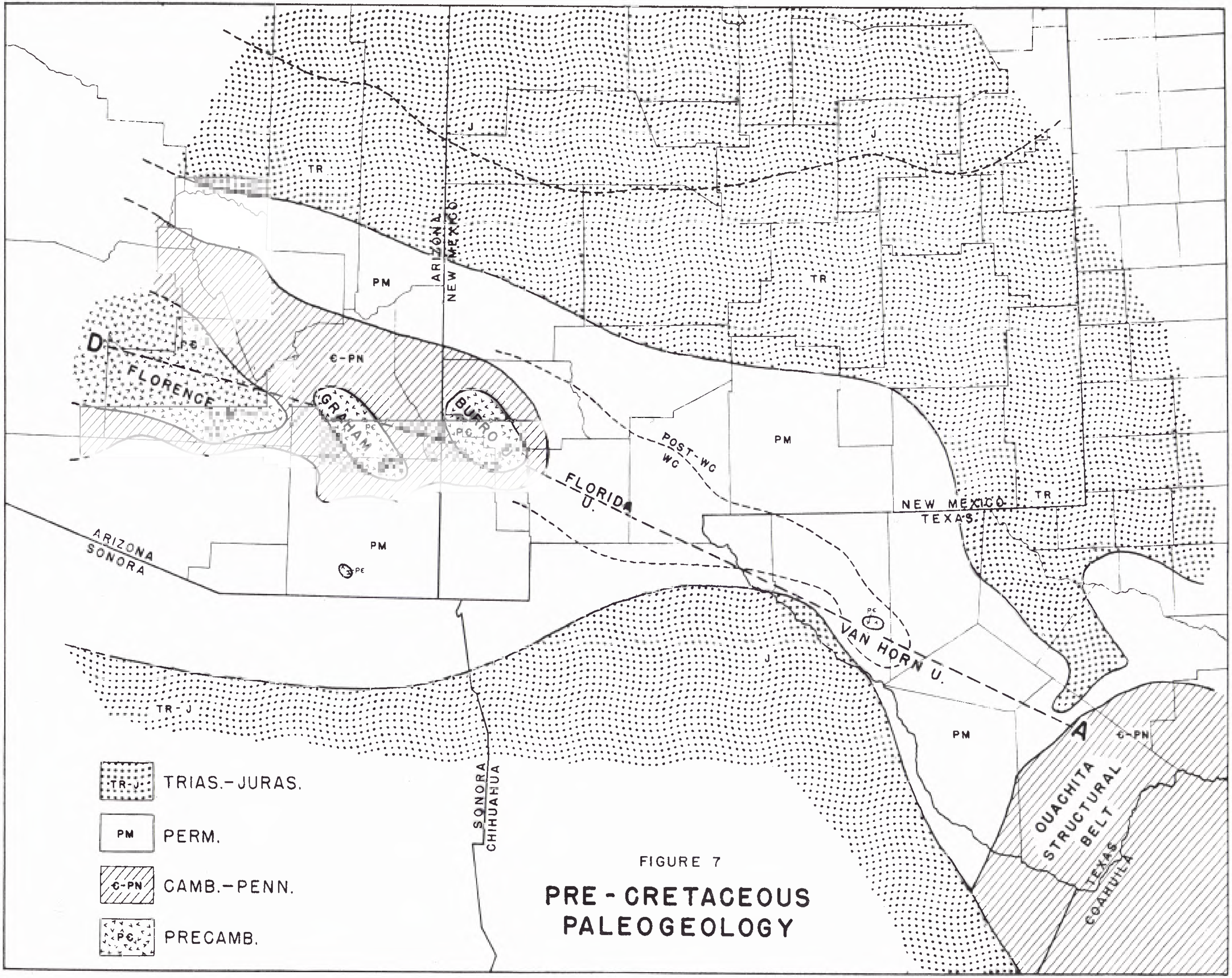

FIGURE 7

PRE-CRETACEOUS PALEOGEOLOGY

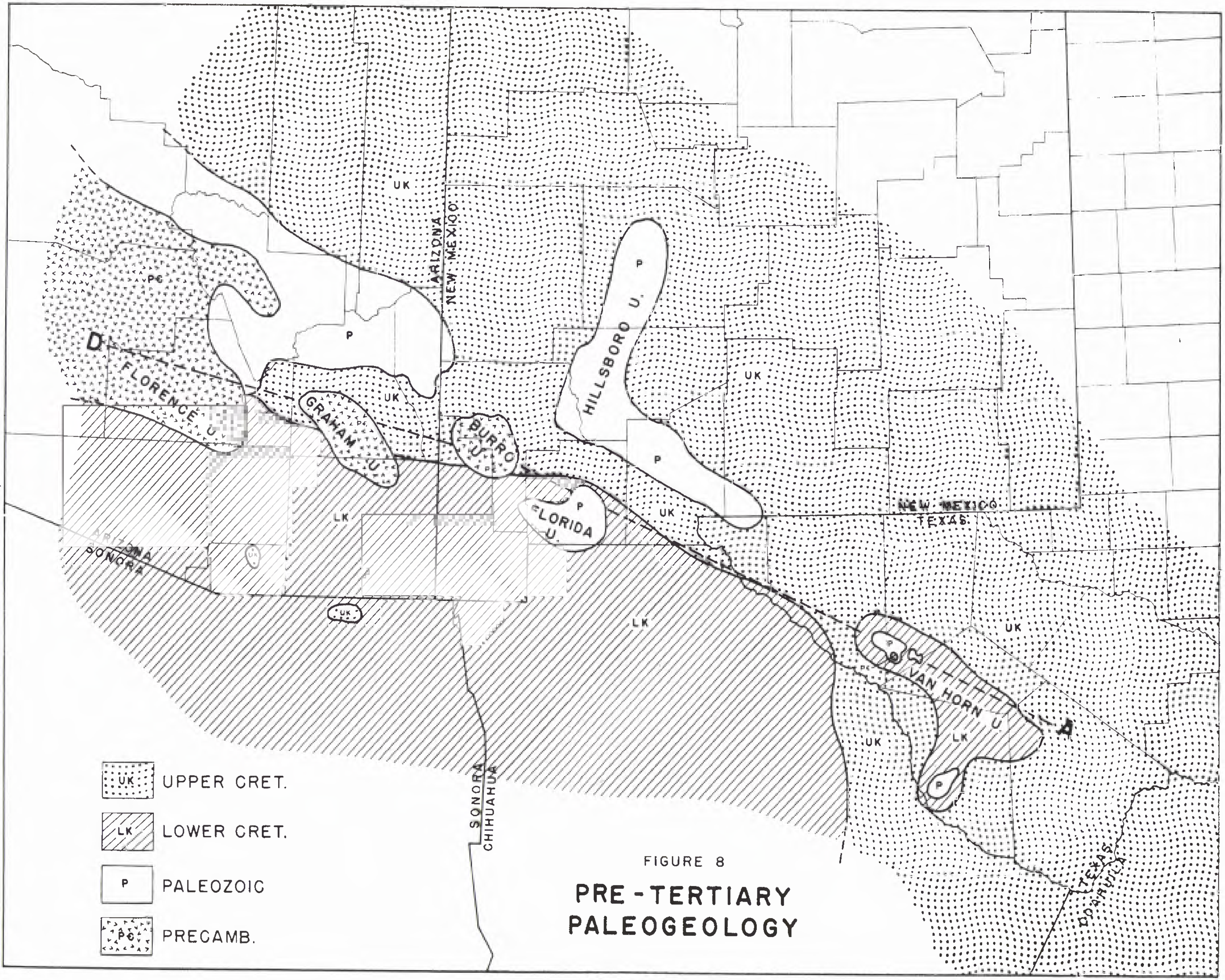

FIGURE 8

PRE-TERTIARY PALEOGEOLOGY

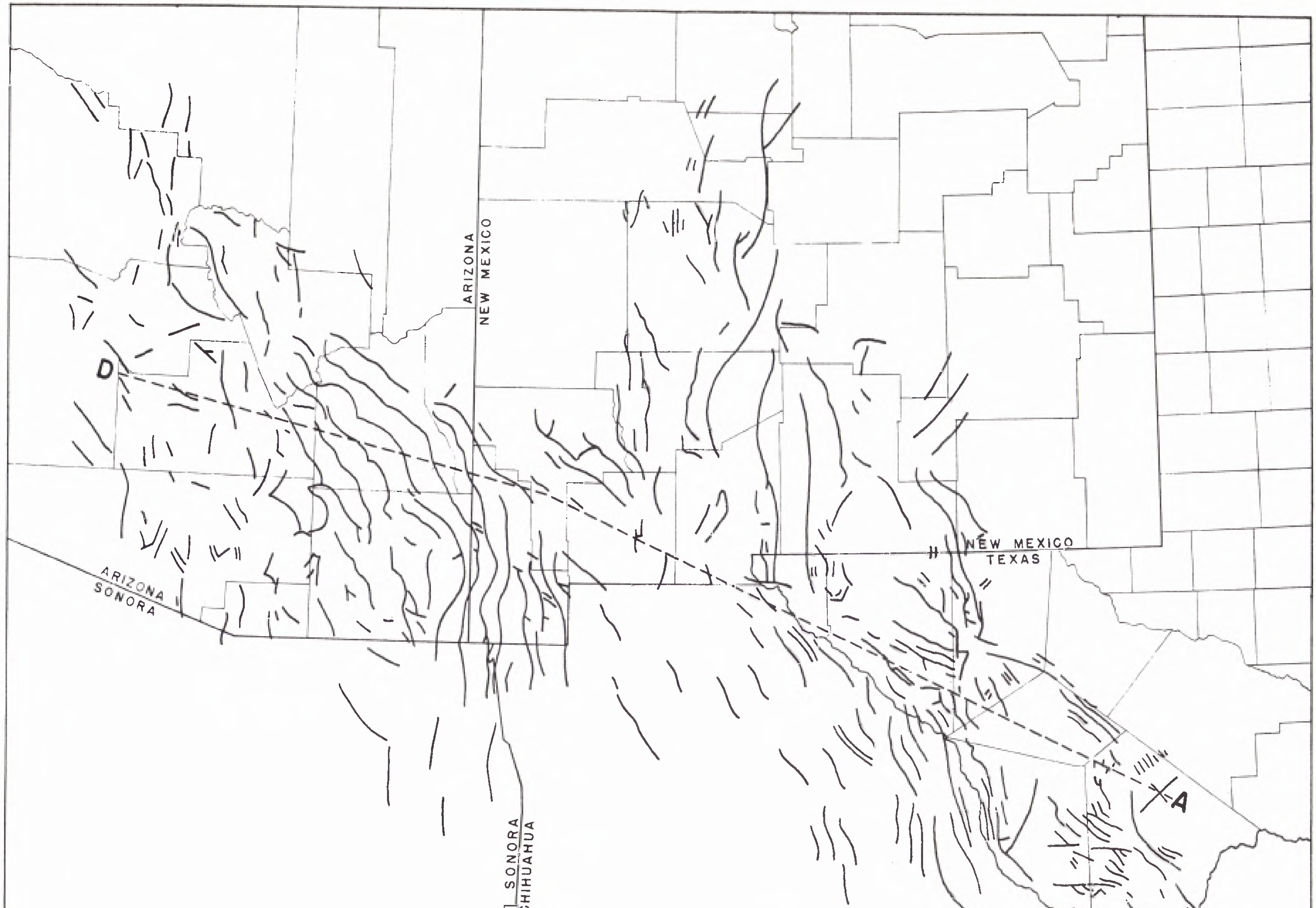

FIGURE 9

LARAMIDE AND CASCADIAN STRUCTURAL TRENDS

as lineament are more likely due to refraction effects across the ancient Deming axis than to some form of regional shear or wrench-fault tectonics.

Lateral continuations, if any, of the Deming axis beyond the area of the present study are open to question. However, if the definition of the Texas lineament is of significance it might extend to the west through the Transverse ranges of southwestern Arizona and southern California. To the east, cogent arguments could be made for extending it: (1) along the trends of the Fort Stockton high, Yates-Todd (Ozona, Pecos) arch, Llano uplift and San Marcos arch; (2) along the trend of the Ouachita structural belt and Devils River uplift; (3) past the Marathon uplift to the Burro uplift and Tamaulipas peninsula of Mexico; or (4) southward along the axis of the Coahuila peninsula. It may also be speculated that unstable eastward branchings of the Deming axis may have successively established each of these trends during different intervals of geologic time.

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