Geofís. Int., Vol. 28-5, 1989, pp. 897-906
Spec. Vol.: Dynamics and Evolution of the Lithosphere, Part 2.

THE PALEOZOIC MARGIN OF NORTH AMERICA IN WEST TEXAS AND NORTHERN MEXICO

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(Received: October 20, 1987)
(Accepted: September 5, 1988)

RESUMEN

A partir del análisis de datos gravimétricos del oeste de Texas y norte de México se delínean dos áreas mayores caracterizadas por prominentes altos gravimétricos lineales. Una de las áreas corresponde a la Plataforma Central de la Cuenca Pérmica y la otra corresponde al Levantamiento Tascotal, de la región de Big Bend. La orientación en ambos casos es oblicua al margen continental inferido para el Paleozoico temprano. En la Plataforma de la Cuenca Central se ha documentado la presencia de un cuerpo máfico. En el Levantamiento Tascotal, la respuesta gravimétrica es compatible con la presencia de un cuerpo máfico. Nosotros interpretamos las dos áreas en términos de reactivación de núcleos máficos de 'rifts' fallidos o incipientes desarrollados durante el establecimiento del margen continental sur de Norteamérica en el Precámbrico tardío - Paleozoico temprano. Esta reactivación durante la actividad orogénica compresional del Paleozoico tardío dominó la evolución estructural de la región y debe haber influenciado grandemente la sedimentación y los patrones de circulación oceánica en la región durante el Paleozoico tardío.

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ABSTRACT

Analysis of gravity data from west Texas and northern Mexico delineates two large areas characterized by prominent, linear gravity highs. One feature corresponds to the Central Basin Platform of the Permian Basin, while the other corresponds to the Tascotal Uplift of the Big Bend area. Both features trend at high angles to the inferred early Paleozoic continental margin. A large mafic body is known to underlie the Central Basin Platform, while comparable gravity signatures over the Tascotal Uplift are also compatible with the presence of a large mafic body at depth. We interpret both the Central Basin Platform and the Tascotal Uplift as being related to reactivated mafic cores of failed or incipient rifts developed during establishment of the late Precambrian - early Paleozoic southern continental margin of North America. This reactivation during late Paleozoic compressional orogenic activity dominated the structural evolution of the region and must have greatly influenced sedimentation and marine circulation patterns in this area during the late Paleozoic.

INTRODUCTION

Structures in the southwestern United States and northern Mexico have been the subject of intense scrutiny for many years as a result of the search for hydrocarbons. Although basin wide structural studies have been published periodically for decades, practical considerations have dictated that most studies be of a local nature. The purpose of this brief report is summarize the results of ongoing research efforts at the University of Texas at El Paso which are aimed at providing a better understanding of the structural setting of the border region from central Sonora and Arizona eastward. These studies involve the integration of publicly available geological and geophysical data primarily in the form of mapping and drilling results and gravity and magnetic measurements.

EXTENT OF THE OUACHITA SYSTEM

The Ouachita orogenic belt is a major key to an understanding of the tectonic history of southwestern North America. There is general agreement that the Ouachita orogenic belt is the result of late Paleozoic plate convergence. However, details of the lithospheric plate interactions which occurred are controversial.

The position of the middle Paleozoic continental margin is an important part of the Ouachita puzzle (Fig. 1) and has been the subject of considerable recent interest (*e.g.* Palmer *et al.*, 1984; Ewing, 1985; Ross, 1986). Studies of gravity data in the area of the Ouachita system (Nicolas and Rozendal, 1976; Kruger and Keller, 1986; Smith, 1986; Smith and Keller, in preparation) suggest the positive gravity anomaly associated with the interior zone of the Ouachita system approximately locates the position of the Paleozoic continental margin. This interpretation is consistent with

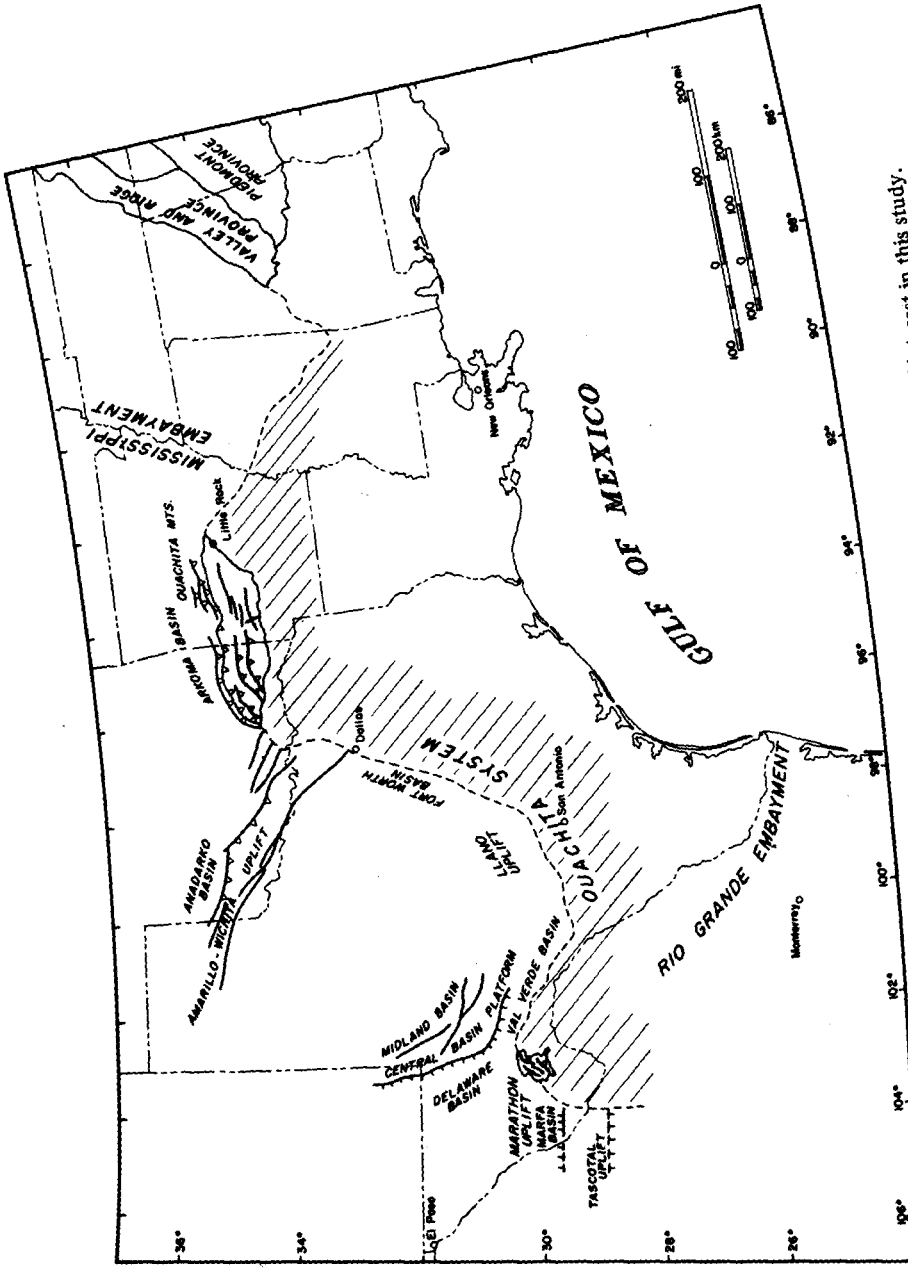

Fig. 1. Index map of the Ouachita system area showing the major features of interest in this study.

deep drilling data and regional structural data in the portion of the Ouachita system extending from the Llano Uplift to the Mississippi embayment (Kruger and Keller, 1986). As shown in Figure 2, this interpretation can be extended to the western portion of the Ouachita system. A prominent positive anomaly correlating with the known position of the interior zone can be traced from the area south and west of the Llano Uplift, through the Devil's River Uplift, into the Marathon Basin area, and southwards into Mexico. The position of this anomaly places the Marfa Basin area and the eastern portion of the State of Chihuahua in the foreland area on the craton behind the Ouachita orogen. This suggestion is in agreement with recent studies of Paleozoic and Precambrian exposures in central and eastern Chihuahua (Handschy and Dyer, in preparation, 1986). These studies have not detected the presence of any deep water, lower Paleozoic "Ouachita facies" rocks.

ORIGIN OF THE CENTRAL BASIN PLATFORM

The position for the continental margin proposed above also provides an internally consistent (but certainly not unique) interpretation for the origin of both the Central Basin Platform and Tascotal Uplift. A late Precambrian-Cambrian failed rift has been suggested to be present in the Permian basin area by several authors (*e.g.* Walper, 1977; Shurbet and Cebull, 1980; Keller *et al.*, 1983). This proposed rift would have originated during a late Precambrian continental breakup which evolved into the Paleozoic southern continental margin.

Such a feature should intersect the Paleozoic continental margin at a high angle. As is shown in Figures 2 and 3, gravity data indicate that the positive anomaly associated with the Central Basin Platform indeed intersects the Ouachita interior zone maximum just west of the Devil's River Uplift. The configuration of gravity anomalies in this area is similar to that in the region of the intersection of the Wichita-Arbuckle Uplifts and the Ouachita system. However, sediments of the Fort Worth and Arkoma Basins are not of sufficient thickness to mask the gravity signature of the uplifts of southeastern Oklahoma and northeastern Texas. Conversely, the deep Val Verde Basin cuts across the trend of the Central Basin Platform Uplift and masks its gravity signature to some extent. Thus as a structural feature Val Verde Basin can be interpreted as a later feature which has been superimposed over the older structures related to the proto-Central Basin Platform.

The geometric and geologic smilarities between the widely recognized southern

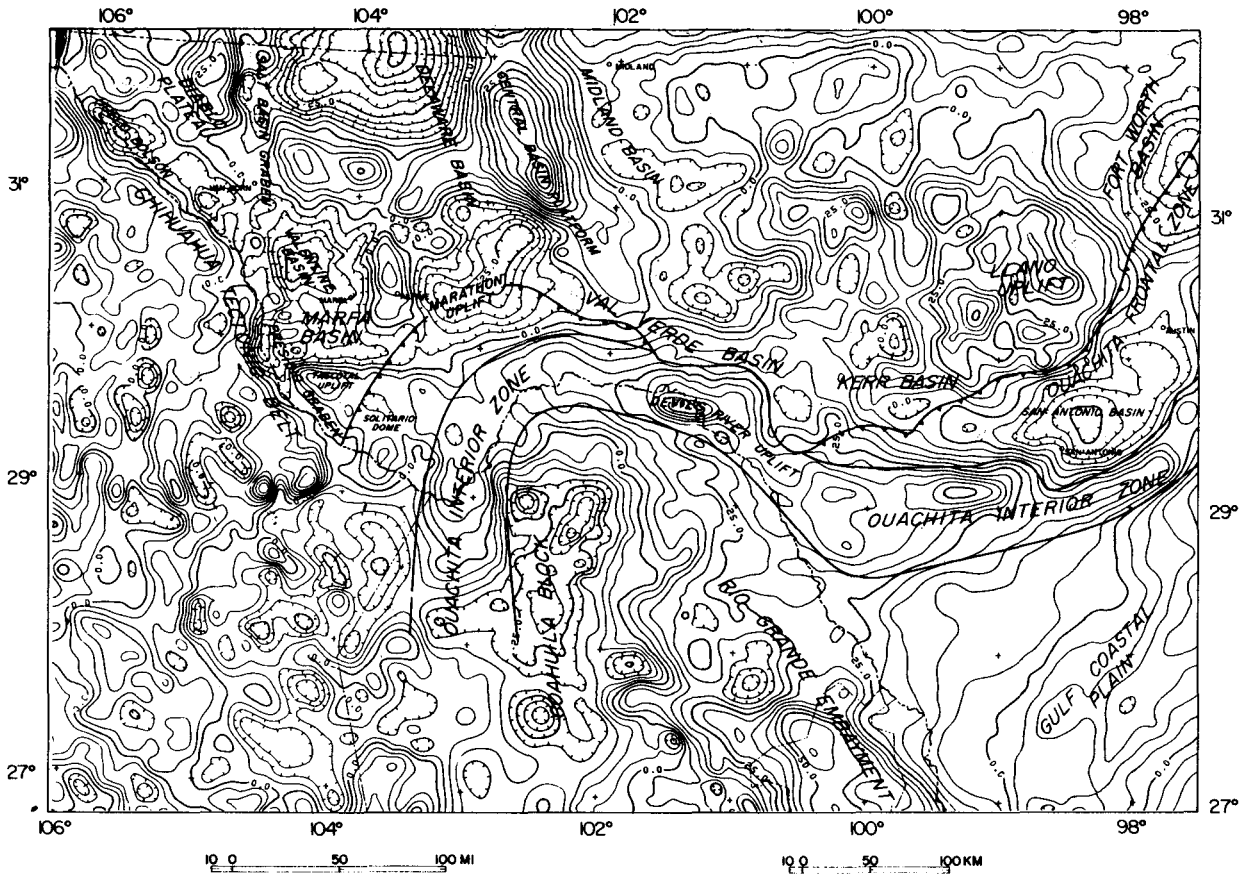

Fig. 2. Residual gravity map showing the major tectonic features. A second order polynomial surface was removed from Bouger gravity values to obtain this map (see Smith, 1986, for details on data processing). Contour interval is 5 mgal. Modified from Smith (1986).

Oklahoma aulacogen and the Permian Basin area are considerable (Fig. 1), and are the basis for the rift interpretation in west Texas (*e.g.* Shurbet and Cebull, 1980). However, in Oklahoma, extensive rift-related Cambrian igneous rocks overlie older mafic complexes (Gilbert, 1983). No igneous rocks of Cambrian age have been found in the Permian Basin area. In Southern Oklahoma, Upper Cambrian sandstones overlie the older igneous rocks but show no pronounced thickening, promting Brewer *et al.* (1983) to characterize the southern Oklahoma aulacogen as "probably a fairly, insignificant late Precambrian-Early Cambrian feature". The early Paleozoic Tobosa Basin of west Texas (Galley, 1958) is similar to the early Paleozoic basin of southern Oklahoma in age, geometry and stratigraphy.

The large positive gravity anomaly associated with the Central Basin Platform caused Keller *et al.* (1980) to suggest that this platform had a mafic core similar to that found in other rifts such as the Southern Oklahoma aulacogen and the Midcontinent rift system (*e.g.* Keller *et al.*, 1983). The # 1 Nellie well, drilled in northern Pecos County by the North American Royalty Company in 1985, provided a test for this hypothesis. The data and samples from this well were released to U. T. El Paso and have been under study for several months (*e.g.* Hoover *et al.*, 1985; Hoover and Hills, 1986). In this well, gabbroic rocks were encountered from the top of the basement (4 600 ft) to TD (19 100 ft). Based on the extent of the associated gravity (Figs. 2 and 3) and magnetic anomalies, these rocks constitute one of the larger layered gabbro complexes in the world (Hoover *et al.*, 1985 and in preparation). Such complexes are found in southern Oklahoma and other rifted terranes. Although these rocks are difficult to date radiometrically, new techniques will eventually yield an age. However, this discovery further strengthens the analogy with the southern Oklahoma aulacogen and gives added weight to the interpretation that the Central Basin Platform area was once the locus of rifting.

ORIGIN OF THE TASCOTAL UPLIFT

Another positive gravity anomaly intersects the Ouachita system interior zone gravity anomaly at a high angle in west Texas. This anomaly is associated with the Tascotal Uplift in the Big Bend region (Fig. 3). Ewing (1985) recognized that this uplift was a major tectonic feature. However, he suggested it was associated with the Devil's River uplift. We propose a simpler interpretation in which the area of the gravity high associated with the Tascotal Uplift is a region of incipient rifting also associated with late Precambrian-early Cambrian continental breakup.

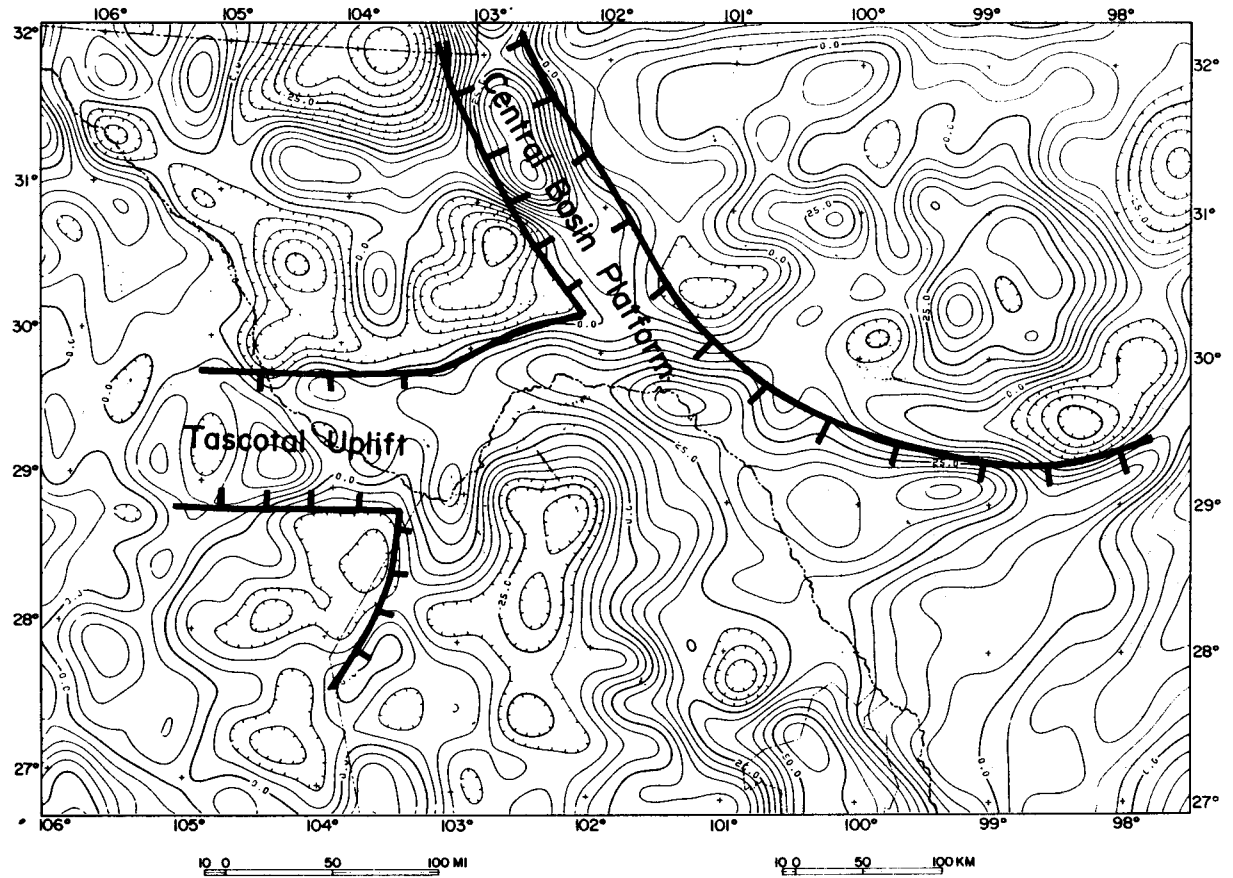

Fig. 3. Filtered version of Figure 2 where anomalies whose wavelengths are less than 50 km have been removed. The approximate boundaries of the late Precambrian-Cambrian rifted areas are delineated by hachured lines. Contour interval is 5 mgal. Modified from Smith (1986).

Existing data are scarce, but there is no evidence for significant thickening of lower Paleozoic rocks in this area (Ammon, 1981; Luff, 1981). Thus, we can speculate that this rift never developed very far, but provided a zone of weakness which could be reactivated in the late Paleozoic to form the Tascotal Uplift.

The Tascotal Uplift is bordered on the north by the Marfa Basin which in our model would be analogous to the Midland Basin in that it borders an uplifted basement block. To the west and south, over 3 km of Wolfcampian (and younger?) distal turbidities have been found in the Cerro el Carrizalillo area (Figs. 2 and 3). Facies relationships with comparable rocks in adjacent ranges are somewhat obscured by structural complications, but initial examination by Torres-Roldan and Wilson (1986) suggests that these late Paleozoic rocks are all cratonal foreland deposits. The presence of these late Paleozoic rocks is compatible with the presence of a late Paleozoic basin adjacent to the Tascotal Uplift.

The geometry of this basin is poorly constrained. The prominent gravity lows in far eastern Chihuahua (Figs. 2 and 3) may at least in part reflect Tertiary basins and voluminous Tertiary volcanics, which in turn would mask the gravity signature of any underlying late Paleozoic basins. However, these lows appear similar to the lows associated with the Val Verde and southern Delaware basins. Thus, based on geometric and geophysical similarities between the Central Basin Platform and the Tascotal Uplift and their apparently comparable geologic histories, we infer the existence of a late Paleozoic basin south of the Tascotal Uplift which would be analogous to the Delaware and Val Verde basins.

SUMMARY

These interpretations provide an internally consistent working model and a structural framework for the Permian Basin area. Late Precambrian-Cambrian continental breakup formed a complex of failed rifts and a rifted continental margin (Fig. 3) which have exerted strong control on the development of younger features. In this model, the Central Basin Platform and Tascotal Uplift are reactivated failed or incipient rifts (aulacogens), basement complexes of which contain significant volumes of mafic rocks. The complex boundaries of these uplifts at least partially coincide with old normal faults. During late Paleozoic Ouachita-related compression, the rigid cores of these old rifts were structurally raised, with synchronous development of adjacent deep basins. Reactivation of these "rift cores" dominated the structural

evolution in the area, and must have greatly influenced sedimentation and marine circulation patterns in this area in the late Paleozoic.

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