EXTENT OF THE OUACHITA OROGENIC BELT IN NORTHERN MEXICO

FEDERICO A. MORENO

Department of Geological Sciences

APPROVED:

Dr. G. Randy Keller, Chair

Dr. P. C. Goodell

Dr. E. Alan Dean

Dr. K. L. Mickus

Associate Vice President for Research and Graduate Studies

This thesis is dedicated to my family, and to Silke who supported me through the easy and difficult times.

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by

Federico A. Moreno, B.S.

THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at El Paso

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE

Department of Geological Sciences

UNIVERSITY OF TEXAS AT EL PASO

December, 1993

ACKNOWLEDGEMENTS

Various faculty, students and staff have provided invaluable assistance and comments on my thesis study. The primary help came from my committee chairman, Dr. Randy Keller, who was responsible for suggesting the topic, obtaining the necessary gravity data for this study, and helping me throughout the research process. Also, the other members of my committee, which included Dr. Phillip Goodell, Dr. Kevin Mickus, and Dr. Allen Dean, provided the help I sought during my research. Don Adams, Carlos Montana, Don Roberts, Abdunnur Suleiman, Raed Aldouri were instrumental in providing needed advice on my work as well.

I'd like to thank my parents, Gilberto and Margarita Moreno, for supporting me throughout my life and for providing the drive for me to never quit in school or life. Deep thanks to my brothers and sisters who supported my efforts 100 percent and were always there when I needed them.

A special thanks goes to Silke Paul. She has been as much a part of thesis as myself and has been incredibly understanding throughout the whole process of my study. This work would probably never have been finished without her encouragement and sincere support.

Lastly, I would also like to thank the office staff at the Department of Geological Sciences for their promptness in answering so many of my questions regarding the necessary paperwork for my thesis.

ABSTRACT

The southern margin of the North American continent during the late Paleozoic can be approximately delineated by the extent of the Ouachita orogenic belt which stretches over 2000 km from the southern end of the Appalachian Mountains westward through Arkansas, Oklahoma and into Texas. In the Big Bend region of west Texas this belt deviates from a westward direction and trends southward toward the United States/Mexico border. In both recent and past studies its position within northern Mexico has been the subject of much debate. In this study the question of its extent into Mexico and tectonic setting is addressed.

Based on the degree of deformation and metamorphism the Ouachita system has been divided into two tectonic domains, the frontal and interior zones. The frontal zone is characterized by unmetamorphosed, deformed sedimentary rocks as observed from well data in Texas and outcrops in the Marathon and Solitario regions of west Texas. The interior zone, which is defined by wells in western and central Texas as well as by an outcrop at Boquillas, Mexico in northern Coahuila, is characterized mostly by deformed metasedimentary rocks that range in age from early Pennsylvanian to middle Permian. This highly sheared metamorphosed zone is also associated with a distinct gravity high in Texas known as the interior zone maximum (Kruger and Keller, 1986). Based on this association and on analysis of Paleozoic outcrops in Coahuila, the Ouachita belt has been speculated to extend from the Big Bend region in west Texas southward through Coahuila at least 100 km (Handschy et al., 1987). Stewart (1988), however, postulated a southwest extension of the Ouachita orogenic belt Chihuahua, and recent Pb isotope studies presented by Rudnick and Cameron (1991), Cameron et al. (1992), and James and Henry (1993) suggest a similar trend.

In order to test the above hypotheses, three gravity-structure profiles extending NW–SE (from eastern Chihuahua into Coahuila), N–S (from Jeff Davis County, Texas into southern Chihuahua) and NE–SW (from central Texas through central Coahuila into northeasternmost Durango) were constructed utilizing geophysical and geological data bases which are maintained at the University of Texas at El Paso in the Department of Geological Sciences. The resulting models indicate two possible interpretations for the extension of the Ouachita orogenic belt into northern Mexico for each profile. The first interpretation, representing extension of the Ouachita belt southward into Coahuila, is consistent with the previously proposed southward extension of the Ouachita system by Handschy et al. (1987). On the basis of the location of the Ouachita related suture zone in this model and of the existence of a large gravity low anomaly situated in the La Olivina area of eastern Chihuahua, a large foreland basin is interpreted to exist west of the suture zone. This basin is analogous to those observed north of the Ouachita system in Texas. The models for this interpretation also support the idea that the gravity high associated with the suture zone is mostly governed by crustal thinning.

An alternative interpretation which was investigated extends the Ouachita suture zone southwestward from the Big Bend area of west Texas into Chihuahua. Other interpretations extending the Ouachita orogenic belt southwestward postulate its extension further westward into Sonora (Stewart, 1988) or southwestward into Durango where it is truncated by the proposed Mojave–Sonora megashear (Silver and Anderson, 1974; Anderson and Schmidt, 1983). It is noted that Stewart's model does not require the existence of a large megashear through Chihuahua. The gravity high that extends into Coahuila, which

Handschy et al. (1987) associate with the Ouachita interior (suture) zone, is interpreted here as a transitional zone which separates two accreted terranes, the Coahuila terrane (Handschy et al., 1987) and the proposed Mapimi terrane of this study. In this scenario it is unknown if the material in this transition zone is related to the material representing the Ouachita suture zone.

Neither of the above interpretive models unambiguously defines the Ouachita in northern Mexico. However, the southwest trending suture model is in agreement with isotopic studies conducted by Cameron et al. (1992) and James and Henry (1993). Cameron et al. (1992) have suggested that the La Olivina area lies within the suture zone or south of this region. This allows for the presence of an accreted terrane, namely the Mapimi terrane proposed in this study. James and Henry (1993) delineated two crustal provinces in Trans–Pecos Texas and northeastern Chihuahua which are separated by a central province, trending N35°E, that is interpreted to be the contact between the North American craton and thrusted rocks of the Ouachita orogenic belt. The location of this province is in agreement with the extension of the Ouachita belt as interpreted in the southwest extension model from west Texas into Chihuahua. Additional geophysical and Pb isotopic studies in Chihuahua and Coahuila, however, are required to definitively prove or disprove the southwest extension model.

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INTRODUCTION

The Ouachita system represents a Late Paleozoic orogenic belt that extends over 2000 km from the southernmost end of the Appalachians westward through Arkansas, Oklahoma and Texas, where it passes through the Marathon region and into Mexico. Figure 1 displays the extent of the Ouachita system in the United States along with the major related tectonic elements. Only approximately 440 km of this overthrust belt is exposed, with the remainder overlain by sedimentary rocks of the Gulf coastal plain. The extension of this thrust and fold belt into northern Mexico has been studied by numerous authors utilizing lithologic, isotopic and geophysical information. Basically three directions for the continuation of the Ouachita orogenic belt into northern Mexico have been proposed and they trend to the south and southwest from the Big Bend area of west Texas. It is the validity of these proposed extensions that is the major focus of this study. Also, the consideration of the relationship between the Tascotal uplift, located in the Big Bend region (Fig. 1), and the Ouachita orogenic belt will be addressed. The Tascotal uplift, described as a large basement complex (Keller and Dyer, 1989), contains significant volumes of mafic rock which were raised by Ouachita-related compression during the late Paleozoic. The history of the tectonic setting of this basement uplift is of upmost importance in understanding the role and location of the Ouachita system in northern Mexico. This study aims to provide a better understanding of the structural setting of the Ouachita system in northern Mexico which is a major key to understanding the tectonic history of the southcentral United States and northern Mexico.

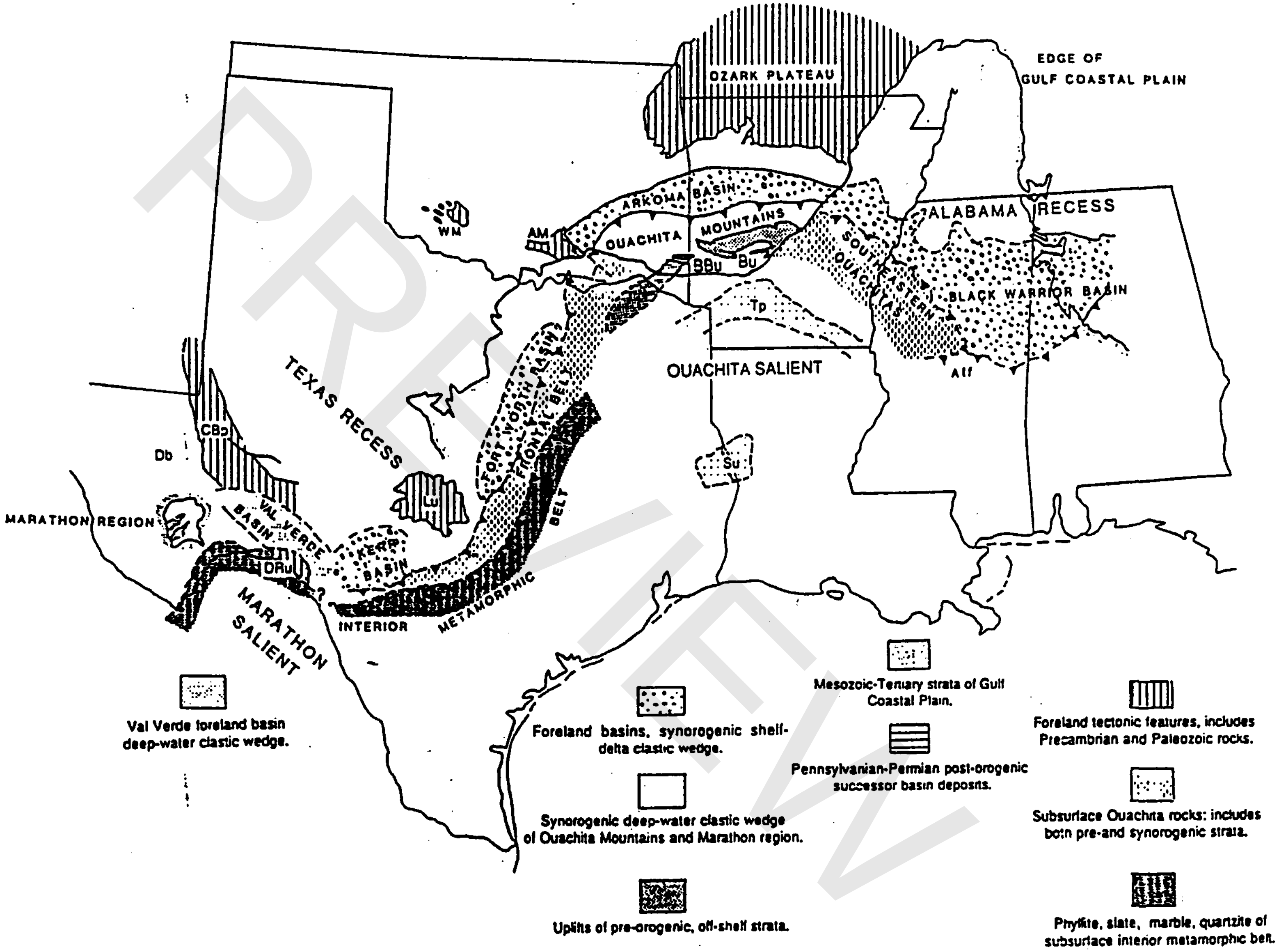

Figure 1: Ouachita-related tectonic elements. From Viele (1989).

The uncertainty in determining the trend of the Ouachita tectonic belt into northern Mexico is due to the lack of surface exposure of pre–Mesozoic strata and sparse well control, especially in Mexico. In this study, gravity anomalies, well data, and sparse seismic control were employed to enhance our understanding of the tectonic setting of the Ouachita system in northern Mexico. Acquisition of additional gravity data, available from the national database at UTEP, and well data, presented herein, has allowed a more detailed study to be undertaken. In addition, information gathered from isotopic studies recently presented by Rudnick and Cameron (1991), Cameron (1992), and James and Henry (1993) that pertain to the Ouachita system in Mexico have been utilized. Also, this study used other geological and geophysical studies on the Ouachita system as a guide for comparing the geologic structures and geophysical signatures of the Ouachita in the United States with those of northern Mexico. Low, high and band pass filtered gravity maps were used to enhance the crustal contributions of the gravity data set and thus isolate the tectonic elements related to the Ouachita orogenic belt. Computer gravity models were constructed utilizing the additional well log information and other geophysical constraints.

GEOLOGIC HISTORY AND TECTONIC SETTING

During Precambrian–Early Cambrian time, rifting and transform faulting, began on the southern continental margin of North American craton. This led to the development of a deep–seated Ouachita basin, the Proto Atlantic ocean (Ewing, 1991), and several rift–related basins. Figure 2 shows the occurence of these features. It was postulated that these features had a profound influence on the tectonic setting of the late Paleozoic Ouachita system (Keller and Cebull, 1973). Several tectonic models representing the position and shape of this Cambrian continental margin have been proposed (Thomas, 1976; Cebull et al., 1976; and Walper, 1977). Walper (1977), Shurbet and Cebull (1980), Keller et al. (1983), Viele and Thomas (1989), and Arbenz (1989) addressed the question of the position and the depositional environment of the postulated Cambrian rift basins in the Ouachita orogenic belt (Figure 2). Three areas of subsidence, the Mississippi Valley graben (Reelfoot aulocogen; Thomas, 1985), the Southern Oklahoma basin (Southern Oklahoma aulacogen; Webster, 1977; Keller et al., 1983; Larson et al., 1985), and the Tobosa Basin (Galley, 1958), were interpreted by Walper (1977) as aulacogens or failed rift arms which had similar tectonic histories that involved the following evolution: (1) existence as rift valley grabens, (2) subsidence and development of troughs due to a retreating plate margin, (3) deposition of carbonate rocks into troughs, and (4) vertical and transcurrent movements due to an episode of plate convergence and continental collision. In contrast to this interpretation, Viele and Thomas (1989) proposed that the tectonic evolution of these features were somewhat dissimilar. Ewing (1985) discounted the hypothesis of the existence of the Delaware aulacogen in pre–Late Cambrian

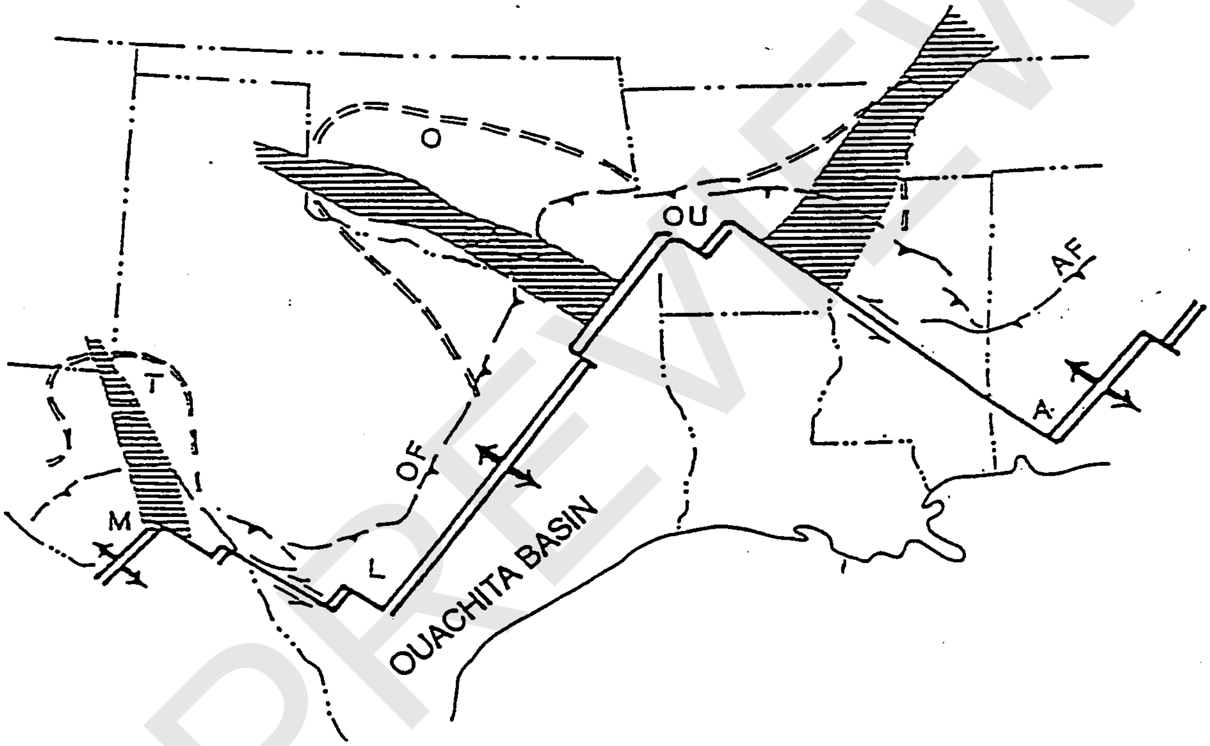

Figure 2: Eocambrian rift basins. After Arbenz (1989).

time based on the lack of evidence of rocks of similar age in west Texas. He subsequently proposed an east–west trending aulacogen from the Devils River uplift area to the Tascotal uplift region (in the Big Bend region) based on similarities in orientations and Paleozoic histories of the Chalk Draw and the Carta Valley fault zones and the tectonic features they bind. In 1989, Keller and Dyer proposed that the gravity high associated with the Tascotal uplift represented an Early Paleozoic rift area that did not extend far to the west of the Cambrian continental margin. The Cambrian rift event is best represented in the rocks of the Wichita and Arbuckle Uplifts of southern Oklahoma and also in the Devils River Uplift region. Gabbroic rocks in the Wichita Uplift region have been reported by Bowring and Hoppe (1982) to have an age of 550–560 Ma, and a rhyolite unit, which overlies this gabbroic complex, has been dated as Early to Middle Cambrian (525–545 Ma) by Muehlberger and others (1967). Also, Cambrian age dates have been obtained for rhyolitic metavolcanic rocks in the Devils River Uplift area (Nicholas and Rozendal, 1985).

As Cambrian rifting terminated, a broad carbonate platform, representing the Ellenburger Group in Texas and the Arbuckle Group in Oklahoma, developed over much of North America. Subsequently, carbonate and clastic deposition occurred until the Late Devonian. This period marked the deposition of Woodford shale. Two large Early Paleozoic Basins, the Tobosa Basin and the ancestral Anadarko Basin, were affected by the Cambrian events and are shown in Figure 3. The ancestral Anardarko Basin, containing a thick lower Paleozoic sequence, resulted from tectonothermal subsidence centered on the Southern Oklahoma rift basin (Ewing, 1991). A much thinner sequence, equivalent to the platform sediment in the

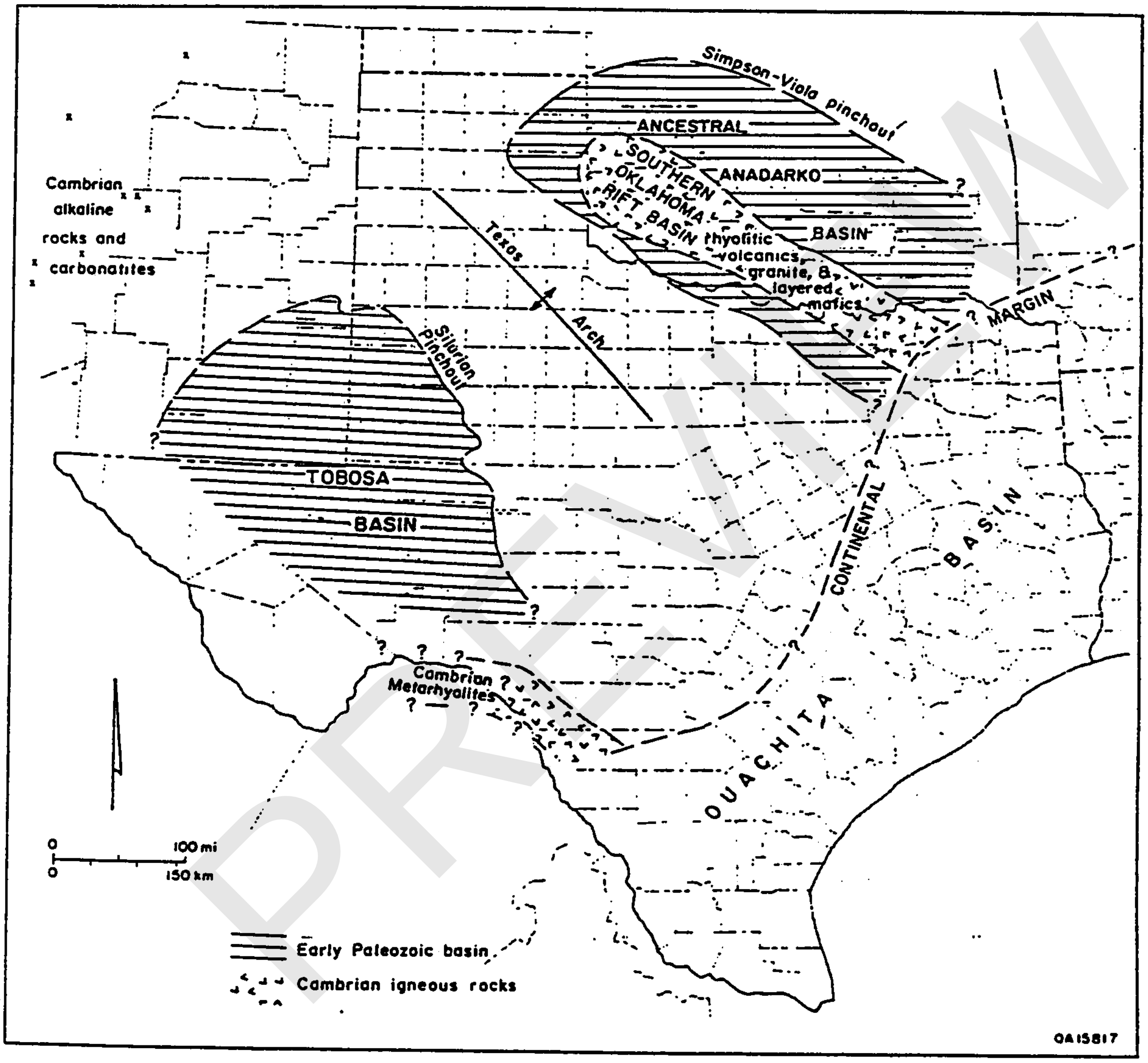

Figure 3: The Early Paleozoic Tobosa and ancient Anadarko basins. From Ewing (1991).