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SOME KEYS TO THE GEOLOGY OF NORTHERN CHIHUAHUA

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ABSTRACT

Some of the keys to the geology of northern Chihuahua are the Texas lineament; the Diablo platform; the Ouachita geosyncline; the Paleozoic sedimentary rocks that crop out in the Franklin Mountains and near Placer de Guadalupe; the Permian (?), Jurassic (?), and Cretaceous evaporites of the Chihuahua trough and their diapirs; gypsum in the Malone Mountains; Kimmeridgian-Tithonian rocks near Placer de Guadalupe and in the Malone Mountains; Neocomian fossils from Samalayuca and the Malone Mountains; the Aldama platform; and the Eocene-Oligocene vertebrate fossils and K-Ar dates of the Rim Rock country.

RESUMEN

Algunas indicaciones importantes de la geologia de la parte septentrional de Chihuahua son el alineamiento de Texas, la Plataforma del Diablo, el Geosinclinal Ouachita, las rocas sedimentarias del Paleozoico que afloran en las Montaflas Franklin y cerca de Placer de Guadalupe; las evaporitas del Pérmico (?), Jurásico (?) y Cretkico del Canal de Chihuahua y sus cuerpos diapiricos; el yeso de las Montanas Malone, las rocas del Kimerigdiano-Titoniano cerca mesa Placer de Guadalupe y Montanas Malone; los fósiles neocomianos de Samalayuca y las Montañas Malone; la Plataforma de Aldama, los fosiles vertebrados del Eoceno-Oligoceno y edades K-Ar de la region de Rim Rock.

INTRODUCTION

Some of the keys to the geology of northern Chihuahua are on the south and southeast in Mexico; for example, the three deep tests drilled years ago by Pemex near Ojinaga. The wells that Pemex is now drilling in Chihuahua will open new vistas. Most of the keys to Chihuahuan geology are in the southwestern United States, because more geologists have scrutinized more outcrops there, while others have studied the subsurface geology disclosed by thousands of deep wells in western Texas. One key is the international boundary itself!

It is the fashion to ridicule geological discontinuities at political boundaries, to make fun of "state-line faults" and formations that end abruptly at the border of a province. The same stratigraphic scoffers do not hesitate to advocate "arbitrary cutoffs" to suit their own convenience. Nevertheless, there is something to be said for the coincidence of government and geology, especially if the communal junction is not a straight line.

THE TEXAS LINEAMENT

The international boundary between Texas and Chihuahua marks a major geotectonic discontinuity. Rio Bravo del Norte (the Rio Grande) pretty much follows it for 200 miles (320 km) from Ciudad Juarez past Ojinaga and on, another 75 (120 km), to the Big Bend at the common corner of Chihuahua, Coahuila, and Texas. The first hundred miles downstream from Juarez include the type locality of the Texas lineament (Albritton and Smith, 1956) . From Texas, standing on the flat-lying beds of late Paleozoic-Mesozoic platforms, one looks across the border at Chihua huan mountains of intensely folded Cretaceous limestone and sandstone in a late Mesozoic geosyncline. Consider, for example, the great contrast between the tilted Paleozoic formations of the Franklin Mountains in El Paso and the contorted Cretaceous formations in the Juarez Mountains just across the border. Furthermore, the Cretaceous formations in Texas are only thin transgressive edges of the thick sequence in Chihuahua.

Some geologists have projected the Texas lineament from Van Horn eastward across the Diablo platform and on into south-central Texas. If it joins the anomalous Ouachita trend extending from Marathon past Uvalde, a case can be made for 250-300 miles (more than 400 km) of right-lateral strike-slip displacement either during Precambrian time or no later than Carboniferous. Moody and Hill (1956) tried to export Cenozoic left-lateral strike slip from California into the type locality of the Texas lineament, but the Cretaceous strata are not there laterally displaced.

The creation of the Diablo platform during Carboniferous time was completed early in the Permian Period. In the latter part of the Mesozoic Era an arm of a Late Jurassic-Cretaceous sea occupied the Chihuahua trough along the southwestern flank of the Diablo platform from Juarez to Ojinaga. During Laramide orogeny, culminating in the Eocene Period, the thick Cretaceous formations of Chihuahua were thrust over against this flank of the platform, which stood as a structural unit or bastion no longer breached by the Texas lineament. The ensuing Eocene-Oligocene volcanic outburst was followed by Oligocene block faulting. The trends of these subsequent gravity faults more or less coincide with the Laramide trends on which they were superposed. The master fault with thousands

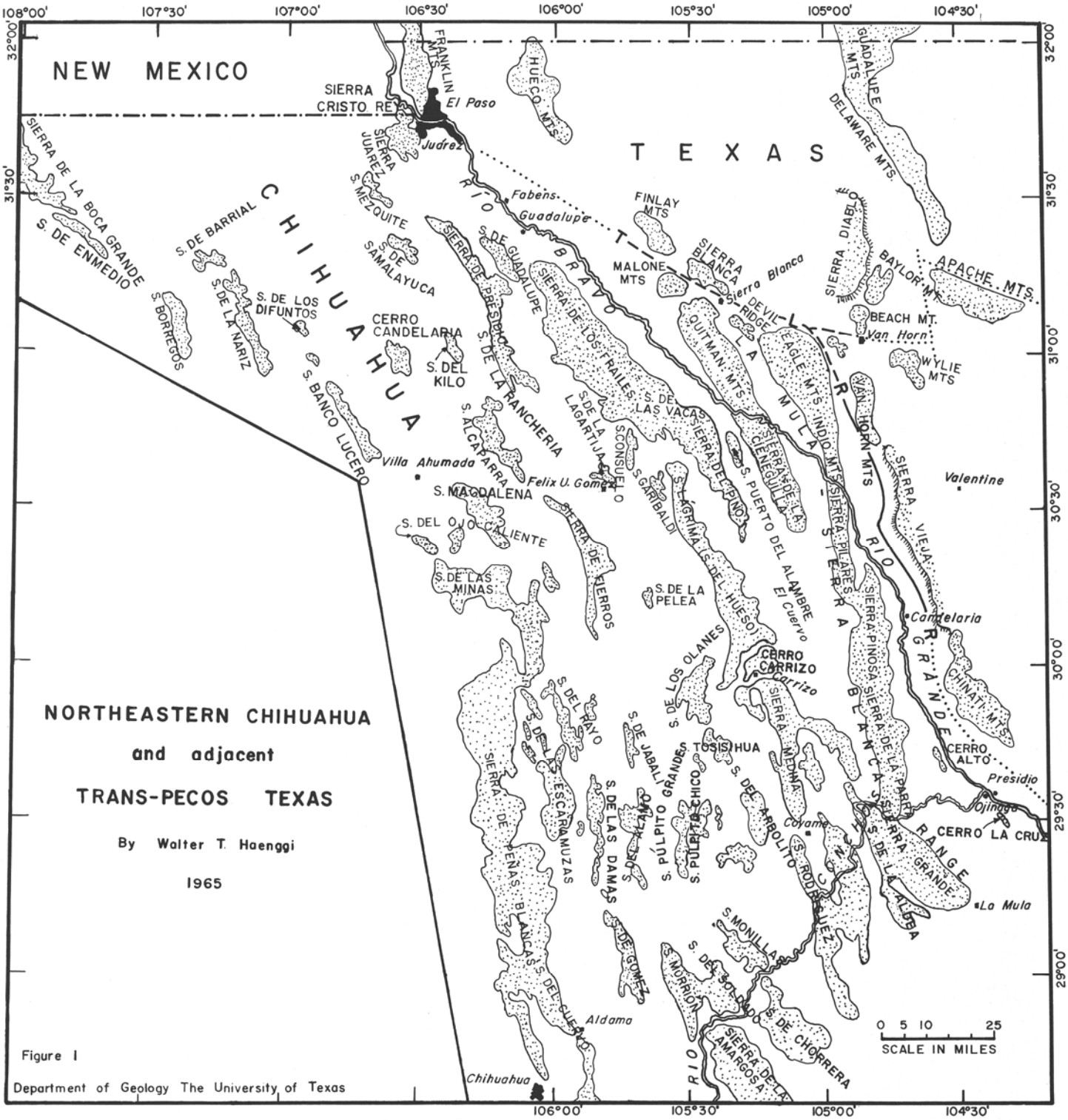

FIGURE 1.

Explanation: TL, type locality of Texas lineament; RR, Rim Rock Fault. The SW flank of Diablo platform extends from Hueco Mountains to Sierra Vieja, inclusive. Cuchillo Parado is W of Ojinaga on Rio Conchos near the H in "Conchos"; upstream (SW) is S. Monilla, and Placer de Guadalupe is near the NW end of the sierra; Mina Plomosas is at the base of the I in "Monilla". From Aldama the NE flank of the Aldama platform extends generally NNW.

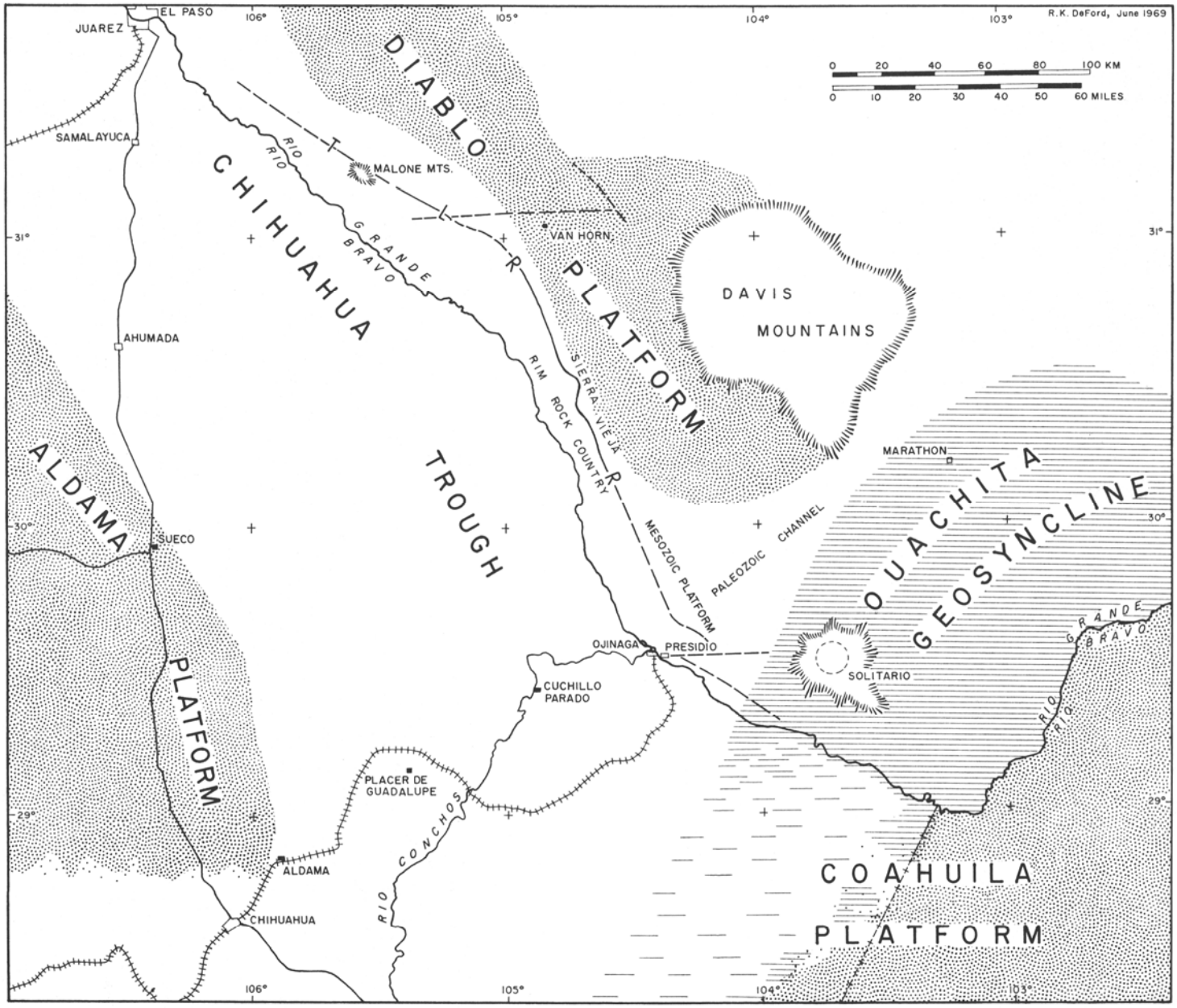

FIGURE 2.

Tectonic framework of northeastern Chihuahua. TL: type locality of Texas lineament. RR: Rim Rock Fault. Volcanic rock covers most of the area of: Davis Mountains; southern part of Diablo platform on to Solitario; inferred extension of Ouachita geosyncline into Chihuahua.

of feet of displacement follows the flank of the platform; it runs along the Texas lineament in its type locality and swings southward as the Rim Rock fault extending toward Presidio-Ojinaga.

The Texas lineament may mark an edge of a North American Precambrian craton beyond which lay a more mobile Mexican region. Some observers would seem to wish to project this contrast a thousand million years into the present, as if to make the lineament a boundary between phlegmatic Anglos and volatile Latins. The linea ment, they say, is the absolute southern margin of the "Basin and Range province", and on the south is the "Sierra Madre Oriental". Yet, "the Diablo Plateau on the north is a broad tableland carved by erosion into scattered mesas and cuestas", whereas on the south in Chihuahua are basins and ranges! 'They neglect time! Tectonic provinces overlap in time. The block faulting that characterized the Basin-and-Range country came after the Laramide folding and extended into northern Chihuahua some tens of miles at least.

Photographs taken from airplanes and satellites show other northwest-southeast lineaments in Chihuahua. These may be old basement fractures on which movement may have been locally renewed; for example, along Haenggi's (1966) La Parra fault the downthrown block switches sides.

THE OUACHITA GEOSYNCLINE

The Ouachita geosyncline at Marathon is characterized by graptolite-bearing early Paleozoic formations and mid-Paleozoic novaculite, neither especially thick, and by 12,000 feet (c. 4 km) of Carboniferous flysch and molasse. The geosyncline trends southeast from Marathon toward Ojinaga and is last seen in the Solitario less than 20 miles (30 km) from the border. It is unknown in Mexico. If extended a few miles into Chihuahua, its trend would meet the trend of the axis of the Chihuahua trough nearly at right angles (c. 70°) . Perhaps it does so meet it, marking the place of a later barrier, the western flank of the Coahuila platform which may have there a southwesterly trend instead of the south-by-east trend usually so confidently drawn.

The pre-Carboniferous sequence of sedimentary formations that Bridges (Bridges and DeFord, 1961) discovered near Placer de Guadalupe and Mina Plomosas resembles the strata that crop out in the Franklin Mountains in El Paso and yield oil from the subsurface in West Texas. Bridges' discovery attests to the presence of this platform facies in the yet-to-be-explored subsurface beneath the exposed Cretaceous rocks of northern Chihuahua and suggests that the southerly subsurface trend of the Ouachita geosyncline passes east of Placer de Guadalupe and Mina Plomosas.

On the west, however, the outcrops at Aldama between Placer de Guadalupe and Ciudad Chihuahua present a paradox. Beneath the Cretaceous near Aldama is a thick sequence of dark gray siltstone that resembles the thick Wolfcampian (Early Permian) siltstone that lies directly against and follows the northern flank of Ouachita geosyncline north of Marathon and follows its northwestern flank southwest of Marathon as it trends toward Mexico. Does the Ouachita geosyncline, passing east of Placer de Guadalupe, perhaps turn west to Ciudad Chihuahua?

EVAPORITE IN THE CHIHUAHUA TROUGH

From our surficial place of view, the Chihuahua trough appears to be a late Mesozoic feature. Nevertheless, it is bounded by the Diablo platform, a Pennsylvanian feature. The thick shale and sandstone, and reef limestone in the Chinati Mountains, Permian mudstone with slump features in Pinto Canyon, the Permian marlstone and conglomerate in the Finlay Mountains, and the pre-Carboniferous formations preserved beneath the Carboniferous rocks of the Hueco and Franklin Mountains all show that the Diablo platform had a southwestern flank that now forms the northeastern flank of the Chihuahua trough.

The trough, abutting on the southeast against the Coahuila platform rather than running alongside it, was a place for the deposition of salt and anhydrite. One could have predicted the presence of subsurface evaporite from the structure of the limestone sierras. The Pemex wells at Cuchillo Parado south of Ojinaga verified it by drilling thick salt, and Haenggi and Diaz G. have found gypsum associated with diapiric features in the sierras between Ojinaga, Juarez, Samalayuca, and Placer de Guadalupe.

The salt may be of Permian age, yet the only direct evidence of Permian age is the gypsum of the Briggs Formation in the Malone Mountains, which is said to be Permian. A black limestone member beneath the gypsum bears Permian fossils. Buff dolomite above most of the gypsum has rugose corals that indicate merely that the uppermost part of the Briggs Formation is of Paleozoic age. According to Helen Duncan, much of the skeletal structure was obliterated by silicification and is too poorly preserved to indicate more than that the coral is one of the lophophyllids (Albritton and Smith, 1965) . An advocate of the Mesozoic age of this gypsum might either challenge the corals, insinuate that thrusting was associated with the gypsum, or even suggest that intrusion of the gypsum had been overlooked in the field. The overlying Jurassic Malone Formation includes some gypsum.

At the base of Haenggi's Cretaceous section, beneath the Las Vigas Formation, he found the Navarrete Formation (*nomen* nudum; Haenggi will propose this name), which has been pierced by older intrusive gypsum in a number of places. The beds at Samalayuca that yield Neocomian ammonites seem to be correlative with the Navarrete and with the Torcer Formation of the Malone Mountains.

A Jurassic sea invaded Mexico from the south. Outcrops near Placer de Guadalupe and in the Malone Mountains show that this sea reached the Chihuahua trough during Kimmeridgian time in the latter part of the Late Jurassic. The sea occupied the trough between the Diablo platform on the northeast and the Aldama platform on the southwest; it was confined by the Coahuila platform on the southeast. Although the trough sank to admit the sea beginning in Late Jurassic Kimmeridgian time, the region continued sinking and the Coahuila platform and Aldama platform did not sink beneath the sea until Aptian time. The oldest strata on the Diablo platform comprise thin layers of Albian age.

Perhaps the Kimmeridgian-Tithonian trough was the site of deposition of salt (unless Permian salt was already there). The intrusive gypsum in the Navarrete Formation suggests the possible presence of a subsurface Neocomian evaporite layer. Aptian gypsum is prominent in the outcrop of the type Cuchillo Formation at Cuchillo Parado.

LARAMIDE DECOLLEMENT

In the Laramide decollement, Cretaceous beds slid over the subjacent lubricating evaporites. The new mountains were eroded almost as fast as they rose out of the trough. The folding and overthrusting preserved Upper Cretaceous shale and sandstone in the deepest part of the trough, alongside the Diablo platform. The absence of Upper

Cretaceous rock on the west side of the trough is somewhat of a mystery. Perhaps uplift of the Aldama platform was earlier and more pronounced so that Upper Cretaceous sediments were never deposited or the rock was removed during early Laramide tectonism. Upper Cretaceous shale was also eroded from the Diablo platform and from West Texas generally, but this was a Miocene event. Remnants are preserved beneath Oligocene lava flows in the Davis Mountains and beneath ignimbrite, rhyolite, and tuff of the Sierra Vieja along the west side of the Diablo platform. Early uplift of the Aldama platform on the west would tally with eastward tilting and gravity sliding on an evaporite base, but probably Laramide compression was also involved.

VOLCANISM AND BLOCK FAULTING

Relaxation of compression plus volcanic outburst in late Eocene and early Oligocene time accompanied regional uplift that left northern Chihuahua and Trans-Pecos Texas high above sea level. Along the southwestern flank of the Diablo platform and northeastern flank of the easternmost Laramide range, the record of this volcanism is a pile of tuff subdivided by layers of ignimbrite and lava. This sequence is exposed in the Rim Rock country on the west side of Sierra Vieja (DeFord, 1958). The vertebrate fossils from the tuff and the K-Ar dates from the flow rocks make it a unique reference section for the Basin-and-Range province of the southwestern United States and for the Mexican highland including Chihuahua (Wilson et al., 1968) . The age ranges from very late Eocene through early Oligocene (40 to 33 million years before the present). The rock record is extended into the Miocene by work in the Big Bend National Park.

The block faulting that followed this late Eocene-early Oligocene volcanism (DeFord and Bridges, 1959) accentuated the southwestern flank of the Diablo platform and some of the Laramide basins and ranges in Chihuahua. Thereupon the Rio Grande flowed, as it still does, from southern Colorado to El Paso del Norte at Juarez, but not thence to the sea. It spread its debris, filling bolsons between ranges as far south as Bolson Mapimi at Torreón 450 miles (700 km) south of Juarez.

Oligocene volcanism seems to have been almost world wide. How much of the tremendous pile of ignimbrite and other flow rock in the Sierra Madre Occidental in western Chihuahua is of this age? On this western side of Chihuahua geological research becomes modern or even avant-garde, for the Sierra Madre Occidental is associated in origin with the Gulf of California, which is said to have been formed, and still to be forming, by sea-floor spreading.

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