Geology of Sierra Del Carmen, West Texas and Mexico: A General Geologic Framework to Support Mapping of Biologic (Botanical) Resources

by

Edward W. Collins and Jay A. Raney

Bureau of Economic Geology

Noel Tyler, Director

The University of Texas at Austin

Austin, Texas 78713-8924

Final Report

Prepared for

National Biological Service under contract no. 1445-0004-95-9115

August 1996

Contents

Figure

Plate

Introduction

The purpose of this study is to provide geologic base maps to support the mapping of biologic (botanical) resources in the Sierra del Carmen, Coahuila, Mexico, and adjacent areas in Big Bend National Park, Brewster County, Texas. Sierra del Carmen, which generally trends north-northwestward, includes the eastern part of Big Bend National Park and extends southerly into adjacent Coahuila (fig. 1). The range, which is within the Chihuahuan Desert, rises abruptly from the desert floor and has topographic relief that exceeds 2,000 m. Terrane is rugged, and the range is marked by numerous narrow and steep-sided canyons and valleys. The stratigraphic framework of the range is one aspect that controls the distribution of vegetation throughout the area. In general, different rock types can weather into soils of different composition, and the rocks and soils may contain different amounts of moisture. Thus, different plant species may be associated with specific rock lithologies. Geologic structures such as faults, folds, and fracture zones control the position of the rock units and influence landforms, drainage directions, and canyon development. Structures may also influence the concentration and retention of surface moisture.

The geologic map of this region is intended to assist other scientists, students, and interested visitors in understanding the geology of this fascinating area and in interpreting the influence of the geologic framework on related sciences. The map emphasizes bedrock and surficial units that can be important controls on the distribution of plant communities.

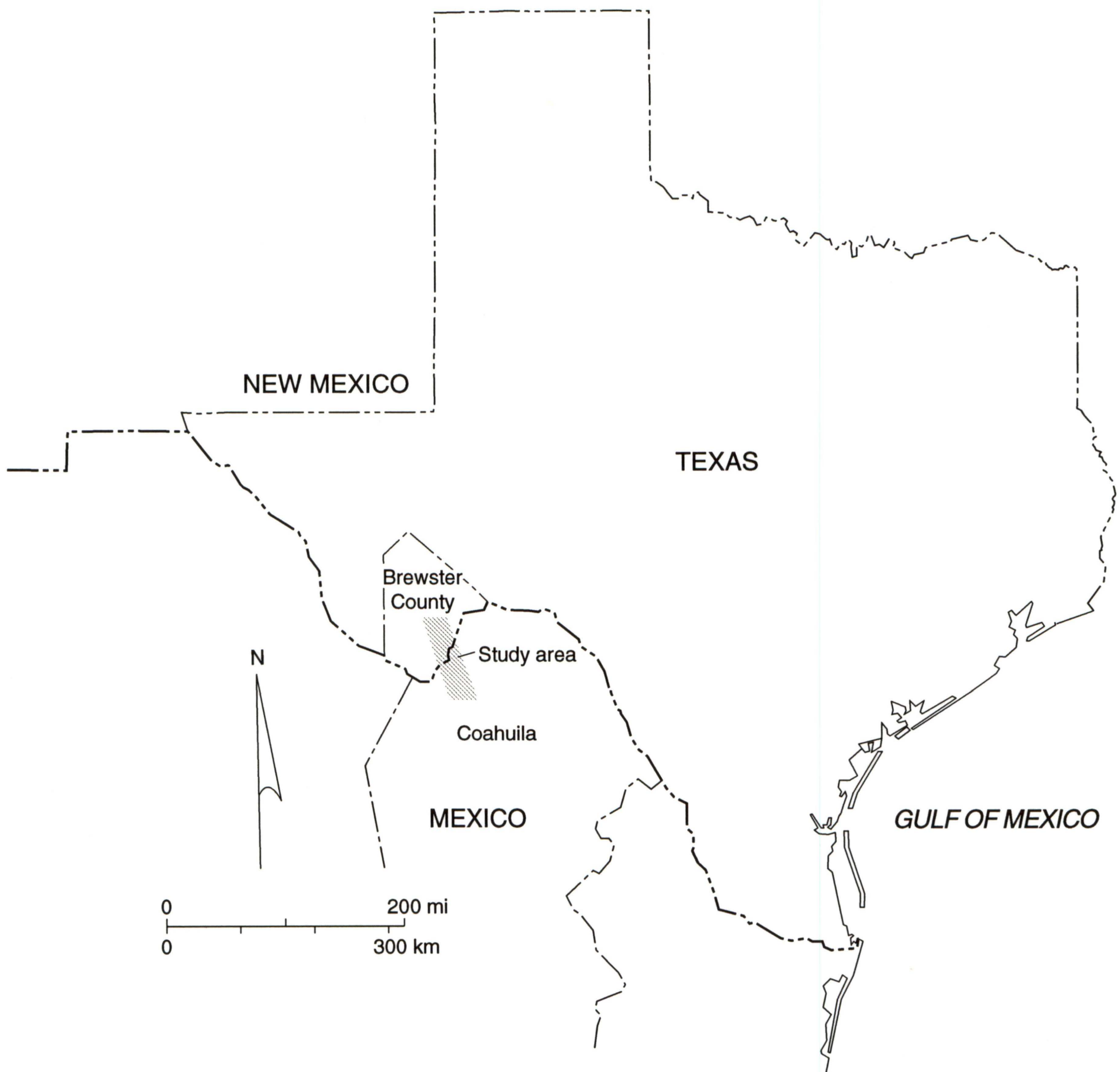


Figure 1. Location map of study area.

Methods and Previous Work

The geologic map was constructed at a scale of 1:100,000 and 1:50,000. The southern part of the study area was mapped at 1:50,000 because a 1:100,000-scale base map does not yet exist. The map was constructed by compiling existing geologic maps, making geologic interpretations using 1:50,000- and 1:62,000-scale aerial photographs, and checking previous interpretations through aerial-photograph mapping and reconnaissance field mapping. Time constraints on the project prevented field work in Coahuila, Mexico.

The Texas part of the study area is included in the classic geologic map by R. A. Maxwell and J. T. Lonsdale that is included in reports by Maxwell and others (1967) and Maxwell (1968). Much of the study area was more recently mapped by Moustafa (1988), who presented new structural interpretations for the area. Maps covering smaller portions of the Texas part of the study area were done by St. John (1966), who mapped the Black Gap area east of Sierra del Carmen, and Maler (1989), who mapped the Boquillas Canyon area.

The Coahuila, Mexico, part of the study area is included on a regional, 1:250,000-scale map by Smith (1970) and two 1:250,000-scale Mexican Instituto Nacional de Estadistica Geografia e Informatica maps, San Miguel H13-12 (1982) and Manuel Benavides H13-9 (1982). Carpenter (1996) mapped in detail, at an approximate scale of 1:2,260, a part of the Sierra del Carmen escarpment. She interpreted structural complexities that cannot be illustrated on larger scale maps, and her study indicates that detailed mapping of Sierra del Carmen in Coahuila is needed to completely understand the region's structural history. Barcelo-Duarte (1983) described the Lower Cretaceous stratigraphy of a region including Sierra del Carmen.

Physical Stratigraphy

Geology of the Sierra del Carmen reflects a long history with Paleozoic, Cretaceous, and Tertiary to Quaternary rocks being present along and within the range. The map explanation in the appendix summarizes the stratigraphy of this area. The oldest rocks in the range include Paleozoic schist, marble, and metaquartzite (Smith, 1970; Barcelo-Duarte, 1983; Carpenter, 1996). These rocks are locally at the surface west of the Sierra del Carmen escarpment in Coahuila. They occur on the footwall block of a large west-dipping fault that is partly responsible for the escarpment. These low-grade metamorphic rocks are thought to be associated with the Ouachita deformational belt, which was a zone of thrusting and folding along the southern North American cratonic margin during the Paleozoic (Flawn and others, 1961).

Overlying the Paleozoic rocks in Coahuila is a thick, >450-m, section of lower Cretaceous conglomerate, limestone, marl, shale, and siltstone that composes three units: an unnamed conglomerate unit and the La Pena and Cupido Formations. The units are undivided on the map (plate), and they only crop out in Coahuila. Overlying these units is a thick section of Cretaceous limestone interbedded with shale and marl, the Glen Rose Limestone. In Coahuila, Glen Rose strata are ~560 m thick, although in Texas the thickness ranges from 180 to 300 m. Glen Rose strata commonly crop out on the upthrown blocks of faults along valley and canyon walls; thus these strata are not areally extensive within the study area.

A relatively thin, 45- to 55-m-thick unit, Telephone Canyon Formation, overlies Glen Rose Limestone. Telephone Canyon is a nodular limestone and marl and mostly forms a slope between the more erosionresistant Glen Rose and overlying Del Carmen Limestone. Del Carmen Limestone is a cliff-forming unit that is between 105 and 135 m thick. These strata mostly occur along valley and canyon walls. Sue Peaks Formation composes about 75 to 130 m of limestone, marl, and shale. It is a slope-forming unit that overlies Del Carmen Limestone and is beneath the Santa Elena Limestone, a 240- to 300-m-thick cliff-forming unit. Santa Elena Limestone caps much of the Texas part of Sierra del Carmen and much of the northern part of the range in Coahuila. Locally the Santa Elena Limestone is overlain by as much as 36 m of Del Rio Clay and ~30 m of Buda limestone and marl.

Upper Cretaceous strata include as much as 263 m of Boquillas flaggy limestone and chalk beds separated by thin claystone beds. Boquillas strata are overlain by as much as 210 m of Pen claystone. Above the Pen Formation is 90 to 210 m of Aguja sandstone, claystone, and siltstone. Javelina claystone, about 72 m thick, overlies the Aguja Formation.

Tertiary rocks include both intrusive and extrusive volcanic rocks. The most areally extensive igneous rocks on the Texas part of the range lie along the western margin within McKinney Hills. The principal rock type of this laccolithic intrusion is an augite-hornblende granite (Maxwell and others, 1967; Moustafa, 1988). Within the Coahuila part of Sierra del Carmen intrusive and extrusive rocks make up a large portion of the range. Large parts of the range are capped by extrusive flows that occur as capping units on mesas.

Tertiary to Quaternary surficial basin-fill deposits consist of sand, gravel, silt, and clay of alluvial fans, incised alluvial fans, and bajadas. These deposits flank the margins of Sierra del Carmen and occur within small fault-bound valleys (graben) of the range. Quaternary sand, silt, gravel, and clay of drainageways and young arroyo and Rio Grande terraces occur locally within the study area.

Summary of Proposed Units to Aid in Evaluating the Distribution of Plant Communities

The stratigraphy of the Sierra del Carmen, Appendix: Explanation of Geologic Units, consists of many formal geologic units illustrated in the geologic map of the area (plate). Many of these units have similar lithologies and thus have similar soils and appear to have similar vegetation. We propose seven informal lithologic units to be considered as an aid in the extrapolation of plant communities. Some of these units may be subdivided. These units are based only on lithology, and important factors such as slope and elevation have not been used to differentiate the units.

Unit 1 consists of sand, gravel, silt, and clay of the Tertiary to Quaternary surficial basin-fill alluvium and the Quaternary alluvium of the more active drainageways. The latter deposits generally occur in relatively more active geomorphic settings, such as arroyo channels; thus they may be divided from the other alluvium.

Unit 2 comprises the Tertiary igneous rocks. The igneous rocks of the McKinney Hills area in Texas can be subdivided from the large areas containing volcanic rocks in Coahuila.

Claystone, siltstone, and sandstone of the Pen, Aguja, and Javelina Formations make up Unit 3. Unit 4 consists of limestone and chalk from the thick, ~260-m, Boquillas Formation and limestone, marl, and claystone from the thinner, less areally extensive Buda Limestone and Del Rio Clay.

Unit 5 encompasses a large part of the range and is composed of limestone, marly limestone, marl, and some shale of the Santa Elena, Sue Peaks, Del Carmen, Telephone Canyon, and Glen Rose Formations. Strata of the latter four formations occur mostly along steeper slopes of valleys and canyons; thus they may be divided from the more areally extensive Santa Elena Limestone.

Conglomerate, shale, siltstone, limestone, and marl of the La Pena, Cupido, and an unnamed unit make up Unit 6. This unit only occurs within a small area in Coahuila. Unit 7 also only occurs locally in Coahuila. It consists of Paleozoic schist, marble, and metaquartzite.

In addition to lithologic relationships to vegetation, fault and fracture zones may create local areas of moisture variation; thus unique plant communities may exist along and adjacent to these structures. Sometimes the axes to folds may be more fractured than surrounding areas, and these areas also may be considered when extrapolating plant communities within the range.

Acknowledgments

This work was funded by the National Biological Service under contract no. 1445-0004-95-9115.

References

Barcelo-Duarte, J., 1983, Lower Cretaceous stratigraphy and depositional systems in northwestern Coahuila, Mexico: The University of Texas at Austin, Ph.D. dissertation, p. 15–25.

Carpenter, D. L., 1996, Tectonic history of the metamorphic basement rocks of the Sierra Del Carmen, Coahuila, Mexico: The University of Texas at Austin, Master's thesis, 117 p., map scale ~1:2,260.

Flawn, P. T., Goldstein, A., Jr., King, P. B., and Weaver, C. E., 1961, The Ouachita System: University of Texas, Austin, Bureau of Economic Geology Publication No. 6120, 401 p.

Maler, M. O., 1989, Structural geology of the southernmost Sierra Del Caballo Muerto/Boquillas Canyon area, Big Bend National Park, Texas: The University of Texas at Austin, Master's thesis, 75 p., map scale 1:12,000.

Manuel Benavides H13-9, 1982, Instituto Nacional de Estadistica Geografia e Informatica, 1:250,000.

Maxwell, R. A., Lonsdale, J. T., Hazzard, R. T., and Wilson, J. A., 1967, Geology of Big Bend National Park, Brewster County, Texas: University of Texas, Austin, Bureau of Economic Geology Publication No. 6711, 320 p., map scale 1:62,500.

Maxwell, R. A., 1968, The Big Bend of the Rio Grande, a guide to the rocks, landscape, geologic history, and settlers of the area of Big Bend National Park: The University of Texas at Austin, Bureau of Economic Geology Guidebook 7, 138 p., map scale 1:62,500.

Moustafa, A. R., 1988, Structural geology of Sierra del Carmen, Trans-Pecos, Texas: The University of Texas at Austin, Bureau of Economic Geology, Geologic Quadrangle Map No. 54, 28 p., map scale 1:48,000.

San Miguel H13-12, 1982, Instituto Nacional de Estadistica Geografia e Informatica, 1:250,000.

Smith, C. I., 1970, Lower Cretaceous stratigraphy, northern Coahuila, Mexico: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 65, 101 p., map scale 1:250,000.

St. John, B. E., 1966, Geology of Black Gap Area, Brewster County, Texas: University of Texas, Austin, Bureau of Economic Geology, Geologic Quadrangle Map No. 30, 18 p., map scale 1:62,500.

Appendix: Explanation of Geologic Units

QUATERNARY

Qa—Undivided alluvium of drainageways and young arroyos and Rio Grande terraces. Sand, silt, gravel, and clay. Includes young deposits in relatively active geomorphic settings.

TERTIARY AND QUATERNARY

QTa—Undivided alluvium of alluvial fans, incised alluvial fans, and bajadas. Sand, gravel, silt, and clay. Locally includes slope-wash alluvium and colluvium.

QTl—Landslide deposits.

TERTIARY

Ti—Undivided intrusive igneous rocks.

Ts—Mafic rocks of sills.

Tv—Undivided volcanic rocks; includes both intrusive and extrusive volcanic units. Commonly used where expression on aerial photographs appeared massive and not layered.

Tve—Volcanic rocks of probable extrusive origin. On aerial photographs, the volcanic units appeared to be layered over a significant part of the area, but layering is not everywhere well displayed. Tve also includes local informal units on the Torrecillas Quadrangle that appear to be extrusive flows that commonly occur as capping units on mesas. Three local units are named for the mesas with which they are associated: (1) Tvemf—Volcanic flow of Mesa Los Fresnos, (2) Tvesc—Volcanic flow of Sierra el Carmen, and (3) Tvemg—Volcanic flow of Mesa Guadalupe.

Tb—Black Gap basalt.

UPPER CRETACEOUS

Kj—Javelina Formation. Claystone, varicolored; contains silicified wood and dinosaur bones. About 72 m thick.

Ka—Aguja Formation. Lower part is composed of 1.5 to 10.5 m of rusty-brown sandstone overlain by 52 to 150 m of claystone. Reddish-brown concretions common. Lower part was deposited in a marine environment. Upper part is 90 to 210 m of dark carbonaceous claystone, siltstone, and crossbedded sandstone. Upper part contains silicified wood, dinosaur bones, and coal interbeds. Upper part was deposited in a nonmarine environment. Total formation thickness is 90 to 210 m.

Kp—Pen Formation. Claystone and rare sandstone. Dark-colored; sandstone beds as much as 1 m thick; commonly covered with float. Maximum thickness is 210 m.

Kbo—Boquillas Formation. Flaggy limestone and chalk beds separated by thin claystone beds. On aerial photographs Boquillas strata exhibit a pattern of narrow, alternating light and dark bands. Unconformably overlies Buda Limestone. Maximum thickness is 263 m.

LOWER CRETACEOUS

Kbu—Buda Limestone. Limestone and marl. Light-gray. Lower part is limestone with 0.6- to 1.5-m-thick beds. Middle part is nodular marly limestone and marl. Upper part is limestone with 0.6- to 1.5-m-thick beds. Average thickness is ~30 m.

Kdr—Del Rio Clay. Claystone and shale; less common thin limestone. Weathers easily and typically covered by float. Thickness as much as 36 m.

Kse—Santa Elena Limestone. Limestone with minor marly limestone. Beds 1 to 3 m thick; abundant chert nodules; silicified fossils. Cliff-forming unit. Thickness is 240 to 300 m.

Ksp—Sue Peaks Formation. Limestone, marl, and shale. Lower part is yellowish-gray marly shale and is ~20 m thick. On aerial photographs the lower part has light tone. Upper part is ~55 m of limestone and marl. Slope-forming unit. Average thickness is ~75 m in Texas and thickens to ~130 m in Coahuila.

Kdc—Del Carmen Limestone. Limestone. Beds 1 to 3 m thick; elongate lenticular lenses of chert; cliff-forming unit. Thickness ranges from 105 to 135 m.

Ktc—Telephone Canyon Formation. Nodular limestone and marl. Forms slope between resistant underlying Glen Rose Limestone and overlying Del Carmen Limestone. Maximum thickness is ~45 m in Texas and ~55 m in Coahuila.

Kdv—Devils River Formation. Limestone and marl. Platform-margin facies equivalent to Del Carmen, Sue Peaks, and Santa Elena Formations. Located in southern part of study area.

Kgr—Glen Rose Limestone. Limestone interbedded with shale and marl. Limestone beds 1 to 2 m thick. Wackestone, packstone, and mudstone fabric. Base not exposed in Texas. Thickness ranges from 180 to 300 m in Texas and is ~560 m in Coahuila.

Klpc—Undivided La Pena and Cupido Formations, and basal Cretaceous conglomerate. La Pena Formation is shale, siltstone, and shaly mudstone. Thickness is ~58 m. Cupido Formation consists of limestone and less commonly marl. Wackestone, grainstone, and mudstone fabric. Units not present in Big Bend National Park. Thickness is ~210 m. Basal Cretaceous conglomerate may be as thick as ~200 m. Conglomerate consists of pebble- and cobble-sized chert, limestone, vein quartz, sandstone, minor schist, and rare volcanic rock fragments.

PALEOZOIC

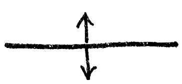
P—Paleozoic metamorphic rocks. Schist, marble, and metaquartzite.

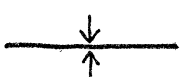
 Normal fault

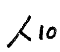
 Thrust fault

 Fracture zone, small displacement fault, or dike

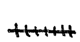
 Monocline

 Anticline

 Syncline



Strike and dip of beds

 Fissure