GEOLOGY OF EL RANCHO CIMA

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A GUIDEBOOK FOR BOY SCOUTS

GUIDEBOOK

to the

GEOLOGY OF EL RANCHO CIMA

Hays & Comal Counties, Texas

by

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PREFACE

In scouting, boys learn to do by doing. The method is likewise applicable to surface geology, which cannot be learned well except in the field.

Each year thousands of boys attend summer camp at El Rancho Cima. Of that host, only a small percentage are geology merit badge candidates. It is our desire that many more boys seek the fun and knowledge to be gained from working field geology while at camp.

The camp is situated in an interesting geological setting. Here can be found abundant remains of ancient marine life preserved as fossils in the strata. Two faults are present across the area.

Specific aids are provided herein to explain how the geology merit badge requirements may be fulfilled while at summer camp. Definitions of geologic terms are listed under the glossary.

For these purposes is this guidebook designed. We hope that it may serve well the needs of the Boy Scouts and of their leaders in the Sam Houston Area Council.

The Authors

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I. INTRODUCTION

Location

El Rancho Cima is located 18 miles west-northwest of San Marcos, Texas in Hays and Comal Counties. The intersection of latitude 29° 57' north and longitude 98° 10' east falls in the central part of the Camp. Convenient access to El Rancho Cima is afforded by the farm-to-market road, FM 32. (See location map, figure 1.)

From The Devil's Backbone the roadside park offers an excellent vantage point overlooking almost all of the Camp. The view northward toward the Blanco River is one of the most scenic in the hill country of the Edwards Plateau.

History

Purchased by the Sam Houston Area Council in 1953, the Ranch consists of approximately 2,480 acres. That portion which lies in Hays County can be traced back to an early Texas land grant. The Comal County acreage was once part of a Spanish land grant to Maria Ampora.

In March, 1845, Prince Solms of Germany negotiated for two leagues which included the Comal tract. Thus the early settlers were German immigrants who located principally in New Braunfels and Fredericksburg. These hardy pioneers survived food shortages, severe winters, disease, and Indian attacks to establish homes in this region. At a council meeting on March 1-2, 1847, Meusebach, the spokesman for the German people, made a treaty with the Comanches. It is not certain whether that tribe was guilty of all the atrocities against the Germans, for wandering bands of hostile Wacos and Lipans made the country unsafe in that day.

Dr. Ferdinand Roemer, the first geologist to work in the region surrounding the Camp, arrived in New Braunfels on March 24, 1846.

In more recent times, most of the land now making up the Ranch was owned by the Donalson family who lived at Horse Shoe Bend. A present reminder of that tenure is Donalson Hill, located due west of the Ranger's headquarters.

It is believed, though not proven, that a farm house once sat on the flat meadow now called Old Homestead.

At the time of its purchase by the Sam Houston Area Council, El Rancho Cima was bounded on the north by the Blanco River. Later, part of the land was traded for a narrow strip along the north bank. Nowadays, Scouts have legal access to both sides of the river within the Camp boundaries.

Although its facilities are used for a variety of Scouting purposes, the Ranch functions primarily as a summer camp for Scout units of the Council. Permanent buildings have been erected at all camp sites except Rocky Gulch, which is reached only by foot trails.

Wild Life

Good conservation practices have made the Ranch a veritable game preserve.

Mammals commonly seen on the Ranch are the opossum, raccoon, skunk, squirrel, jackrabbit, cottontail rabbit, whitetail deer, field mouse, and armadillo. Present, but seldom seen, is the ring-tailed cat.

Songbirds are about in great numbers and variety. Other feathered representatives are the chaparral, poor-will's-widow, hoot, and screech owls. Hawks are occasionally seen along the river, while the raven and American vulture appear at times.

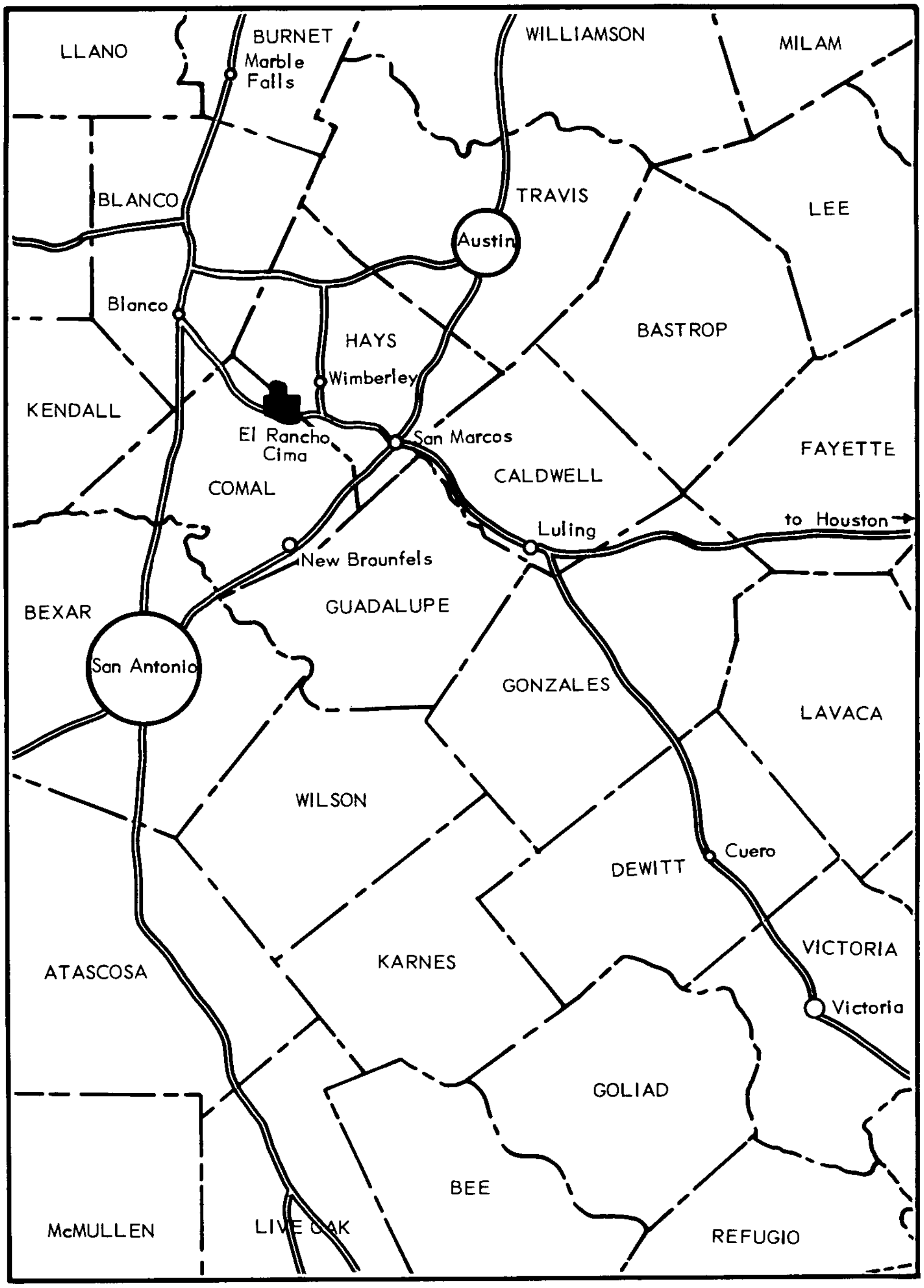


Figure 1. Location Map

Poisonous reptiles are seldom encountered, although the rattlesnake, copperhead, cottonmouth moccasin, and coral snake all are inhabitants of the area. Nonpoisonous snakes are sometimes captured by Scouts for reptile study. Skinks and swifts join the anoles as typical lizards frequenting the ranch. Both tortoises and water turtles abound.

Among the well known fishes taken from the Blanco River are smallmouth bass, bream, perch, and catfish.

In addition to the wild animals mentioned above, such domesticated animals as the horse, donkey, and burro are present on the ranch. They are used for transportation and recreation.

Plant Life

Cedar, oak, and elm groups characterize the vast majority of trees found on the Ranch. Many other kinds of trees, including hickory, cypress, sycamore, and wild plum, grow in lesser numbers.

Grasses and shrubs are abundant, and often cover the outcrops so thickly that accurate description of the marl beds is difficult.

Soils

Vegetation, as well as the combined effects of relief, source rocks, climate, erosion, and weathering determine the type of soils found at Camp. Bed rock is broken up by extreme temperature changes, by erosion through the agencies of wind and water, by plant roots growing through crevices, and by chemical alteration. Soils on the hillsides are thin, and in some areas absent altogether. They are derived from the calcareous limestones and marls and mixed with decaying tree leaves, grasses and other organic matter to form a dark loamy soil on which vegetation flourishes. Soil in the lower valleys is mixed with the recent stream deposits shown as alluvium (Qal) on the geologic map.

Climate

The data listed here were recorded at San Marcos and are reasonably applicable to El Rancho Cima.

Overall, the climate is temperate. The average year-around temperature is 67.8°F, while the mean monthly temperature for January is 50.6°F, and that for August is 84.0°F.

The average annual rainfall is 32.81 inches.

Methods of Investigation

The base map was made from stereoscopic aerial photographs. Field information was recorded on transparent overlays directly over the photos and later traced onto the base map.

A calibrated rod (long ruler) with an attached hand level was used to measure the total thickness of exposed strata.

Elevations were calculated by the interval-step method using a Gurley transit. Additional elevations, established previously by gravity survey, were incorporated into the construction of the topographic contour map. The horizontal attitude of the strata simplified the use of stereoscopic-pairs in tracing elevation contours.

Five days were spent in the field during the interim from March 30 to May 19, 1963.

* * *

II. TOPOGRAPHY

Relief

The limestone hills of the Edwards Plateau are in sharp contrast to the flat-lying Gulf Coastal Plain south of San Marcos and New Braunfels.

The maximum difference of elevation between the Blanco River and The Devil's Backbone is 400 feet. Canyon walls in the Camp - at Rocky Gulch, for example - stand as high as 200 feet above the valleys. An asphalt road from the river trail to the mess hall rises 200 feet over a distance of approximately 1500 feet. Hungry Scouts, hiking to the chuck house, have appropriately called this steep slope "Appetite Hill."

Erosion and Drainage

Topographic features on the Ranch have been shaped by the work of erosion and weathering. Small particles of rock fragments are being slowly eroded from all of the hills. Differential erosion of alternating layers of hard limestones and soft marls causes the hills to appear terraced or "stairstep" in profile.

Rock particles are being carried by streams such as Cima Creek and Rocky Bottom Creek to the Blanco River, thence to the San Marcos River, and eventually to San Antonio Bay. Imagine that. There are probably some small particles of sediment on the ocean floor which were once present at El Rancho Cima.

The Devil's Backbone forms a drainage divide between the Blanco and Guadalupe River valleys.

* * *

III. STRATIGRAPHY

General Information

Remove the map from the pocket at the back of this guidebook and refer to the columnar section while we talk about the rocks at El Rancho Cima.

All of the strata which crop out within the Camp belong to the Comanchean Series of Lower Cretaceous age. The Cretaceous, present over great expanses of the earth's surface, is noted for its great thicknesses of carbonate rocks. Classification of Cretaceous rocks is further refined to include shorter intervals of strata, having similar character, under a group name.

The Trinity Group includes strata, such as that in the Glen Rose (and underlying formations not present in Camp), which consist of alternating limestones and marls, sandy shales and shaly sandstones.

Massive limestones, with fewer shales and marls, are predominant in the overlying Fredericksburg Group. In this group are the Comanche Peak and Walnut Formations. Also included, but not present in Camp, is the Edwards Formation. The highway leading from San Marcos to Camp is constructed, for the most part, over this massive limestone.

For purposes of mapping smaller stratigraphic units in the field, formations are sometimes divided into smaller intervals called members. The Glen Rose Formation is divided into an upper and a lower member. Two fossil zones in the Upper Glen Rose Member are indicated by symbols on the geologic map. Local names for individual beds and fossil zones in the Upper Glen Rose Member are original with the writers, and are not recognized as formal stratigraphic names outside the Camp area.

Almost all of the topographic features of the Camp are formed in the Upper Glen Rose Member. A small area of exposure of the Lower Glen Rose Member is present in the extreme northwest corner of the Camp and along the Blanco River campsites. Outliers of the lower part of the Fredericksburg Group are present along The Devil's Backbone and on the tops of Square End Mountain, Gunsight Ridge, and Northeast Mountain.

The total thickness of all formations which crop out in the Camp is 533 feet. Many of the limestone outcrops have "honeycomb" structure due to solution by water. All contacts between formations are conformable. For their complete description, turn to the measured sections in the appendix. (See figure 3).

Trinity Group

Glen Rose Formation

Alternating limestones and marls comprise the entire 523 feet of the Glen Rose exposed in Camp. A distinct ridge-forming limestone bed which has small pelecypods (*Corbula martinae*) on its upper surface marks the division between the upper and lower members. These fossils resemble "wheat seeds" because of their small size and abundance. Campsites 4 through 10 sit almost on the outcrop of this limestone.

Lower Glén Rose Member. - The Lower Glen Rose Member is 126 feet thick in the Camp. The lowest part is not exposed. In surrounding areas it has a thickness of 200 feet.

Limestones in this member are characteristically thicker than those in the upper member, and are very fossiliferous. Rocks of the Lower Glen Rose which crop out nearest Circle Bar-One campsite are the oldest strata in Camp.

Upper Glen Rose Member. - More space will be devoted to the description of the Upper Glen Rose because it crops out over most of the Camp area. It is composed of 397 feet of alternating limestones and marls which lie above the *Corbula martinae* bed and below the Walnut Formation of the Fredericksburg Group.

In general, the lower 135 feet of the member is very fossiliferous with abundant pelecypods, gastropods, and echinoids. The overlying 262 feet is composed of non-fossiliferous strata except for a 65-foot interval which lies 113 feet below the contact with the Walnut Formation.

Located 66 feet above the *Corbula martinae* bed is the base of a 20-foot interval of limestones and marls so fossiliferous that they are termed coquinal. Good exposures of the coquinal zone are present just south of Iron Wheel Mesa; along Schneider's Road where it enters White Tail Canyon; and on the sides of Telephone Hill. The outcrop of the coquinal zone is shown on the geologic map.

Overlying the coquinal zone is an interval 84 feet thick having very few fossils. The Ranch House Limestone bed, on which rests the Ranger's home, marks the top of this nonfossiliferous interval.

Above the Ranch House Limestone is a fossiliferous interval 65 feet thick which includes strata up to the base of the Sentinel Peak Limestone bed. The upper 8 feet of this interval marks the abundant occurrence of *Loriolia rosana*, a small echinoid, in a very fossiliferous marl bed.

A convenient exposure for collecting fossils from the *Loriolia rosana* zone is located 25 feet below the lone cedar tree at the top of Sentinel Peak. Another excellent collecting site for this assemblage of fossils is at the small hill just north of Dead Man Knob.

In the Dead Man Knob area *Loriolia rosana* is also present in a 10-foot marl whose top lies 27 feet below the uppermost occurrence of *Loriolia* as seen at Sentinel Peak. The lower occurrence of *Loriolia* was not observed on the side of Sentinel Peak because of vegetational cover over the outcrop.

A 7-foot thick, non-fossiliferous limestone bed overlies the *Loriolia rosana* zone. It will be called the Sentinel Peak Limestone in this guidebook. The bed is well exposed in a circular outcrop around Sentinel Peak. It forms the erosional saddle between the highest point of Sentinel Peak and the small flat-topped area just north of the peak. It also caps the small hill just north of Dead Man Knob.

The Sentinel Peak Limestone bed is easily recognizable by its wavy contact with the underlying marl. The lower portion is yellowish and marly, with platy bedding. It grades upward into a hard, tan, finely crystalline limestone, and weathers into a blocky surface.

The 106 feet of Upper Glen Rose strata which lie above the Sentinel Peak Limestone bed and below the Walnut Formation has only a few fossils. This interval contains more silt and sand than any other part of the Upper Glen Rose Member.

The sandy character of the upper measures of this member can be observed in the road cut on Highway 32 at the west end of The Devil's Backbone. A few fossils (*Nerinea* and *Exogyra texana*) are present at this location. Calcite geodes and veinlets are abundant in this outcrop.

Fredericksburg Group

Walnut Formation

The Walnut Formation consists of 5 feet of calcareous, silty shale with white calcareous nodules and sparse fragments of *Exogyra texana* . It weathers on the surface to a bluish crust. The white calcareous nodules are weathered to soft forms which disintegrate under slight pressure into a fine substance resembling face powder. The Walnut overlies the sandy shales of the Upper Glen Rose in the same roadcut on Highway 32 as was mentioned above. At other localities along The Devil's Backbone the Walnut is less than 5 feet thick.

Comanche Peak Formation

Only the basal 5 feet of the Comanche Peak was observed in the roadcut on Highway 32. At that locality it forms the top ledge of the steep slope above the highway. The roadside park is on this limestone.

Stream Alluvium

Stream deposits in the Blanco River flood plain and in the valleys of its tributary streams are recent in age. Their distribution is restricted to a very small area of the Camp along the swimming area above the dam and to Old Homestead area in Cima Canyon. The alluvium contains much clay and silt along with some sands and gravels. The thickness of alluvium along the swimming area is estimated at 25 to 30 feet.

* * *

IV. PALEONTOLOGY AND HISTORICAL GEOLOGY

General Information

Several early geologists of Texas made reference to, or briefly described, a few fossils from the Glen Rose Formation. In the early 1930's, Dr. F. L. Whitney of the University of Texas assembled a rather large collection of Glen Rose specimens mostly from Blanco, Bandera, Hays, and Comal Counties. Based upon his collection, his daughter, Marion Isabelle Whitney, compiled in 1937 the first extensive classification text on the fauna of the Glen Rose. Her excellent thesis is still the standard reference on the subject. Further study is needed, for not all of the fossils at El Rancho Cima are well known, and some have not yet been described in the literature.

In this guidebook, no attempt has been made to illustrate all of the forms recognized on the Ranch. Rather, a selected group is presented with emphasis upon the more commonly occurring genera.

Life in the Cretaceous Sea

The limestones and marls were deposited in warm, shallow waters which covered this region about 80 million years ago. Not far to the north was the shoreline of this ancient sea, now long since retreated to the present Gulf of Mexico. Depth of water during the deposition of the marine strata (which now form the surface of El Rancho Cima) was about 50 feet.

These waters were teeming with marine life much like that which thrives today in shallow marine environments. Pelecypods (clams) were the most dominant animals in these waters, followed by gastropods (snails). Echinoderms (sea urchins) were less numerous, but well represented.

Special types of pelecypods, called rudistids, (Plate III), flourished in the Glen Rose sea. They inhabited the sea floor in large "communities" in much the same manner as oysters do today in shallow waters along the coast.

Porocystis globularis (Plate X) was plentiful. These small white balls, having pitted surfaces, are probably seeds of plants which grew on the sea floor.

One of the most abundant fossils which lived during this time was *Orbitolina texana*, (Plate X), a one-celled animal whose cone-shaped shell measures only 1/8 to 1/4 inch in diameter.

Much later in geologic time, after these fossiliferous beds were buried beneath the ocean bottom by younger marine sediments, the sea retreated southward as the land mass was raised to a higher elevation by forces within the earth. (The marine beds exposed at Camp are 900 to 1,300 feet above the present level of the sea). Streams and rivers then began the unceasing task of eroding downward to expose the underlying layers which still contain the evidence of past marine life.

Preservation of Fossils

In general, fossils are abundant in most of the beds, but are not well preserved. The original shells have been removed by solution. For example, most clams are identified only by the shape of their internal molds.

Among the rudistids recognized are *Toucasia*, *Monopleura*, and *Coalcomana*. Of these, *Toucasia* is the most dominant and best preserved.

Corals, sponges and bryozoans were present in the Cretaceous sea, but are scarce in the present outcrops. The bryozoans appear as tiny rectangles of lattice work which usually encrust small portions of larger fossils.

The oyster-like clams such as *Exogyra* and *Gryphaea* are generally well preserved, as is the tiny protozoan, *Orbitolina*. In many places *Orbitolina* can be scooped up by the handfuls from well exposed marl outcrops.

Fossil Assemblages

When several fossils occur in the same bed, they are referred to as a suite or assemblage. Three distinct zones, each of which has a characteristic assemblage, are identified in this guidebook. They are the *Salenia texana* (Plate IX) zone, the Coquinal zone, and the *Loriolia rosana* (Plate IX) zone.

More than 30 different genera are contained within the *Salenia texana* zone, the lowest of the three. The small echinoid for which this zone is named is an index fossil found no other place in the stratigraphic column. This assemblage occurs within a marl with some thin limestone beds. Immediately overlying the *Salenia texana* zone is a limestone whose top is covered with *Corbula martinae*, (Plate V), a tiny pelecypod which occurs in such abundance that the aggregate appearance resembles wheat seeds. The *Salenia* zone is located on the map where the two shades of green color adjoin each other near the Blanco River.

Immediately south of the entrance to Iron Wheel Mesa is the outcrop of a marl bed which is made up almost entirely of *Orbitolina texana*. This marks the base of a 20-foot interval of limestones and marls called the Coquinal zone. The limestones contain many different genera and species of large and small clams and snails cemented closely together. In some of the marls *Orbitolina* shells are cemented together in crumbly masses. Rudistids occur in abundance in and above this zone.

The *Loriolia rosana* zone, highest of the three, is well exposed near the top of Sentinel Peak. This zone was so named because of the abundant occurrence of *Loriolia rosana*, a small echinoid. Here is an interesting and varied assemblage of fossils. Most of them appear to be dwarfed in size when compared with related genera found elsewhere in the section. The zone is distinct in that the strata immediately above and below it are relatively non-fossiliferous.

Explanation of Fossil Drawings

Many of the fossils found at El Rancho Cima are illustrated and classified in the plates which follow. A study of the drawings will help in recognizing them and in learning in which part of the section they are found.

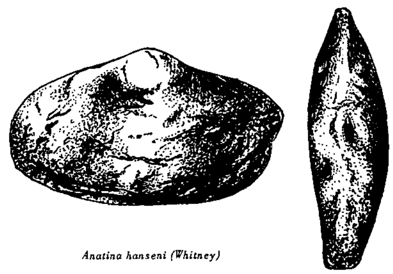
The information on each plate will be useful in finding and classifying specimens. First and second names are generic and specific, respectively. If a third name follows in parenthesis, it identifies the paleontologist who classified the fossil. The indicator "x 1/2" means that the drawing is approximately one-half life size; "x 2/3" means that the drawing is somewhat less than natural size; while "x 5" means that the figure has been enlarged to five times normal size because the actual specimen is too small to be seen clearly in life size. In addition to the name which appears beneath each illustration, there is a reference to the beds from which the specimen has been collected. With few exceptions, it is not an indicator of the total range of the fossil to which it refers.

Even though a Scout may wish to use only the generic (capitalized) name of each fossil for his exhibit, the information has been made more complete wherever possible. Such additional data will prove helpful to geologists who are interested in the area as well as to merit badge counselors.

* * *

PELECYPODS (CLAMS)

All specimens on this plate shown x 1/2

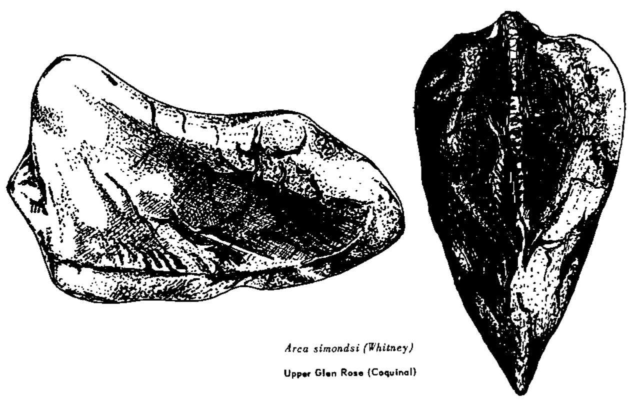


Anatina hanseni (Whitney)

Coquinal Zone

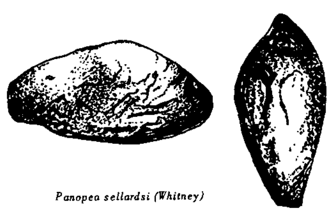
Cardita staffordi (Whitney)

Lower Glen Rose



Arca simondsi (Whitney)

Upper Glen Rose (Coquinal)



Panopea sellardsi (Whitney)

Coquinal Zone

Anatina beckleyi (Whitney)

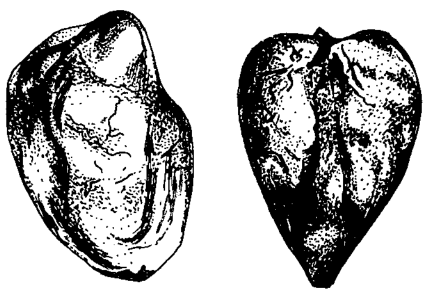
Coquinal Zone

PLATE I

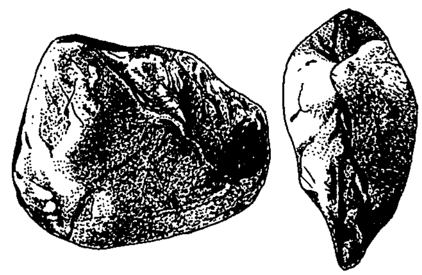
All specimens on this plate shown x 1/2

Corbis hamiltonae (Whitney)
Salenia and Coquinal Zones

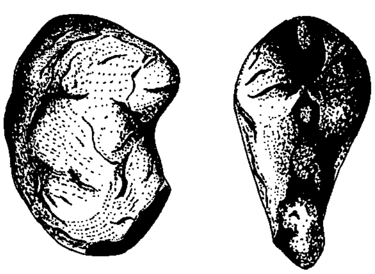
Corbis banderaensis (Whitney)
Coquinal Zone



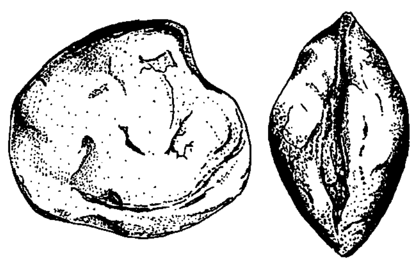
Liopistha walkeri (Whitney)
Coquinal Zone



Liopistha banderaensis (Whitney)
Coquinal Zone



Liopistha fletcheri (Whitney)
Salenia and Coquinal Zones

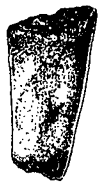


Meretrix hanseni (Whitney)
Salenia texana Zone

PELECYPODS

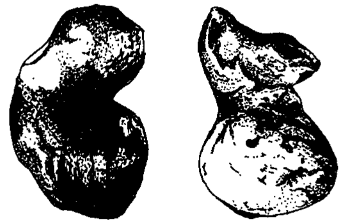
PLATE II

All specimens on this plate shown x 1/2

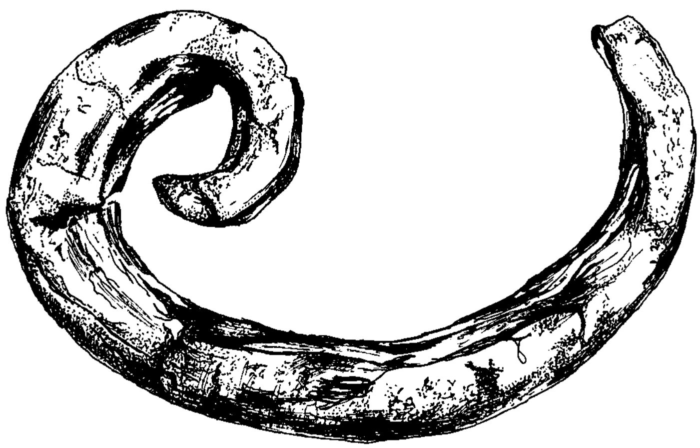


Monopleura sp.
Lower Glen Rose

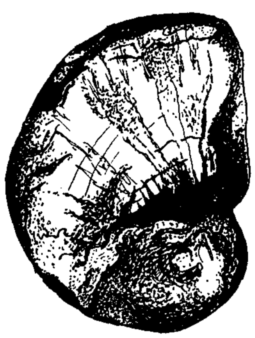
Monopleura subtriquetra (Roemer)
Lower Glen Rose W. of Horse Shoe Bend



Toucasia pseudopatagiata (Whitney)
Upper Glen Rose (Coquinal)



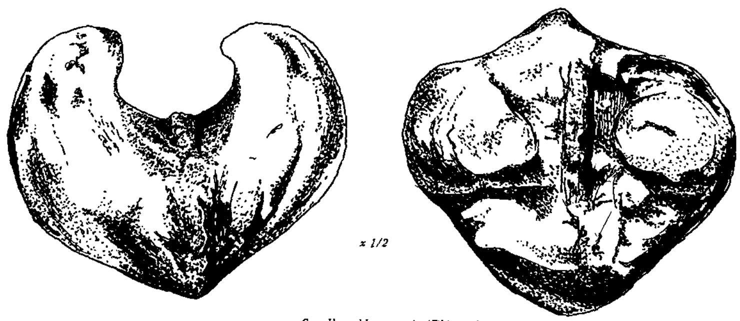
Coalcomana texana (Whitney)
Lower Glen Rose W. of Horse Shoe Bend



Toucasia hancockensis (Whitney)
Upper Glen Rose (Coquinal)

PELECYPODS

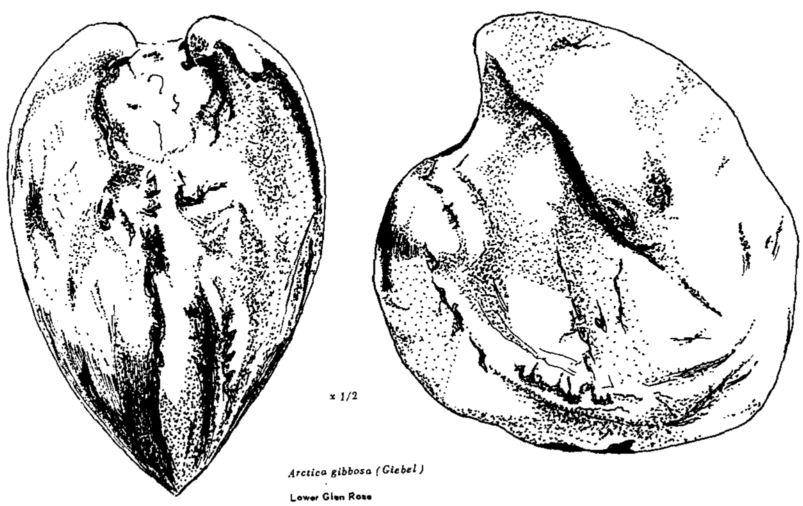
PLATE III



x 1/2

Cucullaea blancoensis (Whitney)

Lower Glen Rose-Salenia Zone



x 1/2

Arctica gibbosa (Giebel)

Lower Glen Rose

x 1

Trigonia whitneyi (Wendler)

Lower Glen Rose and Coquinal Zone

x 1/2

Neithea irregularis (Böse)

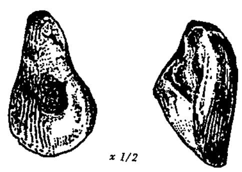
General Glen Rose

PELECYPODS

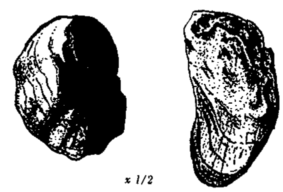
PLATE IV

Corbula martinae (Whitney)
In ls. just above Salenia Zone

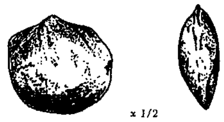
Exogyra paupercula (Cragin)
Upper Glen Rose



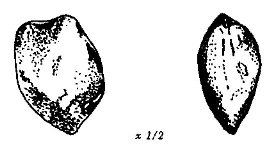
Spondylus olsenae (Whitney)
Salenia and Coquinal Zones



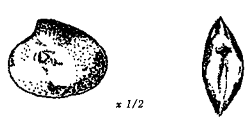
Exogyra weatherfordensis (Cragin)
Upper Glen Rose



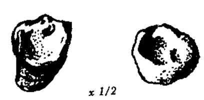
Lucina horni (Whitney)
Upper Glen Rose



Nucula bybeei (Whitney)
Salenia and Coquinal Zones



Tapes bakeri (Whitney)
General Glen Rose

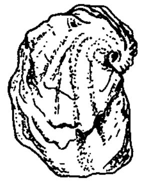


Gryphaea wardi (Hill & Vaughan)
General Glen Rose

PELECYPODS

PLATE V

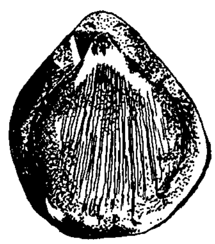
All specimens on this plate shown x ½



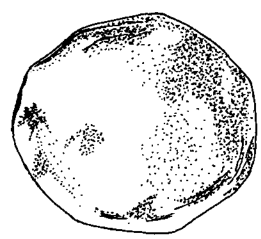
Exogyra texana
Uppermost Glen Rose
and Lower Fredericksburg

Arca texana (Roemer)
Salenia Zone

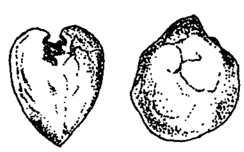
Trigonia wendleri (Whitney)
Salenia Zone



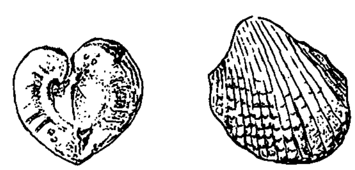
Pecten stantoni (Hill)
General Glen Rose



Cyprimeria texana (Roemer)
Upper Glen Rose



Cardium congestum (Conrad)
General Glen Rose

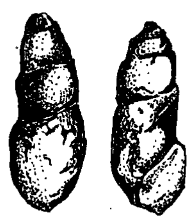


Pholadomya sp.
Upper Glen Rose

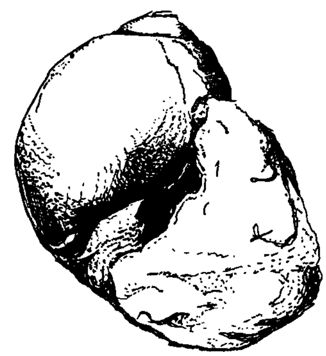
PELECYPODS
PLATE VI

GASTROPODS (SNAILS)

All specimens on this plate shown x 1/2

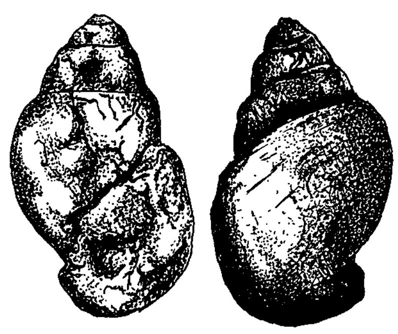


Strombus beckleyi (Whitney)
Salenia and Upper Glen Rose



Lunatia pedernalis (Roemer)
General Glen Rose

Turbo mcallisteri (Whitney)
Upper Glen Rose



Tylostoma travisensis (Whitney)
Salenia and Upper Glen Rose

Turbo cuyleri (Whitney)
Upper Glen Rose

Pleurotomaria glenrosensis (Whitney)
Salenia and Upper Glen Rose

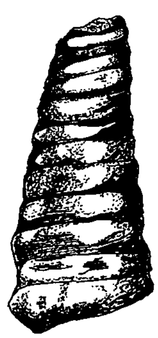
PLATE VII

All specimens on this plate shown x 1/2

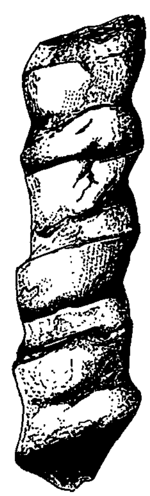
Nerinea ikinsi (Whitney)
General Glen Rose

Turritella sp.
General Glen Rose

Nerinea boyseni (Whitney)
Upper Glen Rose



Nerinea hancockensis (Whitney)
Upper Glen Rose



Nerinea roemeri (Whitney)
Salenia Zone

GASTROPODS

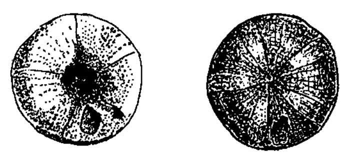
PLATE VIII

ECHINOIDS (SEA URCHINS)

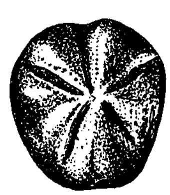
All specimens on this plate shown x 1/2

Salenia texana (Credner)
Index to Salenia Zone (See text)

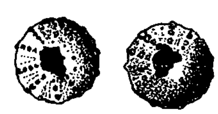
Ennalaster texanus (Roemer)
Salenia Zone



Holectypus planatus (Roemer)
General Glen Rose



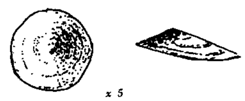
Hemiaster comanchei (Clark)
Salenia Zone



Loriolia rosana (Cooke)
Index to Loriolia Zone (See text)

PLATE IX

OTHER FORMS



x 5

Orbitolina texana (Roemer)
A foraminifer

General Glen Rose

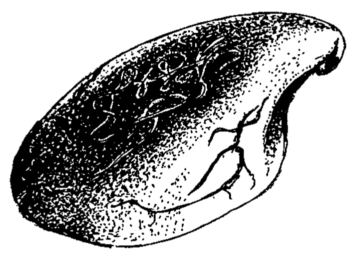
x 2/3

Porocystis globularis (Giebel)

General Glen Rose, Lower Fredericksburg Group

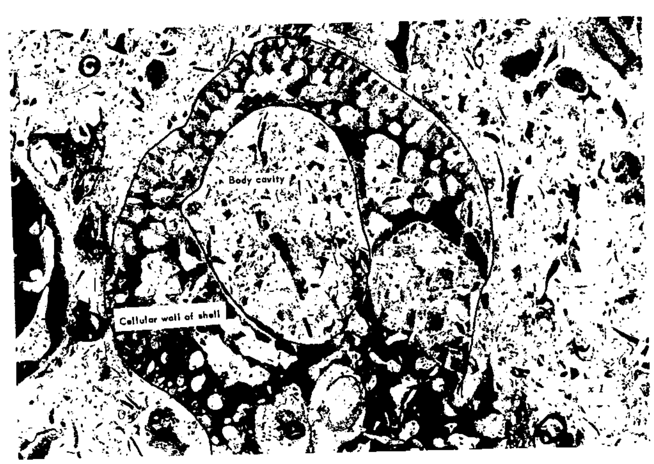
x 1

A fenestellid bryozoan



x 1/2

Worm tubes on a clam



Cross-section of a Caprinulid rudistid
(Courtesy of R. P. Zingula)

PLATE X

V. STRUCTURAL GEOLOGY

Regional Features

Regional Dip. - Though the topography of the Camp and surrounding region is generally rugged, the strata are almost horizontal. To the unaided eye there is no perceptible dip. However, the strata dip slightly to the southeast at a rate of 20 feet per mile, or about one-fourth of a degree.

To the field geologist, these horizontal strata are "layer cake geology." Their thickness is easily determined by measurement with a calibrated rod and hand level.

San Marcos Arch. - A broad upwarp of rock layers called the San Marcos arch underlies the Camp and surrounding region. The structural axis extends southeastward from the Llano uplift into the deep subsurface under the Gulf Coastal Plain. (See figure 2). The arch is many miles wide in a southwest-northeast direction.

El Rancho Cima lies over the central portion, or axis, of this buried feature. No evidence of its presence can be seen at the surface.

Balcones Fault Zone. - At least seven major faults trending N45E occur within the Balcones fault zone through Hays and Comal Counties. Many smaller faults are also present between the larger ones. Two of the major faults are present in the Camp. Their traces are shown on the geologic map as single lines. Actually, each line represents a zone, a few hundred feet across, of several small "breaks" of the strata.

The width of the Balcones fault zone, from New Braunfels northwestward to Spring Branch in Comal County, is about 20 miles.

Most of the downthrown blocks are on the southeast sides of the faults. The total vertical movement, or throw, of all the faults between Spring Branch and New Braunfels has been estimated at 1,700 feet. (DeCook, 1960).

Local Features in the Camp

Wimberley Fault. - The Wimberley fault trends N45E from eastern Comal County to Onion Creek in central Hays County. It is named from the town of Wimberley which is located near the fault trace in Hays County. The presence of this fault near the head of Cima Canyon is indicated by disrupted strata which have random dip orientations.

Frio Spring and Lonesome Valley Spring in Cima Canyon are related to the Wimberley fault. The waters which feed the springs emerge to the surface through pore spaces between the crumbled and displaced strata along the fault plane.

The southeast side of the Wimberley fault has moved downward approximately 93 feet. The amount of throw was determined by subtracting the elevations at which the *Loriolia rosana* zone occurred on the upthrown side at Sentinel Peak and on the downthrown side at Dead Man Knob.

Tom Creek Fault. - The Tom Creek fault crosses the northwest corner of the Camp. It extends in a northeast-southwest direction across the entire width of Hays and Comal Counties. It is named from Tom Creek whose course follows the trace of the fault for a considerable distance (in Comal County).

Contorted and disrupted strata near river campsite number 3 identify the fault trace on the hillside above the large bath house.

The 82 feet of throw of this fault was calculated from differences in elevation of the *Corbula martinae* bed on the upthrown and downthrown blocks.

* * *

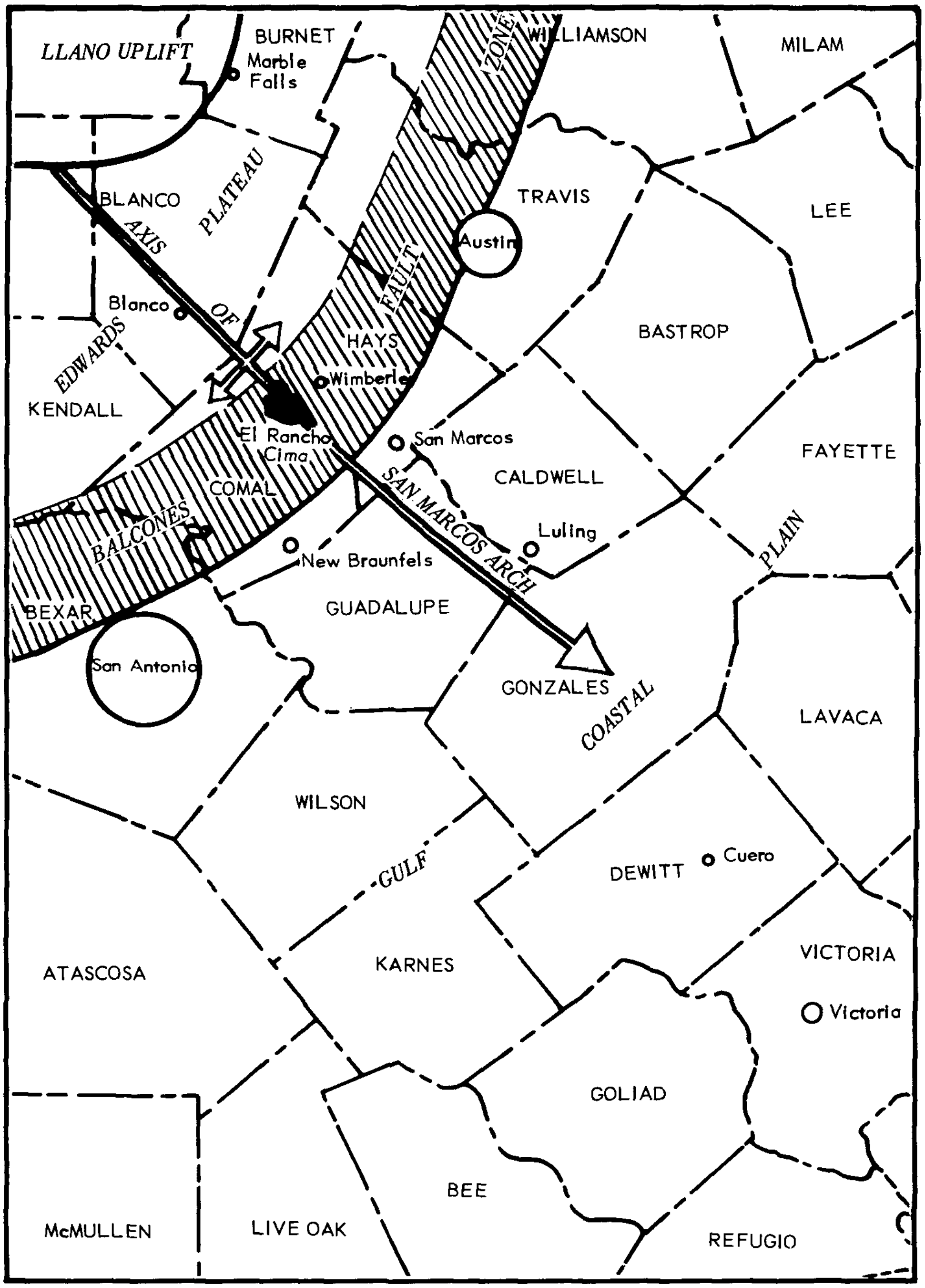


Figure 2. Regional Geologic Features

VI. WATER RESOURCES

Wells

Most of the waters obtained from wells in Comal County are acceptable for stock and domestic purposes.

Aquifers are largely limestones, yielding waters that are moderately hard. Dissolved solids generally range above 200 ppm (parts per million) and below 1000 ppm. Calcium bicarbonate is normally the predominant mineral constituent. Waters from the Lower Glen Rose contain more sulphates and are usually harder than those from the Upper Glen Rose.

At El Rancho Cima the water is produced from five deep wells that are bottomed in the Lower Glen Rose. Camp Headquarters and the River Camp are supplied by a 570-foot well, deepest on the ranch. This well is fitted with a 3-phase pump capable of delivering 10,000 gallons of water per hour into a cistern having a 25,000-gallon capacity. When consumption lowers the water level to a certain position, the pump is automatically started. It operates until the cistern is filled before shutting off. Locations and depths of the other four wells on the ranch are as follows: Horse Shoe Bend - 488'; Iron Wheel Mesa - 400'; Rocky Gulch - 400'; and Ranger's House - 365'.

None of the waters obtained at El Rancho Cima requires chemical treatment for purification.

Springs

Aptly called the "Country of 1100 Springs" is the Edwards Plateau region, where natural springs occur in abundance. Spring water is acceptable for general consumption provided there is no pollution near its point of issue. Springs are of special importance to wild life, particularly mammals, which often depend upon them for drinking water. Some of the springs apparently result from leakage of water upward along fault zones.

The Blanco River

At Wimberley, a gaging station records the runoff from a drainage area of 318 square miles in Hays County and from 60 square miles in Comal County. The average annual runoff from the Blanco River basin between 1929 and 1950 was 209 acre-feet per square mile. (George, 1952).

A concrete dam across the river affords a large swimming and boating area for the Scouts' waterfront program.

* * *

VII. EARNING THE GEOLOGY MERIT BADGE AT EL RANCHO CIMA

Requirements

A Scout should begin earning the geology merit badge by reading the geology merit badge pamphlet and the guidebook on the geology of El Rancho Cima. Also, he should review the chapter in his handbook which explains map reading if he has not recently worked with topographic maps.

If a counselor in geology is present at camp, the Scout should work and consult with him. However, it is possible with the aid of the guidebook and the geologic map, to collect fossils, assemble all needed information and complete the field work without assistance. A counselor may be consulted at a later date if necessary.

A list of requirements with suggestions about how to complete them follows:

Requirement One.

Make a collection of fifteen or more different fossils and five or more different sedimentary rocks which are found at Cima.

1. Label the fossils with their generic names and identify the geologic formation in which they were found. Mark the collection locality on the map.
2. Label the rock samples with their lithologic names and identify the geologic formation from which the samples were taken. Mark the locality on the map. Include limestone, sandstone and shale in the collection.
3. Be able to explain how fossils are formed, how they are used by the geologist, and why they are associated with sedimentary rocks.

Requirement Two.

Visit the water supply system of El Rancho Cima and write a short report about it answering the following questions:

What is the exact location of the well supplying camp headquarters?

What are the pumping, storage, and distribution facilities?

How deep is the well and how much water does it produce?

What is the aquifer and how is it charged?

What are the impurities in the water and what is done to prevent contamination?

Requirement Three.

Demonstrate that you are able to read a geologic map by doing the following:

1. Point out the geologic symbols used in making the map of Cima and be able to explain what they stand for.
2. Draw a combination topographic profile and geologic cross section across the map along a line which passes through the windmill on Devil's Backbone and the Camp headquarters. Be sure to include the faults and fossil zones as well as the geologic formations shown on the map.

3. Use your map and cross section to point out some relationships between topography and geology.

Requirement Four.

Write a short paragraph outlining the geologic history of El Rancho Cima. Use your map and cross section and be sure to give the events in order of occurrence from the oldest to the youngest.

Hints in Making a Geologic Cross Section

First, draw the cross section line on your map specified in requirement number 3.

Then, secure a piece of paper, ten by fifteen inches, and rule it into one-half inch squares. Graph or cross section paper would be ideal.

Now, make a topographic profile as follows: place the top edge of the long dimension of your paper along the line you drew, keep north on the left. Mark each contour intersection on the edge of the paper and record its elevation value. These points are to be projected down to intersect the horizontal lines. Each horizontal line will equal 50 feet in elevation change (this is a vertical scale of one inch equals 100 feet). Make the top line equal to the highest elevation crossed on the line of section and number all lines to the bottom of the paper each 50' lower than the one above. Construct your profile. Be sure the streams are in the valleys and the hills are in the right place. The profile represents the surface of the ground and is important to the next step which is filling in the geology which lies below this surface.

After completion of the topographic profile, place the top of your section along the line as before and mark the geologic boundaries. Project those down until they intersect the profile and draw your contact lines. Use vertical lines for the faults. Use the guidebook to get the proper thickness of members which do not have an exposed base along the line of section.

Finish up by naming the hills, valleys, streams and geologic formations as given on the map. Put your name in a title box in the right-hand corner.

Equipment for Collecting Fossils

Most fossils are heavy for their size. You can fill your pockets in a few minutes and have no space left for more specimens. It will help to bring some sort of carrying sack such as an army surplus gas mask holder with straps, or a heavy-duty cloth bag. Small sample sacks which will hold several specimens are usually provided by counselors. These sacks are used by oil companies for packing well samples. Companies have been generous in donating sample sacks for Scouts studying geology at summer camp.

If you really want to dig into the marls or break off pieces of limestone, you should have a geologist's hammer or a small pick.

It is sometimes revealing to look at small fossils or freshly broken rocks with a hand lens, or small pocket magnifying glass. You can see much more detail than with the naked eye. A good hand lens is rather expensive, but perhaps you may borrow one from a geologist friend or counselor.

As you put your specimens in a sample sack, be sure to label the sack with the location. You may want to come back to the same spot later for more specimens. Don't trust your memory.

Searching for fossils is fun. Each new find is an adventure in itself. Happy hunting!

* * *

Mounting and Preparing Specimens

It is a good idea to thoroughly scrub your specimens with soapy water and a stiff brush. An old tooth brush works fine. Many details hidden by the veneer of chalky dust will appear after washing. Among the better looking fossil exhibits are those mounted on varnished plywood. Small specimens may be attached with plastic cement. Larger ones may have to be wired to the board, in which case you will have to drill small holes in the board through which to pass the ends of the wire before twisting them together on the back of the board.

Use the sketches of fossils in this guidebook as an aid in classifying your finds. Your counselor or Scoutmaster can help you. After you get home from camp, put the name and age of each fossil on a gummed label and attach it to the board underneath the fossil to which it refers.

If enough boys in your troop have fossil collections, you may want to display them at the Scout Exposition. Remember, too, your collection can be used as a partial fulfillment of the requirements for the Nature Merit Badge.

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* * *

IX. GLOSSARY

age. An informal unit of geologic time during which a given rock interval was deposited.

alluvium. Earth, silt, sand, gravel and other transported matter of comparatively recent age which has been deposited by streams and rivers on adjacent lowlands.

aquifer. A formation, or part of a formation, that is water bearing.

arch. A term applied to strata which dip in opposite directions from a common ridge or axis. Same as anticline.

assemblage. (See fossil)

axis. (See structural geology)

bed. The smallest unit of layered rocks. Same as layer.

bedrock. Any solid rock exposed at the surface of the earth or overlain by unconsolidated material such as soils.

calcareous. A term used to describe rocks containing a high percentage of calcium carbonate, $CaCO_3$.

contact. The plane, or surface, where two different kinds of rock come together.

coquina. Porous limestone composed of broken shells and other organic debris.

crystalline. Of or pertaining to the nature of a crystal, which is bounded by plane surfaces or faces.

dip. To slope downward from a horizontal surface.

downthrown block. (See fault)

drainage. The gravitational flow of water from an area.

Edwards Plateau. (See plateau)

elevation contour. An imaginary line, drawn on a map, which connects points of equal elevation on the ground.

era. The greatest of all stratigraphic divisions. Era involves a large amount of geologic time.

erosion. All processes by which earth and rock are loosened and removed from place to place. Includes weathering.

fault. A fracture, or fracture zone, along which there has been displacement of the two sides relative to one another. The high side is called the upthrown block, and the low side is called the downthrown block.

fault plane. The plane or surface along which movement has occurred. It is often characterized by crumpled and distorted strata due to frictional dragging of one block against the other.

fault throw. The amount of vertical movement of one block in relation to the other.

fault trace. The intersection of a fault with the earth's surface.

fault (Continued)

fault trend. (More commonly called fault strike). The direction of the trace of a fault on the earth's surface.

fauna. The animals of any place or time that lived in association with each other.

formation. An interval of rocks which have some character in common. The fundamental unit used for geologic mapping.

fossil. The remains or traces of animals or plants which have been preserved in the rocks.

fossil assemblage. A fossiliferous zone defined and identified by a group of associated forms rather than by a single index fossil.

fossil mold (external). A mold which shows the form and markings of the outer surface of the original shell.

fossil mold (internal). A mold which shows the form and markings of the inner surfaces of a shell or organism.

index fossil. (Same as a guide fossil). A fossil characteristic of an assemblage zone and so far as known restricted to it.

genus. A group of closely related species of animals or plants. Plural is genera.

geode. A hollow, globular body, variable in size, with mineral crystals projecting into the hollow center.

group. In stratigraphy: a rock unit consisting of two or more formations (one overlying the other) which have similar characteristics.

index fossil. (See fossil)

layer. (See bed)

limestone. A bedded sedimentary deposit consisting chiefly of calcium carbonate, $CaCO_3$.

lithology. The physical character of a rock.

marine. Of or belonging to or caused by the sea.

marl. A richly calcareous shale.

member. A division of a formation.

mineral. A rock-forming unit of definite chemical composition, usually having crystal faces.

mold. (See fossil mold)

outcrop. The exposure of a bed at the surface of the earth.

outlier. A portion of a rock unit isolated from the main body by erosion. Outliers (such as Northeast Mountain to Square End Mountain) usually cap the tops of hills.

paleontology. The study of fossil remains of organisms.

plateau. An extensive elevated region of flat or hilly surface.

protozoa. A phylum of single celled animals.

range. The time span of an organism in the stratigraphic column.

relief. The difference in elevation between the high and low points of a land surface.

sediment. Solid material settled from suspension in a liquid.

series. A division of a system.

shale. A clay-like sediment.

species. A group of individuals having substantially the same structure, habits, and geographic and geologic range.

stratum. A single sedimentary bed. Plural is strata.

stratigraphy. A descriptive study of rock character and thickness used as a basis of correlation from one locale to another.

strike. The compass bearing of the outcrop of a dipping bed or structure on a level surface.

structural geology. The study of structural features of rocks and their causes.

structural axis. The line following the apex, or ridge, of an upfold or the lowest part of a downfold. (See arch)

system. A division of an era.

topography. The relief and shape of the land surface.

upthrown block. (See fault)

upwarp. An area that has been uplifted; generally used for broad anticlines.

* * *

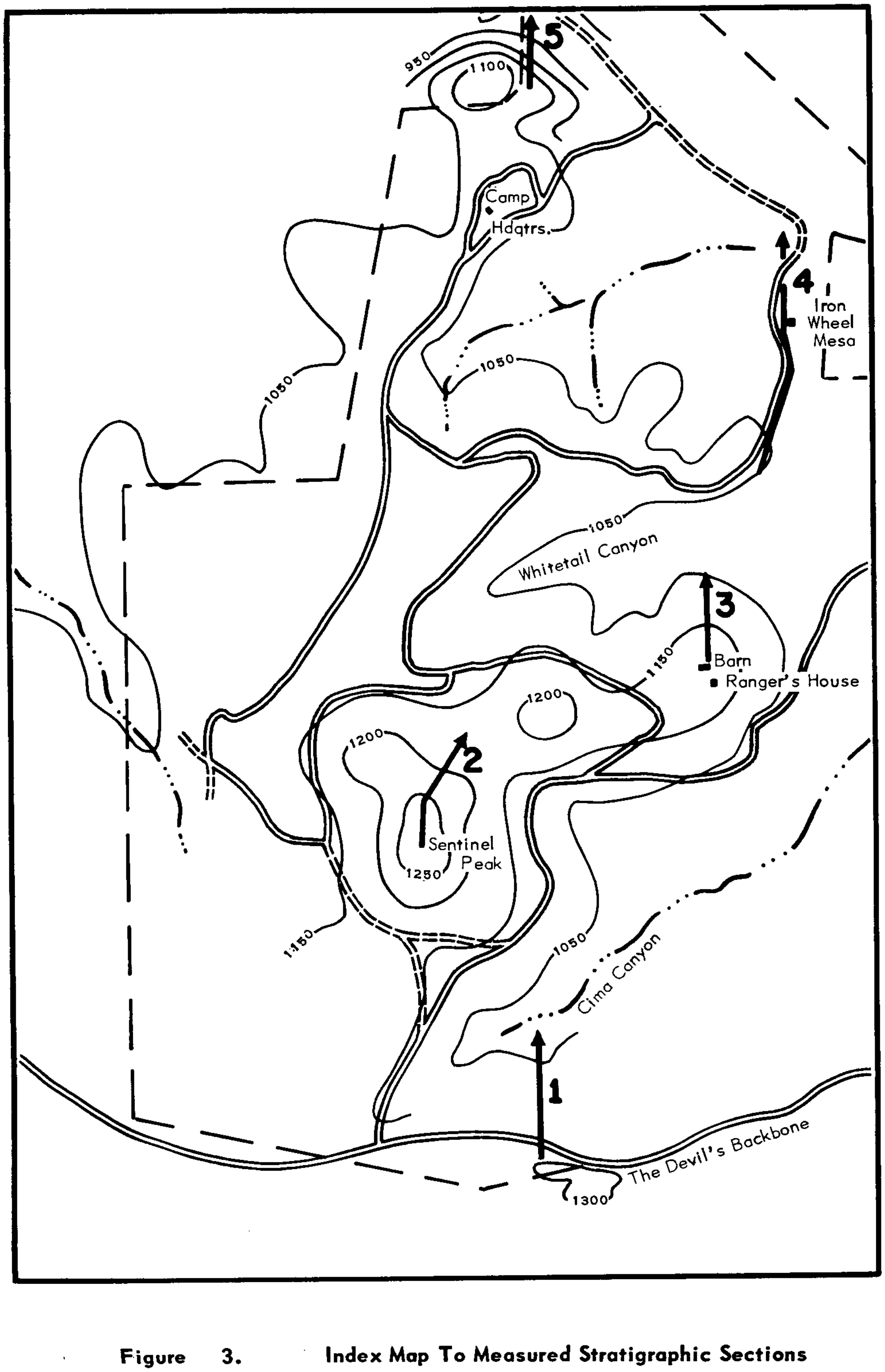


Figure 3. Index Map To Measured Stratigraphic Sections

X. APPENDIX

MEASURED STRATIGRAPHIC SECTIONS

A description of each bed which crops out in the Camp follows. Measurements were taken up the sides of five different hills or slopes between the Blanco River and The Devil's Backbone. For locations of the individual portions of the stratigraphic section, see figure 3.

The description starts with Section 1 at the uppermost layer along The Devil's Backbone and ends with the lowest bed near Circle Bar One campsite as described in Section 5:

	Thickness in Feet	
	Bed	Cumulative
Comanche Peak Formation, limestone, brown to buff to gray, hard, microcrystalline	5.00	5.00
Walnut Formation, shale, clayey to chalky, sandy, weathers to a bluish crust, white calcareous nodules. _Exogyra texana_	4.75	9.75
Glen Rose Formation, upper member:		
Limestone, in three units. Upper: off-white to tan, mottled, silty, dense. Middle: blocky lime intercalated with thin sandy shales. Lower: buff to brown, very hard with dark impurities	8.50	18.25
Marl, firm, sandy, blocky	3.00	21.25
Shale, basal two feet platy, fissile, silty. Fossil zone 5 1/2 feet from base contains a small species of _Nerinea_ and calcite geodes	9.00	30.25
Limestone, off-white, silty, medium-hard, blocky	2.00	32.25
Shale, sandy, blocky	2.80	35.05
Limestone, upper two feet buff to tan, hard, finely crystalline; with secondary calcite. Basal portion buff to tan, very hard; with calcite veinlets	8.00	43.05
Clay, brown, sandy	6.00	49.05
Limestone, tan to buff, finely crystalline, very hard; ripple-marked. Silty in middle and upper portions	8.00	57.05
Marl, in steep slope covered by slump blocks of limestone	27.00	84.05
Limestone, buff to brown, with silt and fine-grained sand; blocky bedding. Slightly fossiliferous	4.12	88.17
Marl, mostly covered	2.50	90.67
Limestone, off-white, chalky to finely crystalline, thin-bedded, ripple-marked. Forms ledge	1.00	91.67
Marl, mostly covered, with sparse fossils in outwash. Chert found in outwash	7.75	99.42
Limestone, white to off-white, finely crystalline, hard; thin, platy, intercalated with covered marl beds	10.00	109.42
Limestone, thin, off-white to tan, finely crystalline, very hard. Underlain by covered marl	5.60	115.02
Sentinel Peak limestone, in three units. Upper two feet: off-white to tan, hard, finely crystalline. Middle: white, chalky, to tan, dense, finely crystalline, medium hard. Interspersed with white chalky limestone. Lower: buff to yellowish, marly, blocky to platy. Fossiliferous	7.50	122.52

This marks the end of Section 1 in Cima Canyon.

This marks the beginning of section 2 at Sentinel Peak.

	Thickness in Feet	
	Bed	Cumulative
Marl, Loriolia zone, buff to tan, partially covered; very fossiliferous. Upper 3 1/2 feet: off-white to tan to brown, platy. Forms wavy contact with overlying limestone. Width of outcrop about 100 feet. Loriolia rosana, Strombus beckleyi, Neithea irregularis, Arctica sp., Cardium congestum, Exogyra paupercula, Exogyra weatherfordensis, Holectypus sp., Nucula sp., Lima sp., Pholadomya sp., Natica sp., Turritella sp., Spondylus sp., Nerinea sp., Turbo cuyleri, Turbo mcallisteri, Cyprimeria texana...	8.00	130.52
Limestone, two units. Upper 2 feet: dark tan, finely crystalline, dense, hard, honeycombed. Basal unit: off-white to light tan, finely crystalline to chalky, medium honeycombed. Gradational contact between units..	4.75	135.27
Marl, white, chalky, platy, partially covered. Thin lime stringer 3'8" above base is off-white to tan, finely crystalline, chalky, medium hard, fossiliferous....................................	7.25	142.52
Limestone, two units. Upper unit: tan, finely crystalline, dense, hard, honeycombed, no observed fossils. Basal unit: off-white, chalky, marly, medium hard. Marly in middle, platy, buff......	3.70	146.22
Marl, buff to tan, somewhat platy, partially covered.............	6.75	152.97
Limestone, three units. Upper unit: light gray to tan, finely crystalline, dense, very hard, slightly honeycombed. Neithea. Middle unit: off-white to tan, medium hard, flaggy. Basal unit: off-white to tan, finely crystalline, slightly honeycombed; contains Cyprimeria texana plus some unidentified fossils. Each lime is separated by a thin marl..................	4.50	157.47
Marl, lower occurrence of Loriolia rosana, buff to tan, almost entirely covered by grass over wide outcrop at Sentinel Peak, well exposed at Deadman Knob..................................	10.00	167.47
Limestone, three units. Upper bed: gray, finely crystalline, dense. Contains Lunatia pedernalis. Middle bed: fine to medium crystallinity, dense, hard, sl. honeycombed. Basal bed: off-white, impure, marly, sl. fossiliferous. Sequence forms sharp terrace. Neithea, Nerinea. Two feet of marl in central portion...	5.75	173.22
Marl, tan, mostly covered; grading upward into limestone..........	5.00	178.22
Limestone, two units. Upper bed: brown to buff, fine to medium crystallinity; dense, hard, very fossiliferous. Lunatia pedernalis, Turbo cuyleri, Strombus beckleyi. Middle portion marly, forms terrace between limes. (3' thick) Lower bed: buff to tan, impure, marly, fossiliferous, honeycombed (1' thick)...	5.50	183.72
Marl, buff, partially covered; with washed out fossils. Tiny gastropods. Sparse occurrence of Orbitolina texana, Porocystis globularis..	4.00	187.72
Ranch House limestone, off-white to tan, dense, finely crystalline, hard. Weathers gray. Fossils sparse. Cyprimeria texana......	5.25	192.97

The above unit marks the end of section 2 at the base of the Ranch House limestone on the north side of Fortress Mountain. (Elevation 1175 feet).

Section 3 starts at base of Ranch House limestone, approximately 175 feet from north gate of barn at Ranger's House.

Marl, covered...	5.50	198.47

	Thickness in Feet	
	Bed	Cumulative
Marl, tan, mostly covered. Thin limestone of unmeasured thickness 4 feet from base: off-white, marly, medium hard, with no observed fossils	4.30	202.77
Limestone, light gray to tan, vuggy, finely crystalline, flaggy	1.20	203.97
Marl, yellow, bedded, blocky fracture	3.75	207.72
Marl, tan, with 1 foot limestone: tan to buff, mottled, very finely crystalline, dense; sparse fossils. Porocystis globularis occurs within this interval	2.30	210.02
Limestone, brown, finely crystalline, dense, with no observed fossils	1.00	211.02
Marl, tan, almost completely covered	4.50	215.52
Marl, tan, mostly covered, with very thin unmeasured limestone stringer near top	2.50	218.02
Limestone, yellow to tan, marly, soft, with no observed fossils	2.00	220.02
Marl, buff to tan, mostly covered	4.00	224.02
Marl, tan, mostly covered, with thin limestone stringer near top: tan to gray, finely crystalline, dense; no observed fossils	5.40	229.42
Marl, white to buff, mostly covered, with thin, unmeasured, honeycombed lime stringer near top	3.75	233.17
Limestone, off-white, finely crystalline, dense, medium hard, honeycombed	1.30	234.47
Marl, tan, mostly covered	5.30	239.77
Limestone, tan, finely crystalline, very hard, with no observed fossils. Lower contact covered	3.00	242.77
Marl, tan, covered; forms slope between limestones	8.25	251.02
Limestone, in two units. Upper bed: tan, fine to medium crystallininity, hard. Small fossils. Marly stringer 1 foot thick in middle. Lower bed: off-white to tan, finely crystalline in lower part; weathers to mottled gray. Thick bedded, with no observed fossils. Forms slight terrace	3.00	254.02
Marl, white, chalky, partly covered	7.75	261.77
Limestone, in three units. Upper bed: tan to gray, fine to medium crystallinity, very hard, Lunatia pedernalis. Middle bed: off-white, chalky, slightly honeycombed; with no observed fossils. Basal lime: tan, finely crystalline, dense, fossiliferous. Flaggy, intercalated with thin marl stringers. Nerinea sp. Sequence forms a marked terrace	5.75	267.52
Marl, covered, no observed fossils	4.95	272.47
Limestone, buff to tan, fine-grained, dense, honeycombed, forms top of promontory. Lower contact partially covered. Lunatia pedernalis	3.25	275.72

Base of unit described above ends section 3.

Section 4 begins at a point almost due south of Iron Wheel Mesa near the south trace of the 1050-foot contour at White Tail Canyon.

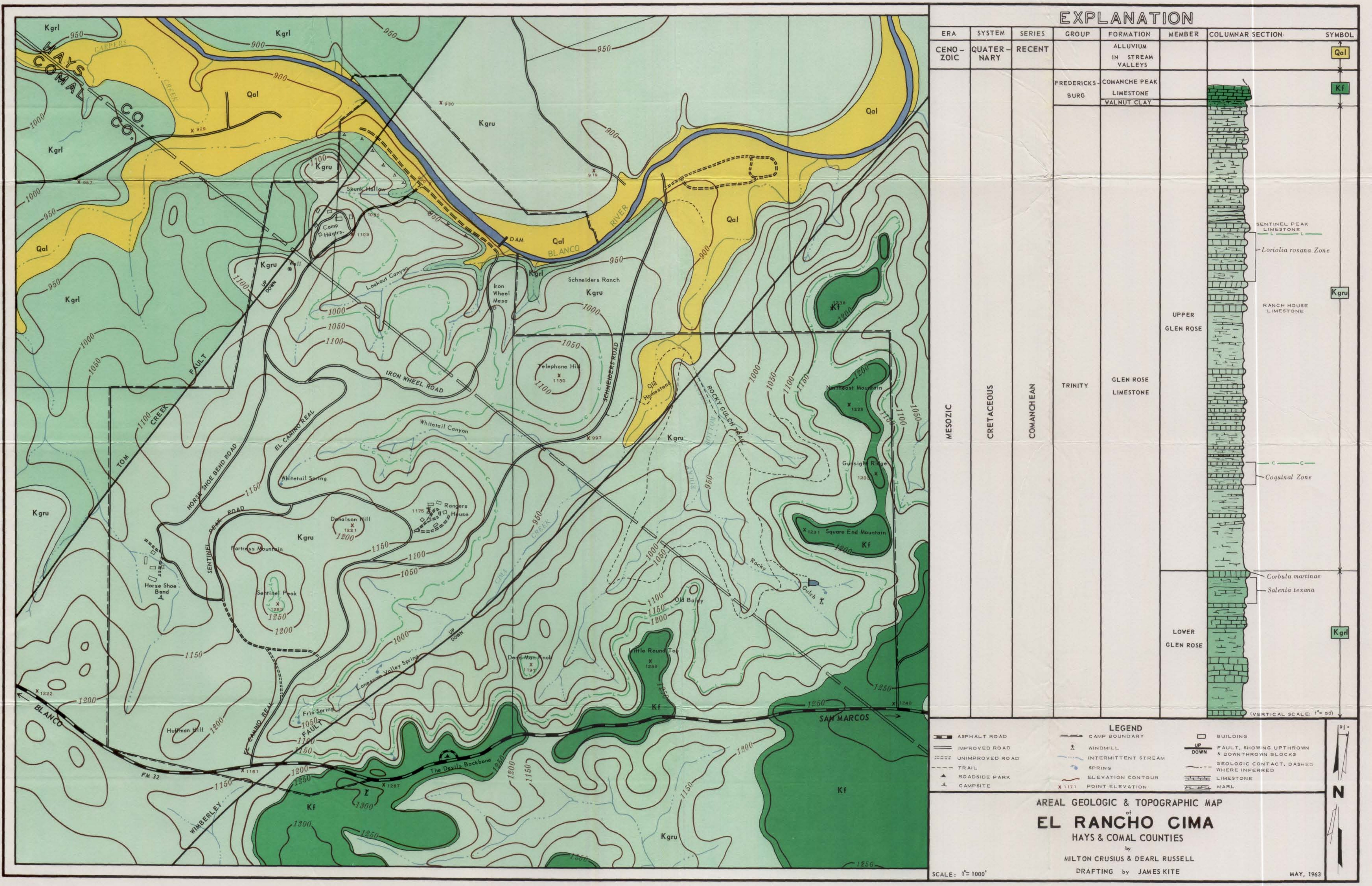
Marl, off-white to tan, platy, chalky	3.30	279.02

	Thickness in Feet	
	Bed	Cumulative
Limestone, in three units. Upper: dark tan, finely crystalline, dense, slightly fossiliferous. Toucasia hancockensis. Middle: grades upward into fine to medium crystalline, dense, tan, lime in top; fossiliferous. Lower: white, chalky, finely crystalline, thin-bedded, flaggy. Intercalated with thin marls. Forms marked ridge....................................	2.50	281.52
Marl, buff to tan, partly covered, very fossiliferous. Tapes bakeri, Trigonia whitneyi, Neithea, Anatina, Nerinea sp. Abundant Orbitolina texana, Gryphaea wardi, Nucula bybeei, Porocystis globularis, Turritella sp., and fenestellid bryozoans..	7.00	288.52
Limestone, off-white, chalky to finely crystalline, dense, hard. Lower part coarser with large calcite crystals. Very fossiliferous. Contains Toucasia and possibly other rudistid forms. Slight terrace..	3.75	292.27
Marl, buff to tan. Orbitolina texana abundant....................	5.25	297.52
Limestone, light tan, finely crystalline, hard, very fossiliferous. Prominent ridge-former.......................................	2.00	299.52
Marl, tan to brown, grading upward into limestone. Orbitolina texana...	4.00	303.52
Limestone, gray, fine to medium crystallinity, hard, weathering to dark gray. Fossiliferous, Corbis, Pholadomya sp. Trigonia whitneyi. Ridge-former.......................................	1.50	305.02
Marl, buff to tan, partly covered. Orbitolina texana.............	2.40	307.42
Limestone, light tan, finely crystalline, hard, very fossiliferous. Weathers gray. Toucasia hancockensis, Trigonia whitneyi, Corbis. Forms a slight ridge..	1.50	308.92
Marl, buff to tan, with thin lime stringers which are brown and finely crystalline. Trigonia whitneyi, Liopistha fletcheri, Arctica sp., Anatina hanseni, Anatina beckleyi.................	5.00	313.92
Limestone, brown, finely crystalline, hard, slightly honeycombed on crop. Weathers dark gray. Corbis, Toucasia. Forms a low ridge...	1.70	315.62
Marl, buff, in closely covered terrace, grading in upper part from yellowish to tan. Orbitolina texana...........................	5.20	320.82
Limestone, mottled gray, slightly crystalline, very hard. Fossiliferous. Corbis, Toucasia. Forms a rather strong ridge.......	2.50	323.32
Marl, top of Coquinal zone, brown, weathering buff to tan; abundant fossils. Gryphaea wardi, fenestellid bryozoans, Orbitolina texana very abundant.....................................	8.00	331.32
Limestone, in two units. Upper: gray, hard, finely crystalline, slightly honeycombed. Fossiliferous. Arca simondsi, Holectypus. Lower: off-white to light gray, medium hard; marly, coquinal, Toucasia pseudopatagiata, Toucasia hancockensis, Liopistha fletcheri, Arctica roemeri, Arctica banderaensis, Corbis banderaensis, Arca simondsi, Arca sp., Anatina beckleyi, Protocardia sp., Spondylus olsenae, Cucullea sp., Trigonia whitneyi, Panopea sellardsi. Ridge-former........................	2.75	334.07
Marl, buff to tan, with wide, partly covered outcrop. Grades upward into coquinal limestone. Most abundant observed occurrence of Orbitolina texana, which forms the major part of the bed. Anatina beckleyi, Tapes bakeri, Gryphaea howei. Trigonia, Neithea. Located just south of Iron Wheel Mesa...............	7.50	341.57

	Thickness in Feet	
	Bed	Cumulative
Limestone, in two units. Upper: light gray, finely crystalline, very hard, vuggy, honeycombed. Lower: off-white to buff to tan in lower portion, micritic, platy, dense	3.80	345.37
Marl, yellow on outcrop; shaly. Platy in lower portion. *Tapes bakeri*, *Tylostoma*	3.75	349.12
Limestone, off-white, micritic to finely crystalline, marly	1.00	350.12
Marl, tan grading to off-white; shaly in lower portion, grading upward into platy zone	6.30	356.42
Limestone, light gray, micritic to finely crystalline. Some secondary dolomitization	1.00	357.42
Marl, buff with brown-yellow streaks; platy. *Gryphaea howei*, *Orbitolina texana*	2.75	360.17
Limestone, buff to tan; calcite crystals in fine to medium-grained matrix; dense. Contains small pelecypods. Medium-bedded at base, very fossiliferous. *Cyprimeria texana*	2.25	362.42
Marl, buff, platy, containing many small pelecypods. Sharp contact with overlying limestone	5.25	367.67
Limestone, buff, finely crystalline, flaggy, ripple-marked, honeycombed. Weathers gray. *Tylostoma travisensis*	5.50	373.17
Marl, brown to buff, slightly fissile	4.50	377.67
Limestone, buff to tan; thinly bedded in lower portion and marly, grading upward into thicker, honeycombed, finely crystalline limestone	1.70	379.37
Marl, buff to tan, fissile in upper part, grading upward into limestone. Slightly fossiliferous	28.00	407.37
This ends section 4 just south of the dam.		
This marks the beginning of section 5 north of Camp Headquarters.		
Glen Rose Formation, lower member:		
Limestone, *Corbula martinae*, buff to tan, medium crystallinity, hard; with secondary calcite crystals. *Corbula martinae* limestone overlying the *Salenia texana* zone	2.00	409.37
Marl, *Salenia texana zone*, buff to tan, many large pelecypods and gastropods. *Orbitolina* abundant	7.50	416.87
Limestone, gray to tan, hard, medium crystallinity; with secondary calcite. Coquinal. *Nerinea*, large pelecypods	3.75	420.62
Limestone, off-white to buff, chalky, soft; very fossiliferous. An *Orbitolina* coquina	4.50	425.12
Limestone, medium crystallinity; with secondary calcite veinlets. Hard, with pitted erosional surface. Dense	2.20	427.32
Marl, partially covered, very fossiliferous. *Orbitolina* common	6.75	434.07
Limestone, buff to tan, soft, friable, *Orbitolina* coquina	1.50	435.57
Marl, mostly soil-covered. Pelecypods and *Orbitolina* very common. Thin, chalky, fossiliferous limestone stringer near middle	5.75	441.32
Limestone, off-white to chalky; hard in upper portion, medium-hard in lower portion. Weathering irregular, nodular. Abundant *Orbitolina*	3.33	444.65

	Thickness in Feet	
	Bed	Cumulative
Marl, buff to tan. Very fossiliferous. Tapes bakeri, Holectypus sp., and plentiful Orbitolina..................................	2.33	446.98
Limestone, tan to buff, very hard, micritic. Arca sp.............	4.20	451.18
Limestone, off-white, chalky, medium-hard to soft. Coquinal, detrital..	4.50	455.68
Marl, covered, forming wide terrace beneath overlying prominent ridge...	5.75	461.43
Limestone, tan to buff, hard......................................	1.00	462.43
Marl, off-white to tan; chalky, platy.............................	10.00	472.43
Marl, mostly covered. One-foot limestone near top................	5.00	477.43
Marl, covered. Thin limestone stringer in middle.................	5.00	482.43
Limestone, white, chalky, platy, soft. Scattered large pelecypods, many small fossils. Crops out in 30 to 40-foot clearing along fence line..	20.00	502.43
Marl, hard in upper portion grading into limestone. Middle portion softer, blocky. Basal 15 feet mostly covered with dark organic soil. Buff to tan, silty, blocky......................	29.00	531.43
Limestone, light gray to tan, medium-hard. Coquinal, and highly porous due to random arrangements of large numbers of Toucasia. Also Neithea and Nerinea.......................................	2.00	533.43

Section 5 ends at the contact between the Lower Glen Rose and the Alluvium near Circle Bar One campsite at the west boundary fence line.


EXPLANATION
ERA | SYSTEM | SERIES | GROUP | FORMATION | MEMBER | COLUMNAR SECTION | SYMBOL
CENO-ZOIC | QUATERNARY | RECENT | ALLUVIUM IN STREAM VALLEYS | Qal
MESOZOIC | CRETACEOUS | COMANCHEAN
FREDERICKSBURG | COMANCHE PEAK LIMESTONE | Kf
WALNUT CLAY
TRINITY | GLEN ROSE LIMESTONE
UPPER GLEN ROSE | Kgru
LOWER GLEN ROSE | Kgrl
SENTINEL PEAK LIMESTONE
Loriolia rosana Zone
RANCH HOUSE LIMESTONE
Coquinal Zone
Corbula martinae
Salenia texana
(VERTICAL SCALE: 1" = 50')
LEGEND
ASPHALT ROAD
IMPROVED ROAD
UNIMPROVED ROAD
TRAIL
ROADSIDE PARK
CAMPSITE
CAMP BOUNDARY
WINDMILL
INTERMITTENT STREAM
SPRING
ELEVATION CONTOUR
X 1171 POINT ELEVATION
BUILDING
UP DOWN FAULT, SHOWING UPTHROWN & DOWNTHROWN BLOCKS
GEOLOGIC CONTACT, DASHED WHERE INFERRED
LIMESTONE
MARL
N
AREAL GEOLOGIC & TOPOGRAPHIC MAP
of
EL RANCHO CIMA
HAYS & COMAL COUNTIES
by
MILTON CRUSIUS & DEARL RUSSELL
DRAFTING by JAMES KITE
SCALE: 1" = 1000'
MAY, 1963
HAYS CO.
COMAL CO.
BLANCO RIVER
CARPERS CREEK
DAM
Skunk Hollow
Camp Hdqtrs.
Lookout Canyon
Iron Wheel Mesa
Schneiders Ranch
SCHNEIDERS ROAD
Telephone Hill
IRON WHEEL ROAD
Whitetail Canyon
Whitetail Spring
EL CAMINO REAL
HORSE SHOE BEND ROAD
SENTINEL PEAK ROAD
TOM CREEK FAULT
Old Homestead
ROCKY GULCH PARK
Northeast Mountain
Gunsight Ridge
Square End Mountain
Rocky Gulch
Rangers House
Donalson Hill
Fortress Mountain
Sentinel Peak
Horse Shoe Bend
Old Baldy
Little Round Top
Dead Man Knob
Lonesome Valley Spring
Frio Spring
FRIO FAULT
Huffman Hill
The Devils Backbone
BLANCO
SAN MARCOS
WIMBERLEY
FM 32
Qal
Kgrl
Kgru
Kf