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STRATIGRAPHY OF THE PLAINS AREA ADJACENT TO THE SANGRE DE CRISTO MOUNTAINS, NEW MEXICO

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INTRODUCTION

Lying adjacent to the eastern side of the Sangre de Cristo Mountains is a plains area which is underlain by the Las Vegas-Raton structural basin. This plains area includes a series of plains or surfaces which rise in step-like fashion from southeast to northwest. The lowest surface, standing at altitudes of 4,000 to 4,500 feet, lies south of the Canadian Escarpment. The Las Vegas Plateau, which covers the greater part of the area and lies north of the Canadian Escarpment, stands at altitudes of 6,000 to 6,500 feet. Rising above the Las Vegas Plateau are several surfaces which extend to various altitudes; the highest of these is represented by Ocate Mesa and the mesas in the vicinity of Raton.

The Las Vegas-Raton structural basin underlies the area of plains adjacent to mountains. This structural basin is a large asymmetric syncline which plunges northward. The west limb of the syncline, which culminates at the crest of the broad Sierra-Grande arch, generally dips at a rate of about 100 feet per mile, but this gentle dip is interrupted by a few sharp domes.

The sedimentary rocks exposed in the area range in age from Late Triassic to early Tertiary and Recent. The igneous rocks present are of early Tertiary, late Tertiary, and Quaternary age.

The following resume describes the rocks of the plains area adjacent to the mountains – exclusive of the Raton Coal basin. The uppermost Cretaceous and Tertiary rocks of the coal basin are discussed elsewhere in the guidebook.

SEDIMENTARY ROCKS

Triassic Rocks

Dockum group – Rocks assigned to the Dockum group of Late Triassic age are the oldest rocks exposed in the plains area adjacent to the Sangre de Cristo Mountains. These exposures are mainly along the Canadian Canyon and south of the Las Vegas Plateau, but local exposures are present in the central areas of Turkey Mountain in Mora County and in Temple (Chico) dome in Colfax County.

The Dockum group is approximately 1,000 feet thick and consists of the Santa Rosa sandstone and the Chinle formation. The lower unit, the Santa Rosa sandstone, is 300 to 400 feet thick and is composed of slightly silty, fine- to coarse-grained conglomeratic sandstone, with subordinate maroon mudstone. The Santa Rosa sandstone is massive to thin-bedded and commonly cross-laminated. It is gray on fresh surfaces, but it generally weathers to buff or dirty grayish-tan, and some surfaces are stained to darker hues by a mixture of iron and manganese oxides. Individual grains composing the sandstone are angular to subround and consist of quartz and feldspar. The conglomeratic fragments are limestone, quartz, quartzite, and shale. The cement of the sandstone is clay and calcium carbonate. The interbedded maroon mudstone is generally in lenses of local extent, but one sequence of mudstone near the top of the unit ranges to over 50 feet thick and may be continuous.

The upper unit of the Dockum group of Triassic age, commonly referred to as the Chinle formation, is 600 to 700 feet thick. This unit consists mainly of shale, mudstone, and fine-grained silty sandstone the color of which is maroon to pastel red. There are also some thin beds of variegated marly shale and some thin beds of light greenish-gray limestone and limestone-pebble conglomerate. In addition, the Chinle contains at many places a conspicuous sequence of gray sandstone beds. This sequence, ranging over 50 feet thick, is about 250 feet above the base of the Chinle and has been called the middle member of the Chinle formation (Northrop, et al., 1946). The lithology of these gray sandstone beds is identical with that of the Santa Rosa sandstone.

Naranjo formation – The Naranjo formation was named by Bachman (1953) from exposures near the village of Naranjo in northwestern Mora County. The formation also is present in Turkey Mountain and at places in the Canadian Canyon, but it is absent in the vicinity of Las Vegas as well as at several places along the edge of the Canadian Escarpment.

The Naranjo overlies the Dockum group conformably and is overlain unconformably by the Ocate sandstone. It consists of orange-red to light brownish-red sandstone and siltstone. The sandstone is fine grained; the siltstone is argillaceous. The bedding is rather regular, and individual beds range from 1 to 10 feet thick. The entire unit is 64 feet thick at the type locality.

Because of its lithology and its relations to the over-

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and under-lying formations, Bachman (1953) has tentatively correlated the Naranjo with some part of the Glen Canyon group of Triassic and Jurassic age of northwestern New Mexico and adjacent areas. The Naranjo may also be correlative with the Sheep Pen sandstone (Parker, 1933) of Union County, New Mexico and with the Redondo member of the Chinle formation of Quay County, New Mexico.

Jurassic Rocks

San Rafael (?) group – Strata which tentatively have been correlated with the San Rafael group of Jurassic age overlie the Dockum group and Naranjo formation in the area adjacent to the Sangre de Cristo Mountains. These strata consist of the Ocate sandstone (Bachman, 1953), the Todilto limestone (Northrop, et al., 1946), and the Wanakah formation (Bachman, 1953; Wood, et al., 1953).

The Ocate sandstone is a thin but very persistent and conspicuous formation which generally forms a vertical or slightly rounded cliff at its exposures along the Canadian Canyon and around the Canadian Escarpment. It also crops out in Turkey Mountain in Mora County and in Joyce and Temple (Chico) domes in Colfax County. At most of these exposures the Ocate consists of a single massive bed which shows tangential cross-bedding. At some places, along the Canadian Escarpment, however, horizontal bedding occurs near the top and bottom of the unit.

The Ocate is white to light-buff to pale-red and ranges from 50 to 75 feet thick. It is a well-sorted, fine- to medium-grained sandstone, and the individual grains are generally well-rounded and frosted. Nearly all grains are colorless quartz, but there are a few grains of pink quartz and pink chalcedony. The lithology and stratigraphic position indicates that the Ocate probably is correlative with the Entrada sandstone of northwestern New Mexico.

The very distinctive, thinly laminated Todilto limestone overlies the Ocate sandstone at a few places. It has been noted at Romeroville and Kearny Gap near Las Vegas and at Joyce dome in Colfax County. At these places it is 10 to 15 feet thick. Over much of the area the unit is absent.

A unit of sandstone and siltstone overlies the Ocate conformably at many places. This sandstone and siltstone unit is apparently continuous along the Canadian Canyon. It also is present in Turkey Mountain in Mora County and in Joyce and Temple (Chico) domes in Colfax County. This unit tentatively has been correlated with the Wanakah formation. It consists of parallel-bedded sandstone and siltstone. The sandstone beds are 1 to 5 feet thick and are white to buff to pale-red in color. Individual grains are fine to coarse and very much like those of the Ocate sandstone. The intervening siltstone beds are 1 to 3 feet thick and greenish-gray to brownish-red in color. Both types of beds are calcareous and a thin bed of gray limestone is present in the formation near Ocate in Mora County and at Old Mills in the Canadian Canyon in Harding County.

Morrison formation – The Morrison formation apparently overlies the San Rafael group conformably although it rests on different parts of the San Rafael group at different places. Southwest of Las Vegas, for example, the Morrison rests on the Todilto limestone; southeast of Las Vegas, for several miles along the Canadian Escarpment, it rests on the Ocate sandstone; but along the Canadian Canyon, at Turkey Mountain, and at Temple (Chico) dome, it rests on the Wanakah formation.

In general, within the area discussed, the Morrison consists of two subdivisions. Approximately the lower half consists of light gray sandstone which weathers buff to pale grayish-red and dark red shale which is to some extent mottled with grayish-green. Within this subdivision sandstone appears to be volumetrically more important than shale. The upper half of the formation is mainly grayish green shale with subordinate thin sandstone beds.

The Morrison is doubtless continuous within the area adjacent to the Sangre de Cristo Mountains, and it ranges in thickness from 150 feet in northwestern Mora County to 370 feet thick at Old Mills in Harding County. The wide range in thickness is believed to be due to post-Morrison erosion.

Cretaceous Rocks

Dakota sandstone – Rocks that have generally been included in the Dakota sandstone overlie the Morrison formation. The Dakota of this usage consists of three members within the area discussed. The lowest member is a white to light-gray sandstone which weathers buff to tan. This member commonly shows low-angle cross-bedding, and it contains numerous lenses of pebbles composed of quartz and chert. Ranging from 70 to 100 feet thick, the lower member forms a vertical or steep ledge around the edge of the Las Vegas Plateau and along the Canadian River and its more prominent tributary canyons.

The middle member is a dark bluish gray shale about 50 feet thick. At some places it contains thin beds of sandstone. This member is very poorly exposed, but at several places it forms a low bench between the lower member and the upper member.

The upper member, also about 50 feet thick, consists of fine-grained, highly quartzitic sandstone with some interbedded shale of dark gray color. The sandstone beds are thinner and tend to weather to a darker color than the sandstone of the lower member.

It is likely that the lower part of the Dakota sandstone as above described includes beds that have been assigned to the Purgatoire formation elsewhere in northeastern New Mexico and southeastern Colorado. It has also been suggested (Northrop, et al., 1946) that equivalents of the Purgatoire may be present in the upper part of the Morrison formation of the Las Vegas area.

Graneros shale – The Graneros shale lies conformably on the Dakota sandstone, and it crops out from the vicinity of Las Vegas northward into Colfax County. Good exposures are present in only a few places as the soft shale forms grassy slopes. The best exposures are in the vicinity of Las Vegas in San Miguel County and at Taylor Springs in Colfax County. In both areas approximately the upper 50 feet of the shale is exposed locally in low cliffs.

The Graneros shale consists mainly of dark gray to black fissile shale, but two thin limestone beds, one 2 inches, the other 7 inches thick, are present about 30 feet below the top of the shale at Taylor Springs, and thin beds of white bentonite are present in the upper 25 feet of the shale at both Taylor Springs and Las Vegas. Foraminifera are abundant in thin silty to finely sandy laminae.

The Graneros shale decreases in thickness northward. It is 215 feet thick near Las Vegas and about 160 feet thick in southern Colfax County.

Greenhorn limestone – The Greenhorn limestone overlies the Graneros shale conformably and consists of an alternating sequence of limestone and shale beds. The limestone beds are very finely crystalline and range from gray to nearly black in color. Individual beds are about 2 inches to 2 feet thick. All of these beds weather light gray. The intervening shale beds are calcareous, of dark gray color, and range from about 1 inch to 5 feet thick. The entire unit ranges from about 15 to 35 feet thick.

Inoceramus labiatus and Foraminifera are abundant. In Colfax County most of the limestone beds are only 3 to 6 inches thick but near Las Vegas some are as much as 2 feet thick. Joints perpendicular to the bedding yield typical "fence-post" blocks.

Carlile shale – The Greenhorn limestone grades upward into the Carlile shale, a sequence of dark-gray thinly bedded shale which is more or less calcareous. This shale sequence, about 210 to 220 feet thick, contains two distinctive zones in its upper part. One is a zone of large septarian concretions ranging from about 1 to 5 feet in greatest dimension. This zone is 20 to 30 feet thick and lies 50 to 80 feet below the top of the Carlile. The other distinctive zone is 10 feet thick and occurs 10 to 20 feet below the top of the Carlile. This zone is composed of thin beds of gray shale and brown argillaceous to silty limestone, each in beds about 1 inch thick. Present in these beds are abundant *Scaphites warreni*, *Prionocyclus wyomingensis*, *Ostrea sp.*, and shark teeth. Locally, as at Storrie Lake near Las Vegas, the rounded shell-crushing teeth of the skate or ray, *Ptychodus* cf. *whippleyi*, are abundant.

Niobrara formation – The Niobrara formation is exposed in two areas on the Las Vegas Plateau. The southerly area of exposures is relatively small and lies between Las Vegas and the Mora River. The northerly area of exposures extends from northwestern Mora County northeastward across eastern Colfax County.

The Niobrara overlies the Carlile shale conformably and consists of two members. The lower member, the Fort Hays limestone, apparently ranges in the southern part of the area from the vanishing point to about 10 feet thick north of Las Vegas. It thickens northward and is as much as 25 feet thick in eastern Colfax County. This member consists of alternating beds of fine-grained limestone and calcareous shale. The limestone beds are medium gray and weather to a pale cream color. Individual beds are 1 to 2 feet thick, contrasting with the generally thinner beds of the Greenhorn. The intervening beds of shale are gray and range from about 1 inch to 2 feet thick. Fossils are less numerous than in the Greenhorn.

The overlying Smoky Hill marl member is about 900 feet thick. The lower 150 to 200 feet of the member consists of gray to dark gray, calcareous, silty shale which contains several thin beds of shaly limestone. The carbonate content of this portion of the member

decreases upward. Above this is 75 to 150 feet of gray, calcareous, sandy shale. Locally, this part of the sequence grades to calcareous shaly sandstone. The upper 550 to 650 feet of the member consists of gray calcareous shale which is locally sandy. This part of the member characteristically weathers to an earthy buff color.

Pierre shale -- The Niobrara grades into the overlying Pierre shale which crops out in an elliptical belt around the Raton coal field. Above the transition zone, which is about 50 feet thick, the Pierre shale is largely dark-gray to black, non-calcareous, fissile shale. However, it contains several zones of calcareous concretions, and approximately the upper 100 feet is composed of interbedded dark gray shale and gray sandstone which represents a transitional sequence and a zone of interfonguing with the overlying Trinidad sandstones.

The thickness of the Pierre shale, as indicated by measurements in central Colfax County, is 1,600 to 1,650 feet.

IGNEOUS ROCKS

The igneous rocks of the plains adjacent to the Sangre de Cristo Mountains are represented by two groups (Griggs, 1948; Collins, 1949; Stobbe, 1949). One is a group of laccoliths, sills, and dikes of early Tertiary age which are present mainly in the Chico hills of eastern Colfax County. The other is a group of flows with some associated dikes and plugs which range in age from late Tertiary to Recent and which are present mainly in eastern Colfax and western Mora Counties.

Igneous Rocks of early Tertiary age

The laccoliths, sills, and dikes present in the Chico hills were mainly intruded into the Graneros shale although a few of the sills were emplaced in the Carlile shale and one sill at Tenaja Mountain occurs in the Smoky Hill marl member of the Niobrara formation.

Two main rock types occur in this group of intrusives. One type is represented by fine-grained, light-gray latite with phenocrysts of plagioclase, pyroxene, and hornblende. The other type is represented by fine-grained, grayish-green phonolite with large white phenocrysts of potash feldspar and less conspicuous phenocrysts of green pyroxene.

A laccolithic body, probably also of early Tertiary age, apparently underlies Turkey Mountain in northwestern Mora County. According to Bachman, (Bachman, G. O., informal communications) there are local exposures of a medium-grained porphyry in the interior of Turkey Mountain, and the presence of a laccolith body beneath the mountain would best explain the sharp domal structure which lies in an area of relatively undeformed rocks.

Igneous rocks of late Tertiary and Quaternary age

The late Tertiary and Quaternary igneous rocks cover large areas in eastern Colfax and western Mora Counties. They are present only locally in San Miguel County. These rocks have been divided roughly into four age groups, and a fifth group has been further subdivided on a basis of difference in composition (Griggs, 1948).

The oldest flows are normal olivine basalts that belong to two periods of eruption. The flows of the earlier of the two periods cap the highest mesas in the vicinity of Raton and the highest parts of Ocate Mesa. The flows of the later of the two periods cap slightly lower surfaces. The flows of both periods are alike chemically and mineralogically and can be separated with certainty only where they occur at different elevations in close proximity. The older of these flows is believed to be of late Pliocene age. The younger sequence is believed to be of early Quaternary age.

The volcanic rocks of an intermediate age group are variable in composition and include many rock types although only the basaltic and felsic types have been separated in mapping. Several periods of eruption are included in the group as the flows cap erosion surfaces which stand at various altitudes. All of the flows undoubtedly are of Quaternary age. It is of interest to note that the basaltic rocks of this intermediate group include normal basalts which are both olivine-bearing and olivine-free and plagioclase-poor and plagioclase-free basalts which carry nepheline, hauynite, and analcite.

The youngest volcanic rocks are normal olivine basalts which obviously were erupted recently. Flows and cinder cones of this group are typified by Capulin volcano.

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