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CONTRIBUTION TO THE GEOLOGY  
OF THE  
SANGRE DE CRISTO MOUNTAINS  
OF COLORADO

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INTRODUCTION

This paper is presented with the object of putting on record and bringing up for discussion some new observations and interpretations of the geology and structure of the Sangre de Cristo Range. The field work on which this paper is based was done in the summer of 1927; when the writer was making a study of the Permo-Carboniferous stratigraphy of the areas for the Texas Production Company. Acknowledgments are due to Mr. Hugh Stewart of that company for permission to publish this information, and to Mr. Glen S. Dille, who assisted with the field work; and last, but by no means the least, to Merle K. Johnson, who assisted both in the field and in the compilation and elaboration of the field material.

LOCATION AND TOPOGRAPHY

The Sangre de Cristo, or as written by older writers the Sangre de Christo, mountains form a steep, rugged and sur-

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prisingly narrow range extending across south-central Colorado in a south south-easterly direction from the Arkansas River down into New Mexico. In general the range reaches an average elevation of around 12,500 feet, while several of the peaks rise over 13,000 and one at least reaches 14,000.

The upper portions of the range are highly glaciated by alpine glaciers. The well developed cirques in the valleys provide the geologist with excellent outcrops. The lower slopes are heavily timbered with pine, aspen, spruce and fir.

To the east of this range lies the Wet Mountain Valley, east of which is a smaller and nearly parallel range known as the Wet Mountains. West of the Sangre de Cristo Mountains is the famous San Luis Valley.

Travel across the northern part of the range is relatively easy, thanks to the National Forest Service trails. In the area south of La Veta Pass travel is more difficult, and the higher peaks are frequently reached only with difficulty. Sheep and game trails provide the only routes of access.

#### PREVIOUS WORK

Very little previous work has been done in this area since the days of the Hayden and Wheeler surveys. Their work was purely of a reconnaissance character; and their reports suggest that in this area they were not as accurate as in most other localities.

#### STRATIGRAPHY

Sedimentary rocks outcrop abundantly along the east side of the range. From the New Mexico line northward to Hillside these consist entirely of upper Paleozoic rocks of Pennsylvanian or Permo-Pennsylvanian age. North of this town lower Paleozoic sediments gradually appear beneath the Pennsylvanian beds. The generalized column given on page 5 shows the sequence and general character of the beds.



## GENERALIZED SECTION—SANGRE DE CRISTO REGION

AGE	FORMATION	CHARACTER	THICK- NESS FEET
Pleistocene	Recent	Glacial and stream deposits	0-300
Cretaceous	Dakota	White to buff sandstone	About 70
Unconformity			
Jurassic	Morrison	Shales and sandstones, green, white, and red	600-700
	Sundance (?)	Thin limestone layers and shales, mainly gray	0-30
Permo-Pennsylvanian Probably largely Permian	Upper Sangre de Cristo Formation	Coarse clastic sediments, largely red beds. Sandstones, grits and conglomerates. Upper portion all red beds. Lower down some beds are gray to buff or even brownish	8000-11000
Unconformity			
Pennsylvanian	Lower Sangre de Cristo	Sandstones, shales, and limestones. Some conglomerates. Some beds quite fossiliferous	2100+
Unconformity			
Mississippian	Leadville (?)	Hard gray to white limestone. Found only at northern end of range	0-300+
Unconformity			
Ordovician	Harding formation	Thin limestones and sandy limestones, found only at northern end of range	25+
Unconformity			
Pre-Cambrian		Gneisses, Schists, and Granite	

## HARDING FORMATION

This was observed only at the extreme northern end of the range. A narrow outcrop was seen but not studied along the Arkansas River a few miles below Salida.

The Van Diests (39) report a silicious limestone of "Silurian" age from the Rio Seco about six miles northeast of the town of San Luis, Costilla County, on the southwestern side of the range. Unfortunately our field work did not extend as far south on the west side of the range, so we did not see these outcrops.

## MISSISSIPPIAN (LEADVILLE?) LIMESTONE

This outcrops along the northeastern side of the range, but disappears a few miles south of the Arkansas River. The best exposures are around the Colorado Fuel and Iron Company's quarries back of Calcite. Brachiopods of Mississippian type were found in these beds.

## SANGRE DE CRISTO FORMATION

Throughout most of the area studied the Pennsylvanian was found immediately on the Pre-Cambrian. In some places there was a normal overlap relation. In others there was a fault contact.

The Pennsylvanian-Permian beds may be divided into two series, separated by an unconformity.

The lower Pennsylvanian series varies in thickness from about eighteen hundred to twenty-six hundred feet, averaging about twenty-one hundred. It consists of a series of grit, sandstone, shale and limestone, usually occurring in the order named, with many such sequences one upon the other. As one approaches the top of the section the amount of clastic sediment becomes steadily greater, until in the upper eight hundred feet there is very little limestone. All of the fossils collected came from this lower series, mainly from the limestones and shales. All were of Pennsylvanian age, correlating closely with the Magdalena of New Mexico and Hermosa of southwestern Colorado. Fossils were much more

abundant than had been expected. Fair to large collections were obtained in every section. The following list from La Veta Pass is representative.

*Protozoa*

Fusulina cylindrica  
Fusulina secalica  
Fusulina sp ?

*Anthozoa*

Campophyllum torquium  
Chaetetes milleporaceus  
Lophophyllum profundum  
Syringopora multattenuata  
Zaphrentis?

*Vermes*

Worm tubes (Spirorbis)

*Pelmatozoa*

Eupachyrcrinus verrucosus

*Bryozoa*

Fenestella  
Fenestella tenay  
Fistularia sp ?  
Polypora sp ?  
Rhombopora lepidodendroides  
Undetermined (several species)

*Brachiopoda*

Ambocoelia planiconvera  
Camarotechia sp.  
Chonetes flemingi  
Chonetes granulifer  
Chonetes mesolobus  
Cleiothyridina orbicularis  
Composita argentea  
Composita subtilita  
Derbya crassa  
Dielasma bovidens  
Hustedia mormoni  
Marginifera lasallensis

Marginifera muricata  
Marginifera sp ?  
Marginifera wabashensis  
Orbiculoidea missouriensis  
Orbiculoidea sp ?  
Productus coloradoensis  
Productus cora  
Productus costatus  
Productus humerosus  
Productus inflatus  
Productus semireticulatus  
Productus sp ?  
Productus spines  
Rhipidomella pecosi  
Schizophoria resupinoides  
Spirifer boonensis  
Spirifer cameratus  
Spirifer rockymontanus  
Spirifer sp ?  
Spirifer triplicatus  
Spiriferina kentuckyensis  
Squamularia perplexa

*Pelecypoda*

Allorisma terminale  
Acanthopecten carboniferous  
Astartella sp ?  
Astartella concentrica  
Astartella compacta  
Aviculopecten sp?  
Deltopecten sp?  
Myalina sp?  
Nuculopsis ventricosa  
Schizodus sp?

*Gasteropoda*

Bellerophon crassus  
Bellerophon perarniatus  
Bellerophon sp ?



Euphemus carbonarius  
Murchisonia sp?  
Naticopsis sp  
Patellostium montfortianum  
Pleurotomaria granulostrata  
Schizostoma catilloides  
Strophostyllus remex ?  
Sphaerodoma sp  
Worthensis tabulata  
Zygopleura sp?

*Cephalopoda*

Goniatites undetermined  
Orthoceras sp.  
Pseudorthoceras cf. cribbasum

*Crustacea*

Phillipsia sp.

*Vertebrates*

Fishtooth (petalodus)

*Plants*

Fragments (calamite)

The upper series of beds are separated, at least in some localities, from the lower by a distinct unconformity which, in some places, is slightly angular but in other places has been obscured by faulting. This series, except at one locality, consists entirely of clastic sediments, unusually coarse sandstones, grits and conglomerates. The color is gray to red, the red predominating. The series is of enormous thickness, the sections measured showing from eight to eleven thousand feet. The beds in general are highly lenticular and vary rapidly in thickness and in coarseness of the sediment. Many of the conglomerate beds are of considerable thickness (up to sixty feet) and are composed of material which varies greatly in size. Rounded fragments were observed three or four feet in diameter, (Fig. 1). The coarsest material was found in the area west and southwest of Westcliffe. Some of the pieces here are large and angular to subangular and suggest material along or near the base of a sea cliff. It was

from this area that Emmons reported fragments "twenty-five or even fifty feet in diameter" (10, p. 262). In general, however, the pieces do not exceed twelve or fourteen inches across. These pebbles and boulders, with few exceptions, are derived from crystalline rocks showing a considerable variety of granites, gneisses and schists. The exceptions are to be found in the upper part of the series where, in some localities, a fair number of fragments of the lower sandstones occur. At several points remains of land plants and trails of land animals were found in the sandstone beds. The plants were poorly preserved, but could be generically determined as Calamites, Lepidodendrons, and related types of common "Coal Measure" plants.

This series reaches its maximum thickness in the area between Westcliffe and Crestone; here also the conglomerates attain their maximum thickness and coarseness. It is interesting to note that in this region, on the divide west and a little north of Comanche lake, we obtained our only collection of marine fossils from this series. These occurred in a thin limestone bed surrounded by shaly material and sandwiched in between coarse conglomerates. The fossils consisted of foraminifera, corals, bryozoa and a number of very poorly preserved brachiopods. Stratigraphically these occurred rather low in the series, but the horizon was probably several thousand feet above the base. The base, however, was not exposed, so the exact stratigraphic location could not be determined.

Portions of the upper series in general form the present land surface, consequently the original thickness of the formation cannot be determined. In the southern part of the area studied, the series is overlaid by Jurassic beds, but it is separated from them by a very distinct erosional unconformity, and in places the basal layers of the Jurassic give every indication of consisting of reworked material from these beds.

As to the age of this upper series, or the "Red Beds," as they are usually called, we have no definite evidence. The general opinion among geologists would place at least a con-