NOTES ON THE PENNSYLVANIAN FORMATIONS IN THE RIO GRANDE VALLEY, NEW MEXICO[1]

C. H. GORDON
Knoxville, Tenn.

INTRODUCTION

A number of papers have appeared in recent years concerning the Carboniferous formations in the Rio Grande Valley. As the observations therein recorded were almost wholly of a reconnaissance nature, it is not to be wondered at that more or less divergence is manifest in the views of the different writers concerning the stratigraphy of the region. This paper is based on observations made during a year's residence at Socorro, together with several months' field-work in connection with the investigation of the mines and mining districts of New Mexico under the direction of Mr. Waldemar Lindgren of the U. S. Geological Survey. The results of that investigation are to appear in a forthcoming bulletin of the Survey. In the present paper it is the chief purpose of the author to present a brief description of the rocks in the Rio Grande Valley which represent the lower part of the "Coal Measures" of adjoining regions, and to discuss their stratigraphical relations and the nomenclature connected with them. For these beds in the Survey paper above mentioned the name Magdalena has been adopted as a group term.

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GENERAL RELATIONS OF THE PENNSYLVANIAN ROCKS IN THE REGION

In the Rio Grande Valley the Upper Carboniferous or Pennsylvanian series is represented by a succession of limestone, shale, and

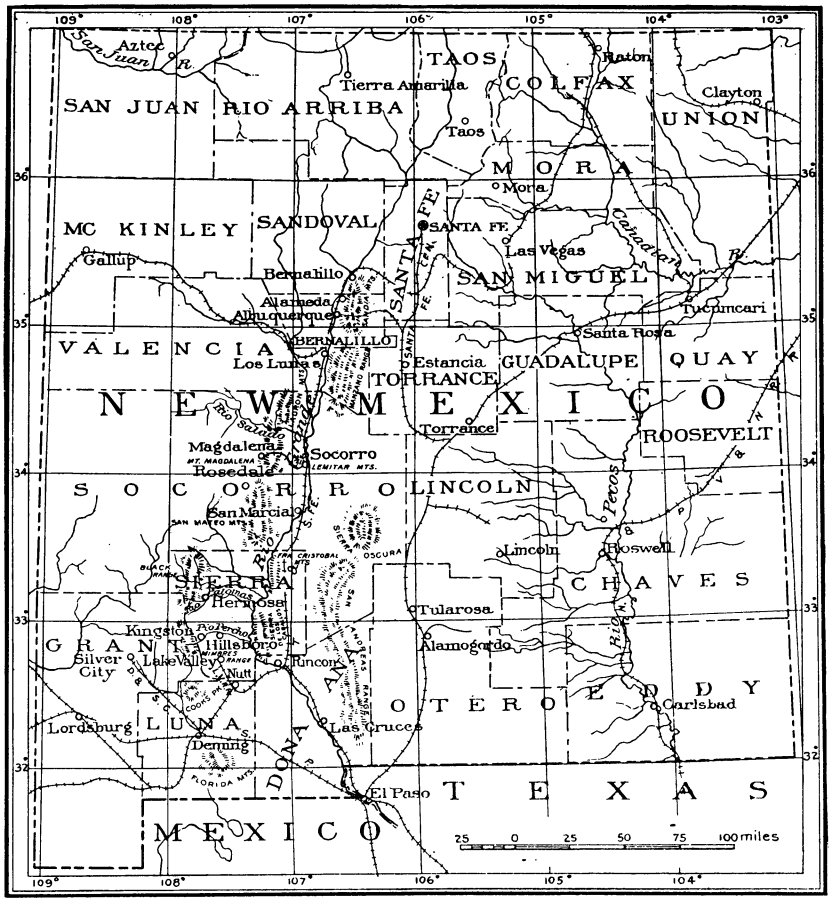
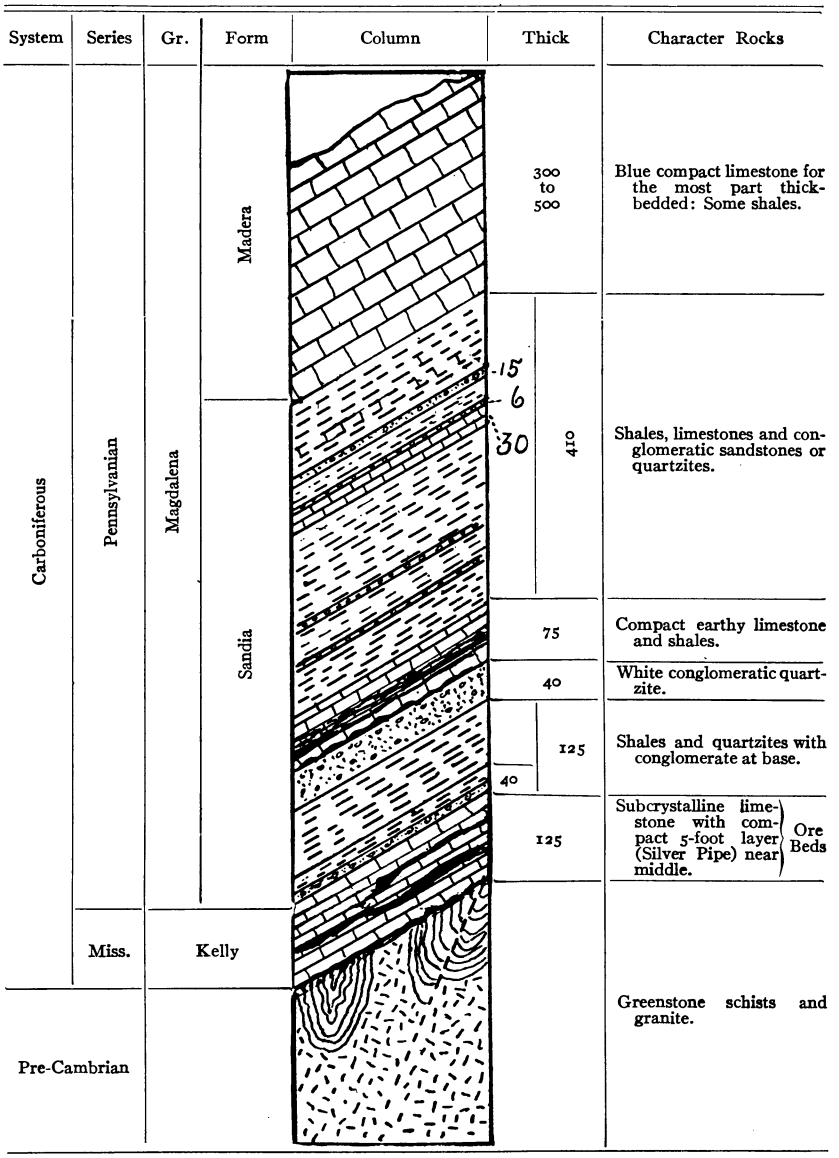


FIG. 1

sandstone formations, having an aggregate thickness of from 3,000 to 5,000 feet. These may be separated into two main divisions or groups, to the lower of which the name Magdalena is here applied, from the Magdalena Mountains, where they are well exposed, while the upper division comprises the formations, chiefly sandstone, to

MAGDALENA SECTION



which Herrick[1] applied the term Manzano, from the Mountains of that name northeast of Socorro, in Valencia County, together with the limestones found overlying the sandstones in regions south of Bernalillo County, which Lee[2] has shown to belong to the series.

Southward in Sierra County, where the Pennsylvanian and Lake Valley (Lower Carboniferous) formations occur together, the relations are those of apparent conformity. The Lower Carboniferous formations thin out northward in Socorro County and are not known to occur north of the Ladrone Mountains. In the Magdalena Mountains the basal beds of the Pennsylvanian are conglomerates and shales, which rest with apparent conformity upon the Kelly (Lower Carboniferous) limestone. Northward in Bernalillo County the Pennsylvanian rests unconformably upon granites and other rocks of supposed pre-Cambrian age. A well-marked unconformity occurs also at the base of the Manzano division east of Socorro, as shown by Herrick,[3] who first recognized it and who states that this is evidently an unconformity by overlap. Lee[4] has shown that the Manzano beds are separated from overlying formations by great erosional unconformity. The twofold division of the Pennsylvanian formations is sustained therefore both by faunal distinctions, according to Dr. George H. Girty,[5] and by relations of unconformity as well. The faunal studies thus far made do not show any marked change in the life represented within each division, and the subdivisions are based entirely on lithological distinctions.

THE MAGDALENA GROUP

In general the Magdalena group may be said to be characterized by the predominance of limestone, while, on the other hand, sandstones constitute the most prominent feature of the Manzano group. In Sierra County the Magdalena group consists for the most part of massively bedded blue and gray limestone, interstratified with which

[1] C. L. Herrick, *Journal of Geology*, Vol. VIII, p. 115, 1900; *Am. Geol.*, Vol. XXV, p. 337, 1900; *Bull. Univ. New Mex.*, Vol. II, Fascicle No. 3, p. 4, 1900; *Jour. Geol.*, Vol. XII, p. 244, 1904.

[2] W. T. Lee, *ibid.*, Vol. XV, pp. 53, 54, 1907.

[3] *Jour. Geol.*, Vol. XII, p. 244.

[4] *Ibid.*, Vol. XV, p. 54.

[5] *Ibid.*, p. 54.

are thin-bedded limestone and dark-blue shale. Occasionally, a thin bed of sandstone may be seen. At Kingston, on the east slope of the Black Range, the basal beds consist of about 300 feet of dark-blue and gray limestone in thick beds with thin shale partings. The upper portion has about the same thickness and consists chiefly of blue and drab shale interstratified with several limestone formations varying from fifteen to twenty feet in thickness. Resting unconformably upon the shale formation are the red sandstones and shales of the Manzano group.

At Palomas Camp, in the Black Range, twenty-five miles north and a little west of Hillsboro, the county seat of Sierra County, and two miles east of Hermosa, the Rio Palomas has cut a gorge 1,000 feet deep through the sedimentary formations. The walls of the canyon are nearly vertical and consist almost wholly of blue and gray limestone of the Magdalena group. The lower half of the escarpment consists of limestone and shale in about equal development, while the upper portion is made up of hard, massively bedded gray limestone. About half-way up the cliff a few thin beds of quartzite appear interstratified with limestone. The overlying Red Beds of the Manzano group, together with some of the upper beds of limestone, have been removed by erosion at this point, but the red sandstones occur in considerable development a short distance to the northwest.

In the Caballos Mountains, about twenty-five miles east of Hillsboro, the group is represented chiefly by limestones, with some shale beds in the basal part, as at Hermosa, but we are unable to give details of the formation at this locality. They were observed resting with apparent conformity upon other limestones considered to be of Lower Carboniferous age, while below these, and separated from them by a thin bed of the Percha shale (Devonian), is a heavy development of limestone (900 ft.) belonging to the Mimbres formation (Ordovician).

The data at hand concerning these formations in Sierra County are insufficient to warrant an attempt to subdivide the group. The character of the beds at Hermosa suggests the twofold division observed farther north, and in connection with the character of the formations in adjoining districts indicates a gradual transition in sedimentation from shallow-water conditions at the north to deeper waters toward the south. With the progress of time the entire region apparently

assumed conditions of deep and clear waters wherein were deposited the extensive limestone beds which constitute the upper part of the division (the Madera limestone).

Northward in Socorro, Valencia, and Bernalillo Counties the Magdalena division comprises from 1,000 to 1,300 feet of sediments, the character of which in their typical locality will be seen from the section on p. 807.

The rocks of this division contain a characteristic Pennsylvanian fauna, which shows no essential variation from the base to the top of the series, but on lithological grounds they are readily separable into two formations, to the lower of which Herrick[1] gave the name Sandia Beds (or series), from the Sandia Mountains, where they were first studied, while the upper is known as the Madera limestone.[2]

Sandia beds.—In Socorro County the Sandia formation consists of alternating beds of blue and black clay shale, compact earthy limestone, and conglomerate, vitreous sandstone or quartzite, the shale and limestone predominating. In places, the shales are highly carbonaceous and sometimes show traces of coal, but thus far no coal beds of importance have been discovered in this formation. The sandstones are usually hard, with a vitreous fracture, and present the characteristic appearance of quartzites. The beds are often conglomeratic, the included pebbles consisting for the most part of pure-white quartz. The basal beds of the series in the Magdalenas, comprising a thickness of ten to fifteen feet, consist of a moderately coarse conglomerate interbedded with dark shale. While these beds rest apparently conformably upon the limestones below, the relations are undoubtedly those of unconformity. About 125 feet above the base of the series is a formation of coarse white quartzite or conglomerate in massive ledges separated by thin beds of shale. Some of the quartzite beds are filled with pebbles. Overlying this is a limestone formation eighty to ninety feet thick, in which appear some thin beds of shale and quartzite. At the base of this limestone formation is a thick-bedded dark-blue subcrystalline limestone six

[1] C. L. Herrick, *Jour. Geol.*, Vol. VIII, p. 115, 1900; *Am. Geol.*, Vol. XXV, p. 235, 1900; *Am. Geol.*, Vol. XXXIII, p. 310, 1904.

[2] C. R. Keyes, "Water-Supply Paper No. 123," *U. S. Geological Survey Report*, 1904.

feet thick overlaid by about twenty-five feet of shale and thin limestone above which occurs two feet of quartzite followed upward by fifty feet of compact bluish earthy limestone. It is at the contact of the shale and limestone formation with the conglomerate below that the "upper" or "surface" ore deposits occur at Kelly.

These Sandia beds are well exposed on the east slope of Mount Socorro, and northward in the Limitar Mountains. They also appear on the east side of the river opposite Socorro and elsewhere.[1] Southward, as stated above, there is a marked decrease in the porportion of sand and clay beds accompanied by an increase in calcareous sediments. The shaley beds which constitute the lower part of the escarpment near Hermosa are evidently the equivalent of the Sandia beds as represented in Socorro County, but farther south the distinction between the upper (Madera) and lower (Sandia) divisions of the Magdalena is not recognizable.

The thickness of the sediments referred to this division varies from 500 to 700 feet.

Madera limestone.—Overlying the Sandia beds in Socorro and Bernalillo counties is a dark-blue limestone, for the most part in thick beds alternating with other thin shaley beds and blue shale. The limestone contains many fossils of the same type as those found in the Sandia beds below, but owing to the extreme hardness of the rock specimens are difficult to obtain.

These limestones constitute the top of the ridge above Kelly, where they have a thickness of about 300 to 500 feet, having been partly removed by erosion. On Mount Socorro they reach a thickness of about 700 feet, while good exposures of the beds appear also in the Limitar Mountains. The Madera beds constitute the great limestone plate along the back slope of the Sandia Mountains, and upon this limestone plateau is located the little Mexican town of La Madera, from which the formation is named.[2]

Herrick[3] has described the lower part of the formation in the Sandias as consisting of dark limestone, while the upper beds are of massive, gray siliceous lime with an intervening sandstone or con-

[1] C. L. Herrick, *Jour. Geol.*, Vol. VIII, pp. 114, 115, 1900.

[2] C. L. Herrick, *Bull. Univ. of New Mex.*, Vol. I, p. 104, 1899.

[3] C. L. Herrick, *Jour. Geol.*, Vol. VIII, pp. 114, 115, 1900.

glomerate of inconstant thickness (40 feet at the maximum) which he calls the Coyote sandstone, from the canyon of that name in the south end of the Sandia Mountains.

THE MANZANO GROUP

Above the Madera limestone and resting unconformably upon it in the Rio Grande region, is a series of red and pink sandstones and shales with deposits of gypsum capped by a prominent formation of limestone. These red sandstones and shales constitute in part the beds usually regarded as the equivalent of the Kansan Red Beds called Permian, while some of the upper beds were thought by Herrick to be Jura-Trias in age.

The writer's observations of these formations, though limited, led him to regard them as belonging to the Pennsylvanian series, a conclusion fully established by the more detailed studies of W. T. Lee,[1] of the U. S. Geological Survey. The series of variegated sandstone, shale, and gypsiferous beds was described by Herrick[2] from the Manzano Mountains, northeast of Socorro, in 1900, and by him named the Manzano series. In the southern part of the region a limestone formation several hundred feet in thickness overlies the red beds, and from it Lee obtained a large collection of fossils which are distinctly allied to those obtained from the red series, the whole, as stated by Dr. Girty,[3] being distinctly Pennsylvanian, though markedly differing from the fauna of the lower, or Magdalena, group. Northward in Bernalillo County the upper limestone member is absent, and variegated sandstone and shale beds, similar to those of the Morrison formation, rest upon the pink sandstones, with an intervening erosion unconformity.[4] Lee considers the Manzano group lithologically separable into three divisions, the lowermost of which consists principally of dark red sandstones interstratified with red sandy shales and some thin beds of bluish-drab earthy limestones. At the base of the

[1] *Jour. Geol.*, Vol. XV, pp. 52–58, 1907.

[2] *Jour Geol.*, Vol. VIII, pp. 115, 116, 1900; *Bull. Univ. New Mex.*, Vol. II, Pt. 1, Fascicle No. 3, p. 4, 1900.

[3] Quoted by Lee, *Jour. Geol.*, Vol. XV, p. 54, 1907.

[4] The description and classification of the Manzano beds is to appear in a forthcoming publication by Messrs. Lee and Girty.

formation is a limestone conglomerate the pebbles of which were derived from the underlying Madera beds. Above this, as seen in the hills east of Socorro, is a coarse red granitic quartzite conglomerate. The thickness of the red sandstone division varies from 400 to 800 feet. Overlying these beds occur alternating strata of yellow, pink, and white sandstones and shales with lenses of gypsum and a subordinate amount of limestone. In places the gypsum is massive and reaches a thickness of 140 feet. The total thickness of this formation ranges from 500 to 1,000 feet. The uppermost division of the Manzano group consists for the most part of gray limestone in which an abundant fauna occurs. These beds are well developed in the mountains east of Socorro and southward in the San Andreas Mountains east of Engle, but were not observed on the west side of the Rio Grande. According to Lee this limestone is not present in the Sandia Mountains. The total thickness of the formation is from 300 to 500 feet. Several miles northeast of Socorro, and in plain sight from this place, are a number of minor elevations called the Coyote Buttes. At this locality the Manzano beds are well exposed in the west face of the hills, the strata dipping sharply to the northeast. The red sandstones of the lower division occur on the west of the Magdalena Range south of Kelly and along the east side of the Black Range from Fairview south to Kingston. The overlying beds were not observed in the Black Range region.

Heretofore these red-sandstone formations have been at times confounded with the Red Beds supposedly of Permian and Triassic age, but according to Dr. Girty,[1] who has made a study of the fossils collected from them by Mr. Willis T. Lee, of the Survey, they are undoubtedly Upper Carboniferous and correspond in their relations to the upper part of Richardson's Hueco formation in Texas and the Aubrey in the Grand Canyon region.

In the Mount Taylor region, sixty miles west of the Rio Grande, there are 1,200 feet of Upper Carboniferous red and yellow sandstones, according to Dutton, who identified them with the Aubrey and used that name for them.

Nomenclature.—While there have been published a great many papers relating to the region under consideration, very little detailed

[1] Personal communication.

work has been done, and the names applied to different formations have been in some cases not at all defined, while in others the descriptions can be interpreted only with the greatest difficulty. A few names, however, are well established. Herrick[1] applied the name Sandia beds, or Sandia series, to the alternation of shale, limestone, and sandstone which constitute the lower half of the Magdalena division in Socorro and Bernalillo counties in 1900, and his description is such that no difficulty is encountered in the application of this term. At the base of the formations east of Socorro is a bed of clay containing Carboniferous plants to which Herrick gave the name Incarnacion Fire Clay, but he expressly states, "There would seem to be no reason for separating the fire clay from the Sandia formation, it being but a local variation."[2]

The limestone formation overlying the Sandia beds he appears to have left unnamed, but to the bed of sandstone which occurs near the middle of the formation in the vicinity of Coyote Springs, Bernalillo County, he gave the name Coyote sandstone.[3]

The same author applied the name Manzano[4] to the series of red sandstone and other beds which overlie the rocks of the Magdalena division in the Manzano Mountains and adjacent regions. His description of these beds does not make it altogether clear whether he meant to apply the name to the lower red sandstone alone or to the whole series, including the gypsiferous beds, the chocolate-colored sandstones, and their accompanying shales and earthy limestones. It would seem, however, that the latter was his intention. He does not seem to have included under this name the limestone overlying the pink and yellow sandstones, which, as shown by Lee,[5] belong in the series.

In a recent paper, C. R. Keyes[6] presents a classification of the Carboniferous rocks of New Mexico in which several new names appear, but without adequate definition. The shale bed at the base of the Sandia formation he separates, giving it the name Alamito, and

[1] C. L. Herrick, *Jour. Geol.*, Vol. VIII, p. 115, 1900; *Am. Geol.*, Vol. XXV, p. 235, 1900; *ibid.*, Vol. XII, pp. 237–251, 1904.

[2] *Jour. Geol.*, Vol. XII, p. 242, 1904. [3] *Jour. Geol.*, Vol. VIII, p. 115, 1900.

[4] *Loc. cit.* [5] W. T. Lee, *Jour. Geol.*, Vol. XV, pp. 53, 54, 1907.

[6] C. R. Keyes, *Jour. Geol.*, Vol. XIV, pp. 147–54, 1906.

makes it the equivalent of a series to which the name Ladronesian is applied. No evidence in support of this separation is given, and Herrick specifically states that none exists. For the remaining part of the Magdalena division Keyes uses the term Manzanan. Even a cursory reading of Herrick's description is sufficient to show that these are not the beds for which the name Manzano was originally proposed. For subdivisions of the rocks included under his term Manzanan, Keyes uses, in addition to Herrick's terms Sandia beds and Coyote sandstone, the name Montosa for the limestone below the Coyote sandstone, and Mosca for that above. No evidence is given that will warrant the establishment of these formation names. Our own observations lead us to conclude the Coyote sandstone to be of local development and the subdivision of the Madera formation to be unsupported by the evidence thus far available.

Overlying his so-called Manzanan, the same author[1] notes a limestone formation which he calls Maderan. Evidently he regards this as the same formation which in an earlier paper he says is, in the Sandia Mountains, called the Madera limestone, and adds that it forms by far the most important portion of the Carboniferous in all the mountain ranges mentioned. From Herrick's description of the geology of the Sandia Mountains, which is corroborated by the studies of W. T. Lee,[2] of the U. S. Geological Survey, it is clear that the great limestone formation of the Sandias is the limestone which constitutes the upper half of our Magdalena division and comprises the formations to which in the same table[3] Keyes gives the names Montosa and Mosca, with the included Coyote sandstone. The discrepancies in this case are apparently due to confounding the Madera limestone in some places with the limestones at the top of the Manzano group. Inasmuch as the name Madera very appropriately applies to the limestone overlying the Sandia beds in the Sandia Mountains, it may well be retained for the upper formation of the Magdalena division.

In the following table is presented, in convenient form for comparison, the classifications of the Pennsylvanian rocks in the Rio Grande region by the different authors mentioned.

[1] "Water-Supply Paper, No. 123," *U. S. Geol. Survey Report*, p. 22, 1905.

[2] Personal communication.

[3] *Jour. Geol.*, Vol. XIV, p. 154, 1906.

Gordon and Lee, 1907				Herrick, 1900		Keyes						
Series	Group	Formation	Character of Rocks			1904		1905		1906		
Pennsylvanian	Manzano		Unconformity Limestone. 300–500 ft.	Limestone	Jura-Trias	Cimarronian	Triassic	Red beds	Permo-Carboniferous	Moencopie shales	Cimarronian	Permian
			Pink or vermilion and yellow sandstones, shales and earthy limestones, and gypsum beds. 500–1,000 ft.	Manzano						Sandstone shales		
			Red sandstones and conglomerates with some earthy limestones. 400–800 ft.		Permian	Bernalillo shales		?		Capitan L. S. Eddy sandstone	Guadaloupan*	
	Magdalena (Gordon, 1907)	Madera	Unconformity Limestones with some shales and sandstones. 600–1,000 ft.	Limestone	Permo-Carboniferous	Madera limestone	Carboniferous	Madera limestone	Pennsylvanian	Maderan limestone	Maderan ("Hueco in part")	
				Coyote S. S. Limestone	Coal measures					Mosca limestone	Manzanan	Pennsylvanian
										Coyote S. S.		
		Sandia	Alternating shales, limestones, and sandstones. Toward south nearly all limestones. 500–600 ft.	Sandia beds (or series)		Sandia limestone		Sandia quartzite		Montosa limestone		
										Sandia shales		
		Unconformity	Unconformity							Alamito shales	Ladronesian	

* Not known to be represented in Rio Grande region.—Gordon.