ART. LVIII.—*Notes on the Geology of Galisteo Creek, New Mexico;* by JOHN J. STEVENSON, Professor of Geology in the University of the City of New York.

GALISTEO CREEK rises near the southern end of the Santa Fe mountains and flows southward for nearly fifteen miles to Galisteo; where, being increased by the Arroyo San Cristobal, coming from the east, it turns westward and flows in that direction to the Rio Grande. Its area is divided by a narrow dike, which forms a distinct ridge and separates the portion drained by the creek in its southward flow, from that drained by the Arroyo San Cristobal and the creek in its westward flow. These divisions may be distinguished as the upper and the lower area of the Galisteo. The region is not wholly unknown to geologists, for it has been visited by Dr. Newberry, Dr. Hayden and Professor Cope, whose views respecting the age of the coal beds and of the peculiar Galisteo sandstone are not in accord. The details of my observations there will be given in my report to Captain Wheeler; here, by consent of the Chief of the Engineer corps, U. S. A., a brief résumé of the results will be given, in so far as they bear upon the matters in dispute.

The shales of the Fort Pierre group (No. 4 of Mr. Meek's general section) are shown at barely sixteen miles below Galisteo dipping gently eastward in mesas on both sides of the creek. They have all the characteristic features of that group and yield its peculiar fossils at many localities. The Laramie group rests on them, and its western outcrop is reached on the south side of the creek at somewhat less than sixteen miles below Galisteo. There the rocks dip toward the east-northeast and at a low angle; this is the northern termination of an extensive area of Laramie, reaching southward for many miles and surrounding the Placer and Sandia mountains. The eastern outcrop of the Laramie beds passes rudely north and south through Galisteo, and there the dip is westward. The width of the area from east to west along the creek is not far from fifteen miles.

A detailed section of 440 feet, taken on the western outcrop, bears no resemblance in detail to sections from the same horizon in the Trinidad coal field, and correlation of the beds in the two fields is not possible. The coal beds in the Galisteo area are thin and variable, and little of economic interest exists aside from the anthracite beds, which contain coal altered by the influence of a gigantic dike passing between the Placer mountains and Galisteo creek. But there is much material of scientific interest, for the Laramie beds show an unexpected intimacy with the underlying Fort Pierre.

Passing the eastern outcrop of the Laramie, one comes at once to a wide park, lying mostly on the south side of the Arroyo San Cristobal and eroded amid the Colorado shales. The Fort Pierre sub-group occupies the western side of this park and, as usual, is much thicker than are the Niobrara and Fort Benton combined. Its shales show the ordinary features, for here are the lines of huge ferruginous concretions, of calcareous concretions, and the succession of dark, gray and yellow shales with abundance of selenite crystals. The concretions, except where showing a cone-in-cone structure, are full of fossils; enormous *Inocerami* with smaller species are common, *Ammonites*, *Baculites*, *Tachytriton*, *Aporrhais*, *Gyrodes*, *Fasciolaria* and *Ostrea* are abundant, all of them belonging to species occurring in the Fort Pierre group at other localities farther north.

Below the Fort Pierre are the bluish-gray argillaceous limestones of the Niobrara sub-group (Cretaceous No. 3) with the same physical features everywhere shown throughout the whole region south from Denver, and containing *Inoceramus problematicus* along with other species always regarded as characterizing this horizon. The exposures of this group are few but ample. An excellent exhibition can be seen at barely a mile southeast from Galisteo, where the limestone was quarried to be burned into lime. The dark brown shales of the Fort Benton (Cretaceous No. 2) are ill-exposed at the base of the Dakota mesa, which forms the eastern boundary of the park, south from the Arroyo.

The Dakota is well exposed, the three provisional groups, which will be proposed in my report, being shown along the Arroyo San Cristobal. The Upper Dakota forms the mesa or east wall of the park and consists of light gray and yellow sandstones; the Middle Dakota consists of blue, white and red sandy to clayey shales, with a bed of limestone, a conglomerate of limestone and iron ore and streaks of gypsum; while the Lower Dakota, made up of gray and yellow sandstones like those of the Upper Dakota, reaches eastward and becomes the upper part of a great mesa, the southwest wall of the Pecos valley.

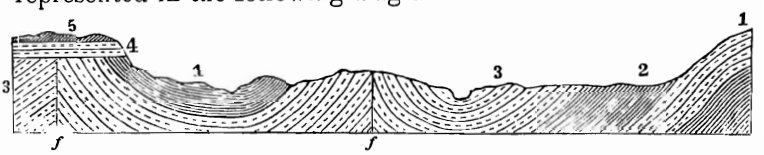
The succession in the lower Galisteo area is absolutely clear, showing the Dakota, Fort Benton, Niobrara, Fort Pierre and Laramie groups in their proper order. All of these dip westward until perhaps eight miles below Galisteo, where the dip is reversed so that the Laramie beds run out at sixteen miles below Galisteo and the Fort Pierre shales come again to the surface. Each of these groups is perfectly characterized and no difficulty is encountered in the attempt to identify them. The physical features and the fossils are not materially different from those found elsewhere in the same groups within the

whole region south from Denver, except that *Halymenites major*, so common at the base of the Laramie group in the Trinidad coal field, is absent here. But impressions of dicotyledonous plants occur in the Galisteo region, which are closely allied to those found in the Trinidad coal field. The coal beds on the northeast slope of the Placer mountains are as clearly Laramie as are those of the Trinidad or the Cañon City coal field.

But the geology of the upper Galisteo area is far from being so simple as that observed along the south side of the creek within the lower area.

No reference has been made to the north side of the creek within the lower area; that can be considered more conveniently in connection with the upper area. A broad uneven park, designated on the Engineer map as the Arroyo de Los Angeles, opens into the lower area at perhaps five miles below Galisteo, and the dike, previously referred to, forms its southeast boundary for several miles.

If a section be carried across the area of the upper Galisteo near its southern edge, the conditions will be found such as are represented in the following diagram.



CROSS SECTION ON THE UPPER GALISTEO.

1. Dakota. 2. Colorado. 3. Laramie. 4. Galisteo. 5. Alluvium.

The Upper Dakota sandstone is in the bluff on the east side, where the dip is very rapid; behind it are the shales and limestones of the Middle Dakota, and the sandstones of the Lower Dakota are shown still further east. Going westward toward Galisteo creek, one crosses the Dakota, the imperfectly exposed Fort Benton and Niobrara, the finely exposed Fort Pierre, and finally before reaching the creek, finds himself on the Laramie sandstones. Thus far the dip has been *westward;* but immediately beyond the creek, the dip is reversed, so that before the low insignificant roll, separating the Arroyo de los Angeles from the Galisteo, is reached, the Laramie rocks are dipping *eastward* and almost vertical, thus forming a synclinal.

But on the opposite side of this low divide, the Lower Dakota sandstones are exposed and dip westward at 65°; at but a little way further westward are the variegated shales and the limestone of the Middle Dakota. On the west side of the Arroyo, the Lower Dakota rocks are dipping very sharply eastward, so that here too a synclinal exists. Thus there are two faults, one following the divide between the Arroyo and the creek, while the other follows the west side of the Arroyo,

whereby this fragment of Dakota has been thrust through the Laramie rocks. The two faults come together on the north side of lower Galisteo at the mouth of the Arroyo and the Dakota rocks do not cross the creek. The Colorado shales do not appear on either side of the faulted area.

But on the west side of this arroyo there appears a series, newer than any yet noticed. It covers the mesa stretching west and north from the Galisteo, and is continuous from the Santa Fe and Placer road on the lower Galisteo almost to the end of the Archean area on the upper Galisteo. This is the Galisteo group. As far as exposed within the area examined, which extends to but a little distance west and north from Galisteo creek, this group is

1. Breccia of trachyte..... 150 feet.
2. Soft, light gray sandstone.. 40 feet.

The breccia is well shown on the lower Galisteo from the Santa Fe and Old Placer road to the mouth of the Arroyo de los Angeles. It is exceedingly dark gray or even lead-colored and is composed altogether, where examined, of trachyte in angular fragments, cemented by finer material apparently of similar nature. This breccia was followed up the Arroyo to the Galisteo and Santa Fe road; but there it practically ends, and the evidence suggests that it was worn away by the erosion which produced the broad mesa. Its fragments litter the surface of that mesa. The thickness assigned this mass is that seen at the mouth of the Arroyo. It may be greater further toward the northwest.

The sandstone is very light gray, excessively soft and incoherent, so that it yields as readily to the weather as though it were loose sand, weathering indeed more freely than do the tough alluvial deposits along the creeks. This is the lowest bed of the group found within the area visited.

The relation of the Galisteo group to the underlying rocks is well shown at the head of the Arroyo, where the Dakota beds dip westward at 65°, while the lower sandstone of the Galisteo rests on their planed-off edges and dips in the same direction at less than one degree. A more curious illustration of the unconformability is shown immediately below the mouth of the Arroyo, where the breccia was deposited around a projecting wall of lower Dakota, which dips at nearly 60°; and the contrast in color is as great as that would be between a trachyte dike and a surrounding mass of basalt. Both the breccia and the underlying sandstone are exposed here and are conformable.

The Galisteo beds are not affected by the faults found in the Arroyo de los Angeles, whereas the Laramie beds are involved in them; the breccia is composed largely of trachyte from Los Cerillos, a group of hills, relics of dikes, shown on the north side of Galisteo creek at sixteen miles below the village. But

the outburst of trachyte, forming those hills, caused frightful distortion of the Laramie beds. It is clear, then, that the Galisteo group can not be conformable to the Laramie. The former group does not cross the Galisteo creek at any point.

The lower sandstone of the Galisteo group was followed up the creek for more than seven miles above Galisteo, and its ashen color gives a strange appearance to the deeply eroded face of the mesa. The vertical yellow and almost white sandstones of the Lower Dakota yield readily to the weather and the debris from the light gray Galisteo sandstone mingles with that from these; so that, to one ascending the creek and following the line of the eastern fault, the Galisteo sandstone seems to be triple, white, yellow and gray, whereas the white and yellow belong to the Lower Dakota, on which the Galisteo sandstone rests unconformably.

The coal beds of the Placer mountains, occupying the plateau between those mountains and Galisteo creek are synchronous with those of the Trinidad coal field and belong to what is known as the Laramie group, which, however, is synonymous, in part at least, with Fox Hills.

The Galisteo group rests unconformably on the Laramie and Dakota; and contains a great bed composed wholly of the later lavas; it is therefore Tertiary.