THE BOTANY AND GEOLOGY OF THE COUNTRY BORDERING THE RIO GRANDE, IN TEXAS AND CHIHUAHUA.*

By PROF. JOHN S. NEWBERRY.

HAVING recently spent some time in Southern Texas and Eastern Chihuahua, a country until recently overrun by the Comanches and Lepans and hence but imperfectly known, I venture to hope that a few words of description of its aspects, geological structure, botany, and resources may not be unwelcome, especially as the attention of our people is being drawn in that direction, since it offers a new field for our surplus population and for the investment of capital.

The eastern and central portions of Texas are so well known as to require no detailed description. Near the Gulf the climate is warm and moist, and sugar and cotton are successfully raised. Beyond this belt, we pass on to plains on which there is little timber but mesquite, but the surface is covered with rich grass, and it is already one of the most productive grazing districts of the United States. The underlying rocks are, for the most part, of the cretaceous formation, without useful minerals, and the climate is dry.

On the western side of these plains, the country is traversed by mountain-chains, which belong to the Rocky Mountain system and which form the outer rim to a region of which the topography is more varied, the mineral resources are greater, and the agricultural capabilities are less than those of central or eastern Texas. This is, in fact, part of a great table-land, that fills the interval between the eastern and western mountain ranges, here nearly a thousand miles apart, which extends with diminished breadth southward throughout the central portion of Mexico. The Rio Grande has cut deeply into this plateau, and, where it has forced its way through the mountains that form its eastern rim, has excavated a series of deep and rocky cañons, which are impassable by boats and rival in their wild scenery those of the Colorado of the West. The country immediately bordering the river is much broken, but north and south there are intervals between the numerous and disconnected mountain-ranges, which are grassy plains, presenting on a smaller scale the features of the Llano Estacado on the north, and the Bolson de Mapimi on the south.

Further west, we reach a still more broken and arid country, in New Mexico, Arizona, Chihuahua, and Sonora, where the ragged outlines of the mountains and the peculiar vegetation —mostly cactus—gave a special aspect to the scenery. This latter country, the home of the Apaches, has been the theater of active mining operations for many years and the scene of unnumbered bloody tragedies. The country lying within southwestern Texas, eastern Chihuahua, and western Goahuila, less rich in gold and silver, seems not to have proved sufficiently attractive to the Mexicans to induce them to brave the danger of its occupation, and it has been not only unoccupied, but much of it unexplored. The line of the Mexican Central Railway, which is being pushed southward from El Paso to the city of Mexico, passes about 200 miles west of the belt of country referred to; and the railway which crosses the Rio Grande at Laredo, and is now extended southwest to Monterey and Saltillo, is about as far away on the east. A concession has been granted by the Mexican Government to European capitalists to build a road from Presidio del Norte or Eagle Pass, or both, to Topolovampo, on the Gulf of California, and this road will probably traverse almost centrally the district under consideration. The general altitude of this country is from 4,000 to 5,000 feet, the Rio Grande, as it passes through it, falling from 3,000 to 1,000 feet above the sea level.

BOTANY.

The country bordering the Rio Grande, in Chihuahua and Texas, is nearly destitute of trees, a feature which marks the aridity of the climate; yet, in certain localities, as on the bottom lands of the Rio Grande and Rio Concho, a vigorous and somewhat varied forest-growth was found at the advent of the whites. No better illustration of the relation between the kind of vegetation and the water supply in a country can be found, than that afforded by the luxuriant growth of trees of several kinds along the Cibola in the Chinati Mountains, Texas; while on all sides this oasis is surrounded by an apparently boundless, grass-covered prairie, where the rain-fall is inadequate for trees. On the mountain-summits, south of the Rio Grande, is a sparse growth of piñon (*Pinus edulis*) and evergreen oak (*Quercus Emoryi*). The lowlands, in certain localities over thousands of acres, are thickly set with mesquite (*Prozopis glandulosa*), here a strong, spreading shrub, never a tree, but with roots disproportionately large, composed of very dense tissue and furnishing a large amount of excellent fuel. Along the arroyos, cottonwood may occasionally be seen, either the narrow or the broad-leaved forms (*Populus monolifera* or *P. angustifolia*), and more commonly the backsberry (*Celtis occidentalis*), and the nogal, the little black walnut (*Juglans rupestris*), the Mexican buckeye (*Ungnadia speciosa*), and the guyacon (*Guyacum Coulteri*). The drier portions, especially the gravel terraces bordering the Rio Grande, are frequently covered with the creosote plant (*Larrea Mexicana*, and *Tonquieria splendens*. The latter forms a cluster of fifteen or twenty canes, ten or twelve feet high, springing from the same root, and bristling with spines, an inch or more in length, of which the bases are in contact. Usually it is without leaves, and seems as though dead, but, for a brief interval in the rainy season, it is covered with small crowded obovate leaves, and from the summits of each stem springs one or more spikes of brilliant crimson flowers.

Among the shrubs which form the "chaparral" or thickets, the *Holacantha* is the most conspicuous, and *Salizaria* the most interesting. The former, as its name implies, is a mass of thorns which are often as large and strong as those of the honey locust. The branches and spines are covered with a green epidermis, which performs the functions of leaves, and, in the spring, these bear bunches of yellow flowers similar to those of *Berberis*. The *Salizaria* is a labiate allied to *Scutillaria*, and the seed is inclosed in a balloon-like capsule, similar to that of the balloon vine (*Cardioz permum*), also found here and having the same function, namely, dissemination by the wind. Two species of *Acacia* and one of *Berberis* (*B. trifoliata*), all spiry, help to make the chapparal as nearly impenetrable as the thickets of cactus further west. We are here fairly within the confines of the cactus country, but not in its heart. Many species differing much in habit are constantly in sight—the "nopal," an *Opuntia*, being the most common, one species growing in a mass ten feet or more in height, with each leaf-like subdivision of the stem a foot in diameter. Though covered with spines, this plant is largely eaten by cattle, and nothing is more common than to see a patch of it trampled down, half eaten, and the flattened stems notched by their semicircular bites. One species or variety of *Opuntia*, growing abundantly in Chihuahua, is of a deep purple color, which makes it conspicuous and often ornamental.

The most striking feature in the botany of this region is formed by the century plant and its allies; other species of *Agave*, *Habranthus*, and *Dasylirion*, and the yuccas. In many places these are the only plants attaining any large size, and are very numerous, scattered over the plains and slopes of the mountains; the plants not crowded, but separated by intervals of a few feet, which are occupied with a luxuriant growth of gramma grass. The yuccas belong to four species or three species and two varieties, *Yucca angustifolia* and *Y. baccata*. Of these, two rise to the height of five to fifteen feet, with trunks from six to twelve inches in diameter, the crowded radiating leaves crowning the summit in a round or oval mass, six feet or more in diameter, the old leaves hanging perpendicularly and forming a peculiar thatch around the trunk and extending to the ground.

The century plant is in Chihuahua represented by a variety with shorter and broader leaves than that commonly cultivated. From the center of the tuft, the flower stalk rises from 10 to 25 feet in height, composed of woody tissue and standing some years after bearing flowers. These persistent flower stalks, crowning the ridges and visible for miles, give a peculiar aspect to the scenery. The century plants are, however, nowhere as numerous as the species of *Dasylirion*, with which they are associated, and which do not die with the effort of florescence. Further south, the agave supplies from its sweet juice the material from which an intoxicating drink is produced. In this region, however, an alcoholic beverage is obtained from the "Sotol" (*Dasylirion Texanum*), which, from its abundance and the use made of it, deserves a prominent place among the economical plants of the country. Hundreds of thousands of acres are covered with this Sotol, and it would seem that it might be much more largely utilized than it is, for the manufacture of alcohol. The leaves are three to three and a half feet long by one and a half inches wide at the base, straight, flat, and garnished on either side by strong recurved hooks. The color is yellow green, and the leaves are very numerous. From the center rises, at a certain stage of growth, a woody flower stalk, ten feet high and at the base as large as one's arm. The trunk rises but a few inches above the ground and is completely concealed. The top of this trunk, composed of the closely imbricated leaf bases, which are broad, yellow, shining, succulent, and sweet, with a pulpy mass at the center, containing much saccharine matter, raw, or better roasted, is palatable and nutritious; so much so, that in the country where it grows it is said the Indians never really suffer for want of food, as this affords them an abundant if not varied aliment.

In the preparation of Sotol whisky—a liquid called *mescal*, as is also that made further west from other plants the portion of the plant which has been described is trimmed so as to resemble a head of cabbage, then roasted and fermented, the product of the vinous fermentation being distilled in the ordinary way. For roasting the Sotol, a pit is dug, some ten feet in diameter and four feet deep, lined with rude masonry. In this a fire is built, and when it has been burned down, the pit is filled with several hundred Sotol heads. When roasted, they are chopped in pieces and fermented in vats.

Another interesting plant, the companion of the Sotol, is the "Lechuguilla" (*Agave heterocantha*), of which the leaves furnish a strong fiber, universally employed for ropes, sacks, etc., in Northern Mexico. This grows on the mountain slopes, generally at an elevation of about 4,000 to 5,000 feet, is common in all northern Chihuahua, and especially abundant on the Chinati Mountains in Texas.

GEOLOGY.

The prevailing rocks of Chihuahua and Texas are cretaceous sediments, chiefly limestones, broken through at frequent intervals by eruptions of trap of various kinds, trachyte, porphyry, diorite, etc. Presidio del Norte is surrounded by mountains, partly eruptive, partly upheaved sediments, with open intervals between them, occupied by the cretaceous strata, generally much disturbed. Between Presidio and the Sierra Rica, the middle and upper cretaceous rocks prevail—apparently the Colorado and Laramie groups, the lower shales with bands of calcareous concretions filled with fossils, the upper sandstones and shales containing impressions of plants and thin coal. The concretions referred to above contain immense numbers of well defined cretaceous fossils, consisting of *Ammonites*, *Nautilus*, *Helicoceras*, *Ptychoceras*, *Baculites*, *Gryphea*, *Ostrea*, *Inoceramus*, etc. The Colorado shales here are very black, though much metamorphosed, and containing *Inoceramus*, form the walls of the vein of the Sierra Rica mine, a clean cut fissure, crossing the bedding of the shales nearly at right angles, having a quartz gangue, containing some very rich but very compound ore, copper, zinc, lead, silver, and iron.

Seventy-five miles southeast from Presidio are the San Carlos Mountains, composed of cretaceous limestones set at a high angle and very much metamorphosed. The San Carlos Cañon cuts through the greater part of the range, showing a section of several thousand feet of rock, mostly light blue, but sometimes black limestones highly metamorphosed, yet often crowded with characteristic cretaceous fossils.

The ore deposit at the San Carlos mine is of extraordinary magnitude and of special interest. It fills a series of chambers in limestone, one of which is several hundred feet in length and more than 200 feet in depth and breadth. It is evidently a chemical deposit, filling cavities made by solution, and consists of black, often crystalline, magnetite, pyrites, galena, and blende, containing both gold and silver. Of this ore there are apparently many millions of tons, and in character it is, so far as I know, without parallel among all the ore deposits of the country. At a distance of half a mile, the limestones are cut through by a great dike of diorite, which has doubtless furnished the heat that was the mainspring of the chemical affinities, but it has apparently contributed nothing to the mineral matter of the ore deposit. At a point further south, the dike crosses the zone of limestone which holds the ore. It is there metamorphosed, but not at all mineralized.

In the same region are other mineral deposits, which will probably prove to be of considerable value. Among these is another series of chambers in limestone, filled with hard carbonate of lead and galena. Others still, which are rich in copper, also carry silver and gold.

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* Abstract of a paper read before the N. Y. Academy of Sciences, 1883.

MISSISSIPPI has 1,731 factories, working 5,941 hands, with a capital invested of $4,501,714, paying annually in wages $1,579,428, and yielding annually in products $8,154,758.

THE SUN'S DISTANCE.

AT the recent meeting of the British Association, Professor Robert Stawell Ball, LL.D., F.R.S., Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland, delivered a discourse on "Recent Researches on the Distance of the Sun." He said:

It seems not unlikely that in early ages the distance of the sun was one of the very first astronomical problems which ever attracted speculation. In modern times, as the problem has gradually approached solution, the interest attached to it has gradually increased until it has culminated in the last few months by the occurrence of the transit of Venus. The importance of this problem arises from the fact that the distance of the sun is the base line in terms of which almost every other lineal magnitude in astronomy is to be expressed. An accurate measurement of this base will infuse accuracy into all the other astronomical quantities which spring from it. When we have learnt the distance of the sun we can measure the bulk of the sun and his diameter, we can measure the great planet Jupiter or the rings of Saturn, and the scale of the whole solar system becomes known to us.

Again, when we attack the loftiest problem in practical astronomy, and seek to stretch a sounding line over the vast abyss which divides our system from the stars, it is the distance of the sun which we must use as our measuring rod. No pains should be spared to give to so fundamental a unit all the precision of which it is capable. Let us define accurately the magnitude to be measured. The actual distance from the earth to the sun is not constant. In these autumnal months the distance is rapidly decreasing. We are at this moment drawing nearer and nearer to the sun at the rate of a thousand miles an hour. Next Christmas we shall be about a million and a half miles closer to the sun than we are to-night. At the commencement of the New Year we shall begin to recede. Next midsummer will find us as far from the sun as possible; then we shall draw in again, arrive next autumn where we are this autumn, and commence anew the cycle of changes I have indicated. Though these changes amount to millions of miles, yet they are at the utmost only a small fraction of the sun's distance. To superficial observation the sun always seems the same size, and hence there can be no great relative changes in its distance. There is no difficulty in understanding what is meant by the average distance of the sun. To express the idea with precision we may borrow the language of mathematics, and say that the distance from the earth to the sun consists of two parts—a large constant part and a small periodical part. The important problem, and the difficult problem, is the measurement of the large constant part. This is the question to be discussed in my lecture this evening.

HISTORY OF EFFORTS IN MEASURING.

The early history of the subject is as easy to sketch as the latter part is difficult. For 14 centuries the doctrines of Ptolemy were adopted on the distance of the sun as on all other astronomical problems. The method of Ptolemy might have succeeded if the sun's distance could have been measured by thousands of miles instead of by tens of millions. As matters stand, Ptolemy's method was utterly inadequate to cope with the real difficulties of the question. It led him to a conclusion which we now know to have fallen far short of the truth. The real distance of the sun is twenty times as great as that which Ptolemy deduced from his observations. But Ptolemy's result was a great step in advance, notwithstanding the tremendous error by which it was vitiated. It was, at all events, an honest attempt to solve the problem by a direct appeal to nature, and he succeeded so far as to demonstrate the great truth that the sun is larger than the earth. It is somewhat remarkable that the first reasonable approximation to the sun's distance was obtained by what can only be described as a well-considered guess.

The illustrious Huyghens, in the 17th century, hazarded a speculation which seemed plausible at the time, and which we now know to have been reasonably correct. Huyghens compared the diameter of the planet Mars with the sun. He compared the diameter of Venus with the sun. The primitive instruments used were capable of making these measures with some accuracy. Huyghens knew that the earth was also a planet revolving outside the path of Venus and inside that of Mars. Was it not reasonable to assume that the bulk of the earth might be comparable with that of its fellow planets, and intermediate between the bulk of Venus and that of Mars? This assumption—and, of course, it was no more than an assumption—gave the means of guessing the distance of the sun, which was concluded to be about 100,000,000 miles. When guesswork came to be replaced by measurement, this estimate of the sun's distance was corrected. It was found to be too large. It was amended first to 95,000,000 miles, then to 91,000,000 miles. This was subsequently found rather too small, and it is now generally thought that the sun's distance must be more than 92,000,000 miles, but hardly so much as 93,000,000 miles. We have here a range of one million miles.

The problem in its present condition can now be distinctly stated. We require to determine the sun's distance accurately to within 100,000 miles, or, to speak in round numbers, we desire to determine the distance of the sun accurately to one-thousandth part of its total amount. Is such a degree of accuracy obtainable? I believe that it is. I do not say that the problem has already been solved with this precision, but an approach has been made, and enough has been done to show that the accuracy I have indicated may be attained. But this margin is not really large when we reflect on the stupendous magnitude of the sun's distance. A favorite illustration in books of astronomy states that a journey to the sun in an express train running night and day without stopping would consume about 300 years. Before entering on such a journey it would, however, be well to recall to mind a very interesting lecture on railway accidents delivered by Sir F. Bramwell to this association a few years ago. From the figures available he showed that, supposing a man made up his mind to be killed by a railway accident, it would usually be necessary for him to travel day and night by express trains for 900 years before he could be quite certain of achieving his purpose. One or two return trips to the sun would no doubt suffice.

There are certain conditions which any method of measuring the sun's distance must fulfill. In the first place it is obvious that we cannot measure the distance directly. We cannot take a tape and measure it as we would the length of a field. We are compelled to resort to indirect methods. In other words, instead of measuring the sun's distance directly, we measure something else, from which we derive the sun's distance by calculation. Whatever that something else may be, there is one obvious condition which must be fulfilled. The method by which the calculation is to be