per day. Meat is rarely eaten by any but well-to-do Neapolitans and the main sources of proteids are bread, spaghetti and beans (*Phaseolus*). It seems to me that in the lack of recuperative power shown by the Neapolitan workmen there is an excellent example of the danger of minimizing the reserve fund of proteids in the system, as suggested by Dr. Meltzer.

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Cambridge, Mass.,
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SPECIAL ARTICLES

GEOLOGY OF THE SIERRA ALMOLOYA, WITH NOTES ON THE TECTONIC HISTORY OF THE MEXICAN PLATEAU[1]

The Sierra Almoloya is situated in the southern part of the state of Chihuahua, about 25 miles west of Jimenez, and midway between the latter town and Parral.

This sierra is one of the numerous isolated mountain blocks of northern Mexico, like Santa Rosalia, Naica, Santa Eulalia and others, which rise in solitude from the vast area of surrounding arid plains constituting the great Chihuahua province, between eastern and western sierras, of the Mexican Plateau portion of the northern cordilleran region.

The mountain is a long and narrow range, about ten miles in length, extending in a northeast-southwest direction and averaging less than two miles in width. It is surrounded on every side by a lower area of sloping plain which has an altitude of about 5,000 feet at the mountain base. The total altitude of the mountain above the plain is fifteen hundred feet, the peaks rising to an altitude of 6,500 feet above the sea, as far as could be determined by a careful aneroid study. To the south of the range are several conspicuous outliers of lower altitude as shown upon the map.

The range is dominated by a narrow axial summit ridge, following the northeast-southwest trend of the mountains. Numerous narrow tongue-like salients radiate from the ridge to the plain, and separate by deep arroyos cutting back to the ridge ('capturing' it) and their valleys making great cirques, or amphitheaters between the salients.

Arising from the central ridge are several conspicuous summit peaks. The highest of these, attains an altitude of about 6,500 feet.

Like the other limestone mountains of the Chihuahua province, this sierra reveals the ancient wrinkled and folded structure of the plateau prior to when it was buried in vast beds of rhyolitic and andesitic volcanic ejecta which once covered this whole portion of Mexico, and which is still preserved in the western Sierra Madre, and like the other ranges mentioned the mountain represents the resistance and survival of the hardest, in the destructive atmospheric erosion and degradation of a once higher surface of the great western plateau.

The Sierra Almoloya is, therefore, a destructional or decadent form of a mountain, representing a remnant of the former extent of the rock material upward and laterally which fact is not only testified in the degraded shape of the mountain configuration itself, but by the vast quantities of talus and debris in process of forming on its surface and now filling the surrounding deserts.

Every detail of its relief such as its axial direction, the character of its slopes, the course of its lateral arroyos and other features are conformed to the arrangement or structure of the rock material composing the mountain, such as the lines of stratification, faults and folds, etc., to be later described.

The exposed rocks composing the sierra consist almost entirely of limestones of varying degrees of purity constituting the main mass and country rock of the mountain. Secondarily these are mineral ores and exceptional fragments of igneous rocks, the latter not found in place of origin.

The Limestones.—The mountain mass is composed of stratified limestones of the Comanche series of Lower Cretaceous age largely and mostly of the particular formation known as the Edwards limestone.

These limestones originated as sea muds in the form of chalk and chalk marls, accompanied by horizons of siliceous flint nodules,

[1] Read before the Geological Section of the New York Academy of Sciences, April 1, 1907.

when the Gulf of Mexico occupied this area. They now occur as gray, blue and black strata intensely hard, greatly altered, and in places converted into white crystalline marble and in others into a semi-schist. The individual beds of limestone vary in proportions of lime, silica and clay, and also slightly in color and texture.

These limestones have been greatly tilted and deformed in the various processes of mountain and continent building, so that instead of lying horizontal as they were originally deposited, they are tilted at every conceivable angle. They have also been folded into close folds. These folds are the most complicated I have ever seen in the rocks of this period, constituting what geologically may be termed thrusted overthrows, recumbent anticlines, etc., of the alpine type of structure.

When viewed from the plain from any direction, the mountain appears an elongated dome with the strata dipping conformable with the slopes in every direction from the central summit axis, so that as a whole it is quaquaversal in its character.

The western slopes of the mountain apparently consist of uniform beds of strata dipping towards the plain. On ascending and carefully studying the salients, it was found that the strata were folded directly back of one another in close compact recumbent folds, and that the dip of the folds corresponds with the ascent of the slope. Upon reaching the shoulder below the summit of Picacho the worn-off edges of the outer layers of the overthrown anticline project upward in great vertical strata.

The higher peaks and narrow connecting summit ridges with the exception of Mount Anticline, at the north end of the ranges, are all composed of the truncated vertical strata of the overturn of the recumbent anticlines. Not only are the rock sheets closely folded, but the folded edges are buckled, or bent, so that the buckling of the folds corresponds in its sinuous course to the axis of the mountain. The general strike of the old folds is north 30 east, north 50 east and north and south.

Had it not been for my previous familiarity with every detail of these Cretaceous rocks, as elsewhere studied, I doubt if the true structure would as yet have been ascertained. In fact, it was not until after many days upon the ground that I discovered, by the aid of the layers of flint nodules embedded in the limestone, how to trace the stratification beds in these greatly disturbed and altered strata.

Alteration.—In places near the acute flexures, the limestones are completely metamorphosed into white crystalline marble, or converted into schists—a fact which I have previously noticed in Mexico at Guaynopita, west of Chilpancingo and other localities. This phenomenon is so frequent as to lead to the inquiry if much of the pre-Cretaceous plexus of Mexico has not lost its integrity through the intense metamorphism of the post-Cretaceous mountain movements.

These limestones are also excessively fractured by several systems of joints, faults, etc. The bedding planes, which, when the strata are vertical, are also exceedingly difficult for the layman or even the geologist to distinguish, from the faults and joints.

In this mountain two distinct systems of faulting are discernible. The first system may be known as the north-south and northeast system, the other as the northwest fault system. The north 80° west faults are related to the northwest system in age.

The faulting and folding in north-south and northeast directions is an older structural feature than the other faults mentioned, and is apparently barren of mineralization. Faulting of this kind may be seen on the northeast side of the Picacho and the east side of Placeras and the west side of America.

Many of the north 40° west faults occur in parallel belts across the mountain range and nearly all the mineral outcrops seem to be closely associated with them.

The movements along the northwest faults has been lateral, displacing the older folds.

No igneous rocks outcrop on the Almoloya Mountains, or anywhere within a distance of ten or twelve miles, so far as I could ascertain. Fragments of rolled rhyolite occur in the talus along the west base of the mountain, and pieces of basalt are found in the Julietta

Valley. It is most probable, however, that the mountain is underlain at depth by igneous intrusions.

At the close of the Cretaceous period, at the time of the great Laranude or Rocky Mountain uplift, the sea bottom was uplifted into land, as a part of the Mexican Plateau province, and the rocks were wrinkled and compressed into the marvelous overthrown folds which they now present, having northeast and north-south trends.

This period of folding was that of the whole of the eastern Rocky Mountain region in north-south directions, and the union of the North and South American continents.

During the later epoch, probably the Miocene, the region and its limestone rocks underwent another orogenic movement, and was intruded from below by a vast igneous magma from which came dikes and ejecta of volcanic rocks which are now found throughout the region. Accompanying this epoch the whole structural or tectonic trend of the southern continent changed from a north-south to north 40° west course, and the north 40° west faults and folds of this later orogenic revolution were developed across the older north-south folds and faults, resulting in the development of the quaquaversal structure of northern Mexico, and I have seen it at La Mitra, Villadama and Candela, in the State of Coahuila, the Big and Little San Vincente, mountains crossed by the Rio Grande at Presidio San Vincente; at Guaynopita, Jesus Maria and Santa Rosalia, Mexico; and at Monument Mountain near El Paso, and in the Santragos Chinati and other mountains of Trans-Pews, Texas. The great mineral lodes of Mexico were mostly intruded, as hot vapors, waters and gases up these northwesterly fault zones.

Since or during this second epoch, the plateau as a whole has been uplifted, increasing the erosion, and the surface has worn down at least 2,000 feet. Some of the mineral contents have been washed away; others have concentrated down the fractures enriching the present ore bodies.

As the writer has previously shown, nearly all of the great ore localities of Mexico are associated with faults in this north 40° west direction. These faults are all of late geological origin, and probably the movements of the earth which made them are still going on, as testified by hot springs, in the vicinity.

By plotting the trends of the faults and folds of the Cordilleran region upon a large map, such as cannot be produced here, it certainly appears as if the northern part of the Mexican plateau province from the Colorado plateau southward through the northern tier of the States of Mexico has been the site of the crux of two distinct periods of mountain making movements, as illustrated in the Sierra Almoloya. One of these, and the older, has northerly trends representing the Laramide movements of the typical Rocky Mountain type, and the other having the northwestern trends of the Coast Range type, probably representing a post-Miocene revolution. The hypothesis of the crossing of these two belts of deformation explains many of the hitherto unexplained phenomena of our continent along the International Boundary and in Northern Mexico. It is certainly worthy of further test by field observation. Further study may show that the post-Miocene belt of northwest-southeast movement crossing the Laramide or Rocky Mountain north-south movement may extend from California across Mexico and connect with the Antillean movements of the West Indies.

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The Biological Laboratory of the U. S. Bureau of Fisheries at Woods Hole, Mass.[1]

Investigators and Assistants.—During the past laboratory season, thirty-two investigators were engaged in the study of various phases of marine biology, this number being somewhat larger than has been recorded for any summer within the last four years. Of these investigators, fourteen received a salary from the bureau, while eighteen are to be classed as volunteers. Thirteen junior assistants were also employed for various duties in the laboratory and in the field, two of whom, from the nature of part of their work, have like-

[1] Report of the work for the summer of 1906.