SCIENCE.—SUPPLEMENT.

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ORIGIN OF PUEBLO ARCHITECTURE.

NEARLY twenty years ago, Lewis H. Morgan called attention to the false views of aboriginal American civilization then current. His remarks were intended to apply particularly to the higher cultures of Mexico and Central America, which had always been interpreted through the medium of the glowing accounts of the Spanish conquerors, who saw in every institution some parallel to their own customs. The resulting exaggerated views of Indian culture have thrown a reflected light upon the architectural remains of the south-west. The deserted pueblos scattered over a large portion of New Mexico and Arizona, and extending far into Utah and Colorado, have been linked with the name of Montezuma and the Aztecs by the early pioneers; and the fact that our first knowledge of these remains reached us through such sources doubtless had much influence in fixing erroneous ideas of the ancient builders. These deserted groups of carefully built stone houses, occurring in the midst of desert solitudes, appealed strongly to the imaginations of the early explorers, and stimulated their fancy to reconstruct an elaborate civilization, and to connect the remains, on such slender basis, with their vague notions of the 'Aztecs' and other mysterious peoples. This early implanted bias has caused the invention of many ingenious theories concerning the origin and disappearance of the builders of the ancient pueblos. They have been regarded as a remarkably advanced people, who were swept from the face of the earth by some mighty catastrophe. Their 'buildings' have been said to 'equal any in the United States, if we except the Capitol;' and many more equally absurd extravagances have been uttered in connection with the ruined houses of the ancestors of the present Pueblo Indians.

The work of the bureau of ethnology in our south-western territories has included an examination of a great many of these ruins, and a comparison with the existing pueblos. In connection with the latter portion of the work, many traditions bearing on the occupancy of the ruins by their ancestors have been secured from the present Pueblo tribes, connecting them clearly both with many of the old village ruins and with the cliff-dwellings. A number of these ruins are the remains of villages that have actually been occupied within the historic period. Both the architectural and traditional evidence are wholly in accord in establishing a continuity of descent from the ancient Pueblos to the present time, many of the present tribes being made up of the more or less scattered but inter-related descendants of clans who in former times occupied the villages whose remains are looked upon to-day as the homes of 'Aztec colonies,' etc.

The complete adaptation to the peculiar environment displayed by this system of architecture would indicate that it had long been practised under the same conditions that now prevail in this region, and which still affect the building-methods of the modern Pueblo Indians. A vast number of these pueblos have been constructed of the tabular sandstone found in natural quarries at the bases of hundreds of cliffs throughout these tablelands. This stone naturally breaks into small pieces of regular form, suitable for use in the simple masonry of the pueblos without any previous artificial treatment. The walls themselves give an exaggerated idea of the regularity of the component stones, owing to the care and neatness with which these are placed. The photographs taken in connection with the bureau's work among the ruins show clearly that the material of the walls was not nearly so regular as the appearance of the finished masonry would suggest, but that this finish depended on the careful selection and arrangement of the fragments, with the best face of each stone placed outwards. In the case of some of the best-finished masonry, the photographs indicate that the *core* of the wall has been laid up with the larger and more irregular stones, and the surface afterwards brought to a finish by carefully filling in and chinking the joints with smaller stones and fragments, sometimes not more than a quarter of an inch thick; the whole surface finally being reduced to a uniform face by rubbing the wall with a slab of sandstone.

Although many details, both of construction and arrangement, display a remarkable adaptation to the physical character of the country, yet the influence of physical environment alone would not suffice to produce the architectural type under consideration. Another element is necessary to give point and direction to such influence, in order to develop the results we find. This element was the *necessity* for *defence*. There are many evidences that the Pueblo population of these south-western tablelands have been subjected to the

more or less continuous operation of this *defensive motive* throughout the period of their occupation of this territory. A strong and independent race of people, who had no invasions of stronger foes to fear, would have been necessarily influenced by the environment to the extent of using the exceptional materials offered, and would have progressed in perfecting their lodges; but the motive for building clusters of rectangular cells — the initial point of departure in the development of the pueblo system — would not have been encountered. The crowding of many habitations within the narrow limits of a small cliff-ledge or other restricted site, bringing about the rectangular room-cluster, would most likely have been due to the imperative conditions imposed by this necessity for defence. The character of many sites occupied is not such as would be selected voluntarily by a people in a low grade of culture, and the choice of such places as homes must have been largely compulsory.

The general outlines of the development of this system, wherein the ancient builders were stimulated to the best use of the exceptional materials about them both by the difficult conditions of their semi-desert environment and by the necessity for constant watchfulness and protection against their neighbors, can be traced in its various stages of growth from the primitive conical lodge, and culminating in the large communal village of a single many-storied building, such as we find on the Chaco and also in the homes of some of the present Pueblo tribes. Yet the various steps have followed from a very simple and direct use of such material as was immediately at hand, with gradually improving methods of employing the same, as the experience derived from frequent experiments in building taught them to more fully utilize local facilities, the builders doing the best they could with the materials at hand. In all cases such material was derived from the nearest available source; and the occasional variations in the quality of the finished work were usually due to variations in the quality of the stone near by, or other local features.

The results accomplished attest the patient and persistent industry of the ancient builders, but the work does not display any evidence of great skill in construction or in the preparation of the material.

The same semi-desert environment that furnished such an abundance of material for the ancient builders, also, from its difficult and inhospitable character and the constant variations in the water-supply, furnished the conditions for compelling the *frequent use* of this material; and this was a most important factor in bringing about the degree of advancement in the building art that was attained. At the present day, constant *local* changes occur in the water sources of these arid tablelands, while the general character of the climate remains unchanged.

The pueblo system of construction, then, may be regarded as the product of the defensive motive, operating through an environment that furnished at the same time both an abundance of suitable building-material and the climatic conditions that compelled its very frequent employment.

The comparative abeyance, within the past few years, of the defensive motive, which has been such an important element in the evolution of this building system, has left its impress on the more recent architecture. Even after the long practice of the system has rendered it somewhat fixed, comparative security from attack by their neighbors has caused many of the Pueblo Indians to recognize the inconvenience of a system of dwellings in such large clusters, and on sites difficult of access, while the sources of their subsistence are necessarily sparsely scattered over large areas. This is noticeable in the construction of single houses of small size at quite a distance from the main villages, the motive of greater convenience to crops, flocks, water, etc., being allowed to outweigh the defensive motive.

The greater security of the Pueblos as the country comes more fully into the hands of Americans, has resulted also in the much more careless methods of construction, as well as of arrangement, that characterize the modern examples as compared with the ancient.

It seems altogether likely, that, as time goes on, the system of building a great number of rectangular rooms in many-storied clusters will be gradually abandoned by these people, in the absence of the defensive motive that bound them together and was the compulsory cause of such construction; and a more convenient system of scattered small houses, located near springs and fields, will take its place, thus again returning to a plan of living that must have prevailed at one period in the past evolution of the pueblo, prior to the clustering of a great many rooms into one large defensive village.

The apparently distinct line of separation between the Pueblo Indians and the neighboring tribes gradually becomes less clearly defined as further investigation makes both sides better known and reveals many connecting links. Mr. Cushing's exhaustive study of Pueblo social, political, and religious systems has clearly established their essential identity with those of other tribes. In the sphere of the arts, where the wid-

est discrepancies apparently occur, it is found, that, by tracing the development of each branch of Pueblo art by means of its own internal evidence of the successive periods of growth through which it has passed, we establish its continuous evolution from the simplest beginnings. Mr. W. H. Holmes has clearly shown how the ceramic art of these peoples has naturally developed from the simplest sources, and such as were more or less common to most of the American aborigines in a comparatively low stage of culture. In the case of their architecture, a similar derivation from very primitive forms can be traced. The builders gradually learned to utilize their environment, and perfect the system, until it culminated in the many-storied fortress-pueblo of a single building (such as the ruined pueblos of the Chaco); yet these highest achievements of their art in building contain within themselves a record that these people at one time dwelt in simple circular lodges, such as were common to many American tribes at the period of their discovery.

VICTOR MINDELEFF.

GEOLOGY OF NEW JERSEY.

UNDER the wise and efficient management of Professor Cook, the very modest annual appropriation of the geological survey of New Jersey is made to yield, year by year, substantial contributions to the geology of the state. The report for 1886 shows that the admirable topographic survey of New Jersey, carried on by the state in co-operation with the U. S. geological and coast and geodetic surveys, is approaching completion. It is being published on a scale of one mile to the inch; and the sheets for the northern part of the state, which were issued some time ago, have been generally accepted as the finest piece of cartographic work, for so large an area, that has been done in this country. They are in constant demand for all the uses requiring an accurate horizontal and vertical delineation of the surface of the country, from laying out water-works and railroads to arranging bicycle tours.

In view of the substantial benefits already accruing from this map before its completion, the wisdom and practical importance of such work cannot be questioned; and it is to be hoped that other states will hasten to profit by New Jersey's enlightened example.

The results of this topographic survey are to be used, on a reduced scale, as the basis of a new geological map of the state.

In the purely geological part of this volume, Dr. Britton's chapter on the crystalline or primitive rocks of New Jersey occupies a prominent place. Three conformable groups are recognized: 1. Massive group, composed chiefly of indistinctly bedded syenitic and granitic or gneissic rocks, and probably equivalent to the Ottawa gneiss or lower Laurentian of Canada; 2. Iron (magnetite) bearing group, embracing a great variety of gneissic and schistose strata poor in white mica, sparry limestone and dolomite, with graphite and serpentine, and bedded deposits of magnetite, franklinite, and other ores (this group agrees well with the Grenville series or upper Laurentian of Canada); 3. Gneissic and schistose group, including biotite and garnetiferous gneisses, mica, hornblende, talc, tremolite, cyanite, chlorite, and other schists; vein granite, bedded diorite, and impure limestone and serpentine. This group resembles Dr. Hunt's Montalban system; and, since it is conformable with the iron-bearing group, the view is advanced that the Montalban may be simply an upper division of the Laurentian. It is interesting to note here that other students of the great Appalachian belt of crystalline strata have been led to propose more or less similar re-arrangements of the crystalline terranes, all of which goes to show the extremely unsettled state of eozoic geology. Dr. Britton introduces a series of sections to show that the same conformable sequence of his three groups obtains in all parts of the highland district; but in view of the massive character of the first group, and the general paucity of outcrops at critical points, this view can scarcely be regarded as definitely established.

It has long been known that the rocks of the highlands, like those of the Appalachian belt generally, are involved in a series of closely appressed folds the axial planes of which are usually inclined at a high angle to the south-east. This report, however, brings out more clearly than ever before, another important feature of these folds; viz., that their axes are not horizontal, but are inclined at an average angle of thirty degrees to the north-east. Since the pitch of the folds is always in the same direction, this involves a series of transverse faults with the uplift on the north-east; and more or less important examples of such faults have already been observed, especially in the iron-mines.

Among the paleozoic strata of this region, none are more interesting, or have proved more puzzling to geologists, than the red conglomerate and associated limestone and slate composing the Green Pond Mountain Range. In the earlier reports of the survey these were referred to the Potsdam, Trenton, and Hudson River groups. The later investigations, however, have resulted in the accumulation of proof, both stratigraphical and paleontological, that these rocks belong much higher in the scale; the red conglomerate being the equiva-