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PUEBLO ENVIRONMENT.[1]

THE southern portion of the Rocky Mountain Highland has two chief geographic features, the one a depression called the Great Interior Basin and the other the Pueblo Plateau. The latter may be subdivided into the Rio Grande Valley, the Colorado Plateau and the Gila Slope, lying in the four political divisions named Colorado, Utah, Arizona and New Mexico.

This plateau, which contains the bulk of the elevation on the western half of the United States, is mainly embraced in the triangle lying between the eastern side of the Rocky Mountains and the Rio Colorado, the western side being bounded by the Great Basin. Its slope is from north to south in the eastern portion where the Rio Grande drains the trough lying just east of the continental uplift, but the main slope is toward the southwest and is drained by the Colorado and its affluents. The plateau lies from four to ten thousand feet above sea level, but there are great contrasts in elevation from 14,000 feet above to 300 feet below the datum. In this region the north and south ranges of the Rockies break up and form a complex of mountains running

[1] Address of the vice-president and chairman of Section H—American Association for the Advancement of Science, New Orleans, December, 1905.

east and west, plateaus, plains, basins, buttes, broad valleys and narrow canyons giving great diversity of the most remarkable natural features to be found in the world.

The geology is that of later rocks, principally the easily eroded Cretaceous and other Mesozoic formations. Tremendous volcanic activity in former times has poured out vast floods of lava which, together with tufas or agglomerated ash, form the most noticeable physiographic features of the region.

Latitude, elevation and natural barriers here conspire to produce modifications in climate. This is seen in the convolutions of the isotherms of 50°, 59° and 68° crossing the region, the scanty rainfall occurring in the winter and summer months, the excessive insolation, the extremes of day and night temperature, the high winds and rarefied air, which characterize the arid environments.

The fitness of the southwest to sustain biotic forms depends mainly upon rainfall, which itself is regulated by cosmic and geographic conditions. Thus the uprush of heated air from the sun-baked plateaus during the summer draws in the moisture-laden air from the oceans, producing rains which are unequally distributed; the higher mountains, acting as condensing centers, receive the most, while the plains are scantily watered. The receptivity of the land must also be considered, the mountains covered with vegetation storing water, and the bare land shedding it into the rivers, which must carry at times vast floods and during long periods remain perfectly dry. Everywhere is evidence of the colossal agencies which are at work reducing the land to sea level. This workshop is littered with the bones of the mountains, and the dust that is sorted by water and wind moves freely to lower levels or is blown higher to again resume its gravitational course.

Despite the generally adverse conditions set forth, there flourishes here a flora of a peculiar character which forms the basis of subsistence for an extensive fauna, and also the newcomer, man, who has pinned much of his faith to nature's supply. The region is not in any part a desert in the true sense of the term, which is applied to lands deserted because of an inhibition of life, but it is rather a semi-arid environment, in which a preponderance of desiccative and other factors have restricted and minimized life. These restrictions are observed in full force among the plants fixed in the earth, and therefore played upon by all the natural forces, to which they must adapt themselves by slower changes than are required by higher biotic forms. The characteristic climatic flora is thus xerophytic where the leaves are small, with structures for preventing too rapid evaporation, stems contain chlorophyl and act when leaves fall away, etc.; these are adaptations which give some plants the freedom of the desert. Other plants are succulent and spring to quick fruition when rains occur; other plants have perfected water-storing organs in stem, root and branches, as the cacti, yucca, atriplex, sarcobatus, etc., and still others can live in soils containing an excess of mineral salts.

Most of the desert plants bear witness to the struggle with sun, wind, rarefied air and inhospitable soil; thus they present a gnarled, wrinkled and bizarre appearance, often simulating trees dwarfed by the gardener's art. Unlimited opportunity is here for isolation by natural boundaries, which, if not a factor in the origin of species, at least powerfully aids in their preservation.[2]

[2] Discussion by Jordan, Bailey and others, in recent numbers of SCIENCE. The Desert Laboratory of the Carnegie Institution, near Tucson, Ariz., is attacking these problems with enthusiasm.

Much that is observed as to plant life is true also of animal life, giving a facies by which Merriam's austral regions may be characterized.

In all discussions of this environment, little or no attention has been paid to the effects of light, which is here at its maximum. Without entering into detail as to the physiological sequelæ of light from other parts of the spectrum, the rays from the violet end may be considered. These rays affect all life submitted to them in a harmful manner by checking or prohibiting cell growth or metabolism. It will be found that many of the protective features of xerophilous plants and of animals which are attributed to aridity, rarefied air, soil, etc., are adaptations due to avoidance of dangerous rays of light. This is to be noticed in the habit of some delicate plants which thrive in the shade of hardy plants, the protective covering and nocturnal habits of animals, and the architecture and shelter instincts, as well as skin color of the ancient and modern Indians who lived in caves, cliff shelters or cavate houses, or whose pueblos as a whole or as to the individual houses were constructed to admit a minimum of light, but from far different causes, though still environmental pueblos were generally oriented with reference to the east; first, for the utilitarian purpose of receiving the early morning sun, grateful after the chilly nights of the high regions; and second, on account of the importance of the rising sun in heliolatry.

Such were the general features of the great area under consideration and on the whole the characteristics are constant to the present time, but it is difficult to realize the immense modification of animal and vegetal life which the white man has wrought in this region during the thirty years of his active occupancy. At the beginning of this period the region was well grassed and supplied with other vegetation adequate to the needs of vast herds of antelope, elk and deer; rodent animals and birds were plentiful and carnivores had abundance of prey. As a result of vegetation a humus had formed on all protected situations, rainfall was absorbed and equalized in distribution and the terrific denudation which gashes the land at present was not begun.

The country was adapted to grazing and especially favorable on account of temperature and latitude, and at once great herds of cattle, horses and sheep were introduced from Texas where pasturage had failed. The result was that the range became overstocked, the grass disappeared under the tongues and hoofs of myriads of domestic animals; shrubs and trees were browsed and destroyed or swept away by fires; from certain regions species of plants vanished; and the land lay bare to the augmented winds and torrential rains. Trails became profound arroyos, the humus vanished into the streams and the surface of the country was stone, sand and gravel. Not the least of this baneful influence was the drying up of springs and other sources of water, and more than one observer collected data going to prove the progressive desiccation of the pueblo region. These facts must be borne in mind in discussion of the environment of the southwest. As an example, it may be stated that in the exploration of one ancient pueblo at Winslow, Ariz., the bones of thirty-seven species of animals were taken from the house refuse; it is not probable at present that a naturalist could collect five of these species from the environment. Wherever the explorer's spade has been put into the ancient ruins, facts of this character come to his notice, even if he has not heard the story from the early settlers or Indian traditionists.

There is no doubt that cycles of dry and wet seasons occur in the southwest, but the

periods have not been definitely observed. Inferential data have been secured from exploration in the ancient ruins that render it possible to explain the migrations of early populations.

The conditions of the environment briefly recapitulated are:

1. A plateau of considerable elevation isolated geographically.

2. Slight rainfall, locally distributed; absence of cloud blanket; excessive light, radiation and evaporation; high winds, dust storms; rarefied air.

3. Forested mountains, plains with xerophytic, hydrophytic and halophytic vegetation; plant colonies; desert animals.

Within this general enclave we have several subenvironments which may be considered from the point of view of the availability for habitation by man.

Subenvironments:

1. Prohibitive to man and in great degree to animal and vegetal life.

2. Precarious except to man in low grade of culture, as roving, hunting and primitive tribes. Animal and vegetal life sufficient.

3. Habitable by man acquainted with agriculture, but more or less precarious.

4. Favorable for agriculture and production of economic surplus.

The subenvironments more favoring in the struggle for existence are:

1. Mountains at sources of rivers. Here are narrow valleys for agriculture with occasional irrigation; game, nuts, fruits and plants; timber, building material, etc. The temperature cold, with short growing season.

2. High plateaus with marshes, lakes, ponds. Land lying well for catchment of water. Temperature as in 1.

3. Mesa country, with broad plains and valleys; springs; streams flushed at seasons.

4. Riverain lands in lower stream valleys suitable for irrigation by canals or warping.

The effect of this environment upon plants is to reduce them to their lowest terms; animals, to modify them in important ways; man, to subject his mind to the stress of severe conditions, reacting noticeably on his body, and mightily on his thought and material progress.

The environment was suitable, or extinction of tribes followed or a movement was made to a new subenvironment. Thus the constant and seemingly erratic migration of tribes which have covered the Pueblo region with remains of ancient towns may have been due to natural causes which disenvironed them, such as earthquakes, failure of springs, etc. The final localization of the Pueblos is an index, in large measure, of the regional fitness.

It is probable that the tribes coming into the pueblo environment were at first confined to mountain regions where there is a permanent water-supply and natural subsistence, and that gradually they spread along the watercourses and into all the subenvironments. With the increase of population, the building of permanent villages of stone, the beginning or extension of the agriculture of maize, which cereal is a major factor in the distribution and permanency of tribes, the settlement of the Pueblo region went on apace.

It is apparent that in the advanced culture stage of the Pueblos the privations of environment had less restrictive character than in earlier stages. Gradually they attained superiority to the environment which had worked on them to the extent of its capabilities, and this has been the history of the growth of mankind.

Thus the regions least favored, in fact prohibitive to tribes who had not the schooling of experience, became the seed-fields of advanced tribes. Given unfailing springs as a starting point, the waste sand flats of

streams occasionally and temporarily filled with water became corn-fields which yielded bountiful returns to the Indian agriculturist. These regions gave the surplus which is necessary for the building of an advanced civilization and here rather than in the favorable subenvironments arose the true agriculture of cereals, on which basis the civilizations of the world now rest.

The environment determined largely the methods of application of water to land. North of the great ridge which crosses the southern portions of Arizona and New Mexico, forming the watershed of the Gila-Salt River, are found the more primitive methods of irrigation, that is by simple canals diverting water from streams to the nearest land and by warping or spreading by means of slight temporary barriers a fan of water from a point in the stream where the bank and bed of the stream are at a uniform level. South of the ridge which absorbs the cloud moisture and diverts it into the Gila is found a more complicated system in the trunk and lateral canals of great extent employed by the Indians who inhabited this region. Here the rivers lent themselves to irrigation and the agricultural tribes were led to employ the facilities to their betterment.

The somatology and culture of the Pueblo Indians in ancient times are known to have presented a remarkable uniformity, and here may be found an argument for the compelling, panurgic force of the environment. Time and isolation must be considered as concomitant factors in the formation of a Pueblo type under the peculiar transforming character of the environment, which, while it produced uniformity in many respects, may have tended to perpetuate the five language stocks that prevail in the region.

The most obvious effects of Pueblo environment are those connected with irrigation, architecture, arts and religion, and in the last the fullest sway of its causation is shown.

Without doubt the following of these and other lines of inquiry relating to the habits and customs of the Pueblo Indians will be productive of valuable material on this subject, necessarily but sketched in this communication.

WALTER HOUGH.

NATHANIEL SOUTHGATE SHALER.[1]

IN ever-growing measure for over forty years, Nathaniel Southgate Shaler made himself part of our life and gave the service of an intensely active personality to the college and the country.

He had an unusual range of experience in contact with the world of men and work: a boy in a slave-holding community, a young officer of the Union army in the civil war, later the director of a survey in his native state and member of various commissions in the state of his adoption, practised field geologist in many parts of this country, observant traveler abroad, expert in two bureaus of the national government, adviser of mining enterprises in the south and west, writer in many fields, orator and poet on our days of celebration, he thus gained that wide acquaintance with external affairs which made him so invaluable a Harvard man: student at eighteen, lecturer at twenty-three, professor at twenty-seven and dean at fifty.

He was impatient of seclusion in his work, and therefore related himself, but without a trace of self-seeking intrusion, to all phases of university life. Confident and courageous, abounding in initiative, he gave direction to work around him and turned the course of events. Inventive and independent, strikingly individualized, he worked to best advantage as a leader or alone, not as one of two; if other names

[1] Minute adopted by the Faculty of Arts and Sciences of Harvard University.