GEOLOGY OF WYOMING

Introduction

Wyoming affords exceptionally favorable conditions for observations from which the geological history of the earth is determined. First, the relief pattern of the state is one of deeply eroded mountain ranges separated by large basin-like depressions. Secondly, the semi-arid climate which prevails, except in the higher mountains, does not support a covering screen of dense foliage, the presence of which would obscure the rocks. Thirdly, the sedimentary formations are unusually rich in the fossil remains of past life, especially the skeletal remains of vertebrate animals. Fourth, the ancient volcanic activity of the Yellowstone plateau area and associated hot water phenomena are exceptional. This combination of factors offers an unusual opportunity to understand and appreciate geological processes and their results. The past history of the earth as preserved in the rocks demands the acceptance of a lapse of time which can only be measured in hundreds of millions of years.

Wyoming is indebted, in a large measure, to various federal institutional and private agencies for its knowledge of the geology of the state. The pioneer investigations of the Hayden and King Surveys, followed in later years by the United States Geological Survey, laid the foundation of present knowledge. Several of the larger museums and universities of the east have made important contributions to our knowledge of the fossil life of the state. The Geological Survey of Wyoming and the Department of Geology, University of Wyoming, have shared in a small way in the investigations.

The Basement Complex (Pre-Cambrian)

The backbones of several of the larger mountain ranges, notably the Laramie, Medicine Bow, Sierra Madre, Wind River and Bighorn Mountains, are composed of an

ancient complex aggregate of metamorphic (meta = change; morph = form) and igneous (ignis = fire) rocks. These constitute the oldest known rocks and, as all younger rocks were laid down upon them, they are collectively spoken of as the Basement Complex.

The metamorphic rocks of the Basement Complex were originally a succession of sediments, such as sandstones, mudstones and limestones, interbedded with extensive accumulations of lava. This succession has a total aggregate thickness of many thousands of feet. These rocks are known to have been laid down not less than five hundred million years ago and the oldest may have been laid down a billion years ago. The character of these ancient sediments tells us that they were derived from still more ancient rocks and that they were originally formed under conditions very similar to those which prevail upon the earth today. During the lapse of time since the sediments were laid down they have been greatly altered by physical and chemical change. The sandstones have been changed into quartzites, the mudstones into a variety of schists, and the limestones into dolomites and marble. The upturned and truncated edges of the metamorphic derivatives of the ancient sediments and associated lavas are admirably exposed in the Medicine Bow Mountains along the Centennial-Saratoga highway.

Intermixed with the metamorphic rocks of the basement complex are many types of igneous rock which were intruded into the older sediments and lavas as liquid rock-forming material (magma). Repeated intrusions of various kinds of magma gave rise to complex associations of rock types. Granites, syenites, anorthosites, etc. cut and invade the quartzites, schists, dolomites and ancient lavas in great profusion. It is believed that the Basement Complex was a half a billion or more years in the making.

A Great Lost Interval

Following the formation of the Basement Complex there ensued a long period of time during which erosion planed off the then existing mountains and bit deeply

into the Basement Complex, which at that time composed the crust of the earth. Many millions of years must have elapsed to have permitted erosion to plane off all relief and to have left a monotonously flat surface. This period of erosion is one of the great lost intervals in the history of the earth.

Older Sedimentary Rocks (Paleozoic)

Lying (unconformably) upon the deeply eroded surface of the Basement Complex is a thick succession of sandstones, shales and limestones, which were, for the most part, deposited beneath the sea, during the Paleozoic Era. This succession is much thicker and more complete in the northwest portion of the state, where formations deposited during the Cambrian, Ordovician, Devonian, Mississippian, Pennsylvanian and Permian periods are found. These formations gradually thin out and, in part, disappear as they are traced into the southeastern part of the state. The high conspicuous hogbacks, along the flanks of mountain ranges, are made up of these old sediments. The oldest (the Cambrian formations) were deposited beneath a sea which covered much of the North American continent 500 million years ago. The youngest (the Permian formations) were deposited some 300 millions of years later. During this long interval of time the sea advanced and retreated many times, so that the record preserved by the rocks is a very disconnected one.

Near the base of this older succession of sedimentary rocks are found fragments of the oldest known vertebrate animal, a primitive fish.

The Sedimentary Rocks of Intermediate Age (Mesozoic)

Resting (disconformably) upon the older sedimentary rocks is a vast succession of sandstones and shales, having a total thickness of more than 20,000 feet, which were deposited between 200 million and 60 million years ago. For the most part, the rock fragments which make up this succession were derived from a mountainous area which occupied a position a hundred miles or so to the west of the western boundary of the state. Rivers flowing eastward from these mountains

transported vast amounts of sediments and deposited them on broad alluvial flood plains and on shallow-sea deltas. Representative formations of Triassic, Jurassic, and Cretaceous systems were deposited during this time.

The Triassic rocks (Chugwater and Jelm) are made conspicuous by their brilliant red color. These "Red Beds" can be traced for miles along the foothills of the mountain ranges. Interbedded with the red shales are numerous seams of white gypsum, which stand out in strong contrast to the enclosing red rock. Remains of semi-aquatic crocodile-like reptiles have been discovered in these rocks in the vicinity of Lander and elsewhere.

Resting upon the red Triassic rocks is a succession of brown and green colored sandstones and shale (Sundance formation) which was deposited in a shallow sea during part of the Jurassic period. The skeletal remains of giant marine reptiles and the shells of many types of sea animals buried in the rocks speak eloquently of the life which inhabitated the world at this time. Recent discoveries have demonstrated that these rocks contain valuable accumulations of oil in certain localities.

Lying directly above the Jurassic rocks is a relatively thin succession of variously colored shales and sandstones (Morrison formation) which were deposited early in Cretaceous time. This formation is one of the most interesting in the entire rock column, for in it are found the skeletons of the giant dinosaurs. When the bones of these animals were first discovered in Como Bluff in Albany and Carbon counties during the seventies of the last century, they astonished their discoverers and others, and will always remain a source of amazement. Many years of arduous toil and many thousands of dollars have been spent in exhuming and re-constructing these fantastic reptiles. Space excludes adequate description of this fascinating chapter in the geological history of Wyoming. When the vast host of giant land-living reptiles first arrived, Wyoming was a great low-lying floodplain, devoid of marked relief. It was upon this floodplain that these mighty creatures

lived, fought and died. Here brute force reigned supreme and twenty-ton living dreadnaughts clashed in awe-inspiring death struggles.

Resting upon the variegated shales of the Morrison formation is a thick succession of sandstones and shales which were deposited during Upper Cretaceous time. Repeated advances and retreats of the Cretaceous sea left in their wake an alternating sequence of marine and continental formations. The shoreline of the sea advanced from the east toward the west. When the sea retreated the shore line shifted from west toward the east. During the times of maximum flooding most, if not all, of the state was beneath the sea, while during the times of minimum flooding most of the state was exposed. The periodic advances and retreats of the sea can be readily traced in the sediments which were deposited during this period. Rocks laid down on the floor of the sea contain the fossil remains of marine organisms, while, conversely, rocks deposited on flood plains contain the fossil remains of land-living animals and plants.

During the latter part of upper Cretaceous time the sea withdrew from the Rocky Mountain Region for the last time. The marine rocks were then buried under several thousand feet of fresh-water deposits. At the time the fresh-water sediments were being deposited great forests of semi-tropical trees covered much of the state. These forests contained a mixture of medieval and modern floras; elms, oaks, maples and magnolias had made their appearance. Luxurious semi-tropical forests gave rise to extensive deposits of coal. In the Green River Basin area alone the estimated supply of coal within 6,000 feet of the surface is more than six hundred billion tons, the second greatest quantity of coal contained in any single area of continuous coal-bearing rocks in the United States.

The marine rocks of upper Cretaceous age contain many valuable oil producing horizons, while the overlying continental rocks contain extensive reserves of coal. The presence of these energy-producing minerals in the rocks gives them great economic value.

The Birth of the Rocky Mountains (Laramide Revolution)

At the conclusion of Upper Cretaceous time all of the existing rock of the earth's crust, throughout the Rocky Mountain Region, was thrown by mountain-making movements into a succession of folds. The larger upwarped areas formed the mountainous areas and the intervening larger downwarps produced the basins. In many instances the strains produced by folding caused the rocks to break and mountainous masses of rock were shoved over adjacent masses. No part of Wyoming escaped these movements although some areas were effected more intensely than others.

When the mountains began to form their newly uplifted crests were attacked by the forces of erosion and their destruction began. No one knows just how long the mountain-making movements lasted, but we know that the time was measured in hundreds of thousands of years. While we can measure the number of thousands of feet of rock which has been removed from the crest of the mountains, we will probably never know their maximum heights, for they were being reduced by erosion at the same time that they were being elevated.

The Younger Sedimentary Rocks (Cenozoic)

Resting (unconformably) upon all the older rocks is a thick succession of sandstones and shales (Fort Union and and Hanna formations) which were derived from the mountainous areas and deposited in the adjacent basins by rivers. This action, namely, the erosion of the mountains and deposition in the basins, continued until the mountains were virtually buried in their own rock debris. The formations which were laid down during this interval contain numerous coal seams and the fossil skeletal parts of the diminutive ancestors of the present great mammalian class.

Following the deposition of the early Cenozoic (Paleocene) sediments, Wyoming was again subjected to mountain making movements which re-elevated the buried mountains and depressed the filled basins. This action was followed by another prolonged period of erosion. Gradually the gradients of the streams were reduced

and their burden of sand and silt brought from the mountains was deposited as a succession of beds. This period of time (Eocene) also marks the beginning of great outpourings of lava and volcanic ash from active volcanoes, notably in the Yellowstone Plateau-Absaroka Mountain region. Many large fresh-water lakes partially filled the basins. The perfectly preserved fossil fish found in the Green River shale in Lincoln County once lived in one of the larger of these lakes. In the flood plain deposits, which were laid down at this time, are found the early ancestors of many of the modern mammals. The diminutive four-toed horse browsed along the banks of the rivers.

Gradually through the elapse of millions of years the mountains wasted away and the basins filled by the transport of rock debris from the mountains and the downfall of volcanic ash. The Yellowstone plateau and Absaroka Mountains were built up by an alternating sequence of lava flows and ash beds. The filling of the basins was frequently interrupted. Erosion stripped some of the accumulated layers and they were transported down the rivers, to be deposited elsewhere. Finally, after an elapse of some thirty million years the mountains lay buried under flanking sediments. A few resistant remnants, the last vestiges of their former grandeur, remained.

The next to the last chapter in the geological history of Wyoming was characterized by a regional uplift, which rejuvenated the streams and put them to work re-excavating the basins. Gradually the mountains reappeared as the blanketing sediments were stripped from their flanks. Because of their greater resistance to erosion the Basement Complex and older sediments did not succumb as rapidly as the younger sediments.

The Great Ice Age

During the last half million years, great continental ice sheets formed in the more northerly latitudes and gradually pushed into more southerly latitudes. None of these great ice sheets penetrated into Wyoming. However, when the great

ice sheets covered much of North America, extensive ice caps formed on the higher mountain ranges of Wyoming. Valley glaciers fed from the ice caps moved down the existing river valleys to the basin floors. These glaciers sculptured the higher portions of the mountains into alpine peaks and U-shaped valleys, and left numerous morainal deposits scattered along the valley floors and as dams impounding beautiful mountain lakes.

Conclusion

There is open to observation, over much of Wyoming, a great stone album, upon the leaves of which are pictured many events in the past billion years of the earth's history. Here are recorded advances and retreats of the sea, great alluvial flood plains, the birth and destruction of great mountain ranges, invasion of liquid rock-forming material into the earth's own shell, great volcanic outbursts and many other events. Entombed in the rocks is a great wealth of fossils, which speak eloquently of the evolution of life upon the earth. Past life preserved as fossils in the rocks is one of Wyoming's greatest heritages. It is doubtful if any other area of equal size in the world has contributed as much to the knowledge of past life as Wyoming. Every summer season for the past sixty years, numerous groups of scientists representing the larger natural history museums and institutions of higher learning have been searching and excavating to bring to light these buried treasures in order that man can better understand the development of life upon the earth.