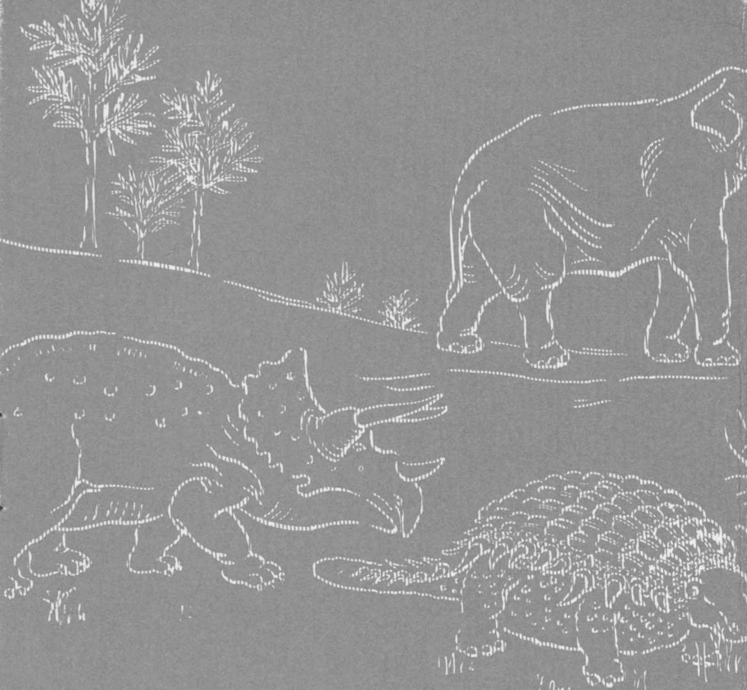
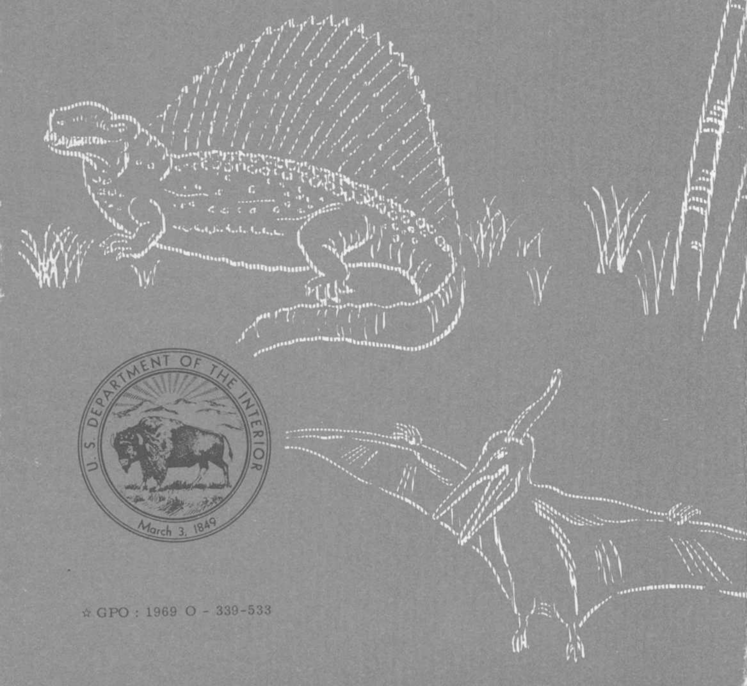


As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities for water, fish, wildlife, mineral, land, park, and recreational resources. Indian and Territorial affairs are other major concerns of America's "Department of Natural Resources."

The Department works to assure the wisest choice in managing all our resources so each will make its full contribution to a better United States—now and in the future.



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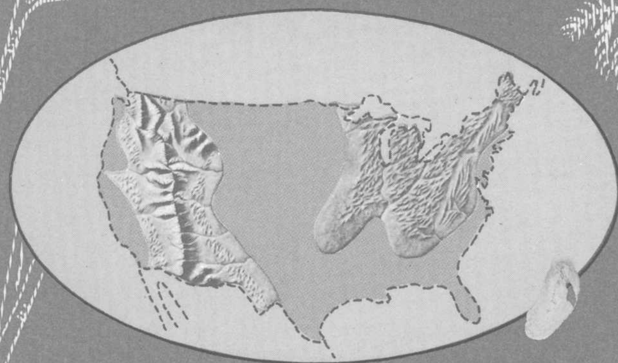
OUR

CHANGING



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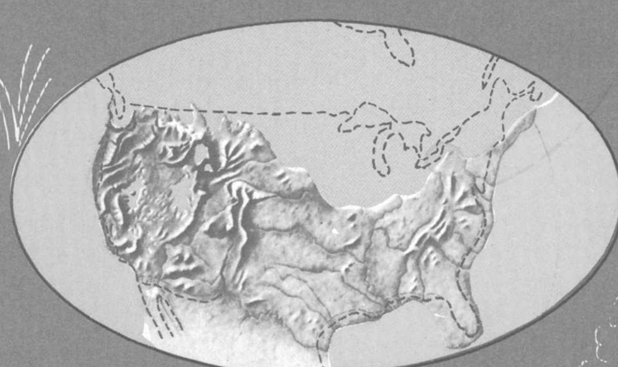


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

OUR CHANGING CONTINENT

Where were the land areas and oceans of the North American Continent one million years ago, compared to our present geography? Was North America always about the same size and shape as it is today?

To answer these questions, we must construct maps of the lands and sea that existed during the past ages. This process of reconstructing ancient geography is called *paleogeography* (from the Greek word "palaios," meaning ancient).

Like a modern day sleuth, the geologist must interpret the clues he finds preserved in the rocks. These clues are of two main kinds; the types of fossils contained in the rocks and the properties of the rocks themselves. When interpreted, these clues can give not only direct knowledge about the distribution of the lands and seas, but also about the natural environment of the area, such as climate, the temperature and salinity of the water, and the downhill direction of slopes on the earth's surface. The last item is very important if we are to infer where the mountains and basins were located in the geologic past.

Fossils as clues. The distribution of fossils (skeletons, shells, leaf impressions, footprints, and dinosaur eggs) in rocks of a certain age tells us about the ancient distribution of lands and seas on the earth's surface. When the remains of coral and clamshells are found in the very old limestones in parts of Pennsylvania and New York, we can deduce that this region was once covered by a shallow sea. Similarly, when the remains of ancestral horses and camels are found in rocks of South Dakota, we can surmise that the area was dry land or that land was near by.

Fossil clam shells of Cretaceous age from north-central Texas

A closer look at these fossils will tell us even more. Not only can the ancient areas of land and sea be identified, but we can also determine the approximate shoreline. Using what we know about living forms, we conclude that thick-shelled animals lived in shallow water close to shore, where their shells were built to withstand the surging and pounding of waves. Thin-shelled, delicate animals probably lived in deeper, calmer water offshore.

In addition to providing a measure of water depth, fossils can also be used to indicate the former temperature of water. In order to survive, certain types of present day coral must live in warm and shallow tropical salt waters, such as in the seas around Florida and the Bahamas. When similar types of coral are found in the ancient limestones, they give us a good estimate of the marine environment that must have existed when they were alive.

All these factors—depth, temperature, currents, salinity—that are revealed by fossils are important, for each detail tends to sharpen and clarify the picture of ancient geography.

Rocks as clues. The properties of the rocks are also important clues, and are used as guides in reconstructing paleogeography. A few examples will show some of the properties of rocks that are used to decipher the past.

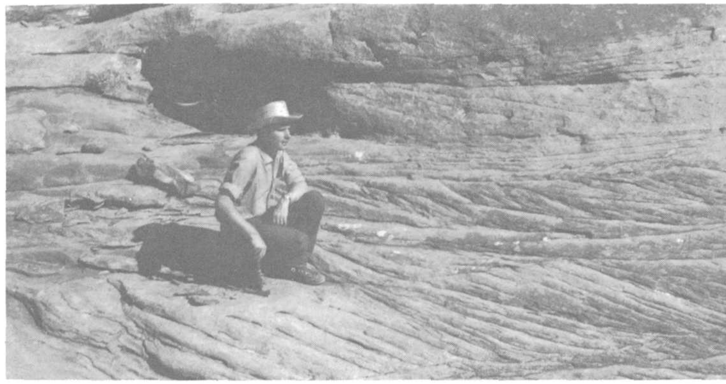
For many years, geologists were mystified about the origin of deposits of boulders crudely mixed with sand, silt, and clay which cover large portions of Europe and North America. Associated with these deposits were large, striated boulders (some as large as a house) and scratched and grooved bedrock surfaces. Some speculated that the deposits originated from debris laid down during the Biblical Flood, whereas others suggested that they were caused by sediment that rained down from melting icebergs.

In 1836 the famous naturalist, Louis Agassiz, spent a summer in the Swiss Alps, where he had an opportunity to examine the glaciers and glacial deposits of the area. From his observations Agassiz became convinced that this blanket of boulders, sand, and clay had been spread across much of Europe by large continental glaciers.

Much of what Louis Agassiz saw could be explained only by glacial action. Because a glacier is a solid mass of ice, it moves very slowly; and, as it moves, it picks up all sizes of debris, ranging from huge boulders to silts and clays. As the ice melts, all the debris is left behind as a layer of poorly sorted material.

From this brief description of glacial deposits, perhaps you can see how geologists piece together a picture of what the earth looked like during a glacial event.

In the same manner, geologists can recognize rocks that were once ancient beach deposits, because most beaches are composed of well-sorted sand. The action of waves along shores of ancient seas washed out the silt and clay and left behind rounded grains of sand, just as we find them today along our shorelines. Offshore, where the bottom waters are calmer, the finer sediment settles as mud. Thus, in a crude way, the size of the sediment grains tells us the direction of slope on the sea floor, because the sandy sediment will be near the shore and the mud will be offshore. This same principle of sorting also applies to ancient rocks; marine sandstones and conglomerates were formed closer

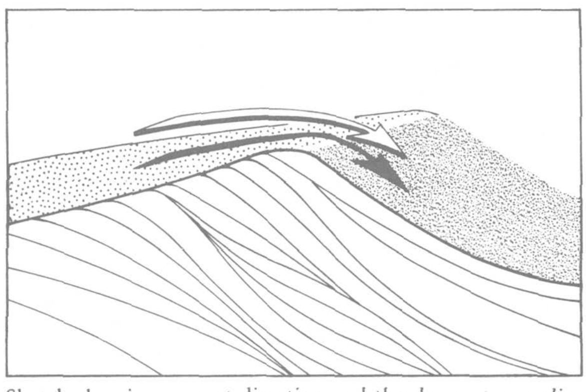


Fluviatile cross-beds in Supai sandstone, Grand Canyon Arizona

to shore than are the more finer-textured marine shales and siltstones.

The same concept of sorting can be used with non-marine formations, such as river and delta deposits, to determine the direction of *paleoslope* (ancient slope). Rivers (like waves) sort the rock debris, leaving the coarser materials near the head of the stream and carrying the finer materials downstream toward the coast.

To provide additional information on the direction of flow of ancient streams, geologists study the arrangement of the layers in stream deposits. A close look at many sandstones, for example show the presence of inclined layers of sand, called *cross beds*. By determining the direction in which the cross beds are inclined, geologists can tell the direction in which water flowed when the sandstone grains were deposited. Even today,



Sketch showing current direction and the down-stream dip of cross beds sands are forming cross beds, particularly in river channels and in shoal areas where ripple-like dunes are formed across the channel. Like dunes in a desert, these dunes slowly move in a downstream direction. The current carries the sand grains up the gentle upstream side of the dunes and deposits them on the more steeply sloping downstream side. The inclined layers of sand are deposited on the front of the dune, and the beds have a downstream (downcurrent) dip. Measurements from a great many cross beds in rocks of the same age that are exposed over a wide area can give a useful pattern of ancient flow direction (paleocurrent). Thus, both sorting and layering of sediments in river deposits can be used to determine the location of ancient highlands and lowlands.

Maps are pictures. To obtain a picture of ancient geography as it existed during a particular interval of geologic time, a geologist plots the distribution of various kinds of rocks for a given geologic age on a map. Then, by noting the location of the delta deposits, the beach deposits, and the stream deposits, he can determine the approximate location of an ancient shoreline that separates land from sea.

We now see how geologists use fossils and the size and sorting of grains and the direction of cross beds in rocks to reconstruct paleogeography. These features are only a few of many, although they are among the most useful. By using these data, geologists are able to reconstruct pictures of the geography of the North American Continent during each of the various periods of geologic time such as the Great Ice Age (Pleistocene Epoch), the Age of Dinosaurs (Cretaceous Period) and the Coal Age (Pennsylvanian Period).

THE GREAT ICE AGE

During the Great Ice Age or Pleistocene Epoch, which began about three million years ago, large portions of Canada and Northern United States were blanketed by the continental ice sheet as shown on the map. Much of the rich soil of the Midwest is glacial in origin, and the drainage patterns of the Ohio River and the Great Lakes were influenced by the ice. The effects of the glaciers can be seen by the stony soil of some areas, the hilly land surfaces dotted with lakes, the scratched and grooved bedrock surfaces, and by the long, low ridges composed of sand and gravel which formed at the front of the ice sheet.

Generalized geographic map of North America in Pleistocene time

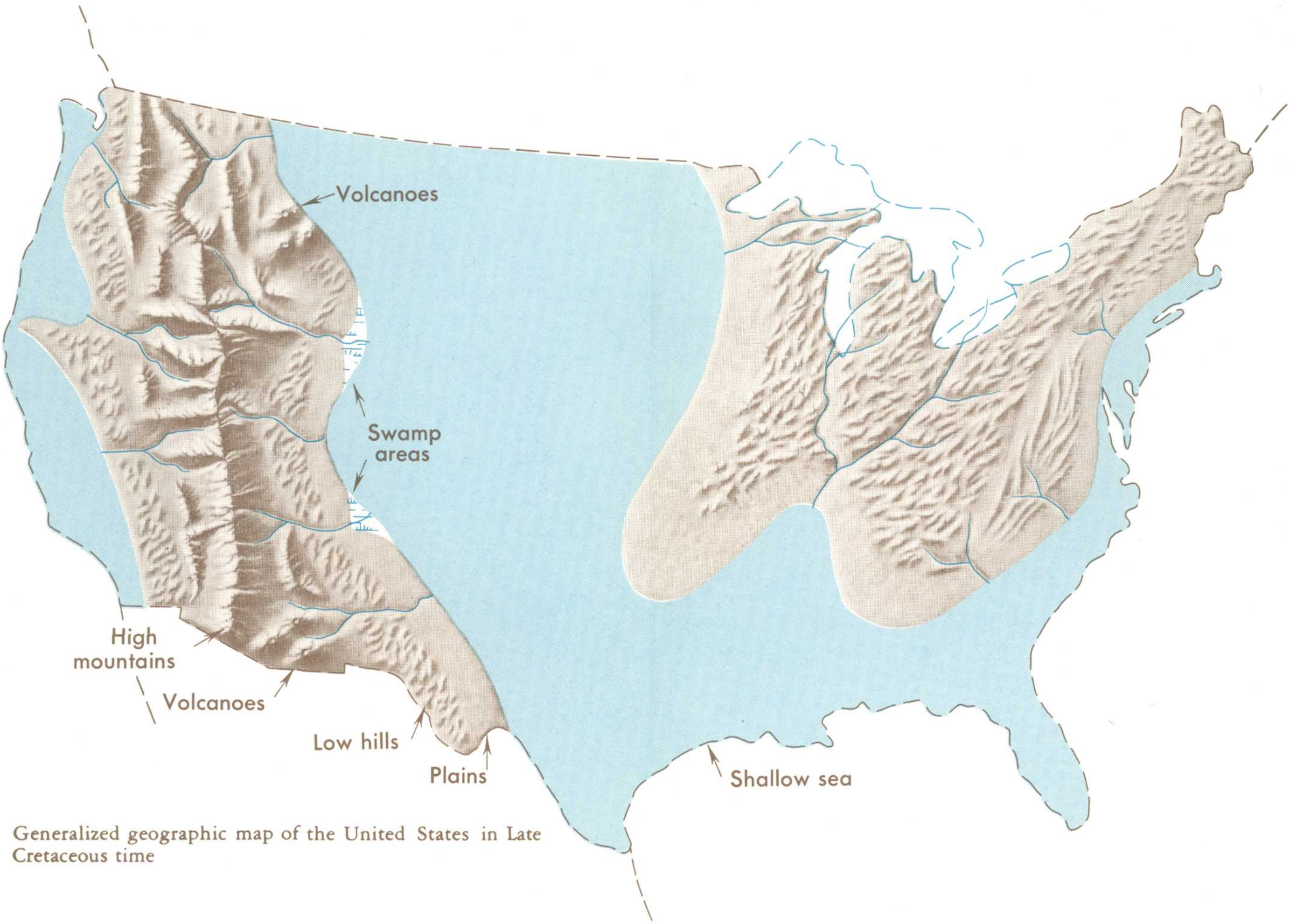
Increased rainfall in the area south of the Continental ice sheet formed large lakes in Utah, Nevada, and California. Remnants of these ancient lakes still exist today, as the Great Salt Lake, Pyramid Lake, Winnemucca, and many others. Ancient shorelines for these old lakes can be found along the sides of mountains, as for example, near Provo, Utah.

The tremendous size of the ice sheet further influenced paleogeography by lowering sea level about 450 feet below the present level; the water contained in the ice and snow came from the oceans. The continental shelves around our continent, as well as the other continents of the world, were above water and, as a result, some states such as Florida were much larger in area than they are today. The presence of shoreline deposits and shells at the edge of the continental shelf, in waters up to 450 feet deep, offers evidence for this marked drop in sea level during the Great Ice Age.

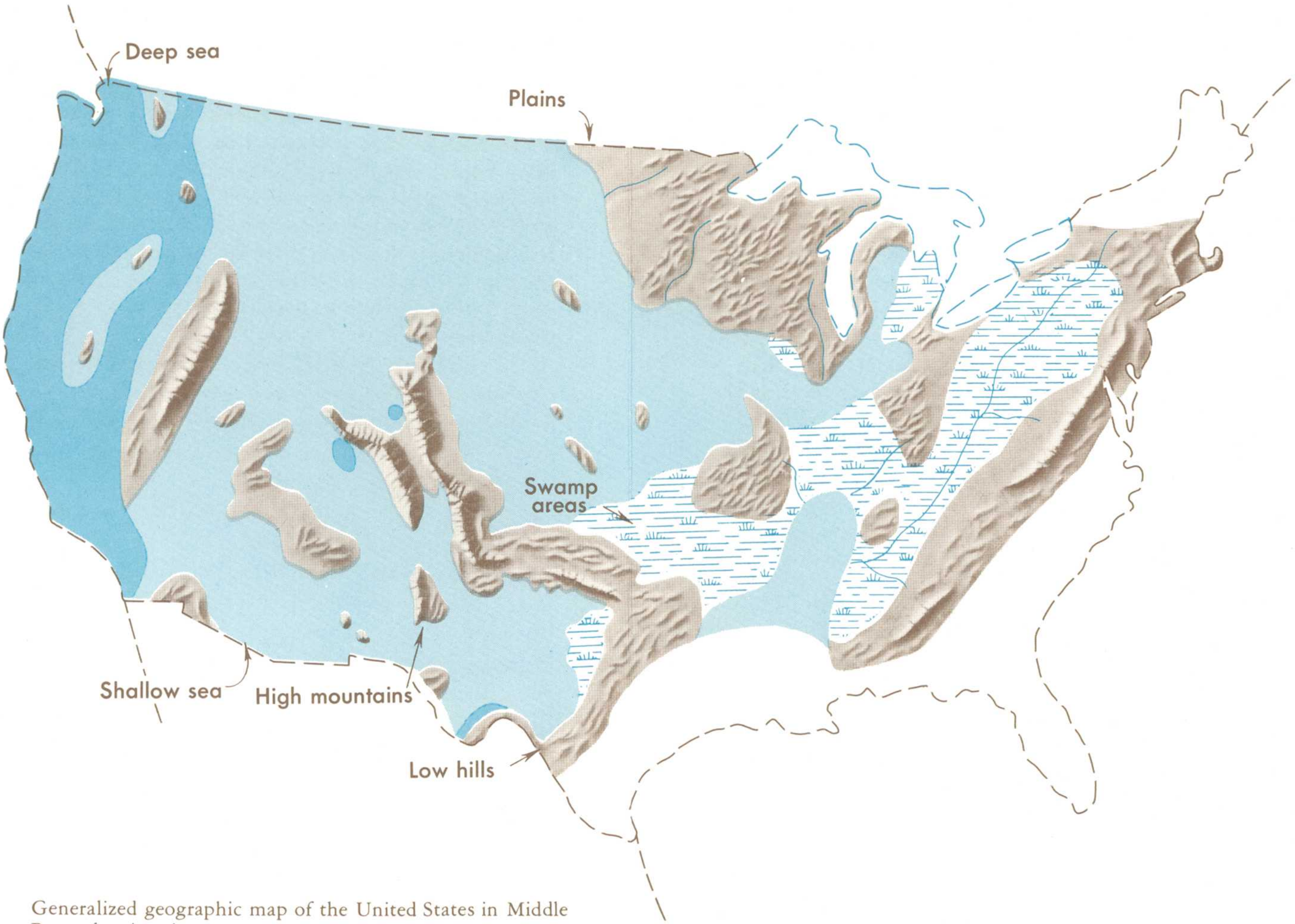
THE AGE OF DINOSAURS

Eighty million years ago, during the Age of Dinosaurs, the geography of North America was very different from that of today. Mountain ranges have changed considerably since this, the Cretaceous Period. The Appalachian Mountains were probably lower and less prominent as a source of sediment than they are today; apparently they supplied appreciable amounts of coarse sediment only in the Southeast (Tennessee, Alabama, Mississippi, and Georgia). The Rocky Mountains, as we know them today, did not exist; instead a giant trough in which marine mud slowly accumulated was situated in this part of the west. Shallow and warm inland seas covered large portions of Southern and Western United States, as shown on the map. Large portions of western California were under water, and in eastern California, Nevada, Arizona, Idaho, eastern Oregon, Washington, and Alberta, a belt of the earth's crust slowly rose to form a new mountain range. Deltas from this vast highland extended eastward into Utah, Wyoming, Colorado, and New Mexico. Still farther to the east, Kansas, Nebraska and adjacent states to the north and south were covered by warm, extensive but shallow seas in which beds of limestone slowly formed.

The Cretaceous Period marked the last extensive covering of the North American continent by the sea. Since then, the continent has gradually emerged to its present size and shape.



Generalized geographic map of the United States in Late Cretaceous time



Generalized geographic map of the United States in Middle Pennsylvanian time

THE COAL AGE

As we move backward in time, from the Great Ice Age, through the Age of Dinosaurs and then to the Coal Age, the contrast in the distribution of land and water from the ancient past to the present becomes more dramatic. The map shows the outline of the United States as it looked during the Pennsylvanian Period some 300 million years ago. It gives the appearance of reversing present-day geography.

A highland which lay to the east, south, and north, supplied much of the sedimentary debris that was spread over the midwestern part of the United States. The Midwest was mainly a low swampy area in which scouring rushes and fern trees grew in profusion.

Sediment was carried into the region from deltas to the east. From time to time, there was a change in sea level—possibly because of glacial conditions in the Southern Hemisphere—and the swamps became flooded and the forests were destroyed. Slowly, layers rich in tree stumps, spores, branches, and leaves were deposited. Later heat and pressure changed these layers into the coal beds that are so extensive in Illinois, Kentucky, Pennsylvania, West Virginia, and Tennessee. To the west, marine limestones, sandstones, and shales accumulated in shallow seas whose vast expanses were dotted with shoals and islands. Some of the very large islands were formed by the buckling and uplifting of parts of the earth's crust.

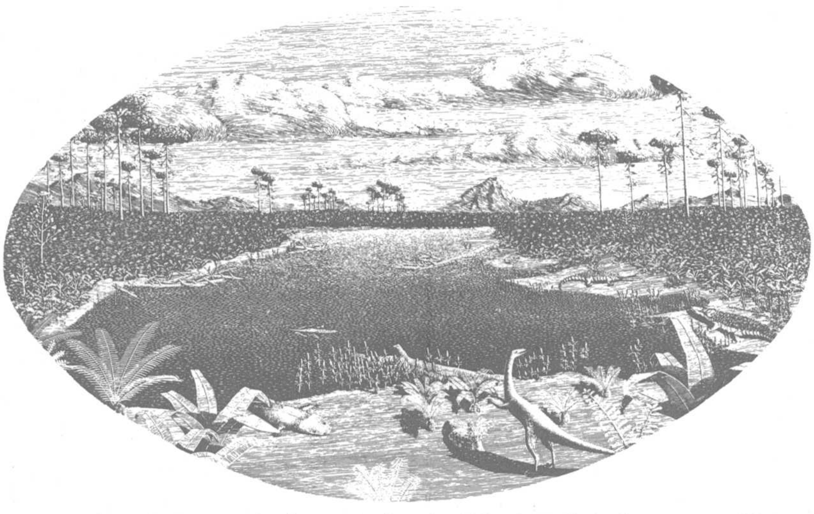
The maps of the Pleistocene Epoch and the Cretaceous and Pennsylvanian Periods give a simplified picture of the changes in the size and shape of the continent. As we probe more deeply into the past, examining older and older rocks, we see that in the earlier periods, the land areas of the North American Continent were much smaller and largely confined to central and northern Canada. In fact, during much of geologic time, large parts of the Continental United States were covered by shallow seas in which lime, mud, and sand accumulated.

From the maps, we can see that mountain ranges have buckled the earth's crust from time to time. Most of these ranges were located along the eastern and western margins of the present continent, and erosion of newly created highlands contributed sediment toward the center of the continent. Eventually, these ranges were worn down (as in the Appalachian region during the Cretaceous Period). However, the process of mountain building continued, either by renewed uplift and erosion of old mountain ranges, such as in the Appalachians, or by building new and youthful mountains, such as those that make up the Coast Range of California.

Thus, the appearance of our continent has been continuously changed by a complicated sequence of mountain building, erosion, and deposition of sediment in slowly sinking troughs, followed by more crustal movement.

These changes are still going on today, although they are so gradual that only occasionally do we become aware of them. One dramatic effect of change is the jolting movement of a portion of the earth's crust during an earthquake. Another is the fire and devastation associated with the building of a volcano. Such spectacular actions by nature to build the continent are combined with the less noticeable processes of erosion and deposition to gradually shape and change the face of the North American Continent and the entire planet throughout geologic time.

Scientists of the Geological Survey, together with all geologists working in the many fields of research, continually add to the fund of information about the earth-its origin, its mineral resources, and the processes that change its crustal features. Studies of the physical and chemical properties of rocks are coupled with studies of the development of life in its myriad forms to provide the data which, when fitted together like jigsaw pieces, lead to an understanding of the successive changes that have occurred on the earth. These concepts, like the maps shown in this leaflet, are imperfect because many fragments of information have yet to be discovered. But as the geologist's knowledge of the earth increases, the pictures become clearer and more meaningful, and gives him the ability to identify, locate, and use the mineral resources needed for our economy.



Reconstruction of a western landscape during the Triassic Period, about 180 million years ago, based on geologic and paleontologic data. (McKee, E. D. and others, 1959, Paleotectonic Maps of the Triassic System: U.S. Geol. Survey Misc. Geol. Inv. Map I-300, frontispiece)