DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 612

GUIDEBOOK
OF THE
WESTERN UNITED STATES

PART B. THE OVERLAND ROUTE

WITH A SIDE TRIP TO YELLOWSTONE PARK

BY

WILLIS T. LEE, RALPH W. STONE, HOYT S. GALE
AND OTHERS

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PRINCIPAL DIVISIONS OF GEOLOGIC TIME.[a]

[A glossary of geologic terms is given on pp. 232-236.]

Era.	Period.	Epoch.	Characteristic life.	Duration, according to various estimates.
				Millions of years.
Cenozoic (recent life).	Quaternary.	Recent. Pleistocene (Great Ice Age).	"Age of man." Animals and plants of modern types.	1 to 5.
	Tertiary.	Pliocene. Miocene. Oligocene. Eocene.	"Age of mammals." Possible first appearance of man. Rise and development of highest orders of plants.	
Mesozoic (intermediate life).	Cretaceous.	([b])	"Age of reptiles." Rise and culmination of huge land reptiles (dinosaurs), of shellfish with complexly partitioned coiled shells (ammonites), and of great flying reptiles. First appearance (in Jurassic) of birds and mammals; of cycads, an order of palmlike plants (in Triassic); and of angiospermous plants, among which are palms and hardwood trees (in Cretaceous).	4 to 10.
	Jurassic.	([b])		
	Triassic.	([b])		
Paleozoic (old life).	Carboniferous.	Permian.	"Age of amphibians." Dominance of club mosses (lycopods) and plants of horsetail and fern types. Primitive flowering plants and earliest cone-bearing trees. Beginnings of backboned land animals (land vertebrates). Insects. Animals with nautilus-like coiled shells (ammonites) and sharks abundant.	17 to 25.
		Pennsylvanian.		
		Mississippian.		
	Devonian.	([b])	"Age of fishes." Shellfish (mollusks) also abundant. Rise of amphibians and land plants.	
	Silurian.	([b])	Shell-forming sea animals dominant, especially those related to the nautilus (cephalopods). Rise and culmination of the marine animals sometimes known as sea lilies (crinoids) and of giant scorpion-like crustaceans (eurypterids). Rise of fishes and of reef-building corals.	
	Ordovician.	([b])	Shell-forming sea animals, especially cephalopods and mollusk-like brachiopods, abundant. Culmination of the buglike marine crustaceans known as trilobites. First trace of insect life.	
	Cambrian.	([b])	Trilobites and brachiopods most characteristic animals. Seaweeds (algæ) abundant. No trace of land animals found.	
Proterozoic (primordial life).	Algonkian.	([b])	First life that has left distinct record. Crustaceans, brachiopods, and seaweeds.	50+.
	Archean.	Crystalline rocks.	No fossils found.	

[a] The geologic record consists mainly of sedimentary beds—beds deposited in water. Over large areas long periods of uplift and erosion intervened between periods of deposition. Every such interruption in deposition in any area produces there what geologists term an unconformity. Many of the time divisions shown above are separated by such unconformities—that is, the dividing lines in the table represent local or widespread uplifts or depressions of the earth's surface.

[b] Epoch names omitted; in less common use than those given.

PREFACE.

By George Otis Smith.

The United States of America comprise an area so vast in extent and so diverse in natural features as well as in characters due to human agency that the American citizen who knows thoroughly his own country must have traveled widely and observed wisely. To "know America first" is a patriotic obligation, but to meet this obligation the railroad traveler needs to have his eyes directed toward the more important or essential things within his field of vision and then to have much that he sees explained by what is unseen in the swift passage of the train. Indeed, many things that attract his attention are inexplicable except as the story of the past is available to enable him to interpret the present. Herein lie the value and the charm of history, whether human or geologic.

The present stimulus given to travel in the home country will encourage many thousands of Americans to study geography at first hand. To make this study most profitable the traveler needs a handbook that will answer the questions that come to his mind so readily along the way. Furthermore, the aim of such a guide should be to stimulate the eye in the selection of the essentials in the scene that so rapidly unfolds itself in the crossing of the continent. In recognition of the opportunity afforded in 1915 to render service of this kind to an unusually large number of American citizens as well as to visitors from other countries, the United States Geological Survey has prepared a series of guidebooks[1] covering four of the older railroad routes west of the Mississippi.

These books are educational in purpose, but the method adopted is to entertain the traveler by making more interesting what he sees from the car window. The plan of the series is to present authoritative information that may enable the reader to realize adequately the scenic and material resources of the region he is traversing, to comprehend correctly the basis of its development, and above all to

[1] Guidebook of the western United States: Part A, Northern Pacific Route, with a side trip to Yellowstone Park (Bulletin 611); Part B, Overland Route, with a side trip to Yellowstone Park (Bulletin 612); Part C, Santa Fe Route, with a side trip to Grand Canyon of the Colorado (Bulletin 613); Part D, Shasta Route and Coast Line (Bulletin 614).

appreciate keenly the real value of the country he looks out upon, not as so many square miles of territory represented on the map in a railroad folder by meaningless spaces, but rather as land—real estate, if you please—varying widely in present appearance because differing largely in its history and characterized by even greater variation in values because possessing diversified natural resources. One region may be such as to afford a livelihood for only a pastoral people; another may present opportunity for intensive agriculture; still another may contain hidden stores of mineral wealth that may attract large industrial development; and taken together these varied resources afford the promise of long-continued prosperity for this or that State.

Items of interest in civic development or references to significant epochs in the record of discovery and settlement may be interspersed with explanations of mountain and valley or statements of geologic history. In a broad way, the story of the West is a unit, and every chapter should be told in order to meet fully the needs of the tourist who aims to understand all that he sees. To such a traveler-reader this series of guidebooks is addressed.

To this interpretation of our own country the United States Geological Survey brings the accumulated data of decades of pioneering investigation, and the present contribution is only one type of return to the public which has supported this scientific work under the Federal Government.

In preparing the description of the country traversed by the Overland Route the geographic and geologic information already published as well as unpublished material in the possession of the Geological Survey has been utilized, but to supplement this material Messrs. Lee, Stone, and Gale made a field examination of the entire route in 1914, Mr. Lee working between Omaha and Ogden, Mr. Stone between Ogden and Yellowstone, and Mr. Gale between Ogden and San Francisco. Information has been furnished by Profs. J. C. Merriam and G. H. Louderback, as well as by others to whom credit is given in the text. Cooperation has been rendered by the United States Reclamation Service and by bureaus of the Department of Agriculture. Railroad officials and other citizens have also generously given their aid, and other members of the Survey have freely cooperated in the work.

For the purpose of furnishing the traveler with a graphic presentation of each part of his route, the accompanying maps, 29 sheets in all, have been prepared, with a degree of accuracy probably never before attained in a guidebook, and their arrangement has been planned to meet the convenience of the reader. The special topographic surveys necessary to complete these maps of the route were made by C. H. Birdseye and J. L. Lewis.

GUIDEBOOK OF THE WESTERN UNITED STATES.

PART B. THE OVERLAND ROUTE, WITH A SIDE TRIP TO YELLOWSTONE PARK.

By WILLIS T. LEE, RALPH W. STONE, HOYT S. GALE, and others.

INTRODUCTION.

The westbound traveler over the Union Pacific Railroad will view in the course of his journey some of the most conspicuous geographic features of the North American Continent. These are shown in the accompanying illustration (Pl. I). The east end of the route lies in the broad, well-watered Mississippi Valley, where an abundance of rainfall is indicated by the numerous branching streams. On leaving Omaha the traveler crosses the Great Plains, which rise gradually to the west and become progressively drier, merging into the relatively barren region formerly called the Great American Desert. This change in character is not very apparent to the traveler, because the railroad follows a valley whose bottom lands in the arid part of the Great Plains are irrigated and do not differ in general appearance from those farther east, where the rainfall supplies sufficient moisture for growing crops. On both sides of this valley in western Nebraska the land is utilized for grazing and for dry farming. The cultivation of the Great Plains by dry farming is rapidly spreading as new methods become more widely understood, and the region can no longer be called a desert. In eastern Wyoming the route is in a belt of grazing country.

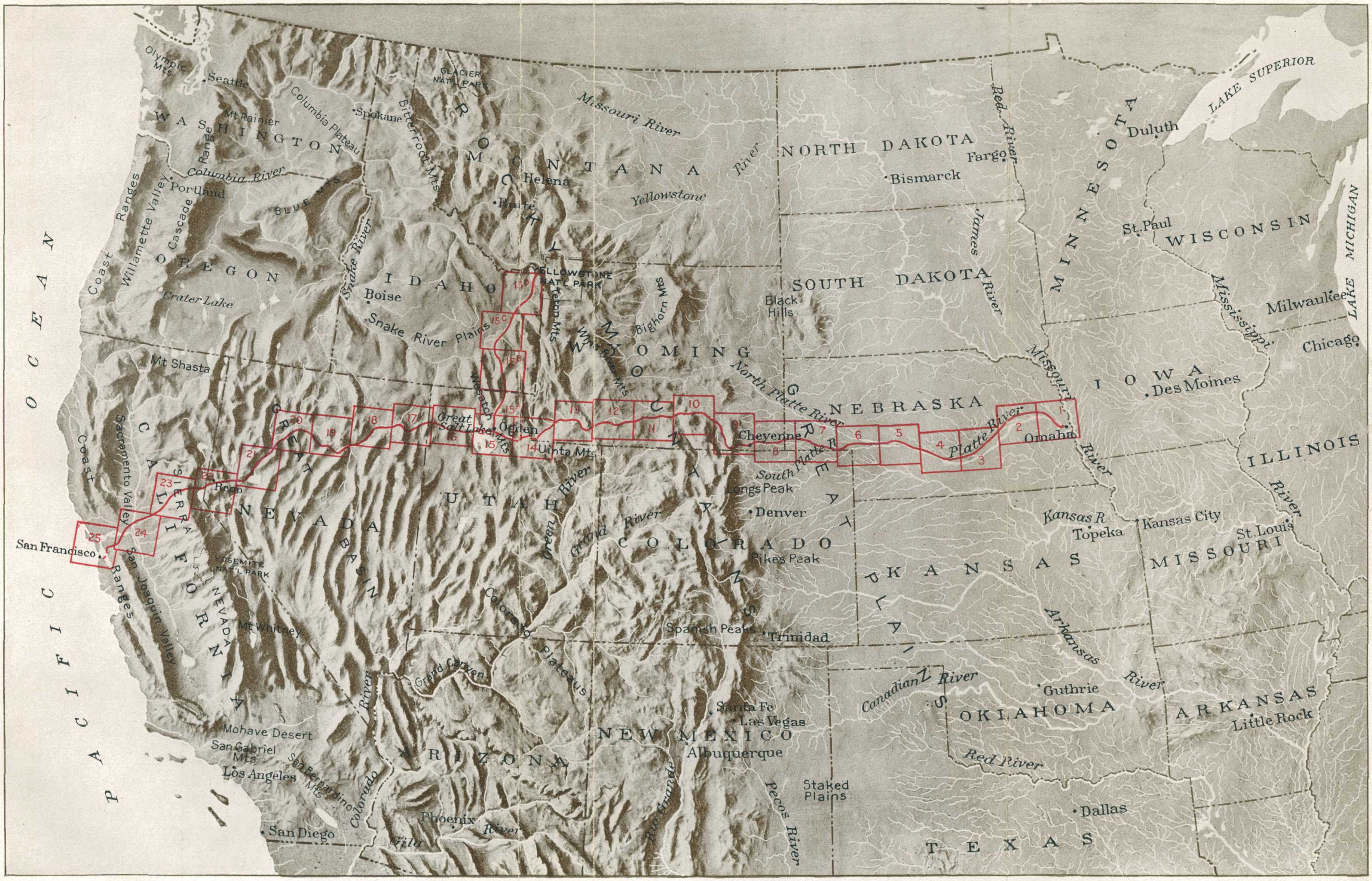
West of the Great Plains lies a general mountainous country, known as the Cordilleran region, which extends westward to the Pacific coast. At Granite Canyon, Wyo., the railroad reaches the eastern margin of the Cordilleran region, marked by a spur of the southern Rocky Mountains—the Laramie Range—and thence westward it winds around detached mountain groups and through the intervening basins. The traveler may not realize that he is in a mountainous region, for most of the lofty mountains of southern Wyoming stand at considerable distances from the railroad. The mountainous part of the route is not well populated. Many of the stations are little more than section houses, and some consist only of a post on which is painted the name, to indicate the location of a sidetrack. This part of Wyoming is used mainly for stock raising, but in the irrigated valleys farther west, in Utah, there are orchards and well-tilled fields.

Soon after entering Utah the traveler crosses the Wasatch Mountains, one of the great ranges of the continent, through the canyon cut by Weber River, and then enters the valley of Great Salt Lake.

Leaving Ogden on the westward journey the traveler is fairly within the Great Basin, one of the major natural divisions or physiographic provinces of the United States, and he will be passing through it for more than 16 hours. The Great Basin is called a desert and as a whole gives an impression of dreariness and desolation, but it has a peculiar interest not possessed by any other part of the transcontinental route. It is one of the most productive mining regions of the world. That it is not all a desert is shown by the fact that large numbers of cattle and sheep are raised within its limits. It is developing, moreover, to an increasing extent in agriculture.

Beyond the Great Basin lies the Sierra Nevada, which on this route marks approximately the boundary between Nevada and California. Through the forest zone of the Sierra the traveler descends into the Great Valley of California and, crossing its broad plains, passes, by way of the one tidal outlet through the Coast Ranges, to the metropolis of the Pacific coast.

NOTE.—For the convenience of the traveler the sheets of the route map in this bulletin are so arranged that he can unfold them one by one and keep each one in view while he is reading the text relating to it. A reference is made in the text to each map at the place where it should be so unfolded. The areas covered by these sheets are indicated on Plate I, and a list of the sheets and the other illustrations is given on pages 237–240. A glossary of geologic terms is given on pages 232–236, and an index of stations on pages 241–244.



RELIEF MAP SHOWING SURFACE FEATURES OF THE WESTERN PART OF THE UNITED STATES.

Areas shown on the sheets of the route map are indicated in red.

ITINERARY.

COUNCIL BLUFFS, IOWA, TO OGDEN, UTAH.

Council Bluffs, Iowa.

Elevation 980 feet.
Population 29,292.

Abraham Lincoln established the eastern terminus [1] of the Union Pacific Railroad on the east side of Missouri River, so that the Overland Route begins at Council Bluffs, Iowa (see sheet 1, p. 18), although the offices, shops, and general terminal facilities of the road are west of the river, at Omaha. Council Bluffs is on the broad flood plain of Missouri River, at the foot of high bluffs

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[1] President Lincoln's Executive order of March 7, 1864, was issued under the law of July 1, 1862, which created the Union Pacific Railroad Co. and which authorized the President of the United States to establish its eastern terminus on the western boundary of Iowa. This required the company to provide for the difficult crossing of Missouri River.

The passage of this law authorizing the building of a road to the Pacific coast was preceded by a long debate. The northwestern region acquired by the Louisiana purchase of 1803 had been explored by Lewis and Clark, whose expedition started in 1804. Their report aroused great interest and stimulated many military, trading, and exploring expeditions, but there was great opposition to the holding of the "western wilderness" in the Union. This was voiced in 1819 in "Universal geography," by Morse, who said: "All settlers who go beyond the Mississippi River will be lost forever to the United States;" and in 1843 by Daniel Webster, who said, in the United States Senate: "What do we want of that vast and worthless area—that region of savages and wild beasts, of deserts, of shifting sands and whirling winds, of dust, of cactus, and prairie dogs? To what use could we ever hope to put those great deserts and those endless mountain ranges? * * * What could we ever do with the western coast, a coast of 3,000 miles, rock-bound, cheerless, and uninviting." Another ingenious argument may be appeciated by transcontinental travelers of the present day. Senator Dickerson, of New Jersey, in opposing the bill providing for the construction of the Union Pacific Railroad, said: "A Member of Congress traveling from his home to Washington and return would cover a distance of 9,200 miles; at the rate of 30 miles per day, and allowing him 45 days for Sundays, 350 days would be consumed, and the Member would have 14 days in Washington before he started home; it would be quicker to come around Cape Horn, or by Bering Strait, Baffin Bay, and Davis Strait to the Atlantic and so to Washington. True, the passage is not yet discovered, except upon the maps, but it will be as soon as Oregon is made a State."

But when California was acquired by the United States, and especially after the discovery of gold, the Pacific coast became of great importance to the citizens of the East, and routes leading to it were carried across what had been a trackless wilderness. The western migration, which received its greatest impetus in the gold rush of 1849, developed some famous trails, one of which, the "Overland Trail," was the forerunner of the Union Pacific and Central Pacific railroads. The convincing arguments in favor of its construction seem to have been military and political rather than commercial. President Lincoln advocated it not only as a military necessity but also as a means of keeping the Pacific coast in the Union. The name Union Pacific probably resulted from the belief that the road would bind the Union together.

composed mainly of a claylike material known as loess. According to tradition these bluffs were used for centuries by the Indians as a common meeting ground; here the several tribes held their pow-wows, smoked their pipes of peace, or declared hostilities, as their inclinations moved them. The name Council Bluffs was originally applied to a locality about 20 miles north of Omaha, where Lewis and Clark held council with the Indians. Later it was transferred to the site of the present city.

The loess[1] north of Council Bluffs lies above loose sand and gravel known as the Aftonian gravels (fig. 1). The outcrop of these gravels is marked by a line of springs, for the underground water passes through them more readily than it passes through the less porous ma-

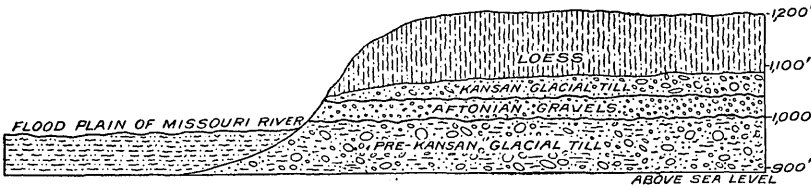

FIGURE 1.—Sketch profile of river bluffs near Omaha, Nebr., showing the Aftonian gravels lying between two beds of glacial till and covered with thick deposits of loess.

terial above and below. From these gravels in some parts of Iowa have been collected the bones of mastodons, camels, and many other animals no longer found in North America.[2] (See Pl. II, p. 10.)

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[1] Loess is a peculiar silt, claylike loam, or fine-grained sand, which strongly resists weathering. The name is supposed to be derived from the German word lösen (to loosen), because of the tendency of the material to split off in vertical columns. In color loess is generally buff or yellowish brown. It covers large areas in North America, where its beds were probably formed after the ice of the glacial period had disappeared. Its mode of origin is not certainly known. Some beds of it consist of material lifted by the wind from the valleys where it had been deposited by streams. Others probably were deposited in water along stream courses or in temporary lakes. In places it contains bones and teeth of animals and shells of snails. If properly watered it makes good soil.

[2] The animals of the Pleistocene (plice′-toe-seen) epoch (see table on p. 2) are interesting because they are nearer to us in time than others of the past and therefore most nearly like some animals now living; yet those that lived in North America during this epoch were very different from those living here to-day. To find the descendants or near relatives of the Pleistocene animals of North America we must go to other continents, for some of them as far away as India. The North American animals were doubtless scattered by the changes in climate that resulted in the advances and retreats of the continental ice sheet during the Great Ice Age.

The fauna, or assemblage of animals, of early Pleistocene time was varied in character. The animals were adapted to the mild climate that then prevailed and remained until after the southward advance of the ice sheet, but were driven away or exterminated before the close of the ice age, and their place was taken by animals such as are now found only in the frozen areas of the North. When the ice melted away and a climate as mild as that of the present day was established, these

The Aftonian gravels separate two glacial deposits known as till, consisting of sandy clay in which are fragments of rock ranging from grains of sand to bowlders 2 feet or more in diameter. These fragments are of limestone, sandstone, quartz, and other rocks, but the largest and most conspicuous are of quartzite and granite, including

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arctic species followed the retreating ice front northward, and their place was taken by animals adapted to life in a temperate climate.

One of the effects of the climatic changes and the resulting migration of animals was a radical change of fauna. Could one of the Pleistocene men return and view the present-day animals they would seem as strange to him as those of an African jungle are to an inhabitant of the Great Plains. Prof. W. B. Scott, in his history of land mammals, says of the Pleistocene fauna:

"It is probable that the Pleistocene fossils already obtained give us a fairly adequate conception of the larger and more conspicuous mammals of the time but no doubt represent very incompletely the small and fragile forms. With all its gaps, however, the record is very impressive. * * * The fossils have been gathered over a very large area, extending from ocean to ocean and from Alaska to Central America. Thus their wide geographical range represents nearly all parts of the continent and gives us information concerning the mammals of the forests as well as of the plains.

"Those divisions of the early and middle Pleistocene which enjoyed milder climatic conditions had an assemblage of mammals, which from one point of view seems very modern, for most of the genera and even many of the species which now inhabit North America date back to that time. From the geographical standpoint, however, this is a very strange fauna, for it contains so many animals now utterly foreign to North America, to find near relatives of which we should have to go to Asia or South America. Some of these animals which now seem so exotic, such as the llamas, camels, and horses, were yet truly indigenous and were derived from a long line of ancestors which dwelt in this continent but are now scattered abroad and are extinct in their original home, while others were migrants that for some unknown reason failed to maintain themselves. Others again are everywhere extinct.

"Most surprising, perhaps, in a North American landscape is the presence of the Proboscidea, of which two very distinct kinds, the mastodons and the true elephants, are found together. Over nearly the whole of the United States and southern Canada, and even with sporadic occurrence in Alaska, ranged the American mastodon (*Mastodon americanus*), which was rare in the plains but very abundant in the forested regions, where it persisted till a very late period and was probably known to the early Indians. This animal, while nearly related to the true elephants, was yet quite different from them in appearance. * * * The tusks were elephant-like, except that in the male there was a single small tusk in the lower jaw, which can not have been visible externally; this is a remnant of an earlier stage of development, when there were two large tusks in the lower as well as the upper jaw. The creature was covered with long, coarse dun-colored hair; such hair has been found with some of the skeletons.

"Of true elephants, the North American Pleistocene had three species. Most interesting of these is the northern or Siberian mammoth (*Elephas primigenius*), a late immigrant from northern Asia, which came in by way of Alaska, where Bering Land (as we may call the raised bed of Bering Sea) connected it with Asia. The mammoth was abundant in Alaska, British Columbia, and all across the northern United States to the Atlantic coast. Hardly any fossil mammal is so well known as this, for the carcasses entombed in the frozen gravels of northern Siberia have preserved every detail of structure. It is thus definitely known blocks of a pink rock known as Sioux quartzite, because the rock mass from which they came is exposed near Sioux Falls, S. Dak. Many of the granite bowlders were carried by the glaciers hundreds of miles, for the nearest native rock of this kind occurs far to the north. (For description of glacial deposits see note on pp. 21–23.)

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that the mammoth was well adapted to a cold climate and was covered with a dense coat of wool beneath an outer coating of long, coarse hair, while the contents of the stomach and the partly masticated food found in the mouth showed that the animal fed upon the same vegetation that occurs in northern Siberia to-day. * * * This is the smallest of the three Pleistocene species—9 feet [high] at the shoulder. The mammoth was not peculiar to Siberia and North America, but extended also into Europe, where it was familiar to paleolithic man, as is attested by the spirited and lifelike carvings and cave paintings of that date. Thus, during some part of the Pleistocene, this species ranged around the entire northern hemisphere."

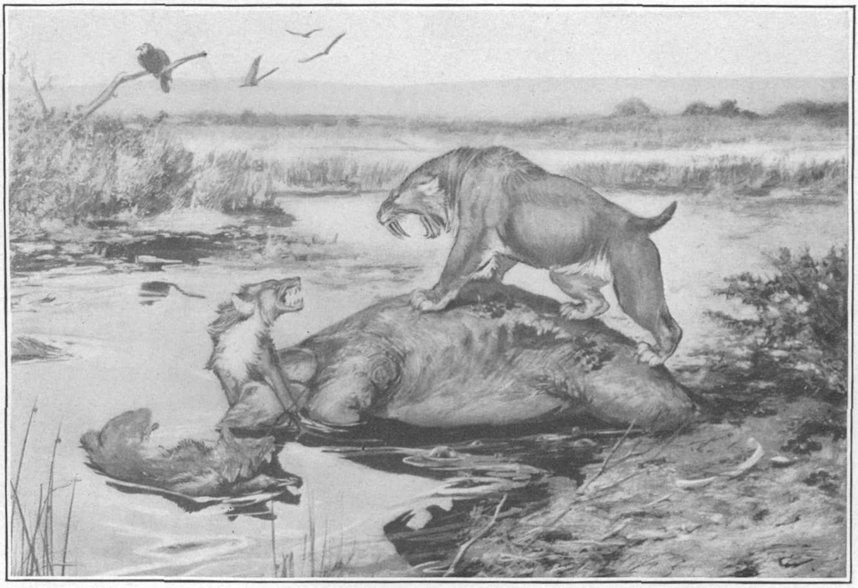
Two notable contemporaries of the mammoth were the Columbian elephant, *Elephas columbi* [Pl. II, *B*], which attained a height of about 11 feet, the size of the largest African elephants, and the imperial elephant, *Elephas imperator*, the largest of the American forms, which attained a height of 13 feet 6 inches.

"This great creature [the imperial elephant] was characterized not only by its enormous stature but also by the proportionately very large size of its grinding teeth and was a survivor from the preceding Pliocene epoch; it is not known to have passed beyond the middle Pleistocene and was thus the first of the species to become extinct. In geographical range the imperial elephant was a western form, extending from the Pacific coast almost to the Mississippi River, east of which it has never been found, and from Nebraska southward to the City of Mexico. The meaning of this distribution is probably that this elephant shunned the forests and was especially adapted to a life on the open plains. * * *

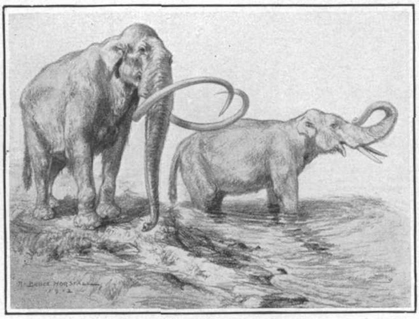
"Many hoofed animals, far more than now inhabit North America, are found in this Pleistocene fauna. The Perissodactyla were represented by horses and tapirs, but not by rhinoceroses; it might seem superfluous to say that there were not rhinoceroses, but, as a matter of fact, that family had a long and varied American history and became extinct only during or at the end of the Pliocene epoch. The horses were extremely numerous, both individually and specifically, and ranged, apparently in great herds, all over Mexico and the United States and even into Alaska. All the known species (at least 10 in number) belong to the genus *Equus*, but the true horse (*Equus caballus*) to which all the domestic breeds are referred, is not represented. The smallest known member of the genus is the pygmy *Equus tau*, of Mexico. [These ranged in size from ponies as large as a Shetland to horses that exceeded in size the heaviest modern draft horses.] * * * The Great Plains must have been fairly covered with enormous herds of horses, the countless bones and teeth of which, entombed in the Sheridan formation, have given to it the name of 'Equus beds.' * * *

"To one who knows nothing of the geological history of North America it would be natural to suppose that the Pleistocene horses must have been immigrants from the Old World which failed to establish themselves permanently here, since they completely disappeared before the discovery of the continent by Europeans. This would, however, be a mistaken inference, for North America was for long ages the chief area of development of the equine family, which may here be traced in almost unbroken continuity from the lower Eocene to the Pliocene. On the other hand, it is quite possible that some of the species were immigrants."

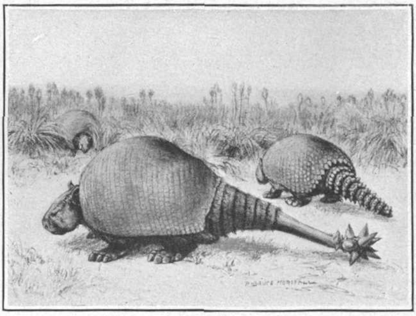
Tapirs, which are now confined to southern Asia, Central America, and South America, were abundant east of the Mississippi but are not known west of that river.



A.

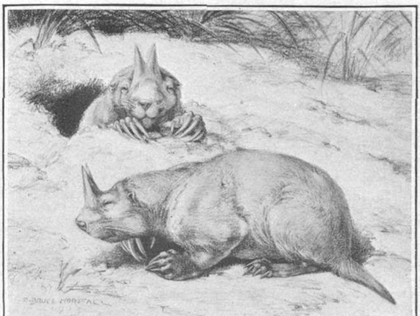


B.



C.

D.

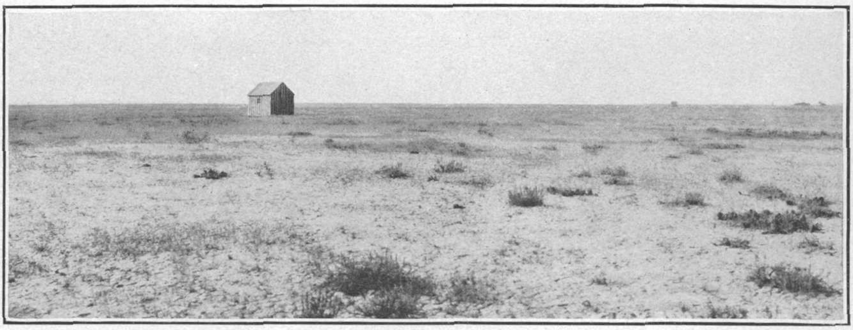


E.

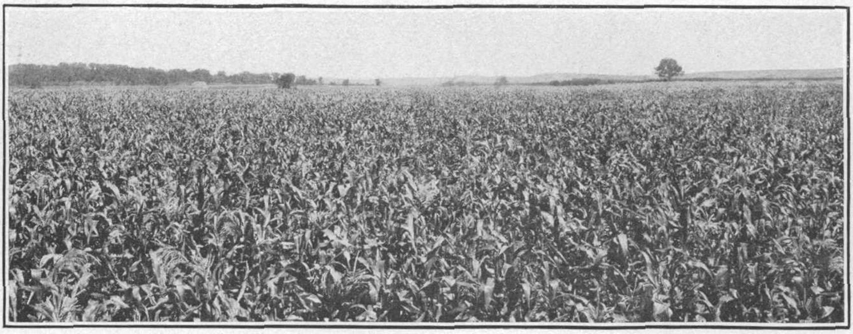
ANIMALS THAT LIVED IN CENTRAL NORTH AMERICA DURING PLIOCENE AND PLEISTOCENE TIME.

A, SABER-TOOTHED TIGER AND GIANT WOLVES ON THE CARCASS OF A PLEISTOCENE ELEPHANT; *B*, PLEISTOCENE ELEPHANTS (ELEPHAS COLUMBI), MUCH LARGER THAN THE MODERN ELEPHANTS; *C*, GLYPTODONTS, PLEISTOCENE ARMADILLO-LIKE ANIMALS (SOUTH AMERICAN FORMS); *D*, PLEISTOCENE MUSK OX, AN ANIMAL AS BIG AS A SMALL COW; *E*, PLIOCENE HORNED GOPHERS, ANIMALS ABOUT THE SIZE OF WOODCHUCKS.

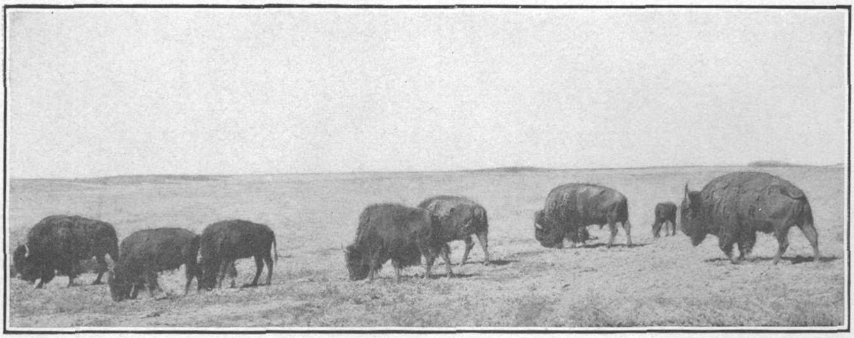
After Scott. Published by permission of The Macmillan Co.



A. FIFTY YEARS AGO.



B. NOW COVERED WITH CORN.



C. WHEN BUFFALO ROAMED OVER THEM.

D. SUPPORTING HERDS OF DOMESTIC CATTLE.

THE PLAINS OF NEBRASKA.

Photographs furnished by Union Pacific Railroad Co.

On leaving Council Bluffs the train gradually rises on a filled incline, about 2 miles long, to the bridge, which is about 60 feet above the ordinary water level of Missouri River. From this incline a good view may be obtained of the broad flood plain over which the river winds in a constantly changing course and upon which at times of flood it deposits the rich loam gathered from the vast areas it drains. The productive fields that present so pleasing an aspect during the growing season and give the appearance of opulence at harvest time are the direct result of this constant activity of the river. But neither these fields nor anything else on the bottom lands can be regarded as permanent, for the great river is continually eating away the plain in some places and building it up in others. This action causes the stream to assume a winding course—that is, to meander in loops and bends that are called oxbows. In this process of shifting its course, when these bends become very sharp the river tends to straighten itself by cutting across the narrow necks, and it thus abandons parts

Missouri River.

Wild hogs, camels, and llamas were abundant. The hoofed animals, such as deer and bison, were numerous, and also the carnivores or flesh eaters. Conspicuous among these were the saber-toothed tigers (see Pl. II, *A*), which were contemporaneous with primitive man and doubtless were his formidable enemies. They have appealed so strongly to the imagination and have been referred to so often in literature that they are among the best known of the extinct animals.

The Pleistocene fauna was not without its grotesque features. Among the most curious animals of the time may be mentioned the ground sloths and the giant armadillos (Pl. II, *C*), of which Prof. Scott says:

"The ground sloths were great, unwieldy herbivorous animals covered with long hair, and in one family there was a close-set armor of pebble-like ossicles in the skin, not visible externally. They walked upon the outer edges of the feet, somewhat as the ant bear uses his fore paws, and must have been very slow moving creatures. Their enormous claws may have served partly as weapons of defense and were doubtless used also to drag down branches of trees and to dig roots and tubers. Apparently, the latest of these curious animals to survive was the very large Megalonyx, which it is interesting to note was first discovered and named by Thomas Jefferson. The animals of this genus were very abundant in the forests east of the Mississippi River and on the Pacific coast, but much less common in the plains region, where they would seem to have been confined to the wooded river valleys. The still more gigantic Megatherium, which had a body as large as that of an elephant and much shorter though more massive legs, was a southern animal and has not been found above South Carolina. Mylodon, smaller and lighter than the preceding genera, would seem to have entered the continent earlier and to have become extinct sooner. It ranged across the continent but was much commoner in the plains region and less so in the forested areas than Megalonyx, being no doubt better adapted to subsisting upon the vegetation of the plains and less dependent upon trees for food.

"The glyptodonts [armadillos, see Pl. II, *C*] were undoubtedly present in the North American Pleistocene, but the remnants which have been collected so far are very fragmentary and quite insufficient to give us a definite conception of the number and variety of them." They were abundant, however, in the South American Pleistocene and hence are well known.

of its former channel, which become bayous, or oxbow lakes. Cutoff Lake, which can be seen to the right,[1] 3 miles north of the bridge, is one of these abandoned oxbows. At the time the river was agreed upon as the boundary between Iowa and Nebraska Cutoff Lake was a part of its channel, but in 1870 it straightened its course, so that the land partly inclosed by Cutoff Lake, although a part of Iowa, now lies west of the river and is almost surrounded by territory belonging to the State of Nebraska. This shifting of the river's course can be prevented to some extent by building levees, or embankments. North of Council Bluffs an embankment has been thrown up and faced with a hard quartz rock (Sioux quartzite) which was shipped for this purpose from Sioux Falls, S. Dak., 160 miles away. The necessity for this protection is obvious, for some of the lowland near Council Bluffs lies below river level.

The building of the bridge [2] was regarded as a notable feat of engineering, and its present importance is indicated by the fact that the traffic of seven railroads passes over it. It spans one of the longest rivers in the world, the Missouri and Mississippi combined, 3,820 miles long. The bridge crosses this great river 669 miles above the junction with the Mississippi, and the drainage from 323,000 square miles, including large parts of Montana, North Dakota, and South Dakota, passes under it. The water surface has a known range of level of 25 feet at this point; the lowest water recorded was in 1867, and the highest in 1881. The discharge at Omaha averages about 50,000 second-feet; that is to say, on the average, 50,000 cubic feet (374,000 gallons) of water passes under the bridge every second.

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[1] The terms right and left as employed throughout this book apply to the westbound journey.

[2] The first bridge built at Council Bluffs was begun by the railroad company in 1869 and completed in 1872 at a cost of $1,750,000. It carried a single track, consisted of 11 spans, each 250 feet long, and was about 60 feet above ordinary flood level, or 50 feet above the highest recorded level. This height served two useful purposes—it brought the track to the level of the bluffs west of the river and allowed boats which were formerly used on the river to pass under it, thus obviating the necessity of a drawbridge. The two eastern spans of this bridge were wrecked by a tornado in 1877, but the bridge was used with temporary repairs until 1886, when it was replaced by the present double-track structure.

The river here during low water is about 900 feet wide. The bridge over the main channel rests on five piers, 250 feet apart, that extend to bedrock at a maximum depth of 76 feet below the level of the flood plain. These were built midway between those of the old bridge. (See diagram on sheet 1, p. 18.) They carry the four main spans, and on each end are three additional deck spans, making the total length of the bridge 1,750 feet. Although the records give no intimation of the kind of rock on which the piers rest, it is supposed to consist of limestone and sandstone of Carboniferous (Pennsylvanian) age, which are known from well borings to underlie the glacial drift in the vicinity of Omaha. These rocks are exposed in the river bluffs near South Omaha but can not be seen from the train.

Although designed to accommodate foot passengers and wagons, the bridge has never been so used. Local traffic passes over the bridge of the Omaha & Council Bluffs Street Railway Co., half a mile farther north, and beyond this is a drawbridge of the Omaha Bridge & Terminal Co., over which pass the trains of the Illinois Central Railroad.

The Missouri is the muddiest river in the Mississippi Valley; it carries more silt than any other large river in the United States except possibly the Rio Grande and the Colorado. For every square mile of country drained it carries downstream 381 tons of dissolved and suspended matter each year. In other words, the river gathers annually from the country that it drains more than 123,000,000 tons of silt and soluble matter, some of which it distributes over the flood plains below to form productive agricultural lands but most of which finds its way at last to the Gulf of Mexico.

It is by means of data of this kind that geologists compute the rate at which the lands are being eroded away. It has been shown that Missouri River is lowering the surface of the land drained by it at the rate of 1 foot in 6,036 years. The surface of the United States as a whole is now being worn down at the rate of 1 foot in 9,120 years. It has been estimated that if this erosive action of the streams of the United States could have been concentrated on the Isthmus of Panama it would have dug in 73 days the canal which has just been completed, after 10 years' work, with the most powerful appliances yet devised by man.

Nebraska.

Nebraska lies mainly in the Great Plains province of the western United States, in altitudes ranging from 842 to 4,849 feet above sea level, and is drained to the Missouri through the Niobrara, the Platte, and many minor streams. The annual rainfall in the State ranges from 13.30 to 31.65 inches and averages 23.84 inches. Dry farming is general and large crops of corn, wheat, and oats are raised. Nebraska claims a greater variety of native grasses than any other State in the Union, their number amounting to more than 200, of which 150 are valuable for forage. In the western part of the State some irrigation is practiced.

Nebraska is primarily an agricultural State and has been called "a State without a mine," but it does contribute to the country's mineral production by some utilization of its clay resources, by a considerable output of sand, gravel, and building stone, and by a practical monopoly of the country's production of volcanic ash, or pumice. The packing industry is large.

The State includes 77,520 square miles and in 1910 had a population of 1,192,214.

Omaha, Nebr.

Elevation, 1,024 feet.
Population, 124,096.[1]

The name Omaha is derived from that of a tribe of Indians that once inhabited this region. The first white settlement was made in 1854, but not until railroad construction began, about 10 years later, did it become a town of importance. Here ground was broken December 1, 1863, for the construction of the road, although little real construction work was done before the spring of 1865; here the first transcontinental train started for San Francisco on September 13, 1870; here occurred on November 1, 1897, "the world's greatest auction," when the Union Pacific, which had cost $115,214,587.79 to construct, was sold for $57,564,932.76; and here are situated the offices, shops, and general terminal facilities of the Union Pacific system.

The station at Omaha is built in a depression eroded in loess (see p. 8), and good exposures of this peculiar material may be seen on the left as the train leaves the station. Thence westward to Elkhorn it lies on either side of the track, through the entire length of the Lane cut-off, which is one of the notable engineering features on the Union Pacific route. Prior to 1908 the trains passed through South Omaha and thence up Papillion Creek to Elkhorn. To avoid this circuitous route a line was built nearly due west from Omaha, cutting to a maximum depth of 85 feet straight through the numerous hills and building across the broad valleys, making, at a cost of $3,000,000, a level roadbed nearly 12 miles long, which shortened the line by about 9 miles.[2]

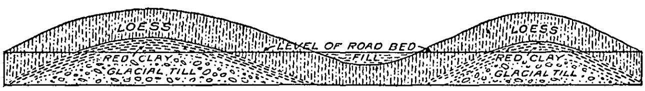

FIGURE 2.—Sketch profile showing relation of loess to underlying beds of clay and glacial till in railroad cuts west of Omaha, Nebr.

The city of Omaha is built on loess, and wherever grading has been done or excavations have been made the characteristic steep walls of this material may be seen. The loess is fine grained, massive, and compact and carries numerous small light-colored limy concretions.

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[1] The figures given for population throughout this book are those of the United States Census for 1910. For unincorporated places the census figures give the population of the election precinct, township, or other similar unit; such figures are marked with an asterisk (*).

[2] The material visible in these cuts is mainly loess and clay. In some places the glacial till under the clay is exposed, but the two can not be distinguished from the train. In nearly all the cuts, however, the division between the loess and the clay is readily discernible. The upper part of the bank in each cut consists of buff-colored loess 30 to 50 feet thick and is rather sharply separated from the lower part, which consists of brick-red clay. A somewhat singular relation may be observed in these cuts. The red material is exposed only in the center of each cut, and its surface in cross section has practically the same outline as the surface at the top. (See fig. 2.) The overlying loess is of nearly the same thickness in all places, as if it were a uniform blanket spread over an older surface that had the same shape as the present surface.

Nearly vertical walls of it have stood practically unchanged for 30 years, and other equally precipitous walls have the appearance of being much older.

The blanket of glacial débris and loess (see fig. 2) overlies limestone and sandstone of Carboniferous age,[1] which have been penetrated by

[1] The only Paleozoic rocks which come to the surface in eastern Nebraska belong to the Carboniferous system, deposited at a time when most of the coal beds in the eastern part of the United States were in process of formation from vegetal deposits. (For types of Carboniferous vegetation see Pl. IV, *C*, p. 20.) They are economically the most important rocks in the State. Most of the building stone, clay, and lime produced in Nebraska come from them. Their relations to other rock formations exposed in eastern Nebraska are shown in the following table:

Geologic column showing relations of rocks exposed in eastern Nebraska.

Age.	Formation.	Character.
Quaternary.	Loess.	
	Kansan drift.	Glacial till.
	Aftonian gravels.	Sand and gravel; locally conglomerate.
	Pre-Kansan or Nebraskan drift.	Glacial till.
Tertiary.		Sand and clay.
Cretaceous.	Niobrara limestone.	Chalky limestone and shale.
	Benton shale.	Blue shale with limestone concretions. (Carlile shale.)
		Hard slaty limestone and blue chalky clay. (Greenhorn limestone.)
		Dark sandy shale. (Graneros shale.)
	Dakota sandstone.	Soft massive yellow sandstone.
Carboniferous.		Limestone, sandstone, and shale of Permian and Pennsylvanian age.

In eastern Nebraska the Carboniferous beds that appear at the surface comprise 200 feet of Permian and 1,200 feet of Pennsylvanian rocks. The lowest series of the Carboniferous, the Mississippian, does not outcrop here. The Pennsylvanian rocks consist of alternating limestones and shales. The rock formations below the Pennsylvanian in eastern Nebraska are of interest because they include certain strata that supply water to artesian wells. Several of these wells drilled in and near Omaha found water at depths of 1,200 to 1,800 feet under pressure sufficient to flow at the surface. The lowest stratum yields the strongest flow.

numerous wells bored for artesian water, but which can not be seen from the train. The Carboniferous period was so named because in many parts of the world its rocks contain an abundance of carbon in the form of coal. In the central and eastern parts of the United States much coal is interlayered with rocks of this age, but only one coal bed has been found in the Carboniferous rocks of Nebraska, and that one is not of much economic value under present conditions. Attempts to mine it have not proved successful.

Elkhorn.

Elevation 1,164 feet.
Population 291.
Omaha 28 miles.

Elkhorn is the first station west of the Lane cut-off and is located on one of the branches of Papillion Creek. East of this station the railroad crosses the eastern margin of the widespread Dakota sandstone, but the rock is so completely covered by glacial drift and loess that in no place can it be seen from the train and, indeed, its exact position is not known.

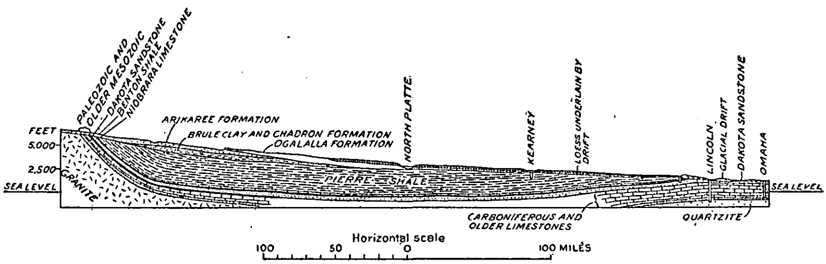

FIGURE 3.—Cross section of the rock formations from the Rocky Mountains to Omaha, Nebr., showing how some of the older rocks that crop out near Omaha extend westward underneath the younger formations and crop out again in the mountains, where all the stratified rocks have been upturned and eroded. (After N. H. Darton.)

Waterloo.

Elevation 1,124 feet.
Population 402.
Omaha 31 miles.

At Waterloo the railroad crosses Elkhorn River, which, unlike most other streams, does not here flow in a valley of its own making but for 25 miles or more meanders over the bottom lands of the Platte.

Between Elkhorn and Waterloo great differences are noticeable both in the character of the surface and in the soil. To the east the surface is diversified by low rolling hills and broad shallow valleys completely mantled with loess. The loess forms a fairly good soil, but its inferiority to the dark-colored loam of the bottom lands is obvious to the most casual observer of the vegetation. West of the hills, in Platte Valley, the surface is flat and unbroken and the soil is more productive. (See Pl. III, p. 11.)

Valley.

Elevation 1,139 feet.
Population 810.
Omaha 35 miles.

Valley is the center of an agricultural district in the rich bottom lands of Platte Valley. Large quantities of garden seeds are grown here. About 35 miles west of Valley the traveler will obtain his first good view of Platte River. The railroad follows this river as far upstream as Julesburg, in northeastern Colorado, a distance of about 350 miles.

Fremont.

Elevation 1,196 feet.
Population 8,718.
Omaha 46 miles.

Although Fremont, the seat of Dodge County, is on the flood plain of Platte Valley, where few exposures of rock can be seen, it stands near the contact of the Dakota sandstone and the overlying Benton shale, a fact determined by observations made both north and south of the valley. The sandstone[1] may be seen in the bluffs at the south end of the wagon bridge south of the city, but the shale is not exposed. These bluffs consist mainly of glacial till mantled by loess.

Fremont is on the main line of the old trail from Missouri River to California and Oregon, which before the Union Pacific was built was known as the Overland Trail.[2] In front of the station stands a rough-

[1] The rocks in eastern Nebraska referred to the Dakota or basal sandstone of the Upper Cretaceous series are about 300 feet thick and consist of sand with clay and local beds of conglomerate. The sandstone was named for Dakota City, S. Dak., where collections were made of fossil plants that were described by Profs. Heer and Lesquereux and later became known as the characteristic Dakota flora, for many years the oldest deciduous-leaved flora known in North America. This flora comprises large and well-preserved leaves of poplars, willows, oaks, alders, birches, beeches, sycamores, persimmons, tulip trees, magnolias, and sassafras and shows that many of the familiar and still dominant types of plants had already been firmly established at this remote time. However, none of the particular species of Dakota plants here discovered are known to have survived in this region beyond the close of the Dakota epoch.

The Dakota is exposed in places in the bluffs of Platte River from Fremont to Plattsmouth. It is one of the greatest water-bearing formations in America. It rises gently toward the west, although covered by younger rocks, and crops out again in the foothills of the Rocky Mountains (see fig. 3), where the surface waters enter it. These waters slowly percolate through its sands for about 450 miles to supply the numerous wells in the Platte Valley and elsewhere. The Dakota sandstone extends 400 miles or more north of the Union Pacific Railroad and an equal distance to the south and underlies the surface of the country from the Rocky Mountains eastward to a maximum distance of 1,000 miles or more. It furnishes excellent water to the citizens of 11 States.

[2] Although four transcontinental railroad routes were surveyed by the Government, the results being published in 11 large volumes, the first line built, the Union Pacific, was explored and located by private enterprise. The Overland Trail seemed to offer the best advantages for railroad construction, inasmuch as it utilized the most feasible passage over the mountains. Gen. Grenville M. Dodge, the chief engineer of the Union Pacific during the period of construction, says of it: "This route was made by the buffalo, next used by the Indians, then by the fur traders, next by the Mormons, and then by the overland immigrants to California and Oregon. It was known as the great Platte Valley route. On this trail, or close to it, were built the Union and Central Pacific railroads to California and the Oregon Short Line branch of the Union Pacific to Oregon." Its history as a definite route seems to have begun in 1804, when Lewis and Clark visited and described the locality that became its eastern terminus. A fur-trading company sent out by John Jacob Astor in 1810, which founded Astoria, Oreg., at the mouth of Columbia River, the following year, returned by a route which had never before been traversed, but which corresponded essentially with that later known as the Oregon Trail. Astor had planned

hewn monument of red granite with the inscription: "This boulder marks the overland emigrant trails through Fremont to Oregon, California, Utah, and Colorado. Erected September 23, 1912, by Lewis-Clark Chapter, Daughters of the American Revolution." Similar monuments have been placed at many other railroad stations on the line of the old trail.

Ames.

Elevation 1,230 feet.
Omaha 53 miles.

From Ames may be seen a gap in the line of bluffs south of Platte River that marks the course of an old valley occupied by the river at an early stage of its development, when its bed was about 100 feet higher than at present. The river then flowed southeastward past Wahoo and thence eastward to the valley which it now occupies south of Waterloo. This old channel is 5 or 6 miles wide and consists of a valley floor covered with loam and sand like the floor of the present valley. Also like the present valley it is bordered along most of its course by steep banks of loess.

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a line of trading posts extending from the Great Lakes to the Pacific, the Sandwich Islands, and China, but the War of 1812 put a stop to this scheme. About 1824 William H. Ashley and Étienne Provost, of the Rocky Mountain Fur Trading Co., discovered South Pass, which made permanent the mountain-crossing route of the Oregon Trail and later attracted the Union Pacific locating parties. Gen. Dodge says further:

"In 1843 the pathfinder, Gen. John C. Frémont, began to spy out the military ways across the West, and the same year the Oregon pioneers took the first wagons westward to the Pacific. The trail that began with the journey of these early pioneers was widened and deepened by the wheels of the Mormons in 1847, and when the herald of the first California Golden Age sent forth a trumpet call in 1849, heard around the world, the trail was finished from Great Salt Lake across the mountains to the sea.

"That era had its great men, for great men make eras. Ben Holladay, William N. Russell, and Edward Creighton gave to the trail the overland stage line, the pony express, and the telegraph.

"Dating the beginning of transcontinental wagon travel from the days of forty-nine, it was 20 years before the railroad reached California. The period was one of great out of door men and women—the last of American pioneers. When the old trail was in full tide of life it was filled with gold seekers from the Missouri to the Pacific; 100,000 travelers passed over it yearly. Towns stirring and turbulent, some now gone from the map and some grown to be cities, flourished as the green bay tree. Omaha, Salt Lake, San Francisco and such lesser places as Julesburg, Cheyenne, Laramie, Carson, Elko, and Virginia City were picturesquely lively.

"The traffic of the old trail was of long wagon trains of immigrants; the great outfits laden with freight for the mines; of Holladay's coaches, six teams in full gallop; of the first riders of the pony express; and of all other manner of moving men and beasts. The protesting savages have no place upon it but, perceiving in it an instrument to alienate their domain, burned its wagon trains and destroyed its stages as opportunity offered. At times great herds of buffalo obliterated great sections of the trail, yet it held its own until the golden spike was driven and passed away as a wagon road only when the need for it had passed. But the railroad lines that took up the burden of stage coach and pony express and ox team have marked the way of the trail upon the map of the West so that it shall endure as long as the West endures."

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

OVERLAND ROUTE

From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

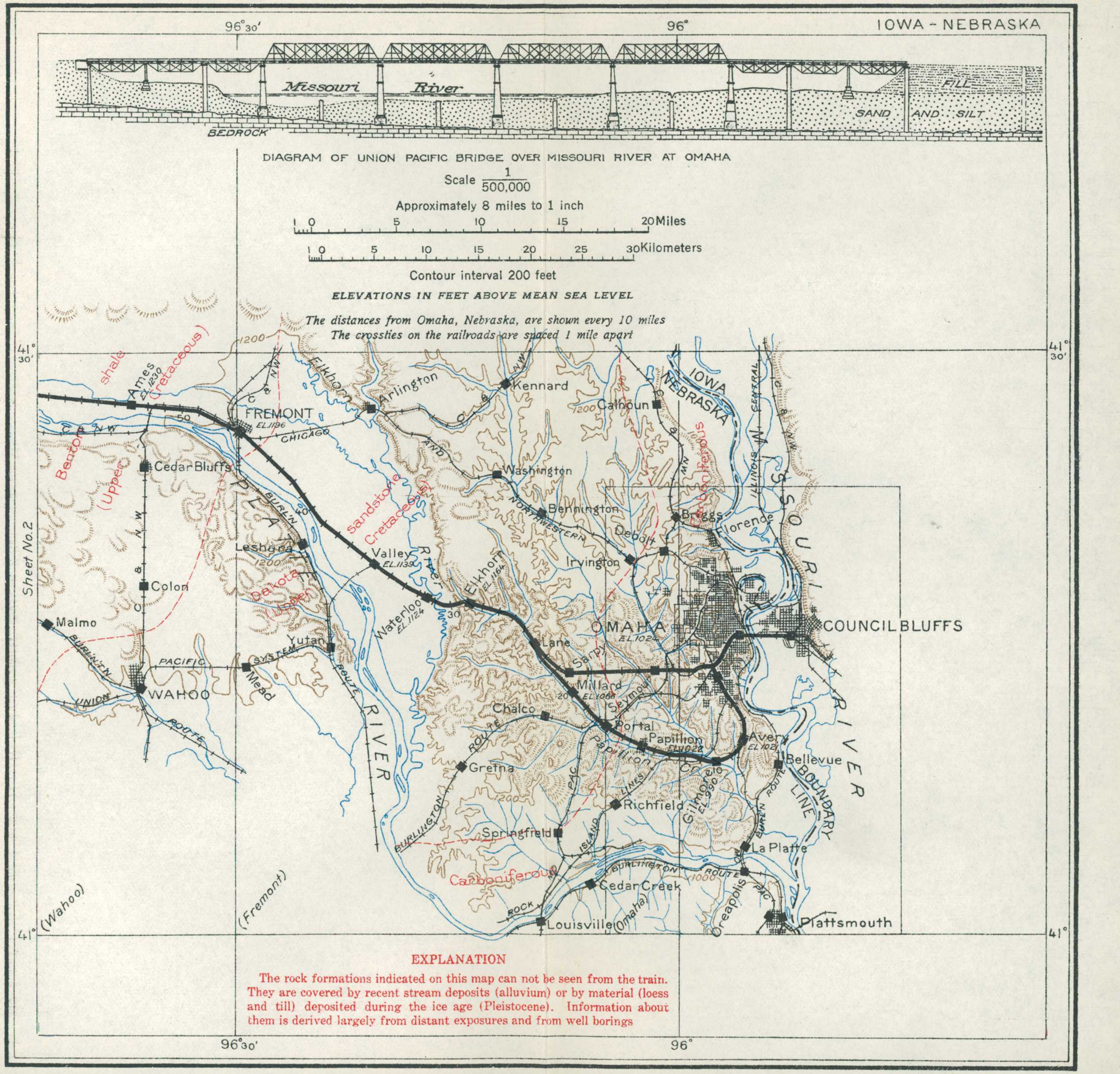
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist   R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.



North Bend.

Elevation 1,274 feet.
Population 1,105.
Omaha 61 miles.

The town of North Bend (see sheet 2, p. 22) takes its name from the northward bend of Platte River at this point, west of which the railroad follows the river in a southwesterly direction for a long distance. South of the river, opposite North Bend, the bluffs are conspicuous, especially west of Morse Bluff, and consist of loess and glacial drift overlying shale of Benton (Cretaceous) age.[1] This shale was formed as a mud deposit at a time when Nebraska was at the bottom of a sea. It contains many fossil shells of extinct species of marine mollusks, such as oysters (see Pl. IV, *A*, *B*, p. 20), clams, and snails, as well as many fossils of types not represented by living forms, such as ammonites and scaphites. It underlies the superficial glacial deposits between Fremont and a point a few miles west of Schuyler.

Schuyler.

Elevation 1,348 feet.
Population 2,152.
Omaha 75 miles.

In the vicinity of Schuyler, the seat of Colfax County, little other than the cultivated fields on the alluvial plain can be seen from the train. The Dakota sandstone, which here lies a little below the surface (see fig. 3, p. 16), is of economic importance because of the artesian water it contains, and this water is held in confinement by the overlying shale. About 6 miles west of the town, between Lambert and Richland, the traveler passes from the Benton shale to the Niobrara limestone,[2] although he would not suspect the change from anything he can see.

The westbound traveler is here passing directly toward the center of the ancient sea in which the sedimentary rocks of Cretaceous age were formed. He has crossed in the order of their deposition or age two formations of the Upper Cretaceous series—the Dakota sandstone and the Benton shale—and now enters upon the third, the Niobrara,

[1] The Benton shale lies conformably on the Dakota sandstone, that is, the beds of the Dakota were not affected by erosion before those of the Benton were laid down upon them. In Nebraska and some other areas a thin limestone (Greenhorn) near the middle of the Benton separates a lower shale (Graneros) from an upper shale (Carlile). The lowest beds crop out near Fremont, where the Dakota passes underneath it not to reappear at the surface again toward the west for a distance of about 450 miles. It is a marine shale representing the first deposits formed after the sea invaded the interior of North America in the Upper Cretaceous epoch.

[2] The Niobrara limestone, so named because of its good exposures on Niobrara River in northeastern Nebraska, appears to extend across the eastern part of the State in a broad band under Tertiary and later deposits. It is exposed for 125 miles along the valley of Republican River, but to the north is seen only in Loup Valley near Genoa until Missouri and Niobrara rivers are reached, in Holt, Knox, Cedar, and Dixon counties, where it can be seen in large exposures. The material is mainly a soft limestone, chalk rock, or limy clay, presenting considerable variation in composition from place to place. The geologic age of this formation is shown in the table presented on p. 15. It is the youngest Cretaceous formation that is exposed near the Union Pacific Railroad in eastern Nebraska.

which differs from the others in that it contains chalk similar to that of the well-known chalk cliffs of England. Some of the deep wells of this region encounter salt water in the shale and chalk rock. This is excluded from the wells by the casing, so that it does not mingle with the fresh water from the underlying Dakota sandstone. Other evidence of the former presence here of sea water are fossil shells of oysters and other animals that live in salt water and the bones of sea monsters such as Mosasaurus. (See Pl. V, *B*, and map on stub of sheet 2, p. 22.)

A comparison of these ancient conditions with those of the present day indicates the slow, continuous change that is now and always has been in progress. Where the tourist now travels comfortably over a dry plain, these monsters sported in the water of the sea long ages ago. On the shores of this ancient sea lived equally strange beasts and birds of types that have long been extinct, and over its water sailed great flying dragons—the pterodactyls. The animals of that day were strikingly different from those of the present. The birds, unlike any now living, had jaws armed with teeth. The monarchs of the air then were not birds but flying reptiles, whose fore limbs had been modified into wings by the enormous elongation of fingers between which stretched thin membranes like the wings of a bat. (See Pl. V, *C*.) These flying dragons, some of which had a stretch of wing of 18 feet, were carnivorous; they were animated engines of destruction that somewhat forcibly suggest the modern war airplanes, of which they were in a sense the prototypes.

Columbus.
Elevation 1,444 feet.
Population 5,014.
Omaha 91 miles.

Columbus, the seat of Platte County, stands in the center of a fertile agricultural district. In 1864 it was a frontier town consisting of a few scattered shacks; but, with total disregard for things as they are and with true western confidence in things as they should be, George Francis Train, one of its citizens, then announced that Columbus was the geographic center of the United States and therefore the proper place for the national capital. Half a century has elapsed, however, and the seat of government is still at Washington.

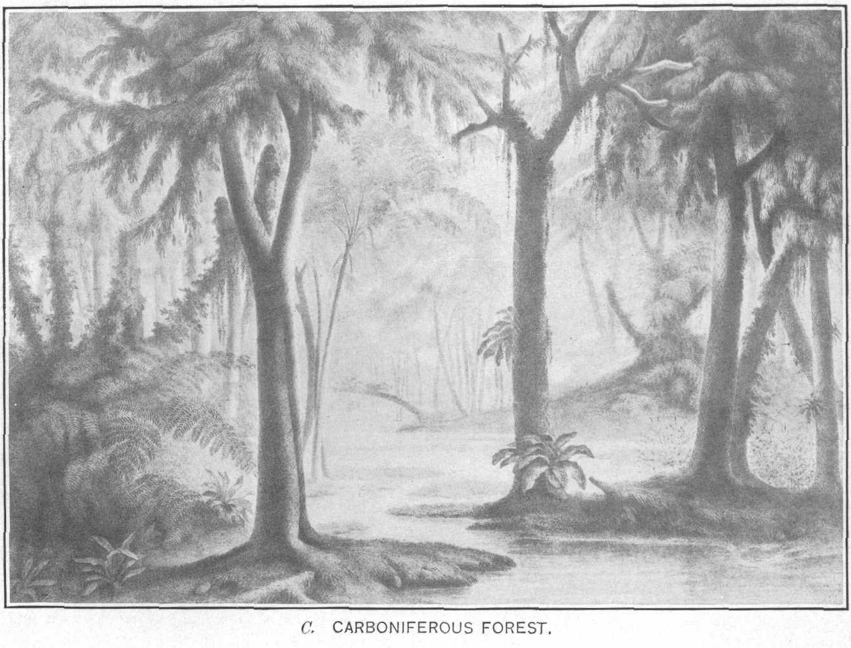
Columbus is on Loup River, or Loup Fork, as it is usually called, near its junction with the Platte. The Loup is a stream of considerable volume and nearly constant flow, draining 13,540 square miles of the sand-hill region of northwestern Nebraska. West of the mouth of the Loup the Platte usually consists of small irregular streams among the sand bars, forming a lacework of small channels, whose pattern changes with every flood. Although the Platte is normally a large river, draining 56,900 square miles and having a maximum discharge near Columbus of 51,000 cubic feet a second, there is little or no water in it above the Loup during the dry season, the water being diverted for irrigation farther upstream.

A.

B.

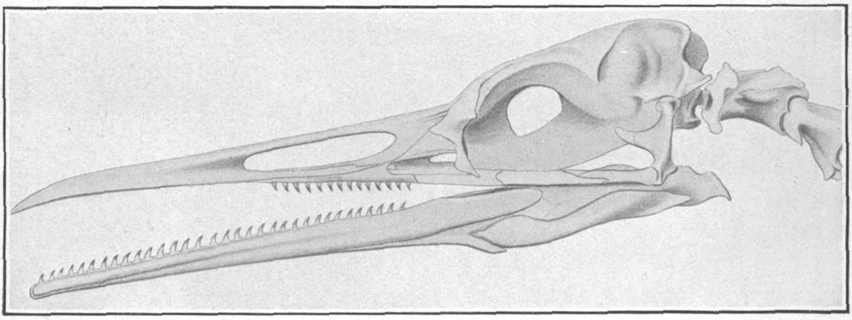
MARINE FOSSILS OF CRETACEOUS AGE.

A, Oysters (Ostrea congesta); *B*, Inoceramus labiatus.



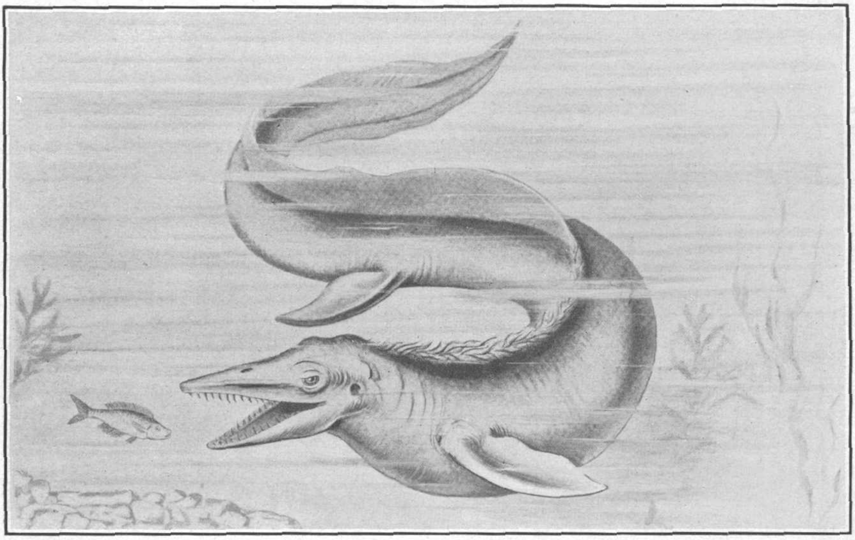
C. CARBONIFEROUS FOREST.

From vegetation of this sort the great deposits of coal were formed.



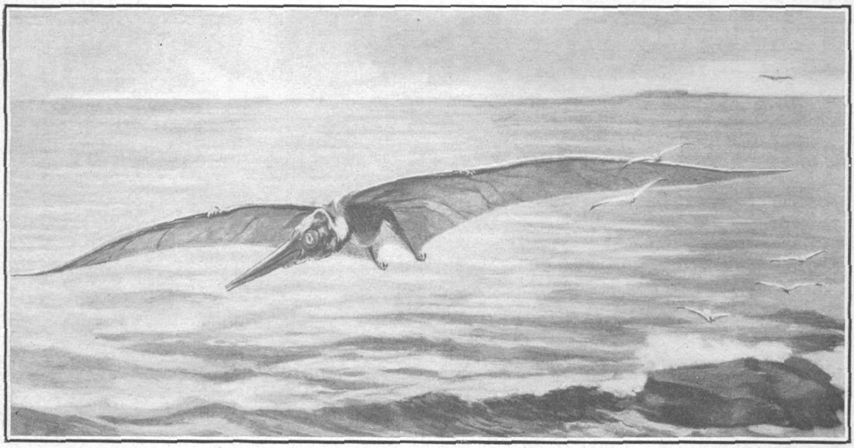
A. SKELETON OF THE HEAD OF HESPERORNIS.

A large diving bird having teeth, which were probably used in catching and holding fish on which it fed.



B. RESTORATION OF A MOSASAUR (TYLOSAURUS).

A sea monster about 30 feet long. (After Hutchinson.)



C. RESTORATION OF A PTERODACTYL (ORNITHOSTOMA).

A flying dragon measuring 18 feet from tip to tip of wings. (After Lucas.)

ANIMALS THAT LIVED IN CENTRAL NORTH AMERICA IN CRETACEOUS TIME.

Here and elsewhere in central and eastern Nebraska large quantities of grain are raised. Much of it, especially the corn, is fed to live stock. Animals raised on the western ranges are shipped here for fattening before they are sent to the market.

In the river bluffs along Platte Valley southeast of Columbus are the westernmost deposits made by the continental glaciers. East of a north-south line passing a little east of Columbus the superficial deposits consist of loess and of glacial till containing bowlders and fragments of rock brought from the north by the glaciers during one of their first southward advances in the Great Ice Age, some features of which are described below by W. C. Alden.[1] These deposits make relatively high rolling plains. West of this line the surface of the

[1] Many of the physical features of eastern Nebraska were produced by sheets of ice that invaded the region during and after the earlier stages of the Great Ice Age. The deposit best exposed, in the street cuts and river bluffs in and near Omaha and along the line of the Union Pacific to the west, is a dustlike clay or loess. Beneath this lies the glacial drift.

Another feature is the great Missouri River, which swings majestically back and forth across its broad valley bottom as it gathers in the waters of the Great Plains on their way to the sea. In late Tertiary time, before the advent of the earliest continental ice sheet, Missouri River as now known was not in existence. The Dakotas were drained to Hudson Bay, and northeastern Nebraska was probably drained southeastward across Iowa. Platte River may have joined Grand River in Missouri. The bedrock east and west of the present lines of bluffs lies relatively low in the Omaha region, so that before the coming of the glaciers there was probably only a valley of moderate size with low slopes instead of bluffs.

The close of Tertiary time and the beginning of Quaternary time was marked in the northern part of the United States by the formation and spreading of vast sheets of ice similar to the great ice cap that now envelops all but the marginal parts of Greenland. From the mild and equable climate of the Tertiary period there was a change, not necessarily sudden or violent—perhaps only the lowering of the average annual temperature a few degrees—so that a large part of the precipitation came in the form of snow, which was not all melted away in the summer. As this snow remained from season to season a vast amount finally accumulated and formed great glaciers. There were three main centers of accumulation and dispersion of this glacial ice, one on the Labrador Peninsula, a second west of Hudson Bay in the district of Keewatin, and a third in the mountains of western Canada. (See fig. 4, p. 22.)

At the opening of the glacial epoch the great Keewatin glacier spread southward and covered large parts of the Dakotas, Minnesota, and Iowa and extended thence into eastern Nebraska, where it was probably several hundred feet thick. The dark-blue clay containing pebbles and small bowlders which is exposed near the base of the river bluffs in South Omaha and near Florence, several miles north of Omaha, is a part of the deposit made by this earliest ice sheet. It is known as pre-Kansan, sub-Aftonian, or Nebraskan glacial till. As the front of the great ice sheet invaded the Dakotas and Nebraska the eastward-flowing streams were blocked and their water was turned southward. This water must have formed a stream somewhere west of Omaha.

This first stage of glaciation was brought to a close by the melting of the ice in a warmer interglacial time or stage—the Aftonian. During this stage the streams of the region swept great quantities of sand and gravel down their valleys. Remnants of these sand and gravel plains is less uneven and slightly lower, and the superficial deposits consist of fragments of rock brought from the Rocky Mountains. These differ from the glacial drift in containing rounded pebbles, none of which bear evidence of glacial origin. They seem to have been brought from the mountains by streams which through long ages were engaged in leveling the Great Plains, much as Platte River is now grading its broad bottom lands, cutting away the higher places and building up the lower ones.

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deposits, deeply weathered and in places cemented to hard conglomerate by lime or iron oxide, overlie the pre-Kansan glacial till at several places in the river bluffs. A remarkable assemblage of animals invaded the region after the ice had disappeared, and the bones and teeth of many of these animals have been found in the Aftonian deposits of western Iowa.

The late Prof. Samuel Calvin identified the remains of horses, camels, stags, elephants, mastodons, mammoths, and sloths. When these animals lived in western Iowa the climate there must have been comparatively mild and vegetation very abundant. Prof. Calvin says: "To supply these great herbivores with food required an abundance of vegetation such as could

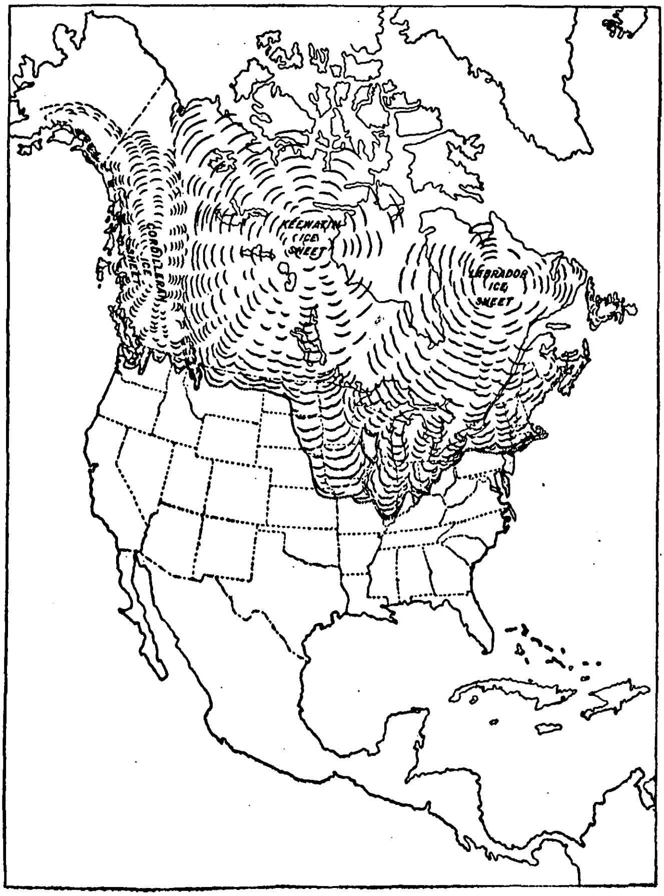
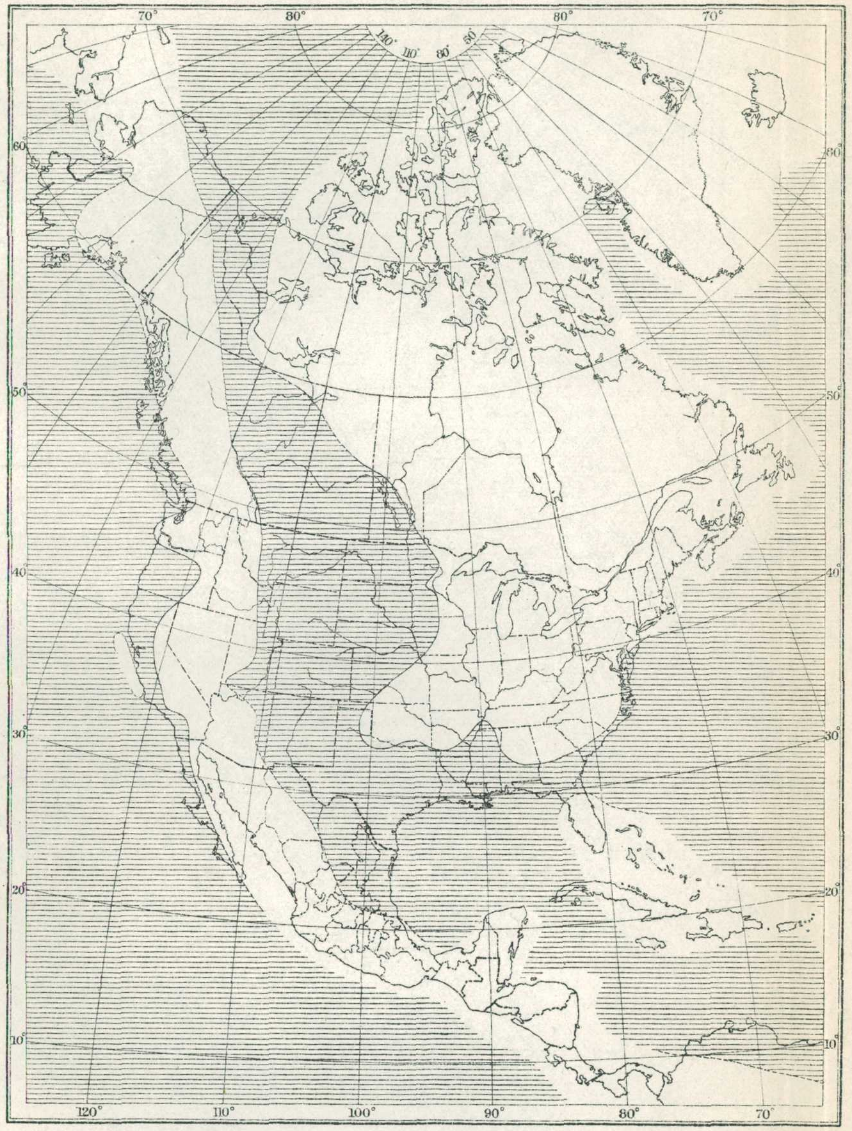
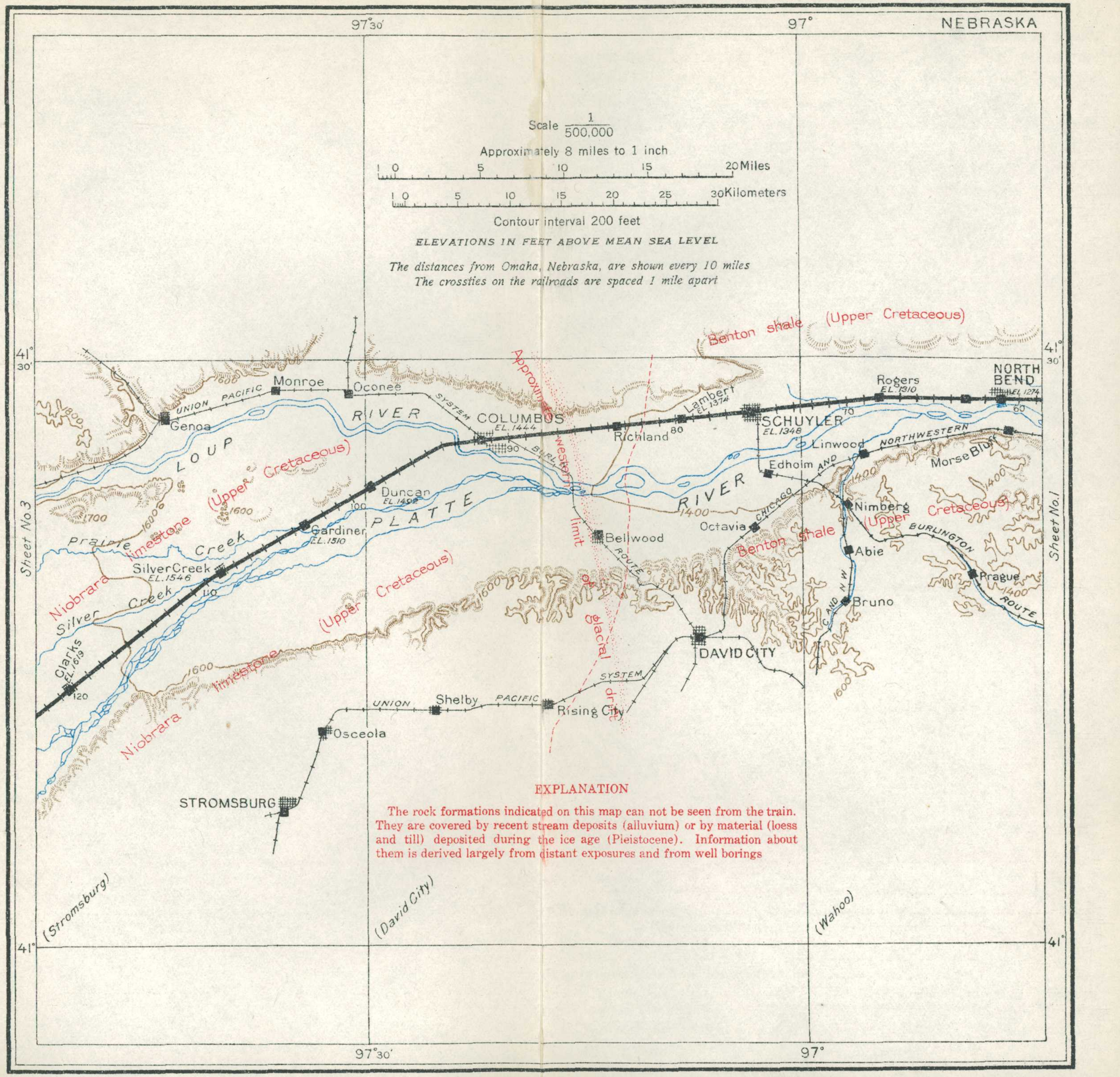


FIGURE 4.—Map of North America showing the area covered by the Pleistocene ice sheet at its maximum extension and the three main centers of ice accumulation.



MAP OF NORTH AMERICA, SHOWING DISTRIBUTION OF LAND AND SEA IN UPPER CRETACEOUS (BENTON) TIME

Area not shaded indicates land, shaded area indicates sea



West of Columbus the railroad is close to Platte River, whose bed is only a few feet below the track level. The flood plain is here 10 to 12 miles wide and is confined between bluffs 100 feet or more in height. It thus lies about 100 feet below the level of the Great Plains, which extend far to the north and to the south. The small towns of Duncan, Gardiner, Silver Creek, Clarks, and Thummel are passed before the next city is reached.

Central City.
Elevation 1,699 feet.
Population 2,428.
Omaha 132 miles.

Near Central City (see sheet 3, p. 26), the traveler passes from the Niobrara limestone, of Cretaceous age, to the formations of Tertiary age.[1] (See table on p. 15.) If the younger Cretaceous formations, the Pierre shale, Fox Hills sandstone, and Laramie formation, were ever deposited here, they were eroded away before the Tertiary beds were laid down. The contact therefore denotes a very long period of time during which the older sedimentary formations were being eroded.

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not be developed until some time after the pre-Kansan ice and all its climatic effects had disappeared from southwestern Iowa."

The character of the shells of the fresh-water and land mollusks found in the Aftonian beds shows that the climate was similar to that of the present time.

After this mild stage the Keewatin glacier again spread southward and invaded the region. The ice reached at this stage its greatest extension in northern Missouri and northeastern Kansas, whence this is known as the Kansan stage of glaciation. As shown on the accompanying map (sheet 2) the western limit of the glacial drift crosses Platte River near Columbus, Nebr. The Kansan glacial drift that was uncovered in the cuts made in South Omaha for the Lane cut-off is bluish-gray clay containing reddish and purplish bowlders of quartzite, popularly known as "Sioux Falls granite," brought by the glacier from the ledges exposed near Sioux Falls, S. Dak. This drift is not now well exposed in these cuts, but it may be seen at a place 1½ miles west of Papillion Creek, where it forms the lower 10 feet of the section exposed. Long exposure after the melting of the Kansan ice has changed the original blue-gray color of the upper part of this drift to rusty red, dissolved out the soluble calcareous ingredients for a depth of 8 feet, and caused many of the granitic pebbles to decay.

After the melting of the Kansan glacier the continental ice sheets did not again reach as far as the line of the Union Pacific Railroad. At the last or Wisconsin stage one lobe of the Keewatin glacier invaded north-central Iowa, extending to Des Moines, nearly as far south as the latitude of Omaha, and another lobe covered the northern and eastern parts of the Dakotas southward to a point about 90 miles north of Omaha, but Nebraska was not again invaded.

An interesting deposit overlying the glacial drift is exposed about 7½ miles north of Omaha and at several places farther west. It consists of volcanic ash which must have accumulated after the melting of the Kansan glacier, at a time when the air was filled with volcanic dust from eruptions, possibly those of the Quaternary volcanoes of northeastern New Mexico.

[1] In marked contrast with the Cretaceous formations, which were laid down in shallow marine water and which are regular in thickness and character over vast areas, the Tertiary deposits of this region are irregular in thickness and character, are nonmarine, and were deposited along streams or in shallow lakes. During the Cretaceous period Nebraska and certain other parts

Grand Island.
Elevation 1,861 feet.
Population 10,326.
Omaha 153 miles.

Grand Island, the seat of Hall County, is a railroad center, a division station of the Union Pacific, where extensive shops are maintained, and a city of considerable commercial importance, having numerous factories and mills. It is in an agricultural district where the raising of sugar beets is one of the principal industries. About 7,000,000 pounds of granulated sugar is produced here every year.

The first known reference to Grand Island is contained in the account of Robert Stuart, an employee of John Jacob Astor, who left Astoria in 1812 and traveled eastward over what was later known as the Oregon Trail. The greater part of this journey was made through a country then wholly unknown. "Le Grande Isle" was the first place he was able to recognize on his way east. Grand Island, a strip of land about 42 miles long, included between two channels of the Platte River, had previously been visited by trappers, most of whom were French Canadians, but white people did not settle here until 1857. In 1866 the Union Pacific was built north of the north channel and the site of the city of Grand Island thus determined.

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of central North America lay beneath the sea, but with the Tertiary period began a new order of things. The sea, which had extended from Iowa to Utah, was expelled by uplift from the interior of North America, and in the midst of the region the sea formerly covered the Rocky Mountains began to rise. It is this change from a quiescent sea to mountainous uplands, with all the disturbances attending it, that marks the division in geologic time between the Cretaceous and the Tertiary period. If at the present time the waters were expelled from the Gulf of Mexico and high mountains raised in their place, the resulting changes in climate, geography, etc., would be less conspicuous than those which marked the change from Cretaceous to Tertiary in the interior of North America.

The earth movements that formed the Rocky Mountains also brought the Great Plains and the intermontane basins above sea level, so that the region now traversed by the Union Pacific from Omaha to the Wasatch Mountains, which had formerly lain under the water of the sea, was changed to dry land and, so far as is known, has never since been covered with sea water. The plains were doubtless very low—not much above sea level at first. Rivers heading in the newly upheaved mountains washed sediment out upon low-lying plains, where it accumulated because the streams were too sluggish to carry it away. This newly emerged land became inhabited by animals, some of which were doubtless developed from ancestors that lived in North America during Cretaceous time, though others immigrated from other continents. The skeletons of these animals were buried in the sands and muds deposited by the streams, and from the fossil remains of their bones the paleontologist is able to determine to some extent their forms, appearance, and habits.

Great changes took place also in the climate, a fact indicated by the character of the plants, a critical study of which shows that although the same general types of vegetation that had flourished throughout the Cretaceous continued into the Tertiary the species were nearly all different.

Grand Island is in the midst of what was formerly known as the great buffalo range. Gen. Dodge says:

When the railroad reached this point, in 1866, buffalo were numerous. In the spring these animals were wont to cross the Platte from the Arkansas and Republican valleys, where they had wintered, to the northern country, returning again, sleek and fat, late in the fall. Gradually their numbers decreased on this range until 1873, when they disappeared. But at Julesburg, 219 miles farther west, a small band was seen to cross the river as late as 1876. In 1860 immense bands were on these plains. On the south side of the Platte, on the old emigrant road, the number was so large that emigrant teams often had to stop while they were crossing the road. At Fort Kearney, on the south side of the river, in 1860, an order was issued by the post commander, forbidding the soldiers to shoot the buffalo on the parade ground.

Some attempts have been made in the region of Grand Island to sink wells to the Dakota sandstone to obtain artesian water. A well put down for the city some years ago penetrated 220 feet of sand, gravel, and clay, consisting of river deposits and probably also of some Tertiary material, and then went through shale to a depth of 935 feet without finding the sandstone. The artesian stratum therefore lies at some greater depth. At Hastings, about 25 miles farther south, a well 1,145 feet deep entered sandstone that may be the Dakota.

Wood River.
Elevation 1,963 feet.
Population 796.
Omaha 169 miles.

On leaving Grand Island the train passes through the middle of the valley, which is here 22 miles wide. From anything the traveler can see from the train he might imagine himself to be passing over a boundless plain, for the bluffs on either side of the valley are too far away to be distinguished. The surface looks level, but as a matter of fact it rises toward the west about 10 feet to the mile. No surface depression, such as the term "valley" might lead one to expect, can be seen. The river flows in many interlacing channels that frequently shift their position.

Over this part of the route there are long stretches of straight track. West of Silver Creek the train runs for 40 miles in a nearly straight line. The roadbed is remarkably smooth and free from dust, being ballasted with Sherman granite. (For description see p. 43.) This part of the route is on the typical Great Plains,[1] which

[1] The Great Plains constitute that part of the continental slope which extends from the Rocky Mountains eastward to the prairies of the Mississippi Valley. Smooth surfaces characterize most of this area, but in some parts of it there are buttes or flat-topped hills and long bluffs or escarpments. In other places there are large areas of bad lands and sand hills.

The origin and development of the Great Plains are difficult to determine. From Omaha westward to the Laramie Range, a distance of more than 500 miles, the surface rises with a regular inclination that is imperceptible to the eye but amounts to more than 5,000 feet. The rocks of this area, aside from the thin Tertiary formations and the superficial rise gradually but regularly from the prairies of Mississippi Valley to the Rocky Mountains.

West of Wood River are Shelton and Gibbon, agricultural and stock-feeding centers. Two small towns, Optic and Buda, are next passed by the train before it enters Kearney.

Kearney.

Elevation 2,146 feet.
Population 6,202.
Omaha 196 miles.

Kearney (see sheet 4, p. 28) takes its name from old Fort Kearney, which stood south of the river, a few miles east of the city, at the junction of the emigrant trail from Kansas City and the Platte Valley trail. It was a center of turbulence during the time of Indian warfare. Here during the construction of the Union Pacific Railroad, according to Gen. Dodge, there were more desperate fights and literally hair-raising adventures than James Fenimore Cooper ever dreamed of, and here Maj. Frank J. North, with his four companies of Pawnee Indians, made history defending the Overland Route against hostile Indians. The Plum Creek, Ogalalla, and Summit Springs campaigns under Maj. North's direction did much to prove conclusively to the Sioux and Cheyenne that he was their absolute master. The same writer says that every mile of the railroad had to be surveyed and built within range of the rifle and under military protection, and much of the success of the enterprise he attributes to the active support of Gen. Grant and Gen. Sherman.

The bottom land, which farther east is about 22 miles wide, here narrows to a width of 6 miles. The river bed is very wide and shallow and the wagon bridge over it south of Kearney is nearly a mile long. Except at times of high water broad stretches of sand in this bed are exposed to the strong northwest winds, which pile it up south of the

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deposits, are of marine origin; they were formed below sea level. Later they were tilted, but without notable warping, through this great distance and beveled by erosion, so that the surface of the plains region extended across the eroded edges of the Cretaceous formations from oldest to youngest. On this surface were later spread out the stream deposits of Tertiary and Quaternary age, and at the extreme east the glacial deposits.

A good illustration of this grading process is furnished by Platte River, which flows in a shallow valley cut slightly below the surface of the plains and has the same gradient or slope as the plains themselves. This gradient is in nice adjustment to the load of sediment that the river carries, so that although during past ages the Platte sometimes cut its channel deeper than it is at present and sometimes built it up, as it seems to be doing now, it has on the whole spent its energy in widening its valley and forming remarkably even bottom lands. If this process goes on long enough the Platte and its neighboring streams will form new Great Plains, slightly lower than the present plains but having essentially the same eastward inclination. On the other hand, should some condition arise whereby the sediment supplied to these rivers would be increased in volume not only might the present valleys be filled with sand, gravel, and clay, but the whole surface of the plains might be built up, the conditions thus supposed to exist simulating the conditions that prevailed in this region during middle and late Tertiary time.

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

OVERLAND ROUTE

From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

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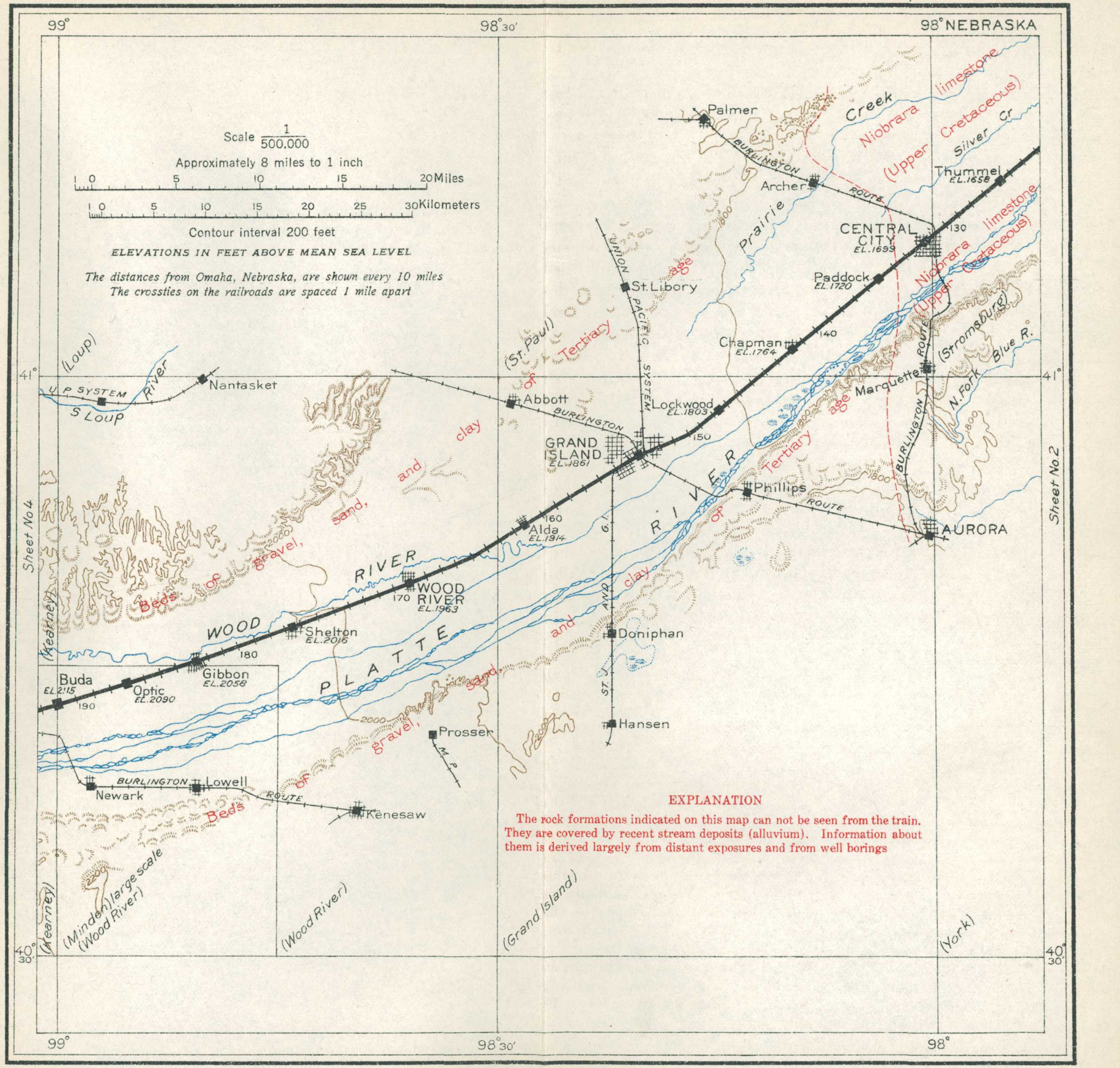

river, destroying much productive land. The sand-dune areas are characterized by irregular, hummocky surfaces, some of the higher mounds rising 100 feet or more above the general surface. The largest bodies of sand extend for 50 miles along the south side of the Platte Valley south and west of Kearney. The width of the wider parts of this sand-dune belt is about 3 miles.

The Overland Route here reaches its southernmost point and turns again toward the north. On leaving Kearney the traveler may see the buildings of the State Normal School on the lowland north of the road and an industrial school on the highlands.

West of Kearney the bluffs, consisting of loess overlying rocks of late Tertiary age,[1] are about a mile from the railroad.

Could the traveler restore the landscape of late Tertiary time, he would find himself surrounded by scenes greatly different from those of the present. The swampy lowlands were covered with vegetation similar to that now growing in moist climates farther south. He would recognize few of the animals, for there were camels, mastodons, rhinoceroses, saber-tooth tigers, and other strange beasts, some like those living now only in far-distant lands. (See Pl. VI., p. 40.) There were numerous horses, but none of them were like the horses of to-day. In place of the one hoof or modified toe on each foot which the modern horse possesses, his Pliocene ancestor had three.[2]

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[1] A large part of the central Great Plains is covered, according to N. H. Darton, by deposits of Miocene and Pliocene age, underlain to the west and northwest by formations of the White River group, of Oligocene age. All these formations lie mainly on the Pierre shale but overlap other formations to a greater or less extent. The average thickness is 200 to 300 feet in eastern Colorado and western Kansas but increases to nearly 1,000 feet in parts of western Nebraska and southeastern Wyoming. Probably the entire region was originally covered by later Tertiary deposits that extended far up the flanks of the Rocky Mountains, the Bighorn Mountains, and the Black Hills, as indicated by the occurrence of outliers at high altitudes.

[2] The Pliocene of western North America is not well known, but along Snake Creek in western Nebraska there are some deposits referable to this epoch, and from fossils found in them and in rocks of the same age in other parts of the country a considerable number of the animals that lived on the Great Plains during Pliocene time are known. Though these animals form an assemblage very different from that of to-day, they much more closely resemble the living animals than those of former ages. Camels and llamas were abundant (see Pl. VI, p. 40) and great ground sloths and glyptodonts (see Pl. II, *C*, p. 10), whose relatives now live in South America, inhabited western Nebraska during Pliocene time. Mastodons with tusks on both the upper and the lower jaws, much like those of the Miocene epoch, still persisted. Short-legged rhinoceroses remained abundant, and there was a great variety of wolf-like carnivora. Saber-toothed tigers and true cats, some of them considerably larger than the modern tigers, were also abundant. Three-toed horses were still numerous, but the modern genus Equus was not among them. One of the most curious animals of the time in Kansas and Nebraska was a gopher-like rodent that had two large horns on its nose. (See Pl. II, *E*, p. 10.) Its enormous claws indicate good burrowing powers, and its horns also may have been used in digging.

After passing the relatively small towns of Odessa, Elm Creek, Overton, and Josselyn, the train reaches the city of Lexington, formerly known as Plum Creek. This was once noted as a favorite locality for depredations by the Southern Cheyenne Indians under Chief Turkey Leg, who captured and burned a freight train here in 1867. It is now more famous for its irrigation system. Farther east the farmers depend on the rainfall to water their crops, but from this point westward the river waters are diverted through large ditches and distributed over the cultivated land.

Lexington.

Elevation 2,387 feet.
Population 2,059.
Omaha 231 miles.

The next station is Darr, beyond which is Cozad, named after a Cincinnati capitalist who purchased a 40,000-acre tract of land and laid out the town on it. The village of Willow Island takes its name from one of the so-called islands included between old channels of the river that are now occupied by water only during floods. It now consists of only a few houses, but has the distinction of being the point from which in 1872 Col. W. F. Cody ("Buffalo Bill") started with Alexis, Grand Duke of Russia, Gen. Custer, Gen. Sheridan, and others for a buffalo hunt over the prairies.

Cozad.

Elevation 2,485 feet.
Population 1,096.
Omaha 245 miles.

Willow Island.

Elevation 2,520 feet.
Population 530.
Omaha 250 miles.

Just before entering Gothenburg the train crosses a large irrigation canal, and farther west such canals are seen in many places. The bottom lands are devoted to the cultivation of crops, and the higher land or general surface of the Great Plains, at considerable distances both north and south of the road, is used largely for grazing. Here, as at almost every other town along the railroad, may be seen elevators, tall buildings used for storing grain.

Gothenburg.

Elevation 2,561 feet.
Population 1,730.
Omaha 255 miles.

West of the town is a prominent ridge of sand hills, which the road skirts for many miles. Their barren aspect is in strong contrast with the appearance of the productive bottom lands. This is a part of the great sand-hill district which covers nearly a fourth of Nebraska. The sand is probably derived by disintegration from the Tertiary beds and was heaped into hills by the wind at a time when the surface was not well protected by vegetation. The movement of the sand is checked by the spread of vegetation, especially the bunch grass that grew here generally before the advent of the white man. Where this protecting cover has been destroyed for any reason, such as overstocking, and the sand is exposed, movement begins again and dunes and blow-outs are produced by the winds.

South of the river, about 5 miles from the railroad but plainly visible from the train, are steep slopes and bluffs rising abruptly to a plain that lies 200 feet or more above the bottom lands. There is a notable contrast between the lands along the river and these bluffs, which parallel the railroad for many miles. The slope is notched

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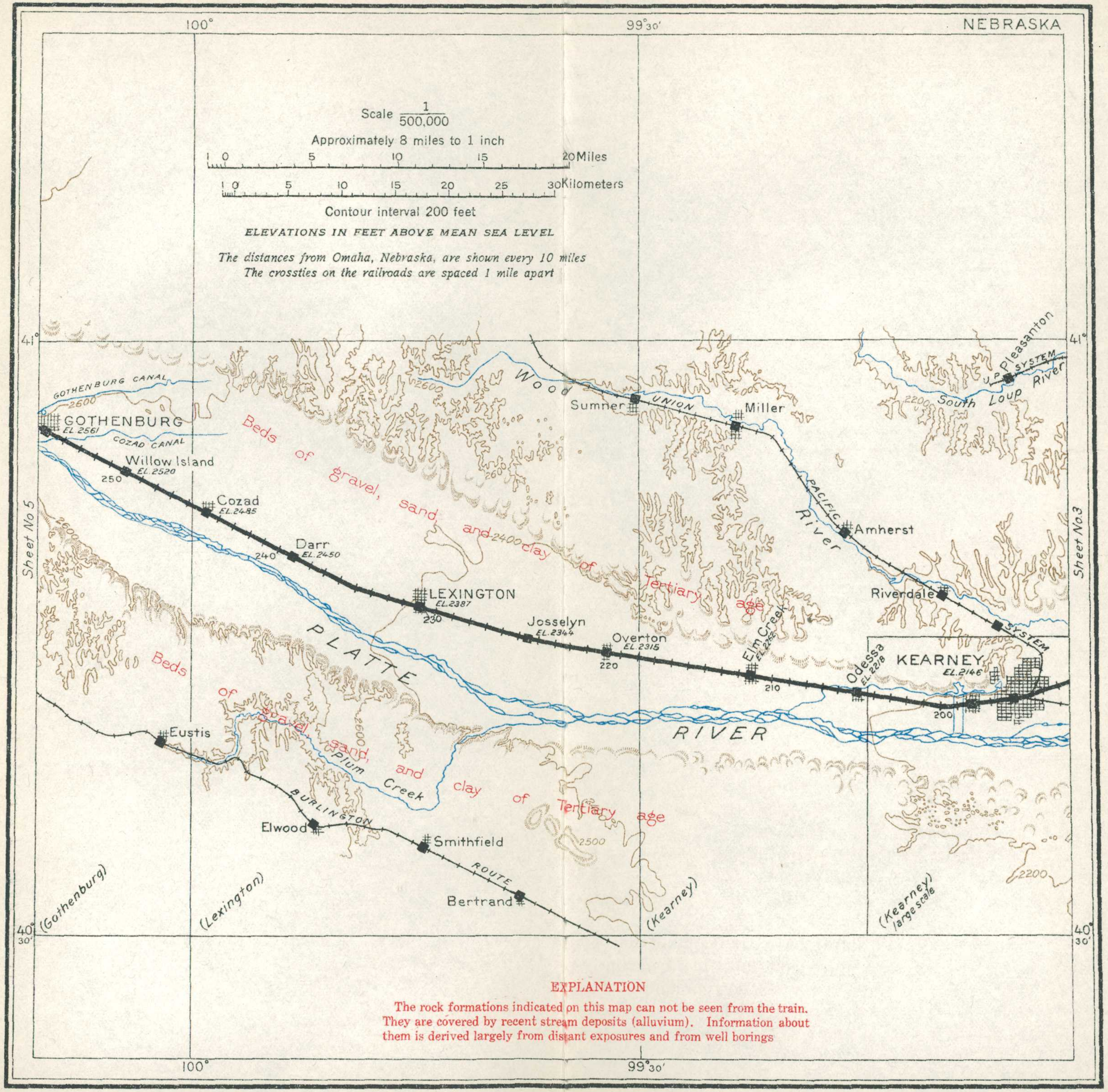

deeply by canyons with precipitous walls of loess nearly 200 feet thick, which is overlain by sand and gravel containing pebbles of rock brought by the streams in past ages from the Rocky Mountains.

West of Gothenburg the train passes Vroman, Brady Island, Hindrey, Maxwell, Keith, and Gannett before entering North Platte.

North Platte.

Elevation 2,800 feet.
Population 4,793.
Omaha 291 miles.

The city of North Platte (see sheet 5, p. 30), the seat of Lincoln County and the chief commercial center of western Nebraska, stands at the junction of North Platte and South Platte rivers. It is in the middle of an irrigation district, where sugar beets, hay, and other farm products are raised. About 1,000,000 tons of hay is shipped annually from this town to the mountain markets. Here are a United States land office and a station of the United States Weather Bureau, and 4 miles south of the city there is a State experimental farm.

North Platte is a railroad division point. Here the railroad maintains extensive shops and an icing plant, said to be one of the largest in the United States, where more than 10,000 cars of fruit and other edibles are iced annually. The plant may be seen to the left by the westbound traveler as he leaves the station. At this station the change is made from central time to mountain time, one hour earlier.

Just before entering the city the train crosses North Platte River, which generally carries a considerable volume of water. The South Platte is dry except during times of floods, because its water is used for irrigation farther upstream. The North Platte is 650 miles long and drains about 28,500 square miles. At North Platte it has a maximum discharge of about 20,000 cubic feet a second and a minimum discharge of 70 cubic feet a second. Its average volume of flow during the nine months from March to November is 3,490 cubic feet a second.

Southeast of the city are prominent bluffs of loess, rising abruptly 400 feet above the bottom lands. The loess is about 350 feet thick and lies on the "mortar beds" described on page 30.

West of North Platte there are many small towns and stations concerning which no information need be given except that shown on the accompanying maps. Many of the stations in Wyoming consist only of section houses, and some are nothing more than signposts.

Hershey.

Elevation 2,901 feet.
Population 332.
Omaha 303 miles.

Beyond North Platte the valley widens considerably, being the double valley of the two rivers, and the train passes for several miles through an irrigated district, in the center of which stands Hershey. The fields in the bottom lands are called farms, but similar fields on the highlands are called ranches. This district is in the transition zone between the East, where each plot of rural ground is a farm, and the West, where each plot other than a town lot, regardless of size or uses, is a ranch. Although the term "ranch" is too dear to the heart of the western man to be easily replaced by the more homely term, the tendency in intensive development under irrigation is to speak of "farms."

Near Sutherland, between the rivers, about 6 miles west of Hershey, begins a narrow ridge which toward the west gradually develops into a broad table-land. From Dexter to Ogalalla the South Platte and the railroad are close to the bluffs bordering this table-land. This stretch of the river bed is dry most of the year, all the water being used for irrigation farther upstream.

Here and at other places where the bluffs come close to the river many travelers in the days of the Overland Trail suffered from attacks by Indians and white outlaws, who would swoop down unexpectedly from their hiding places in the hills to murder and plunder. It is difficult for the modern traveler surrounded by the luxuries of the railway train to realize the hardships and dangers endured by the men and women of indomitable courage and energy who under such conditions invaded and finally conquered the West.

Beyond Dexter the train passes the station called Paxton before reaching the town of Ogalalla.

Ogalalla.
Elevation 3,211 feet.
Population 643.
Omaha 341 miles.

Ogalalla (see sheet 6, p. 34) is a name used by the Brule Sioux, a powerful and warlike tribe which under Chief Spotted Tail is said to have included 10,000 warriors. About 25 miles northwest of the town is Ash Hollow, where Gen. Harney defeated these Indians in 1859. In the early days of the Union Pacific Railroad Ogalalla was notorious for its lawlessness and for the pranks of cowboys. It was the point to which great herds of Texas cattle were driven across Oklahoma, Kansas, and Colorado, to be loaded on the cars for shipment to the eastern markets.

The town lies between the river channel and the rocky bluffs, which are well exposed for several miles to the east. Although the river bed is dry most of the year water can always be found in the sand just below the surface. This supply has been utilized for irrigation at Ogalalla by means of an underflow channel or underground drain into which the water finds its way, to emerge farther downstream upon the lands to be irrigated. The bluffs consist of beds of sand and gravel cemented together in some places into a relatively hard rock, locally known as "mortar beds." This name is expressive of the appearance and character of the rock, which resembles masses of sand and pebbles mixed with mortar. In these rocks are found fossil bones and teeth of extinct mammals. The rocks constitute the Ogalalla formation.[1]

[1] The Ogalalla formation consists mainly of sand and gravel, cemented in some places by carbonate of lime into a resistant conglomerate. It crops out along the Union Pacific Railroad as far west as Pine Bluff and occurs in large areas in western Kansas and Nebraska and eastern Colorado. This formation is widely distrib-

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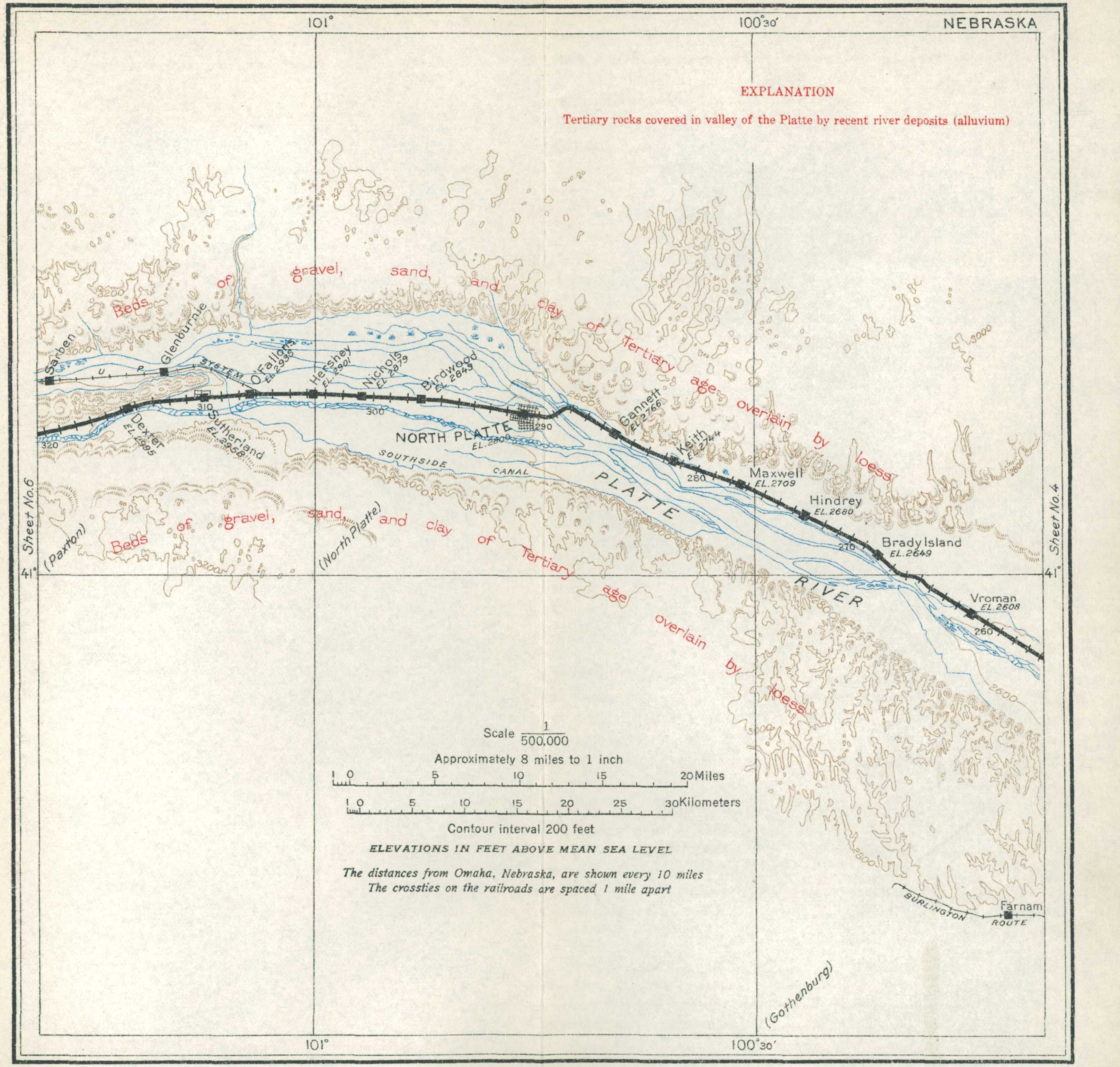

The village of Brule is named for the Brule Sioux Indians, who once inhabited this region. The French word brulé, which means burnt, seems to have been applied by the early French Canadian trappers to these Indians because of the burnt appearance of their painted faces. Also, for some reason not now known, the Indians called themselves "The Burned Thighs."

Brule.

Elevation 3,286 feet.
Population 410.
Omaha 352 miles.

Four miles west of the town is California Hill, where the original California trail left the South Platte and crossed the low table-land to North Platte River. Until 1860 the emigrants went up this river around the north end of the Laramie Mountains and over the Continental Divide at South Pass. But when the United States soldiers were called east at the beginning of the Civil War the northern Indians became so aggressive that emigrants chose the less dangerous route up the

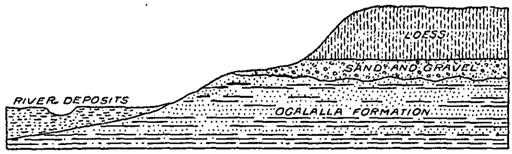

FIGURE 5.—Sketch profile of the bluffs near Brule, Nebr., showing relation of the Ogalalla formation to the overlying beds of coarse sand and gravel, on which rest thick beds of loess.

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uted over the Great Plains. Along the Union Pacific it lies on the Brule clay, a formation of Oligocene (Tertiary) age, the intervening formations being absent here. Its relations are indicated in the following table:

Succession of rocks exposed in central and western Nebraska and eastern Wyoming.

Period.	Epoch.	Life.	Group and formation.
Quaternary.	Recent.	Age of man.	Flood-plain deposits.
	Pleistocene. (Great Ice Age.)		Loess and gravel.
Tertiary.	Pliocene.	Age of mammals.	Ogalalla formation.
	Miocene.		Arikaree formation.
			Gering formation.
	Oligocene.		White River group: Brule clay. Chadron formation.

The Ogalalla formation is overlain by coarse sand and gravel similar to that in the river bed at the present time, and this in turn is covered with the loess that clothes the highlands. The relations are indicated by the sketch profile, figure 5.

South Platte Valley and through southern Wyoming. It was this southern fork of the Overland Trail that the Union Pacific followed and that recently has been chosen for the Lincoln Highway.[1]

Near Big Springs, as the name implies, there are large springs of water, which issue from the bluffs to the right (north) of the station.

Big Springs, Nebr.
Elevation 3,367 feet.
Population 665.
Omaha 360 miles.

Here in 1877 there was a bold train robbery, after which, by an equally bold movement of the authorities, the robbers were overtaken and killed in a fight. Geologically the place is of interest as marking the western limit of the thick loess and underlying gravels previously described. North of Big Springs these deposits terminate by abutting against a sharp rise of the Ogalalla formation, and farther west this formation occupies the surface. About 8 miles west of this station the road dips southward into Colorado, in which it runs for 10 miles before returning to Nebraska.

Julesburg, Colo.
Elevation 3,465 feet.
Population 962.
Omaha 372 miles.

At Julesburg, in northeastern Colorado, the Union Pacific Railroad forks, one branch extending up South Platte River to Denver and the other or main line turning northwestward up Lodgepole Creek. At this point passengers intending to travel by way of the scenic route of the Denver & Rio Grande Railroad through the Rocky Mountains take the Denver branch.

Gen. Dodge writes:

> No town on the western plains has had a more checkered or exciting history than has Julesburg. It has been built on four different sites. In the days of the overland emigration a fort was established here and garrisoned with soldiers to protect travelers from the Indians. Old Julesburg, the first, was located about 1 mile east of the fort, on the south bank of the river at the old ford crossing. It was sacked and burned by the Indians February 2, 1865. In July following the great Sioux war broke out, and from that time on till peace was declared there was more Indian fighting in this vicinity than at any other station along the Platte Valley. During these times Maj. O'Brien says buffalo were more plentiful on the plains around Julesburg than the vast herds of native cattle were in later years. * * *
>
> A second Julesburg was built 4 miles east of the fort. This was moved to the north side of the river, where the town of Weir now stands, and at one time was the terminus of the Union Pacific Railroad and contained 7,000 poeple. Here the desperado element held sway until the better class of citizens organized themselves into a vigilance committee and by their just but necessarily severe verdicts and punishments rid the town of these lawless frontiermen and established a peaceful government.

---

[1] The Lincoln Highway, designed as a memorial to Abraham Lincoln, is to be an improved thoroughfare extending across the continent from New York to San Francisco by the shortest practicable route. It will be 3,389 miles long and will traverse 13 States. The route was laid out and announced by proclamation in 1913 by the Lincoln Highway Association, whose headquarters are in Detroit, Mich., and the work of improving it is progressing rapidly under the direction of local committees. The distinctive red, white, and blue pole markers now cover about 90 per cent of the route, which is already used by numerous touring parties. Between Omaha and San Francisco it follows the Overland Trail.

At that time an Indian would trade a buffalo robe for a cup of sugar or a yard of red flannel. Buffalo skulls were used as tablets and signposts along the trail. A skull may be seen to-day in the Commercial Club in Salt Lake City with the inscription, "Pioneers camped here June 3, 1847, making fifteen miles a day; all well. Brigham Young."

Julesburg was an important stage station on the Overland Route in 1865 and as a supply point was the subject of much attention from the Indians. The station was named after one Jules, agent for Ben Holladay's stage line. He was killed by J. A. Slade, a noted desperado, who fought both for and against law and order and whose career is set forth in Mark Twain's "Roughing it."

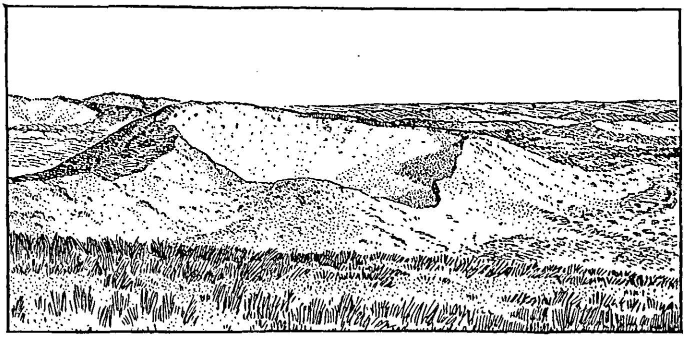

FIGURE 6.—Typical sand dune with blow-out in its top, illustrating the depressions formed by the wind in the sand-dune country, where the sand is loose enough to be easily shifted.

Just beyond Julesburg the main line leaves the South Platte Valley and, turning northward up Lodgepole Creek, reenters Nebraska. At the turn of the road near Weir is a group of sand hills showing characteristic blow-outs [1] or hollows formed by the wind. (See fig. 6.) Lodgepole Creek takes its name from the fact that here the Indians formerly obtained the poles about which they stretched the skins or canvas to form their tents or tepees. Very little timber can be seen now in any part of the valley that is traversed by the Union Pacific. The train passes several stations and small towns—Weir, Ralton, Chappell, Perdu, Lodgepole, Sunol, and Colton—between Julesburg and Sidney.

[1] These blow-outs, some of which occur in the tops of the hills like craters in a volcano, are produced by the wind wherever it gets a chance to lift the sand. The exposed tops of the dunes are especially favorable places. The protecting cover of growing vegetation becomes broken, perhaps by a badger burrowing out a home for his family or by a coyote digging out a gopher for his breakfast. The wind blows out the loose sand, the sides of the hole cave in and make more loose sand to be blown out, and this process goes on until the blow-out is so deep that the wind can no longer lift the sand over its rim.

Sidney, Nebr.

Elevation 4,090 feet.
Population 1,185.
Omaha 414 miles.

Just before entering Sidney (see sheet 7, p. 36) the train passes under the tracks of a branch of the Chicago, Burlington & Quincy Railroad that runs from Denver to Alliance, in western Nebraska. The valley here is confined between bluffs composed at the top of an impure limestone, called "mortar beds." These bluffs are prominent near Sidney, where the rock is used as a building stone. It has furnished material for the depot and for many of the business blocks and public buildings in Sidney and neighboring towns. Were it not for the pebbles of harder rock that are embedded in it and make cutting difficult, it might be a valuable building stone. The "mortar beds" constitute the lower part of the Ogalalla formation and rest with uneven base on the Brule clay. Both these formations contain fossil bones of extinct mammals.[1]

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[1] The fossils found in the Ogalalla formation show that western Nebraska was inhabited in late Miocene time by animals of very different types from those living there now, and also that very different physical conditions prevailed at that time. In place of the dry, barren plains of to-day there were numerous streams and swampy lowlands. The fossils of the Ogalalla and Arikaree formations are not greatly different and will be described together. Both these formations were spread out over a great plain, and it is not surprising to find in them the bones of plains or running animals, such as camels, horses, and deer, as well as of those that inhabited rivers, bayous, and marshes. Some of the horses were as large as small ponies and were more modern in appearance than their diminutive Oligocene and Eocene ancestors. They were also more numerous than their ancestors, and their fossil forms represent several widely different species.

The Arikaree contains great numbers of bones of a peculiar type of animals called chalicotheres. They were larger than a large horse and had a horselike head, long front legs, and shorter hind legs, but every foot had three toes, each of which in place of a hoof bore an enormous claw. One of the forms, known as Moropus (see Pl. VI, *C*, p. 40), was strangely grotesque. An equally strange form of Miocene time is a deerlike animal called Syndyoceras (see Pl. VI, *D*), whose headdress equaled or outdid in grotesqueness that of its Oligocene ancestor Protoceras (see Pl. VII, *E*, p. 41). Its head somewhat resembled that of an antelope but was longer and had four horns, the larger pair, over the eyes, curving inward and the smaller pair, nearer the muzzle, curving outward. Although these are called horns, they were really bony protuberances and were probably not sheathed in real horn.

Camels were common in North America during the Miocene epoch, and several forms have been found. Those of one genus (Procamelus) were about the size of sheep and are supposed to be the ancestors of modern camels and llamas. Others were large and had long necks like the giraffe (see Pl. VI, *E*). All these ancient camels had hoofs like cattle, not cushioned feet like those of the camels of the present day.

Rhinoceroses were abundant in Miocene time. Hundreds of specimens of Teleoceras, a very heavy bodied, short-limbed type (see Pl. VI, *A*), have been found. The proboscidians, of which the elephant is the best-known type and the only living representative, became prominent during the Miocene epoch, when a large mastodon called Trilophodon was common.

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

OVERLAND ROUTE

From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

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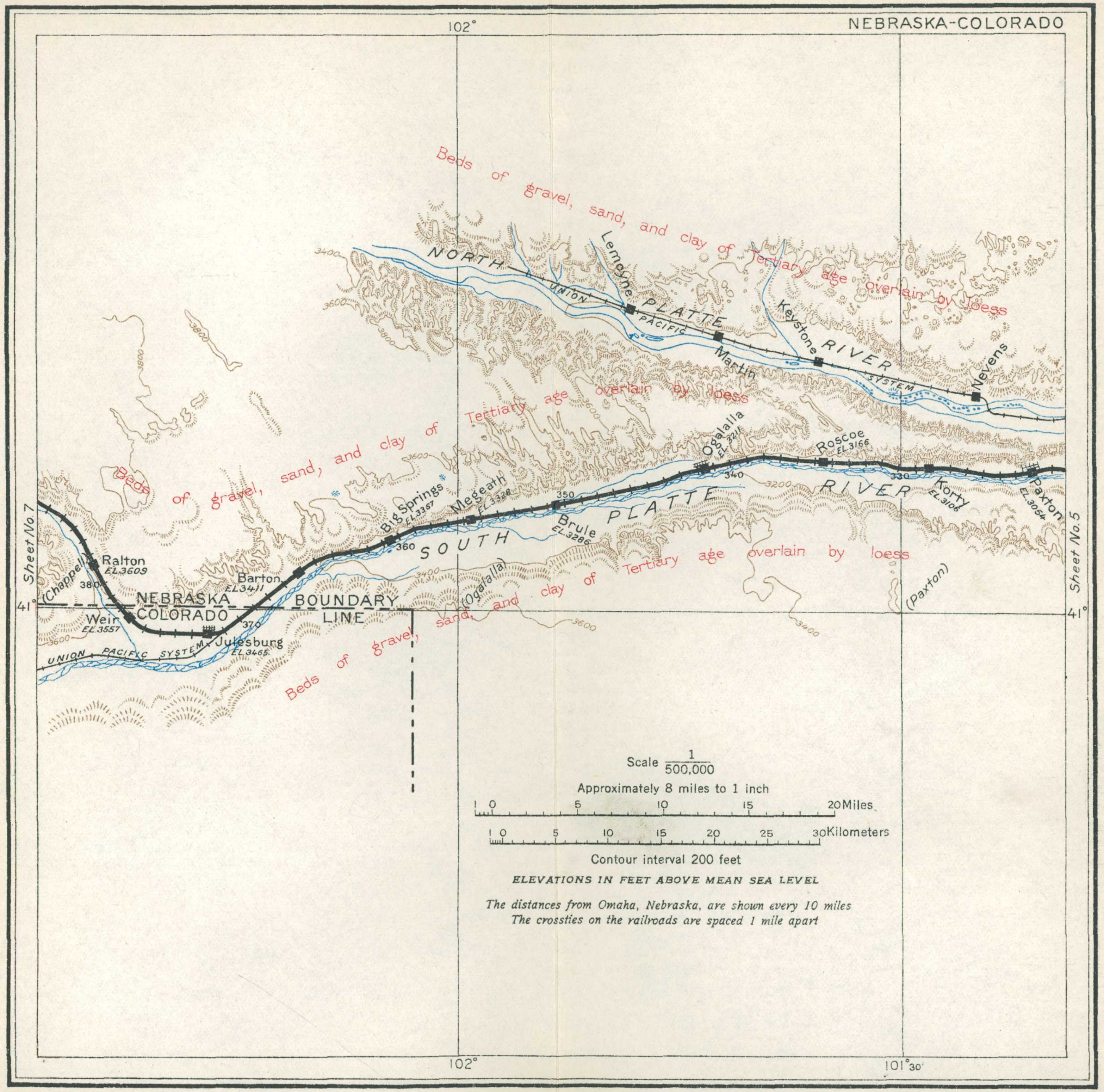

Sidney came into prominence in 1868, when a military post was established here to protect emigrants and railroad builders from the Sioux and Pawnee Indians, the two powerful tribes of western Nebraska. This post was maintained until 1894. Sidney was the point from which freight was hauled to the Black Hills until that region was supplied from railroads running much nearer to it than the Union Pacific.

Beyond Sidney the trains pass several stations and small towns—Margate, Brownson, Herdon, Potter, Jacinto, Dix, and Owasco (all shown on sheet 7)—before reaching Kimball (see sheet 8, p. 38).

Kimball.
Elevation 4,704 feet.
Population 454.
Omaha 451 miles.

West of Sidney the "mortar beds" of the Ogalalla formation, which continue to make conspicuous bluffs north of the track in many places, contain the fossil bones of many animals.[1] These have been described by Prof. W. B. Scott, Prof. H. F. Osborn, and others. In these bluffs below the cap rock may be seen the Brule clay, the youngest formation of the White River group,[2] of Oligocene (Tertiary) age. (See table on p. 31.) The exposures in the Lodgepole Valley are not so conspicuous as those in the North Platte Valley, a little farther north, owing to the covering of grass which protects the surface from erosion. In the North Platte Valley badlands are developed at many places on the Brule clay, and curious buttes, remnants of this clay, have been left by erosion, such as those known as The Jail (Pl. VII, *A*, p. 41) and Chimney Rock, which served as a landmark to many emigrants in the early days.

Smeed, Nebr.
Elevation 4,933 feet.
Omaha 468 miles.

After leaving Kimball the train passes Oliver and Bushnell before reaching Smeed. The "mortar beds" which were observed farther east at the top of the bluffs descend to the valley floor west of Kimball and are not conspicuous, but west of Smeed they rise again in bluffs, become more prominent, and terminate in Pine Bluffs. Just west of Oliver, which is only a signpost, may be seen to the left (south of the railroad) a small reservoir for the storage of irrigation water, which is used in the valley farther downstream.

Just before entering Pine Bluffs the traveler sees to the right, north of the track, a stone monument marking the boundary between Nebraska and Wyoming.

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[1] See footnote on, p. 34.

[2] The White River group, which has been studied mainly in the bad lands southeast of the Black Hills, has long been a favorite collecting ground of the paleontologist. Fossil bones have been found in many parts of the group, and those of certain animals are so abundant as to give their names to the rocks containing them, such as Titanotherium beds, Oreodon beds, and Protoceras sandstone. More complete information on these fossils may be found in the works of Profs. Scott and Osborn. (See p. 230.)

Wyoming.

Wyoming is a State of large resources, whose development has only begun. Within its 97,594 square miles lie the most extensive coal fields and the most productive known oil fields of the Rocky Mountain region, thousands of acres of irrigated and dry-farming lands, and extensive areas of splendid stock range; moreover, some of the finest hunting and fishing in the United States can be found within its borders. Although the precipitation averages only 12½ inches a year, the many irrigated areas are highly productive, and the success which dry farming has here and there attained seems to indicate that a still larger area may be brought under that kind of cultivation. An index of the crops that may be raised is the fact that irrigated oats running 45 pounds to the bushel are by no means uncommon. (The average weight of a bushel of oats is 32 pounds.) The value of the State's agricultural crops for 1914 is roughly estimated by the Department of Agriculture at $22,000,000.

Noted in the early days as the range of the "cattle king," Wyoming has in recent years become even better known as the home of the "sheep baron." It has attained first rank among the United States in the sheep industry, the number of sheep in the State on January 1, 1915, being estimated by the Department of Agriculture at 4,427,000, valued at $20,807,000. It should not be understood, however, that the cattle industry has vanished, for the State still ranks high as a cattle producer.

Among the mineral products of the State coal is preeminent. Its coal fields cover about 41,500 square miles (42 per cent of the State's area), and contained originally about 670,723,100,000 tons. Of this quantity only 178,000,000 tons (about one-fortieth of 1 per cent) has been exhausted, so that there remains in the ground the enormous amount of 670,545,100,000 tons. The production in 1913 was 7,393,066 tons, valued at $11,510,045.

The second in value of production among the mineral resources is oil, of which 2,406,522 barrels, valued at $1,187,232, was produced in 1913. The production in 1914 amounted to about 4,600,000 barrels, equal to more than 60 per cent of the production of Pennsylvania for the same year, and places Wyoming, whose oil fields are newly discovered and only partly developed, in the ninth place among the oil-producing States of the Union.

Other minerals, including gold, copper, iron, gypsum, limestone, sandstone, marble, brick clay, and mineral waters, brought the value of the State's mineral production in 1913 up to $13,682,091. Among the undeveloped resources are bituminous shale, volcanic ash, graphite, asphaltum, manganese ores, bentonite, tin, salt, bismuth, and, perhaps most important, phosphate rock, on which the future of American agriculture may largely depend. It is estimated that

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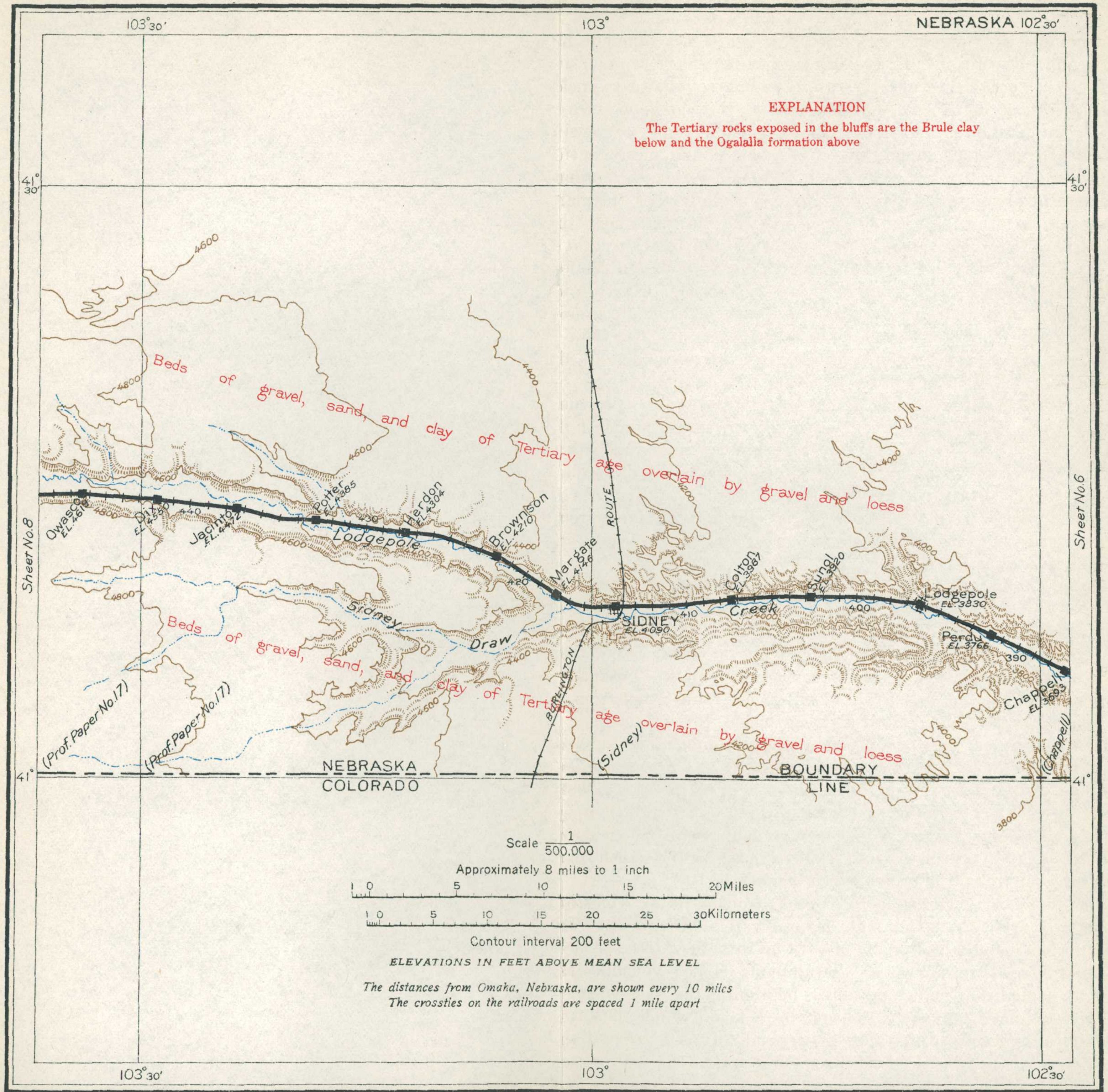

more than 1,250,000 acres in Wyoming are underlain by workable phosphate deposits, a phosphate area greater than that of any other State.

Finally, the scenic resources of Wyoming must not be forgotten, the grandeur of the Bighorn and Wind River mountains and the Tetons being excelled only by the wonders of Yellowstone Park. Thus the State of Wyoming is of interest in its agriculture, stock growing, mining, hunting, fishing, and natural beauty.

Pine Bluffs, Wyo.
Elevation 5,043 feet.
Population 246.
Omaha 473 miles.

The town of Pine Bluffs takes its name from the prominent bluffs of "mortar beds" near by, on which grow a few stunted pine trees. A tree is so rare on these sun-parched plains that these pines seem to have been thought worthy of commemoration in naming the ridge. The bluffs may be seen for a long distance north and south of the road and mark the western edge of the Ogalalla formation.

The Arikaree formation [1] underlies the Ogalalla formation near Pine Bluffs and extends thence westward to Granite Canyon, a distance of 62 miles. It consists mainly of sand loosely cemented into a soft sandstone that contains limestone concretions. These are due to the growth of calcite crystals and usually occur in layers connected to form irregular sheets.

Between Pine Bluffs and Hillsdale are the stations Tracy, Egbert, and Burns.

Hillsdale.
Elevation 5,634 feet.
Omaha 496 miles.

Near Hillsdale station the traveler gets his first glimpse of the Rocky Mountains. To the west may be seen the dark summits of the Laramie Range—formerly called the Black Hills—and farther south, 60 miles away, is visible in ordinarily clear weather the snow-covered top of Longs Peak (altitude 14,255 feet) and other high mountains of the Front Range of the Rockies.

Durham and Archer are stations between Hillsdale and Cheyenne.

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[1] The Arikaree formation underlies a large part of western Nebraska and eastern Wyoming and is widely distributed in neighboring regions. These deposits appear to have been spread out by streams over the low-lying plains. No place in North America now exhibits the physical conditions supposed to have existed in Nebraska and Wyoming when these sediments were being deposited, but similar conditions have been reported as prevailing now in central South America, where every year a plain of some 60,000 square miles is converted during the rainy season into a labyrinth of lakes, ponds, swamps, channels, and islands. On these islands the animals gather and great numbers of them perish. Large quantities of fossil bones are found in small areas in the White River beds. These areas have been called "fossil graveyards" and are supposed to represent "concentration camps" of Tertiary time similar to the isles of refuge of the present day in South America.

Cheyenne.

Elevation 6,058 feet.
Population 11,320.
Omaha 516 miles.

The capital of Wyoming, Cheyenne (see sheet 9, p. 50), is 516 miles west of Omaha and nearly a mile higher. It is rich in memories of the "Wild West," memories which its inhabitants delight in perpetuating, for every year they hold one of the most picturesque gatherings in the country, known as "Frontier Days Celebration," at which Indians, cowboys, and plainsmen from all parts of the West, from Canada to Texas, gather for "broncho busting," steer tying, Indian dances, and the exhibition of all the unique and characteristic features of frontier life. And here gather from far and near spectators to see these performances.

Fort Russell, one of the larger Army posts, may be seen to the right, north of the railroad, as the train leaves Cheyenne. The city is supplied with water from reservoirs fed by springs that issue from the granite of the Laramie Mountains in Crow Creek canyon. Three miles east of the city the Union Pacific crosses the Chicago, Burlington & Quincy Railroad, and a mile west of it the train passes under the tracks of the Colorado & Southern. A little farther west, at Corlett, a branch turns south from the main line, running to Denver, where the westbound traveler can connect with the Denver & Rio Grande Railroad.[1]

From Cheyenne the main line climbs a long, graded incline formed by the Arikaree beds, which extend far up the slope of the Laramie Mountains, where they abut against the foothills of the older sedimentary rocks or overlap the eroded edges of these rocks and the still older granite. (See fig. 7, p. 42.) The Arikaree and the underlying deposits were here probably tilted to some extent after deposition, but the large bowlders contained in them prove that the streams had a steep descent and were swift and powerful. The character of the Arikaree may be seen in the numerous cuts along the railroad and in the bordering bluffs of the valleys, which are plainly visible to the right, north of the incline. In these bluffs may be seen below the Arikaree the rocks of the Gering formation and of the White River group—the Brule clay and the Chadron formation—which contain fossil bones of Oligocene animals.[2] The Brule clay may be distinguished from the train as long barren slopes just below the cliffs.

[1] The branch from Cheyenne to Denver runs parallel with the Front Range of the Rocky Mountains, but at so great a distance that these mountains do not appear particularly impressive. It passes through a prosperous agricultural district in which are situated Eaton, Greeley, Brighton, and other towns. In this district the waters of the South Platte, the Thompson, the Cache la Poudre, and other smaller streams are diverted for irrigation, and from it great quantities of potatoes, beet sugar, canned fruits, vegetables, and farm and dairy products are shipped to market.

[2] The Oligocene epoch seems to have been one of relative quiescence compared with the Eocene, which was characterized by impressive volcanic activity and by the building of great mountain

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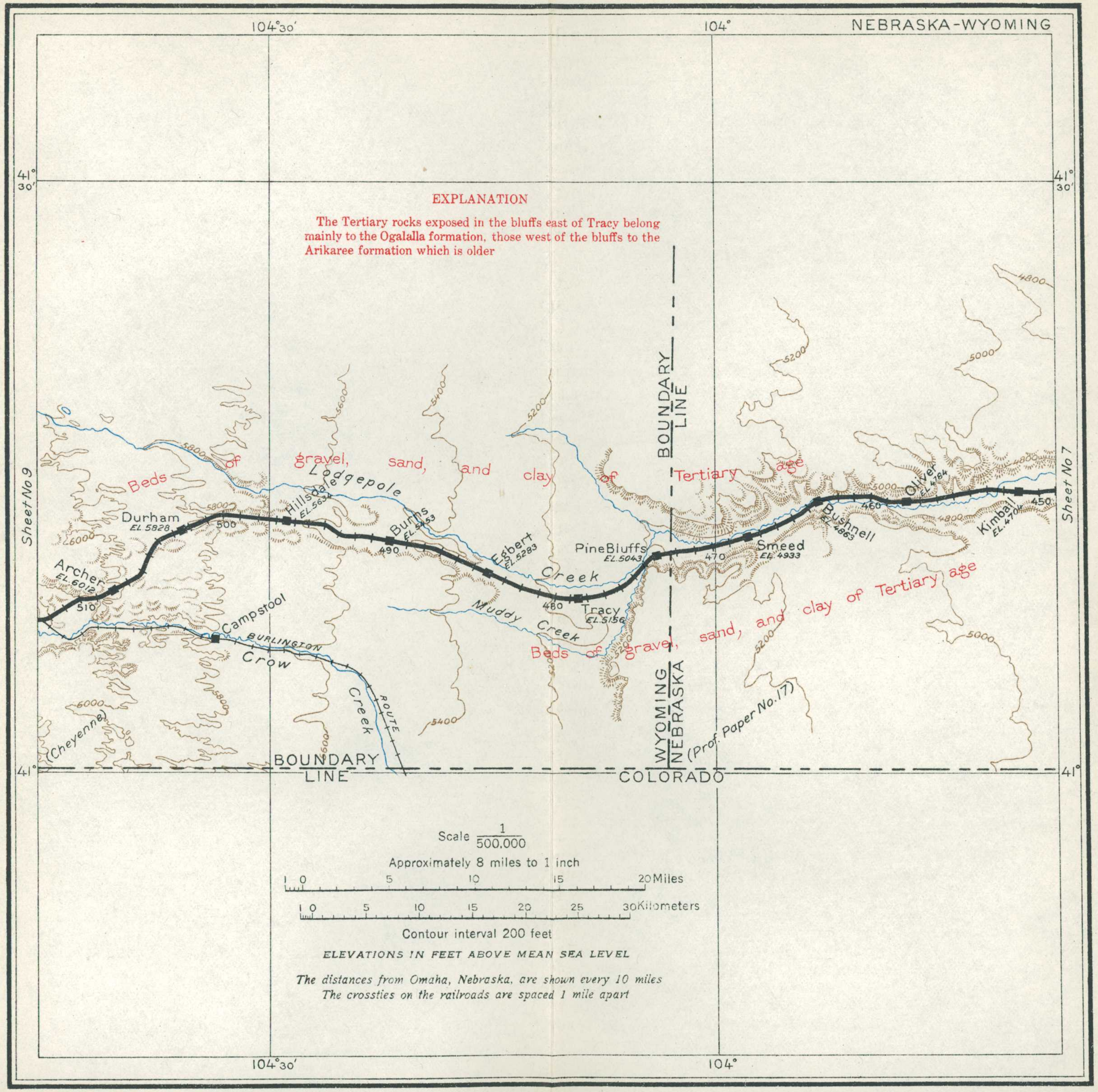

The stations Corlett and Borie are passed between Cheyenne and Otto.

From several places near Otto station good views of the Front Range of the Rocky Mountains may be obtained to the left (south). Longs Peak is plainly visible, as well as the more massive and scarcely less elevated mountains north of it. Toward the right (north) the foothills east of the Laramie Range form conspicuous ridges that are plainly visible from the train. They consist of sedimentary rocks upturned to a nearly vertical position. These rocks range in age

Otto.

Elevation 6,946 feet.
Omaha 530 miles.

systems. The Oligocene formations are among the most widespread and most regularly distributed of the Tertiary formations of the Great Plains and cover a vast area in Nebraska and Wyoming. The sediments composing them were deposited by streams that meandered over low-lying plains and slowly built up the surface, much as the lower Mississippi is now building its delta or the Platte its flood plain, over which the train has just passed. Some of the old stream channels can be recognized by the filling of consolidated sand and gravel.

The plains country of Nebraska and eastern Wyoming was low during Oligocene time and the divides between the streams were not high enough to prevent flooding during high water. The whole country was virtually a great flood plain on which accumulated the sediments that the rivers brought from the mountains. With these sediments occur beds of pure volcanic ash, which must have been carried by the wind or floated by the streams for long distances. The volcanoes that had been so active in western America during the Eocene epoch had not ceased their eruptions—indeed, they have not yet become entirely extinct, as is testified by the recent outburst of Lassen Peak, in northern California, although throughout later Tertiary and Quaternary time their fires have been gradually going out.

The lower Oligocene or Chadron formation is often called the Titanotherium beds because it contains bones of extinct mammals of that name. The titanotheres formed a comparatively short-lived family and seem to have been confined almost entirely to North America. Their remains are the most numerous and conspicuous fossils found in the lower Oligocene beds in western America. They were clumsy brutes of elephantine size having on the front of the skull a pair of great bony protuberances, which although hornlike in form were probably not sheathed in horn. (See Pl. VII, *D*, p. 41.) The head was long and large and of fantastic shape. In its thick heavy body and short, massive legs the titanothere resembled the modern rhinoceros. It was doubtless a sluggish, stupid beast, for its brain was small in comparison with the size of its body. The brain cavity was only a few inches in diameter and was surrounded by thick bone, as if to withstand shocks in battle. The titanotheres were the most formidable animals of the time, and though, so far as known, there were then no carnivores capable of doing them serious harm, yet they seem to have disappeared suddenly from North America. Their bones are not found in strata above a certain geologic horizon. The disappearance of a race of animals from any locality or even from the face of the earth does not necessarily require a long period of time. It is easily conceivable that the titanotheres were exterminated by some disease or that one of the physical changes which were so common in the West during Tertiary time made their life conditions here unfavorable and drove them to some other region, in which their remains have not yet been discovered.

The animals of Oligocene time seem to have been abundant as well as varied in from Carboniferous to Cretaceous; the rocks of the most prominent ridge seen toward the north are those of the Casper formation and the less prominent ridges are formed by hard strata in the red beds of the Chugwater formation (Triassic or Permian) and by the rocks here called the Cloverly formation, the upper part of which may represent the Dakota sandstone of eastern Nebraska.[1]

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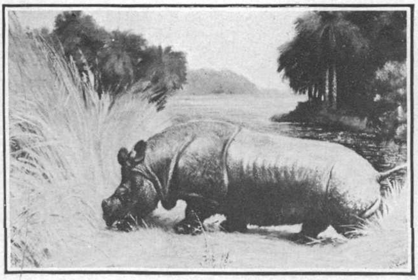
kind. They had a somewhat more modern aspect than the animals that preceded them, for the processes of evolution had been active, and some of the primitive animals of Eocene time had developed into forms more nearly like those with which we are familiar now. Others seem to have left no descendants. Great numbers of Oligocene fossils have been found, and the life of the time is probably better known than that of any other epoch of the Tertiary period. Among the characteristic animals of this epoch were primitive forms of rhinoceroses, peccaries, ruminants, camels, insectivores, and opossums. Some of the creodonts or flesh eaters of Eocene time had developed into true carnivores, including many forms of both doglike and catlike animals. The saber-toothed cats which later developed into the saber-toothed tiger, one of the most formidable enemies of primitive man, first appeared in the Oligocene.

The horses whose history began with the diminutive four-toed Eohippus continued in the Oligocene, where they are represented by many three-toed forms which were about as large as sheep. Hoglike animals were rather numerous, and although many of them were smaller than the modern swine some of them were very large. One of these, *Archeotherium ingens* (see Pl. VII, *C*, p. 41), was a formidable beast with curious protuberances on its head, the use of which is not known. Rhinoceroses similar to those now found in Africa and India lived in western America, and other rhinoceros-like animals known as anymodonts were abundant, but rhinoceroses did not reach their culmination in America until the Pleistocene epoch.

In addition to these animals of more modern appearance there were many that were so unlike anything now living that it is not possible to designate them by any common names. Among these are the animals of the protocerine group, of whose history little is known. They seem to have appeared suddenly in North America in Oligocene time and disappeared from this continent during the early part of the Miocene. They were deerlike creatures about the size of sheep. The head of the male was grotesquely ornamented with short bony protuberances and large scimitar-like tusks. Each front foot had four toes and each toe had a hoof like that of a deer or antelope. The supposed appearance of these curious animals is indicated in the restoration of one of the forms (*Protoceras celer*) reproduced in Plate VII, *E*.

[1] The table on page 41 shows the geologic formations exposed in the vicinity of the Laramie Mountains near the Union Pacific Railroad in the order of their age, the oldest at the bottom and the youngest at the top. The position of these formations in the complete geologic time scale may be ascertained by comparison with the table on p. 2.



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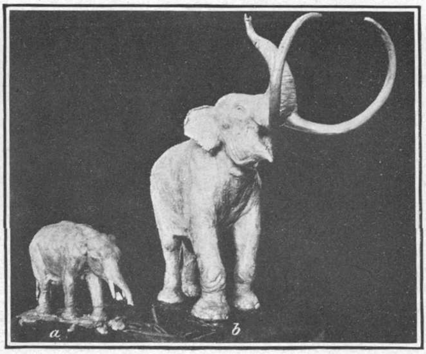

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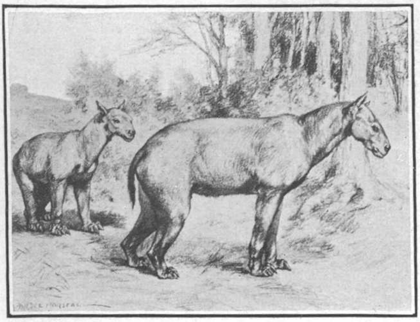

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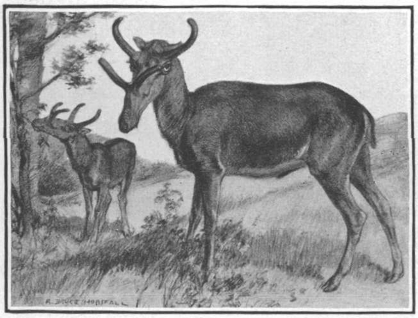

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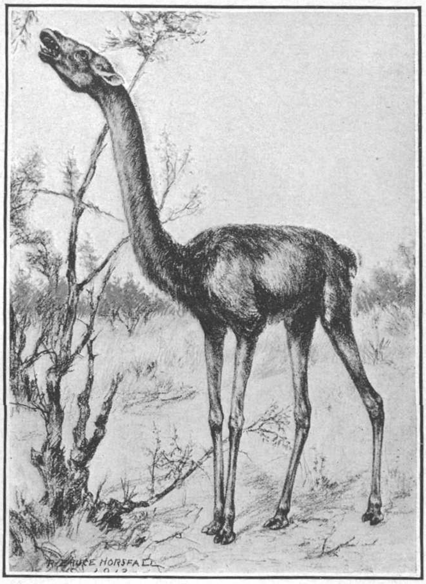

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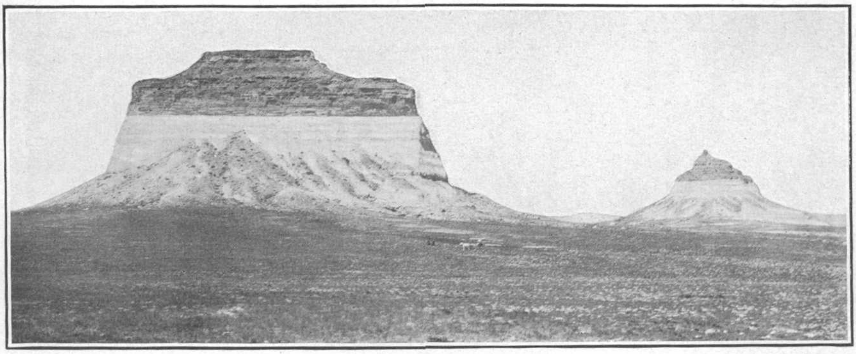

F.

ROCKS OF MIOCENE AGE AND RESTORATIONS OF ANIMALS THAT LIVED IN NORTH AMERICA DURING THE MIOCENE EPOCH.

A, SHORT-LIMBED RHINOCEROS, KNOWN AS TELEOCERAS, AN ANIMAL ABOUT 5 FEET HIGH (AFTER OSBORN); *B*, (*a*) MIOCENE MASTODON (TRILOPHODON PRODUCTUS) AND (*b*) PLEISTOCENE ELEPHANT (ELEPHAS IMPERATOR), AN ANIMAL NEARLY 15 FEET HIGH (AFTER OSBORN); *C*, MOROPUS ELASTUS, AN ANIMAL SOMEWHAT LARGER THAN THE MODERN HORSE (AFTER SCOTT); *D*, A FOUR-HORNED DEER (SYNDYOCERAS COOKI), ABOUT THE SIZE OF THE MODERN DEER (AFTER SCOTT); *E*, GIGANTIC GIRAFFE-CAMEL (ALTICAMELUS ALTUS), ABOUT 15 FEET HIGH (AFTER SCOTT); *F*, MIOCENE BEDS (ARIKAREE FORMATION) RESTING UNCONFORMABLY ON OLIGOCENE BEDS (BRULE CLAY) IN PAWNEE BUTTES, COLO.

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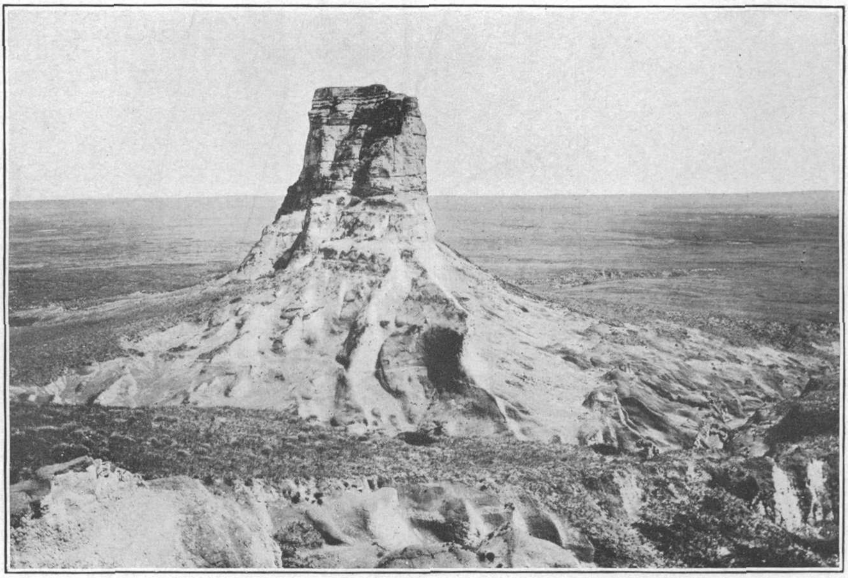

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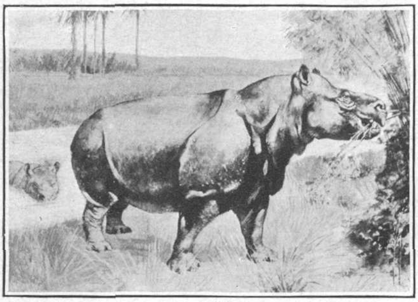

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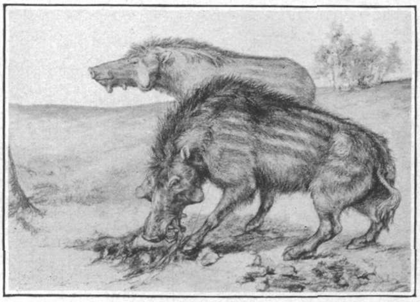

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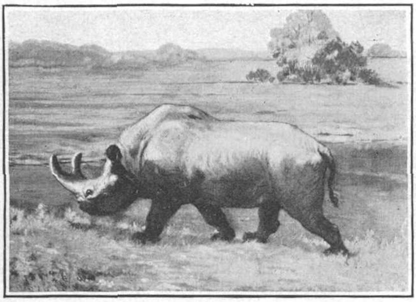

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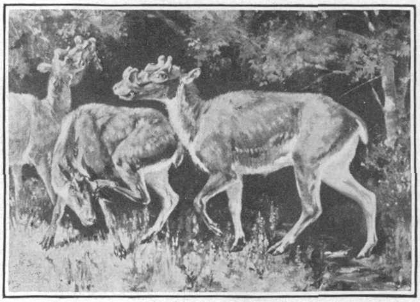

E.

ROCKS OF OLIGOCENE AGE AND RESTORATIONS OF ANIMALS THAT LIVED IN CENTRAL NORTH AMERICA DURING THE OLIGOCENE EPOCH.

A, JAIL ROCK, NORTH OF SIDNEY, IN WESTERN NEBRASKA, THE LOWER PART OF WHICH CONSISTS OF BRULE CLAY; *B*, AN AMERICAN RHINOCEROS (AFTER OSBORN); *C*, "GIANT PIGS," 3 OR 4 FEET HIGH (AFTER SCOTT); *D*, TITANOTHERES, ALMOST AS LARGE AS THE MODERN ELEPHANT (AFTER OSBORN); *E*, PROTOCERAS CELER, ANIMALS THE SIZE OF THE MODERN ANTELOPE (AFTER SCOTT).

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Succession of the rock formations exposed along the Union Pacific Railroad east and west of the Laramie Mountains.

Period and system.	Epoch and series.	Groups and formations.	
		East of Laramie Mountains.	West of Laramie Mountains.
Tertiary.	Pliocene.	Ogalalla formation.	Not represented.
	Miocene.	Arikaree formation. Gering formation.	
	Oligocene.	White River group: Brule clay. Chadron formation.	
Tertiary (possibly including some Cretaceous).			"Upper Laramie" formation.
Cretaceous.	Upper Cretaceous.	Montana group: Fox Hills sandstone. Pierre shale. Colorado group: Niobrara limestone. Benton shale, including Mowry shale.	"Lower Laramie" formation. Montana group: Lewis shale. Mesaverde formation. Steele shale. Colorado group: Niobrara limestone. Benton shale, including Mowry shale.
	Lower Cretaceous.	Cloverly formation.	Cloverly formation.
Jurassic or Cretaceous.		Morrison formation.	Morrison formation.
Jurassic.		Sundance formation.	Sundance formation.
Triassic or Permian.		Chugwater formation.	Chugwater formation.
Carboniferous.	Pennsylvanian.	Casper formation.	Forelle limestone. Satanka shale. Casper formation.
Archean.		Granite (including Sherman granite), gneiss, and schist.	Granite (including Sherman granite), gneiss, and schist.

On reaching the foothills the train passes through a cut made in gray massive limestone and red quartzose sandstone of the Casper formation, which inclines steeply toward the east. Another aspect of this formation may be seen to the left (south) of the railroad, where it makes a steep cliff above the granite against which it is inclined. On Mesa Mountain, a flat-topped table-land which may be seen to the right, the Casper formation is nearly horizontal and forms the top of the mesa.

The limestone of the Casper formation at Granite Canyon furnished lime that was used by the railroad during the period of construction. This limestone is nearly pure calcium carbonate (98 per cent $CaCO_3$), and on Horse Creek, 20 miles farther north, about 55,000 tons is quarried every year to be burned for lime at the beet-sugar factories in eastern Colorado, where it is used in refining the sugar.

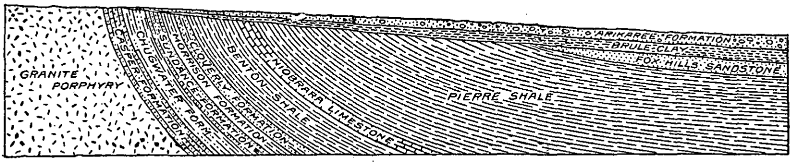


FIGURE 7.—Tertiary sand and gravel overlying the truncated eroded edges of older rocks and forming the approach to the Laramie Mountains between Cheyenne and Granite Canyon utilized by the Union Pacific Railroad.

The ridge up which the train climbs in approaching the mountains is a remnant of the broad plain that once extended uniformly along the mountain front. The streams have made relatively little impression on the hard mountain rocks but have eroded away large parts of the soft Arikaree and other Tertiary beds of this plain, leaving the ridge as the one practicable route by which the railroad can ascend to the high table-land at the top of the Laramie Range.

The Tertiary sands and gravels of the ridge up which the train approaches the mountains form a thin covering over edges of older formations that range in age from Carboniferous to Cretaceous. The edges of the older formations are truncated—that is, the originally flat strata were tilted and their edges cut off obliquely by erosion before the Tertiary deposits were laid down upon them. Such a relation is called an angular unconformity. The attitude of these older rocks is known from exposures in the valleys both north and south of this ridge, and the relations are shown in the accompanying sketch section (fig. 7). The oldest sedimentary formation here is the Casper, consisting of gray to white limestone and red sandstone. Next is the Chugwater formation, which consists of red sandstone, red sandy shale, thin beds of limestone, and thick beds of gypsum. Unconformably on this lies the Sundance formation, consisting of sandstone and shale and containing marine fossils that denote Jurassic age. This is followed with apparent conformity by the Morrison formation, which is noted for its huge fossil reptiles. Upon the Morrison, and apparently conformable with it, lies the Cloverly formation, consisting of two sandstones separated by shale. The upper sandstone is probably equivalent in age to the Dakota sandstone and is therefore the base of the Upper Cretaceous series. Above the Cloverly in conformable succession lie the Benton shale, the Niobrara limestone, the Pierre shale, and the Fox Hills sandstone.

This easy approach to the mountains was discovered in a peculiar manner. For more than two years engineers had searched in vain for a practicable grade by which the railroad might reach the summit of the range. On one of their excursions in the valley of Crow Creek they discovered Indians between them and their escort of mounted soldiers. In their attempt to find a point where the cavalry could see their signals for help the engineers reached the ridge, and in order to get to a place of safety they traveled down the ridge and found that it joined the plain east of the mountains without a break. This was just such a grade as they had been looking for, and further exploration showed that it was suitable for the road.

Granite Canyon.

Elevation 7,312 feet.
Omaha 535 miles.

The station at Granite Canyon is built on granite porphyry, a crystalline rock of igneous origin. This particular granite porphyry is the oldest rock yet encountered on this route, being of pre-Cambrian age. West of the station is a steep slope cut in the Brule clay, which lies directly on the granite porphyry. This is the westernmost exposure of this formation along the Union Pacific line. About 4 miles west of the Granite Canyon station, near Ozone, the road crosses a narrow strip of dark-colored granite gneiss, intruded ages ago into the older crystalline rock which constitutes the core of the Laramie Range.

Buford.

Elevation 7,858 feet.
Omaha 543 miles.

From many points in the vicinity of Buford good views may be obtained of the high peaks of the Rocky Mountains far away to the left (south) and of the relatively low but rugged Sherman Mountains, a part of the Laramie Range, to the right. Two prominent points seen to the north are called Twin Mountains and are celebrated as one of the strongholds of the notorious desperado Slade.

At Buford is the quarry that has furnished ballast for the Union Pacific from Omaha to Rock Springs, Wyo., a distance of more than 800 miles. The quarry is in the crystalline rock of the Laramie Range, known as the Sherman granite.[1] At Buford this granite has

[1] The Sherman granite forms a great mass intruded into older rocks in pre-Cambrian time. It is normally a coarse-grained rock composed chiefly of pink feldspar, glassy-looking quartz, black hornblende, and mica, which in mass give it a spotted appearance. According to report it contains some gold at Buford but not enough for profitable extraction. It shows considerable variation in texture, color, and composition. One of the commonest varieties is coarsely porphyritic, the feldspar standing out in crystals 1 to 2 inches in length. Where the Union Pacific Railroad crosses Dale Creek, west of Sherman, the granite is rich in epidote, a green mineral, which together with the red feldspar imparts to it a mottled red and green color. Although hard when unaltered the Sherman granite breaks up readily into a coarse gravelly soil under the influence of heat, cold, and the action of water, so that it forms smooth, round hills. Where the rock is firm it weathers along widely spaced joints and forms heaps of rounded bowlders, many of which may be seen from the train (Pl. VIII, *A*), particularly west of Buford.

weathered to a depth of 50 feet or more. At the quarry the rock is loosened by heavy charges of explosive, which shatter it to small fragments, and it is then loaded on the cars by steam shovels. This quarry is said to have furnished about 10,000 carloads of ballast every year for the last 14 years and is still in active operation. Ballast is thus obtained at a cost of about 6 cents a ton, whereas the average cost of crushed rock used for railroad ballast is 49 cents.

Sherman.

Elevation 8,009 feet.
Population 115.*
Omaha 547 miles.

Sherman, so named in honor of Gen. W. T. Sherman, is the highest point on the Laramie Range reached by the railroad. It is claimed that from this point on a clear day may be seen Pikes Peak, about 165 miles, and Longs Peak, 60 miles to the south, and Elk Mountain, 100 miles to the west. The railroad was originally built about 2 miles north of its present location and crossed the divide at an altitude 237 feet higher than at present. On this old line a great stone monument was erected in honor of Hon. Oliver Ames and his brother Oakes, to whose energy and perseverance was largely due the construction of the Union Pacific Railroad.

The road here traverses the relatively flat summit of the Laramie Range, on what has been described as the Sherman peneplain.[1] Along the track here and elsewhere in the Laramie Mountains there are numerous board fences or windbreaks. The snow drifts badly in the winter, and these fences prevent drifts from forming on the track.

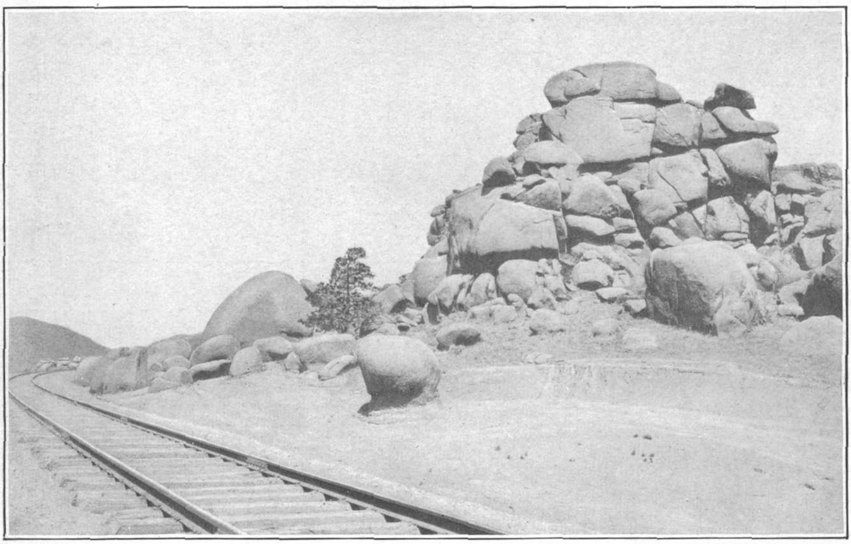
Dale Creek.

Elevation 7,918 feet.
Omaha 550 miles.

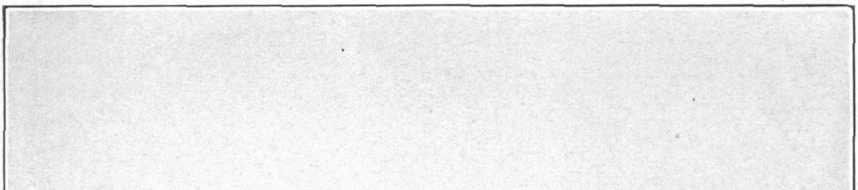
Dale Creek is a point on the new line that crosses Sherman Hill at a point 237 feet lower than the original crossing. This change not only saved the expense of climbing the heavy grades but did away with the famous Dale Creek Bridge, which was 650 feet long and 135 feet high. It also involved some notable feats in engineering. Along the new line there are many deep cuts in which the Sherman granite

[1] The uniform fineness and approximately uniform thickness of the Cretaceous sedimentary rocks on each side of the Laramie Range indicate that they once extended over the area now occupied by these mountains—in other words, that the mountains did not exist during Cretaceous time. At the close of that period the region was uplifted and the Cretaceous as well as the still older stratified rocks were steeply upturned on the eastern flank and slightly upturned on the western flank of the mountains. Then followed a long period of erosion during the Eocene epoch, when the sedimentary rocks were worn away from the top of the mountains, except where they were preserved by being infolded within the granite, and the crystalline rocks underlying them were eroded to a nearly level surface, or peneplain.

At the close of the Eocene epoch the range was again elevated and renewed erosion attacked this planed surface, deriving from it in part at least the material of the Oligocene and Miocene deposits that border the range on the east. These deposits could not all have been derived from this area, however, for in some places they extend over parts of this peneplain. The present irregularities of the plain were probably produced in large measure by late Tertiary or Quaternary erosion, which developed the canyons and removed large parts of the Oligocene and Miocene deposits.

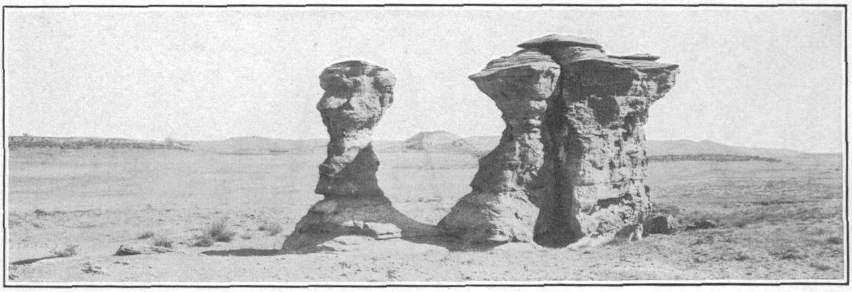


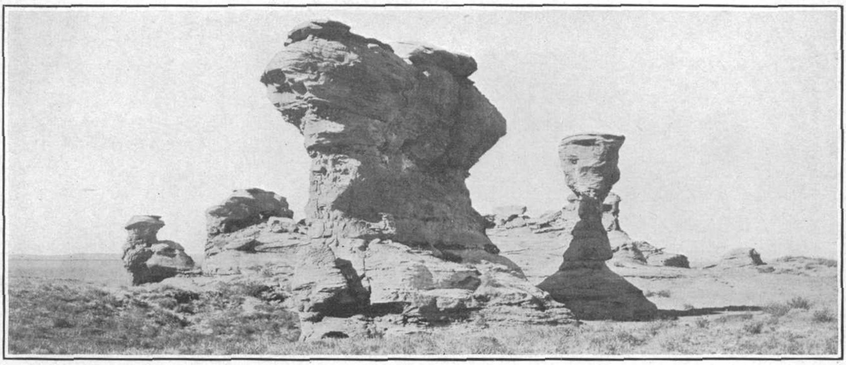
A. VIEW NEAR DALE CREEK STATION, WYO., SHOWING CHARACTERISTIC WEATHERING OF THE SHERMAN GRANITE.

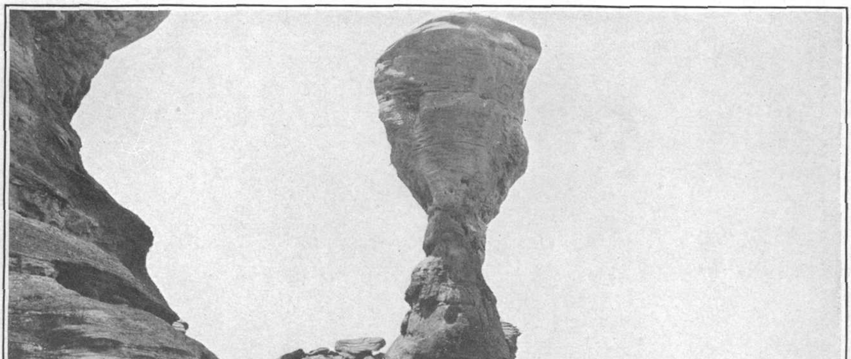


B. SMALL "SODA LAKE" ON THE PLAIN NEAR LARAMIE, WYO.

The bed of the "lake," which contains water only in wet weather, is when dry covered with a white incrustation of salts, mostly alkali, left by the evaporation of the water.







NATURAL MONUMENTS ON THE PLAIN NEAR RED BUTTES, WYO., ERODED FROM RED SANDSTONE OF THE CASPER FORMATION.

These monuments are 20 to 50 feet high.

may be seen to advantage, and a tunnel is driven 1,800 feet through a spur of the same granite 3 miles west of Dale Creek. One hill near this creek, known as Gibraltar Cone, 100 feet high above the grade line, was drilled and loaded with about 1,000 kegs of black powder and 1,000 pounds of dynamite, and on July 4, 1900, this charge was exploded, blowing out the whole hill. The cuts are equaled by some of the great fills. The fill across Dale Creek is 900 feet long and 120 feet high in its deepest part, and 500,000 cubic yards of rock was used in constructing the embankment.

Hermosa.

Elevation 7,862 feet.
Omaha 554 miles.

The name of the next station, Hermosa, which is Spanish for beautiful, seems appropriate, as may be realized by a glance to the left, toward the west. Across the broad Laramie Basin,[1] which the road enters at this point, the mountains rise in rugged grandeur, and near by may be seen natural monuments carved from red sandstone in many forms. Some of these are illustrated in Plate IX.

Red Buttes.

Elevation 7,300 feet.
Population 110.*
Omaha 564 miles.

From a point near Hermosa the road has two lines to Laramie. The westbound trains run by way of Red Buttes, and the eastbound trains come from Laramie over an easier grade by way of Forelle and Colores. Red Buttes is little more than a section house and takes its name from the natural monuments or buttes of red sandstone that are numerous in this vicinity (Pl. IX). From Hermosa to Red Buttes the route has lain on gently sloping red beds of Carboniferous age, consisting of the Casper formation, which was seen east of the mountains; the Satanka shale, made up of red shale and gypsum; and the Forelle limestone. These strata are overlain in some places by deposits of gravel, and at one place, a mile southeast of Red Buttes station, by gypsite. (For description see p. 48.)

About a mile south of Red Buttes is a deposit of gypsum, 20 or 30 feet thick, which is being manufactured into cement plaster or impure plaster of Paris. It is of the form known as rock gypsum and is a

[1] The Laramie Basin as usually defined is 90 miles long and 30 miles in maximum width and has a surface elevation of 7,000 to 7,500 feet. It is a hollow whose form is due to the general structure of the rocks that underlie it. It is overlooked by the Laramie Mountains on the east and the Medicine Bow Mountains on the west. These mountains are the northward continuation of the Rocky Mountain ranges of Colorado, the Laramie representing the Front Range and the Medicine Bow the north end of one of the inner ranges of the Rocky Mountains. The basin was formed by the warping and tilting of the rocks during the several periods of upheaval, and has later been modified by erosion. The Big Hollow, a depression in the general basin a few miles west of Laramie, is 9 miles long, 3 miles wide, and 200 feet deep. Other similar depressions are Big Basin, northwest of Laramie, Cooper Lake Basin, and many smaller hollows occupied by alkali lakes. The basin is partly drained by Laramie River, which crosses the Laramie Mountains through a deep ravine and finally joins North Platte River.

part of the Forelle formation. The most extensive gypsum deposits of this region occur at Red Mountain, 25 miles farther southwest.

Other natural products of commercial importance in this region are volcanic ash,[1] bentonite,[2] and soda.[3]

Colores.

Elevation 7,637 feet.
Omaha 560 miles.

On the track used by eastbound trains between Laramie and Hermosa is a station called Colores, from the highly colored rocks of the Carboniferous formations that are exposed near by. The eastbound trains pass over these red rocks for about 10 miles. The rocks contain water under pressure, and many large springs issue from them along the foothills. A spring near Colores furnishes water to fill a 4-inch pipe. Another spring east of Laramie furnishes the city supply—3,000,000 gallons a day. About 4 miles south of the city spring there is another large spring, which supplies a fish hatchery.

Toward the southwest, across the Laramie Basin, good views are obtained of the Medicine Bow Mountains, which constitute the north end of one of the main ranges of the southern Rocky Mountains and are so high that they are covered with snow during much of the year. Jelm Mountain, the nearest of this group, is a mass of ancient schist

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[1] Beds of volcanic ash occur about 4 miles south of Red Buttes. They are reminders of the volcanoes that were formerly so active in the Rocky Mountain region, but the location of the particular volcanoes that furnished this ash is not known. The material is pure white, soft, and fine grained. It occurs in beds that are comparatively young—that is, Tertiary or Quaternary. (See table on p. 2.) Volcanic ash is sometimes used as an abrasive, for scouring, polishing, or cleaning kitchen ware and other articles.

[2] About 6 miles west of Red Buttes, on the northwest shore of Creighton Lake, is a bed of bentonite, 3 or 4 feet thick, which appears as a white band in the black Benton shale, from which bentonite derives its name. Bentonite is a variety of clay used chiefly to give body and weight to paper, but to some extent in a dressing for inflamed hoofs of horses, in antiphlogistine (a proprietary remedial dressing), and as an adulterant of candies and drugs. It has notable powers of absorption, taking up about seven times its own volume of water. It absorbs twice as much glycerine as can be absorbed by diatomaceous earth, and for this reason has been suggested as a substitute for that material in the manufacture of dynamite. Other beds of bentonite occur farther west. It was first mined in this region in 1888, but with the closing of the western paper mills in 1905 its production practically stopped.

[3] Soda lakes occur near the Union Pacific line in Laramie Basin and at many places farther west. The waters of these lakes are strongly charged with sodium sulphate, and along their edges lie thick deposits of this salt that has been precipitated from the water. (See Pl. VIII, *B*, p. 44.) Three of these deposits were worked prior to 1895. The lakes lie in depressions in Cretaceous shale that contains a variety of salts, some of which were derived from the sea water in which the shale accumulated. Waters issuing as springs from this shale take the salts into solution, and rain falling on the surface of the shale dissolves them and carries them into the lakes. Water can escape from the depressions only by evaporation, so the salts accumulate in them. The soda deposits near Laramie have received more attention than any similar deposits in Wyoming. They cover about 60 acres, and the soda ranges in thickness from 1 foot to 16 feet.

and granite gneiss brought up by faults and contains some minerals of special interest, among which are bismuth ores, allanite, and sperrylite.[1]

Laramie.

Elevation 7,145 feet.
Population 8,237.
Omaha 573 miles.

Laramie is the second city in population in Wyoming and is the center of large stock and manufacturing interests. The University of Wyoming, including the State Agricultural College, the School of Mines, the United States Experiment Station, the Wyoming State Normal School, the Wyoming State School of Music, and the University Preparatory School, is located here. The city, as well as the river, the mountain range, and the county, derives its name from Fort Laramie, which stands at the mouth of Laramie River. This most famous fort on the old Overland Trail was named directly or indirectly for Jacques La Ramie, a French fur trader of the early days. The old maps show the river as La Ramies Fork. Stansbury, Sublette, Bonneville, Parkman, and many others have described the old fort in its various stages from the small trading outpost of a fur company to a United States Army post.

Laramie was the home of Bill Nye, and here he founded the Boomerang, a journal of somewhat fitful existence, and wrote the articles for the Cheyenne and Denver papers that brought him into prominence as a humorist. It is worthy of notice that some 30 years ago Nye and James Whitcomb Riley published a railway guide. "What this country needs," they say, "is a railway guide which shall not be cursed by a plethora of facts or poisoned with information. In other railway guides pleasing fancy, poesy, and literary beauty have been throttled at the very threshold by a wild incontinence of facts, figures, and references to meal stations. For this reason a guide has been built at our own shops and on a new plan. It will not permit information to creep in and mar the reader's enjoyment of the scenery."

The city of Laramie rests on the red beds of the Chugwater formation, which may be seen at several places north of Red Buttes and are conspicuously exposed just north of the city. Cement plaster is

[1] Bismuth, which is used extensively in the manufacture of drugs and of alloys that melt at low temperatures, occurs in Jelm Mountain in the form of carbonate and oxide. Sperrylite, or platinum arsenide ($PtAs_2$), has been found at Centennial, near Jelm Mountain. It is very rare; and this is the only place where it occurs in quantity so large that serious attempts have been made to work it for platinum. At Albany, in this same region, is found allanite, a black mineral containing cerium, yttrium, thorium, and other rare elements. In some places the ore is nearly pure allanite; in others it contains numerous impurities. Cerium, which is now obtained as a by-product in the reduction of thorium from monazite, is alloyed with iron to make the "sparker" in the modern "flint and steel" mechanisms used as gas lighters. Cerium oxide is used sparingly in glass making to produce clear glass free from any greenish tint.

manufactured from an impure gypsum known locally as gypsite,[1] which occurs near the city. Pressed brick are made from the Benton shale for constructing buildings in the city and elsewhere.

Beyond Laramie is the station Bona.

Howell.

Elevation 7,113 feet.
Omaha 580 miles.

The red beds of the Chugwater formation extend as far north of Laramie as Howell, although for most of this distance they are not visible, being covered with beds of gravel. West of Laramie is a low ridge where the Morrison (see pp. 41, 42) and Cloverly formations are exposed. The railroad passes over them just north of Howell, but they are covered with surface débris and can not be seen from the train. About 2 miles north of Howell and also at Wyoming the traveler passes through deep cuts in the Benton shale.[2]

Wyoming.

Elevation 7,138 feet.
Population 194.*
Omaha 584 miles.

From Wyoming station the train passes northward over the Niobrara limestone, which, however, near the track is covered with beds of sand and gravel. Outcrops of it appear as light-colored bands southwest of the station on both sides of the river. Northwest of this station the road crosses a thick deposit of marine shale of middle Upper Cretaceous age, but the shale is here covered with the alluvial deposits of Laramie Valley.

At many places in this region during the summer there are large fields of gorgeously colored wild flowers. In some places the plain is colored red with the blossoms of a variety of loco weed, which is poisonous to horses, and in others large areas are covered with the deep-blue blossoms of the larkspur. Evening primroses are also

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[1] Gypsite is finely divided gypsum mixed with other matter, which does not interfere with its use for cement plaster. It is baked in ovens, its calcium sulphate remaining as a dry powder, which is mixed with water in plastering and then becomes hard.

[2] The Benton formation in Nebraska consists of three members, two of shale and one of limestone, which are recognizable as far west as the east slope of the Laramie Mountains. West of the mountains the limestone is represented by shale indistinguishable from the other members. Near the base of the Benton on both sides of the mountains there is a hard sandy shale, called the Mowry, which weathers almost white and which contains numerous fish scales. Higher in the Benton is a sandstone, about 50 feet thick in the Laramie Basin, which seems to correspond to the Frontier formation of localities farther west. At some places indications of oil have been found in this sandstone.

In general there is no material difference in the Benton on opposite sides of the Laramie Mountains, either in physical character or in age, so that it is believed that when these beds were formed the Laramie Mountains did not exist and that the sea in which the sediments accumulated extended uninterruptedly over the area now occupied by the mountains. Some differences in nomenclature result from the fact that two standard geologic sections have come into use—one for the general region east of the mountains and the other for the region west of them. (See p. 41.) The Laramie Basin is in the transition zone between the two regions.

abundant, but they seem to prefer the gravelly slopes at the side of the road.

For a few miles north of Laramie the train follows more or less closely Laramie River, here a placid meandering stream. Not many miles farther down its course, to the north, the river has cut squarely across the main Laramie Range, below which it flows out into the Great Plains country and empties into the North Platte. A large storage reservoir has been built near the mountains, and here the flood waters of the river are stored to irrigate the Wheatland tract, east of the mountains. This irrigation project was put through under the Carey Act by its author, ex-Senator Carey, later governor of Wyoming. Mr. Carey showed that he not only could draft a law but could operate under it, for the Wheatland project is said to be very successful.

Bosler.
Elevation 7,077 feet.
Population 264.*
Omaha 592 miles.

Just after crossing Laramie River, before reaching Bosler, the route leaves the marine Cretaceous shale and enters an area underlain by the sandstone of the Mesaverde, a coal-bearing formation of Upper Cretaceous age. The Mesaverde is of great economic importance west of the Rocky Mountains because it contains valuable beds of coal. This sandstone near Bosler is soft and has disintegrated so deeply that its character can not be readily discerned from the train. It is well exposed, however, at many places a little farther west.

Cooper Lake.
Elevation 7,031 feet.
Omaha 597 miles.

Near the station of Cooper Lake a small alkali lake surrounded with white incrustations of sodium carbonate is visible near the track, but Cooper Lake itself can be seen only from a point several miles west of the station. This lake is about 4 miles long and 2 miles wide and occupies the lowest part of a broad depression. Like many of the smaller lakes of the Laramie Basin it has no outlet, and the considerable quantities of water entering it through the two creeks that head in the Medicine Bow Mountains to the south escape only by evaporation. For this reason the size of the lake is variable, depending on the balance between rainfall and evaporation.

Lookout.
Elevation 7,120 feet.
Omaha 600 miles.

From Lookout station westward to Medicine Bow the railroad is relatively new. The road was originally built north of the line now operated, crossing Rock River about 10 miles northeast of the present crossing and following that river north of Como Bluff to Medicine Bow. The new route shortens the line 20 miles.

The station at Lookout is built on a sandstone that lies unconformably on the Mesaverde. About a mile west of the station this rock is exposed in railroad cuts and consists of soft yellow sandstone containing pebbles of quartz and other varieties of hard rock ranging from grains of sand to pebbles 2 inches in diameter. In a cut about $1\frac{1}{2}$ miles east of Harper this conglomeratic sandstone [1] (see fig. 8) rests with uneven base—that is, unconformably—on a yellow shaly sandstone that contains marine shells.

Harper.

Elevation 7,073 feet.
Omaha 606 miles.

The section house called Harper (see sheet 10, p. 62) is built on a sandy shale in which have been found numerous fossil shells of Cretaceous marine mollusks. In the deep rock cut just west of the station may be seen a bed of coal about 3 feet 6 inches thick. This coal thickens toward the southwest, where it has been mined to some extent for local use.

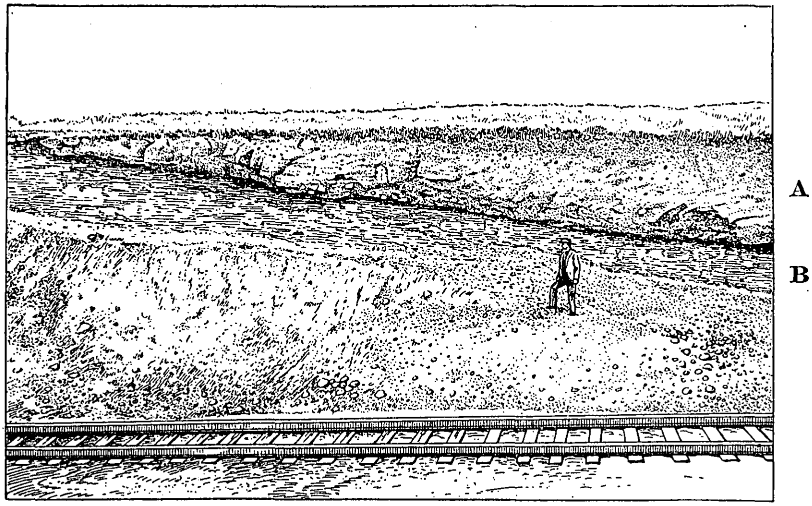


FIGURE 8.—An unconformity in a railroad cut about 4 miles west of Lookout, Wyo., showing conglomeratic sandstone (A) of Tertiary age resting on marine shaly sandstone (B) of Cretaceous age.

Pine Ridge, so named because of a few scrubby piñons, or nut pines, that grow on the sandstone cliffs, consists of a light-gray cliff-making sandstone that forms a prominent northward-facing ledge and belongs near the base of the Mesaverde formation. West of the cut are two prominent ridges formed by large reddish-brown limestone concretions that contain great numbers of marine shells. These are in the transition beds between typical Steele shale and the

[1] The conglomerate contains near the base sandstone concretions in which have been found fossil plants that seem to indicate Tertiary age, although these rocks have usually been regarded as a part of the Montana group of the Upper Cretaceous. These plants indicate that here, as elsewhere in this region, Tertiary beds lie unconformably on older rocks. The significance of this relation is discussed in the footnote on p. 2 and also in the footnote on p. 42. The conglomerate caps the hill south of Harper station, where it rests on rocks containing marine shells, but the contact is not easily determined owing to surface débris.

GEOLOGIC AND TOPOGRAPHIC MAP OF THE OVERLAND ROUTE

From Omaha, Nebraska, to San Francisco, California

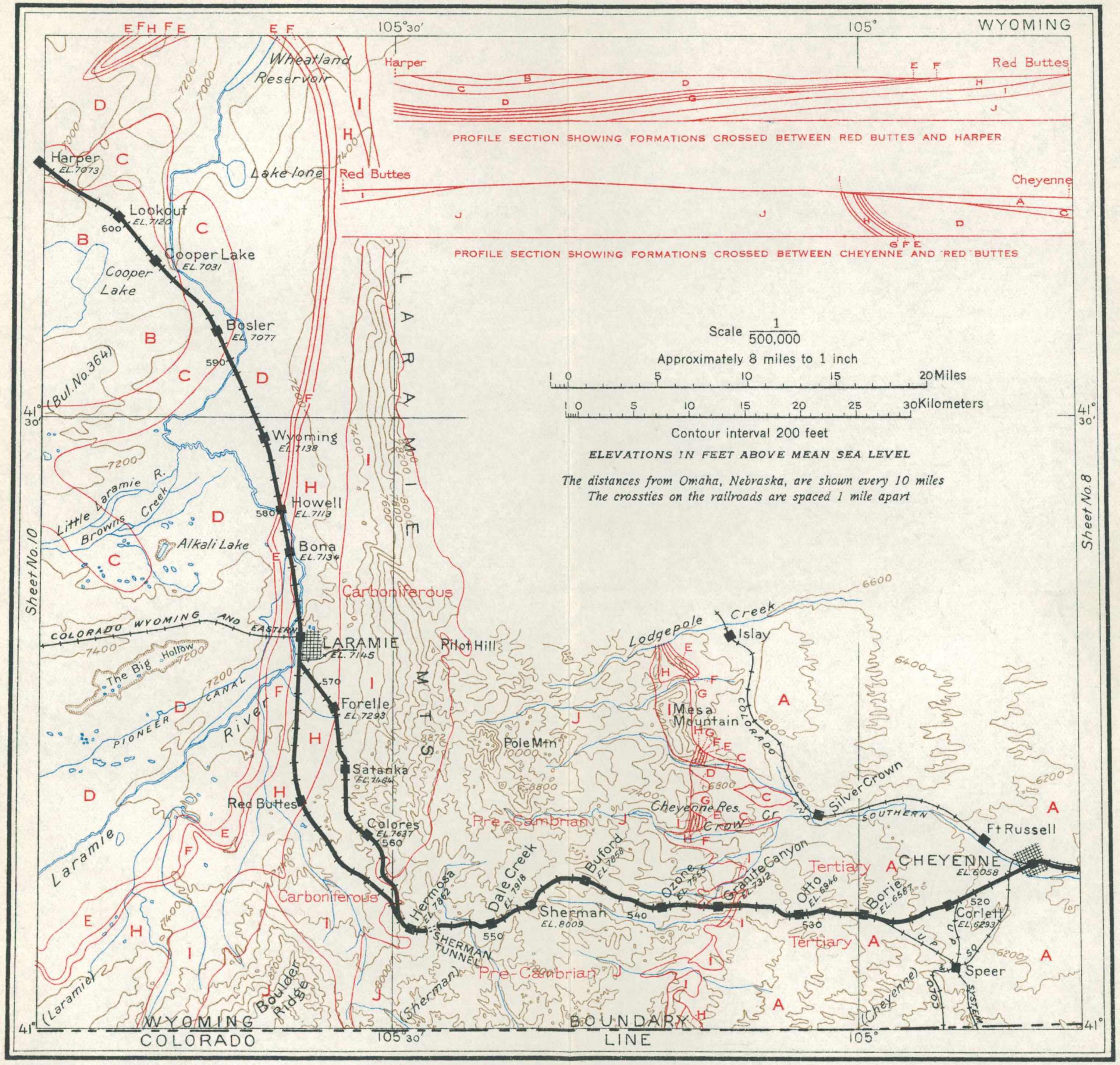
Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

EXPLANATION

		Thickness in feet	
A	Sand, gravel, and clay; fresh-water deposits (Arikaree and Gering formations)	200-250	Tertiary
	Sandy clay; fresh-water deposit (Brule clay)	250	
	Sand and gravel; fresh-water deposit (Chadron formation)	20-100	
B	Sandstone, conglomerate, shale, and coal; fresh-water deposits ("Upper Laramie" and younger formations)	10,000	Tertiary possibly including some Cretaceous
C	Sandstone; marine deposit (Fox Hills sandstone east of Sherman)	700±	Cretaceous
	Sandstone, shale, and coal; marine and brackish water deposits (Mesaverde formation west of Sherman)	2,000	
D	Shale; marine deposit (Pierre shale east of Sherman)	5,000	
	Shale; marine deposit (Steele shale west of Sherman)	2,500-3,000	
	Limestone and shale; marine deposits (Niobrara limestone)	325-400	
	Shale; marine deposit (Benton shale)	700-1,000	
E	Sandstone and shale, probably includes equivalents of Dakota sandstone, Fuson formation, and Lakota sandstone; fresh and brackish water deposits (Cloverly formation)	70-100	
F	Sandstone and shale; fresh-water deposit (Morrison formation)	150-200	Jurassic or Cretaceous
G	Sandstone and shale; marine deposit (Sundance formation)	30-60	Jurassic
H	Red sandstone, shale, and gypsum; fresh or brackish water deposits (Chugwater formation)	1,100	Triassic or Permian
I	Limestone; marine deposit (Forelle limestone)	0-20	Carboniferous
	Sandy shale and gypsum; marine or brackish water deposits (Satanka shale)	0-230	
	Limestone and red sandstone; marine deposits (Casper formation)	800-1,000	
J	Granite, gneiss, schist, igneous rocks (mainly Sherman granite)		Pre-Cambrian



massive sandstone of the Mesaverde formation that lies on it. These transition rocks become gradually more sandy toward the west, and west of Rawlins they form a part of the Mesaverde formation.

Pine Ridge is the divide between the Laramie River drainage and that of Rock River. The waters of its eastern slope pass eastward through the Laramie Mountains and enter Platte River at Fort Laramie, 80 miles to the northeast. Those of the western slope flow through Rock River and Medicine Bow River to the Platte and thence through the Seminoe Mountains around the north end of the Laramie Mountains and after a circuitous route of about 250 miles join those of the eastern slope at Fort Laramie.

Rock River.

Elevation 6,904 feet.
Population 123.
Omaha 612 miles.

Just before reaching Rock River station the train crosses the river of the same name, and good exposures of the Steele shale may be seen in the bluffs in the north bank. Northwest of the town the railroad passes over a broad plain formed on this soft shale.

About 10 miles from Rock River the road crosses a low, sharp hogback of Niobrara limestone. This chalky-white bed, 5 to 10 feet thick, forms a crest because it is harder than the shale above and below it.

Ridge.

Elevation 6,692 feet.
Omaha 623 miles.

Ridge takes its name from the prominent hogback ridge north of the station, formed by a hard sandstone in the Benton shale. The railroad parallels this ridge for a mile or more and then cuts through it west of the station. The lower part of the Benton shale is well exposed north of this sandstone ridge, in the center of the anticline formed by the arching of the strata. The route traverses this shale for about a mile before recrossing the sandstone and the Niobrara limestone and finally returns to the Steele shale in the northern limb of the arch.

Near Ridge the sandstone disappears because the fold that extends westward from the Laramie Range here plunges beneath the surface. Como Bluff, which lies north of Ridge station and which constitutes a part of this fold, consists of the Cloverly formation, the lower conglomeratic portion of which forms the crest of the bluff because of its superior hardness and forms also the long southward slope seen to the right from the train. Underneath this conglomerate occur in descending order the pink and blue shales of the Morrison formation, which, because of the numerous shades of color, are often called the variegated beds; the Sundance formation, containing numerous vertebrate and invertebrate fossils which prove its Jurassic age; and the Chugwater red beds.

The Morrison formation is probably the most interesting of those exposed here, because of the fossil bones of huge reptiles that it contains. The dinosaurs are described below by C. W. Gilmore, of the

United States National Museum.[1] The largest animals that have ever been found lived at a time when reptiles were the ruling types of animals in the sea, on the land, and in the air. Flying reptiles

[1] Como Bluff is classic ground to those interested in the fossil remains of animals that inhabited this region long ages ago, for it was here that the first dinosaur bones were discovered in the Rocky Mountain region. In 1876 Mr. W. H. Reed, now a professor in the University of Wyoming but then in the employ of the Union Pacific Co., found in the bluff above the now abandoned station of Aurora a large petrified limb bone, which he sent to Prof. O. C. Marsh, of Yale University. Prof. Marsh at once recognized the fossil as belonging to some unknown extinct animal and immediately enlisted the services of Mr. Reed. Collecting was actively carried on here for a period of ten years or more, and as a result of this work Prof. Marsh was able to publish the remarkable series of restorations of dinosaurs which appeared from time to time in several publications.

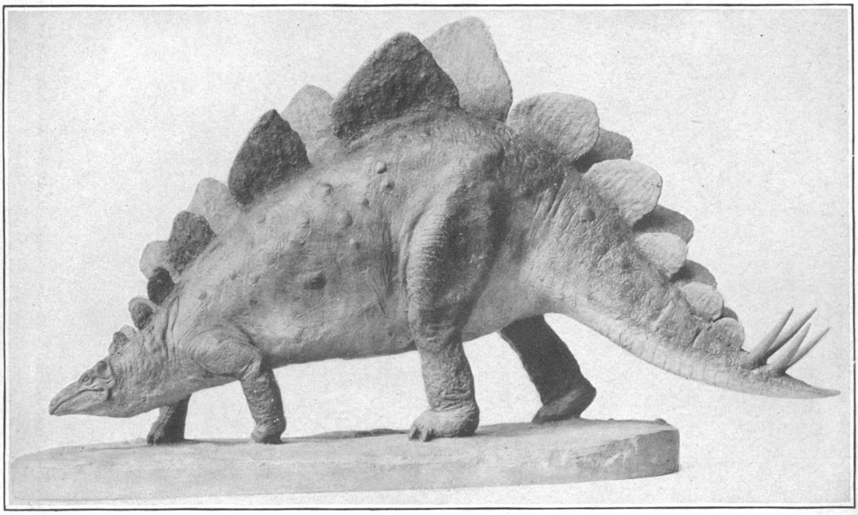
So famous did these fossils become that in 1899 the officials of the Union Pacific Railroad invited the geologists of the country to visit the places where the bones were found. An expedition consisting of geologists from universities and museums in many parts of the United States visited Como Bluff, the Freezeout Hills, and other famous fossil localities. So well known are the bone beds at Como Bluff that some have called the beds the Como formation. However, in the same formation at Morrison, Colo., similar bones were found, and the formation was named Morrison—a name which is now generally accepted. Some of the dinosaurs were the largest land animals that ever walked the earth, and some were very diminutive. They differed greatly in size, shape, structure, and habits. Some were plant eaters; others fed on flesh. Some walked on four feet; others with small, weak fore limbs walked entirely upon the strongly developed hind legs. Some had reptile-like feet; others were bird footed. Some had toes provided with long, sharp claws; others had flattened hoof-like nails. There were dinosaurs with small heads and others with large heads. Some were large and cumbersome; others were small, light, and graceful and so much resembled birds in their structure that only the skilled anatomist can distinguish their remains. Some of enormous size were clad in coats of bony armor, which gave them a most bizarre appearance.

The largest herbivorous or plant-eating dinosaur whose fossil remains have been found in Como Bluff was the huge Brontosaurus, or thunder lizard, as it was called by Prof. Marsh. It was 70 feet long, stood 16 feet high at the hips, and had a long tail, an equally long neck, and a head that was only a little larger than that of a horse. The weight of such a creature has been variously estimated at 18 to 20 tons. This animal doubtless lived on the luxuriant tropical vegetation, but how its enormous bulk could be sustained by such food as could pass through its ridiculously small mouth has caused much wonder. It is not certain whether the name thunder lizard was given to it because of its size or because of the large sum—over $10,000—which Prof. Marsh spent in excavating and preparing it.

Some dinosaurs that are even larger than the brontosaur have been found more recently. A Diplodocus now in the Carnegie Museum in Pittsburgh had the enormous length of 84½ feet. The size of the fossil bones is indicated in the accompanying figure 9.

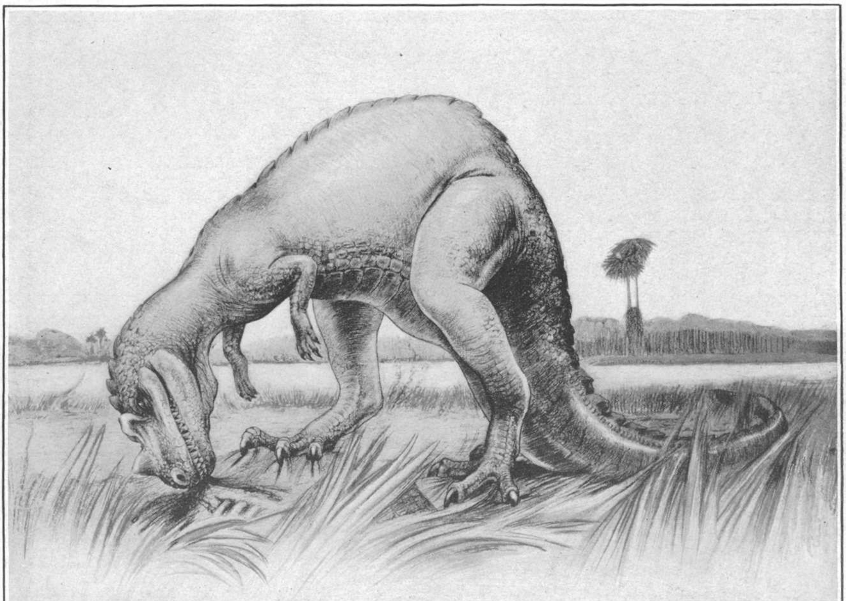
At the time these animals flourished the Rocky Mountain region was a low, nearly level country, covered with tropical vegetation, with many wide, shallow streams and swampy areas, thus furnishing a congenial place for these sluggish swamp-inhabiting creatures to wade lazily about or float in the water, for it has been deemed improbable that the enormous bulk of some of them could be sustained without lateral support such as would be obtained in water.

One of the most striking of the vegetarians of this period was the Stegosaurus,

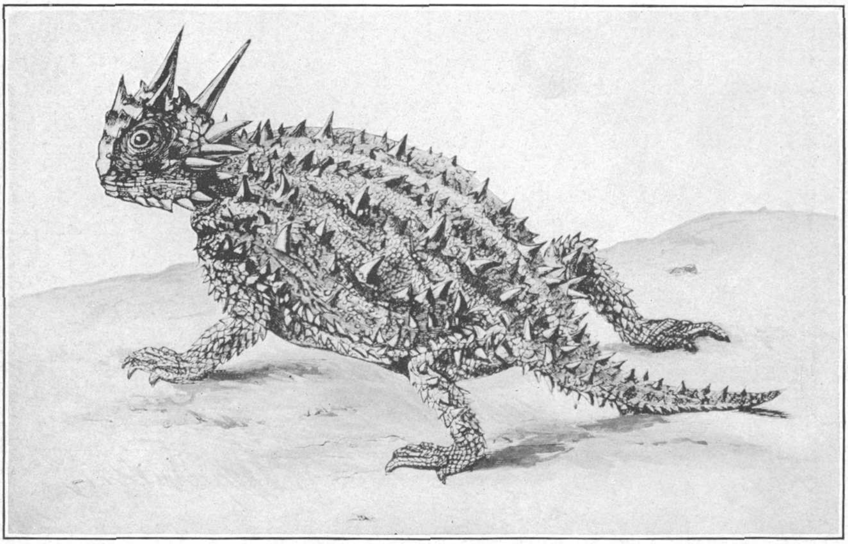


A. AN ARMORED DINOSAUR (STEGOSAURUS).

The bones of this animal, which was about 10 feet high, were found in the Morrison formation.

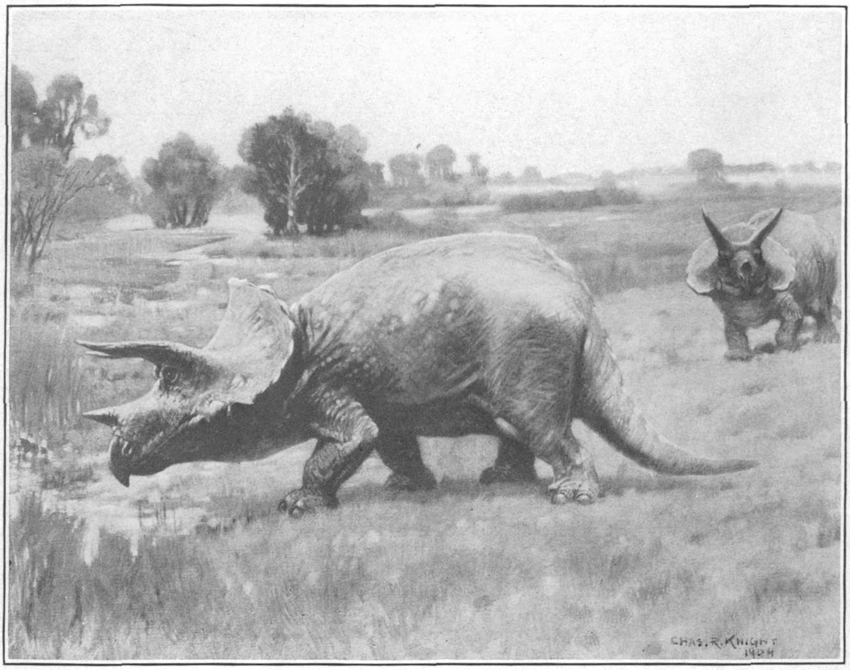


B. A CARNIVOROUS DINOSAUR (ALLOSAURUS) PREYING ON ONE OF THE HERBIVOROUS DINOSAURS.



A. A HORNED TOAD (PHRYNOSOMA CORNUTUM).

A modern lizard about 3 inches long that is armed like some of the ancient dinosaurs. Horned toads are distributed generally over western North America and are especially abundant on the dry sandy plains.



B. THE LAST OF THE DINOSAURS.

This restoration illustrates the appearance of Triceratops, showing the great bony frill over the reptile's neck. From painting by C. R. Knight, made under the direction of J. B. Hatcher.

similar to the one represented in Plate V, *C* (p. 21), were common, and the birds were so much like the reptiles that their remains can scarcely be distinguished.

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or plated lizard, so named because of the bony plates and spines with which its back was adorned. (See Pl. X, *A*.) Some of these plates, although very thin, were from 2 to 3 feet in diameter. They were held in upright position in two parallel rows on each side of the middle region of the back, extending from the base of the skull well down on the tail, the tip of which was armed with two pairs of long bony spines. In some individuals these spines were over 3 feet in length. All the plates and spines during life were covered by a thick, horny skin. The stegosaurs were about 20 feet long and stood about 10 feet high at the hips. The head was extremely small and lizard-like in shape, with a small brain, large eyes, and nostrils that indicate a considerable power of smell. The great disproportion in length between the fore and hind legs, the small pointed head, and the skin ornaments of plates and spines, made it so ugly that it may not have required other means of protection. Some passive protection, through repulsive ugliness or otherwise, seems to have been necessary, for its ludicrously diminutive brain suggests a mentality insufficient for conscious efforts at self-preservation. The want of brain capacity was compensated to some extent by an enlargement of the spinal cord near the hips that was about ten times as large as the brain.

FIGURE 9.—Leg bones of a dinosaur, showing size in comparison with that of a man.

The life of these peaceable plant-feeding animals, however, was not always serene, for there lived at the same time dinosaurs whose powerful jaws armed with long, sharp teeth indicate that their food was flesh. These animals are called allosaurs. (See Pl. X, *B*.) That they fed upon large brontosaurs and smaller animals of their kind is indicated by the discovery of teeth of the carnivorous species together with the bones of their herbivorous contemporaries and of a skeleton of one

The stratified rocks in this region have been greatly affected by the disturbances that formed the mountains surrounding it. The region lies between the Laramie Mountain uplift on the east, the Medicine Bow uplift on the south, and the Seminoe and Shirley mountain uplift on the north. The strata between these mountains have been thrown into a series of folds and domelike arches, and in some localities profoundly displaced. A small dome that brings to the surface the Morrison and younger formations lies south of the railroad, but can not be recognized from the train.

Medicine Bow.

Elevation 6,560 feet.
Population 127.
Omaha 630 miles.

The little town of Medicine Bow is well known to readers of Owen Wister's "Virginian" as one of the places where the cowboys played their laughable pranks, and the name of the novel has been taken by the hotel near the station. The name Medicine Bow is of Indian derivation, but how it came to be applied to the mountains from which the town takes its name is not certainly known. It is known, however, that some of the tribes annually visited the mountains that now bear this name to procure a certain kind of wood for their bows. In Indian talk anything that serves its purpose well is "good medicine," and according to report the mountains and streams where this timber was found became known as places where "good-medicine bows" were obtained.

The Flattop uplift, north of Medicine Bow, is a large, irregular-shaped dome, truncated by erosion and broken or faulted, as it is called, on the northwest side since it was formed. Carboniferous rocks appear at the surface in the center, and around these the younger formations crop out in concentric rings. The Freezeout Hills form a similar dome but expose granite in the center. Some of the smaller domes from whose crests the Cretaceous formations have not been removed by erosion may contain important oil pools.

The town of Medicine Bow is on a rolling plain formed by the erosion of the Steele shale. In this plain are numerous depressions in which water accumulates in wet weather, and as they have no outlet the water becomes alkaline, because it takes up the salts dissolved from the shale and left in the basins when the water previously collected there evaporated. These basins are similar to the alkali lakes of the Laramie Basin and are formed on the surface of the same shale formation. Such intermittent lakes are found in many places in Wyoming.

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of the herbivorous dinosaurs with bones scarred with tooth marks and grooves corresponding exactly to the sharp, pointed teeth of the allosaurs. The accompanying picture (Pl. X, *B*) depicts the remnants of such a prehistoric feast.

The allosaur was a most powerful animal, and skeletons over 20 feet long have been found. The large bones of the limbs were hollow, as were many other parts of the skeleton, this structure affording greater power of rapid movement. The feet were armed with long, sharp claws, especially the fore feet, which were well adapted for catching and holding prey or for tearing and rending skin and flesh.

Allen.

Elevation 6,601 feet.
Omaha 634 miles.

At Allen station, which is only a section house, the railroad passes from the Steele shale to the Mesaverde formation, which is here upturned and dips steeply toward the east. The softer layers, consisting of loose-textured sandstone and shale, have been eroded, leaving the harder layers to form sharp-crested ridges that are prominent along the road for a distance of about 4 miles west of Allen. The Mesaverde here has its full thickness, whereas at Pine Ridge the upper part had been eroded away before the Tertiary beds were laid down upon it.

Although the Mesaverde farther west is an important coal-bearing formation, little coal occurs in it here. A few thin seams less than a foot thick crop out near the road, but none of economic value have been found. The formation is characterized by two zones of hard sandstone separated by softer beds of shale containing fossil oysters and other shells of marine and brackish-water origin. These softer rocks have been eroded to form the depression which was crossed about 2 miles west of Allen, and which contains, north of the track, a small lake fed by sulphur springs at its west end.

From the crested ridges of the Mesaverde formation the traveler passes westward over a relatively smooth surface formed on the Lewis shale. The Lewis is a marine shale, somewhat sandy in places, and contains limestone concretions and great numbers of fossil shells, which belong to the Pierre fauna and indicate Upper Cretaceous age.

Como.

Elevation 6,703 feet.
Omaha 639 miles.

Como is a section house on the new cut-off between Allen and Dana. The original line, now abandoned, was built by way of Carbon, 4 miles south of Como. The new line not only shortens the distance and eliminates sharp curves and heavy grades but passes through Hanna, the center of an important coal-mining district. At Como the road is built through a small lake about a mile long, in which are found great numbers of salamanders that grow to be nearly a foot in length and are locally known as "fish with legs." These salamanders are rather common in southwestern United States and in Mexico, where they are used as food. The Mexican name for them is axolotl and the scientific name is *Amblystoma mavortium.*

About a mile east of Como the road passes from the Lewis shale to a younger formation, called "Lower Laramie," consisting of soft, easily eroded sandstone and shale containing fossil plants and shells of fresh-water invertebrates. West of the section house may be seen the yellow sandstones of the "Lower Laramie" overlain unconformably by the conglomerate at the base of the Tertiary—the "Upper Laramie." Thence westward for 5 miles the road is built on conglomerate, which is well exposed in a prominent hill to the left (south) of the track. It reaches the coal-bearing portion of the "Upper Laramie" in the Hanna Basin, a depression formed by mountain uplifts at the beginning of the Tertiary period and filled with conglomerate, sandstone, and coal-bearing shale. (See table on p. 56.)

Succession and character of the formations exposed in the Hanna coal field, between Como and Fort Steele, Wyo.

System.	Formation.	Thickness (feet).	Character.	Economic features.
Tertiary (possibly includes some Cretaceous).	"Upper Laramie" formation.	10,000?	Alternating beds of shale and sandstone, of drab, gray, and yellow colors. The sandstone is conglomeratic at the base and in a zone about 7,000 feet above the base. The pebbles of these conglomerates represent older rocks, now exposed in the mountains surrounding the basin. The formation contains well-preserved fossil plants, shells of fresh-water animals, and in the lower part, bones of huge dinosaurs.	The most productive coal formation in this coal field. The coal beds are in places 30 feet in thickness but are commonly from 5 to 10 feet thick.
Cretaceous.	"Lower Laramie" formation.	6,200+	Drab and gray shale, alternating with brown to gray sandstone. Fossil plants, shells of fresh and brackish water invertebrates (also marine shells in the lower part), and bones of turtles, dinosaurs, and other animals occur in these rocks.	Contains several thin irregular beds of coal, but none of them are now mined.
	Lewis shale.	3,200+	Dark-gray shale with intercalated sandy beds. The fossils in this formation consist entirely of marine shells.	
	Mesaverde formation.	2,700+	White to brown sandstone and drab shale. Marine shells and the marine plant *Halymenites major* occur in the lower part, and fresh and brackish water shells in the upper part.	Contains a few thin irregular coal beds of little economic value.
	Steele shale.	3,000+	Drab shale and thin beds of sandstone. Contains marine fossils; ridge-making sandstone layers near the top.	

Hanna.

Elevation 6,769 feet.
Population 1,892.
Omaha 650 miles.

Hanna is a coal-mining town in the south-central part of the Hanna Basin. Two beds of coal are worked here, one 24 feet and the other 36 feet thick, according to the mine superintendent. They are separated by about 1,500 feet of strata in which one coal bed 18 feet thick has been opened and several thinner ones are known to occur. There are other coal beds below the lower or 36-foot bed that will be valuable sometime, but nothing has yet been done toward developing them.

Coal was discovered in this region by Frémont in 1843 on Platte River. The beds were opened there in 1856 and some of the coal was used in a forge. From 1862 until the Union Pacific Railroad was built these openings supplied coal for emigrants and for the Overland Stage Co. The presence of coal here was one of the reasons why the Union Pacific was built along the southern branch of the Overland Trail rather than along the northern branch up Platte River and over South Pass. Production of coal for the railroad began at Carbon in 1868, after the completion of the railroad westward to this point, and the coal of this field has furnished power for operating the road ever since that time.

The mines at Hanna were opened in 1890. Until 1902 this town was reached by a branch line, and Carbon, 10 miles to the southeast, furnished much of the coal for the road. But when the main line was diverted to pass through Hanna the town of Carbon was deserted and the mines there were closed.

The higher coal bed at Threetown, east of Hanna, lies rather close to the surface, and the falling of the roof in the abandoned parts of the mine makes bad surface sinks. One such hole about 150 feet across may be seen to the right, on the north side of the track, south of Threetown.

Hanna has a daily coal output averaging about 2,500 tons. The coal is subbituminous and is rather light and free burning. Under the forced draft of the locomotives cinders are thrown out and start numerous fires along the track. Burning grass and smoking ties are familiar sights along this part of the route, and even station buildings are sometimes set on fire. It is estimated that 500 square miles in this basin is underlain by coal and that 33,000,000,000 tons of coal is available for mining.

West of Hanna are several deep cuts in which the coal-bearing rocks may be seen to advantage. Conglomeratic sandstones which appear in two of these cuts dip eastward under the coal beds mined at Hanna. Farther west and lower in the formation there are a great number of coal beds, many of them thick enough to be of value for mining. These are all inclined about 20° toward the center of the basin and are warped and faulted in some places. The rocks here contain many fossils, including impressions of leaves, shells of fresh-water clams and snails, and bones of dinosaurs, described below by C. W. Gilmore.[1] These fossils indicate a period of transition between the old Cretaceous life, in which reptiles were the dominant forms, and the newer Tertiary life, in which the mammals, the familiar class of vertebrates of the present time, predominated. The dinosaurs found here are the last known representatives of their type, and the mammals are primitive and inconspicuous. The plants, however, are of types not greatly variant from those of the present time, although the species are all different.

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[1] Dinosaur bones belonging to the genus Triceratops (which means "three-horned face"), so named in allusion to the three horns with which the skull is armed, are found in the coal-bearing rocks of the Hanna Basin and other formations of the same age. Over each eye was a massive horn directed forward and terminating in a long, sharp point, and the nose usually bore a third but much smaller horn. (See Pl. XI, *B*, p. 53.) A mounted skeleton of a Triceratops in the National Museum at Washington is about 20 feet long and stands 8 feet high at the hips. Some skulls that have been found measure more than 8 feet, over one-third the length of the entire animal. This great length of head is due largely to the remarkably bony development called the frill, which projects backward over the neck like a fireman's helmet.

That Triceratops, although a plant eater, was a fighter and often engaged in combat appears to be shown by the broken and healed bones that have been found. A pair of horns in the National Museum bear witness to such an encounter. One of them has been broken and has healed to a rounded stump. Although Triceratops had an enormous head, it had a smaller brain in proportion to its size than the least intelligent land animal of the present time. In the earlier restorations of this animal as shown in the accompanying picture its skin has been represented as being smooth and leathery, but a recently discovered specimen, in which impressions of the skin are preserved, shows that it was made up of a series of hexagonal scales of various sizes.

Triceratops probably lived on leaves and branches of low trees or shrubs. At the time these animals existed, this part of the country was covered with vast swamps in which peat accumulated and wide watercourses that were constantly shifting their channels, the region presenting an appearance similar to that of the Everglades of Florida. Where the waters were not too deep the region must have been covered by luxuriant vegetation and was inhabited by great numbers of the huge dinosaurs, as well as by smaller crocodiles, alligators, turtles, and diminutive mammals, all of whose fossil remains are now found embedded in the deposits of that time.

Contemporary with the Triceratops was a great duck-billed reptile related to Trachodon, which was the commonest dinosaur of an earlier period. An average-sized individual measured 30 feet from the tip of its nose to the end of its tail, and as it walked erect on its huge three-toed hind feet the top of the head was 12 or 15 feet above the ground. The head was nearly a yard in length, and the fore part of the skull was expanded to form a broad beak that was covered with a horny sheath, as in birds and turtles. This was admirably suited to the pulling up of the rushes and other water plants that constituted the food of this great creature. These trachodont reptiles lived in the swamps and rivers. The webbed fingers of the fore foot indicate swimming ability, and the long, deep, compressed tail must have been an efficient swimming organ, and was also useful as a counterbalance to the weight of the body when the animal

Percy.

Elevation 6,932 feet. Omaha 655 miles.

East of Percy the train enters a cut 65 feet deep and 1½ miles long through beds of coal, carbonaceous shale, and sandstone. It is reported that the coal taken up here by the steam shovel was used in the engine and furnished the power for making the cut. The best bed thus exposed contains coal 8 feet thick.

Elk Mountain, which is visible from many points on the route, is seen to best advantage to the left (south) from Percy station. This great mountain of granite, conical in form and 7 miles in diameter at its base (Pl. XII, *B*), rises to an altitude of 11,162 feet and is at the north extremity of the Medicine Bow Range. To the west of it is a relatively small peak of irregular outline called Sheephead Mountain. Farther southwest can be distinguished on a clear day the Sierra Madre, near the northern boundary of Colorado.

Dana.

Elevation 6,782 feet. Omaha 659 miles.

About 1½ miles west of Dana the traveler passes from the rocks of the "Upper Laramie" to those of the underlying "Lower Laramie" formation, but the change is inconspicuous from the train because the rocks are obscured by surface material near the road. The "Lower Laramie" consists of sedimentary rocks more than 6,000 feet thick, mainly coarse-grained sandstone, in which are a few thin beds of coal.

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walked on its hind legs. From specimens showing impressions of the skin it is known that the animal was covered with an epidermis made up of tubercles, or knoblike plates, of two sizes, the larger ones predominating on the back and sides. One of the most remarkable features about this reptile was its mouth, which was armed with 2,000 or more separate teeth arranged in vertical rows. Each jaw has from 45 to 60 rows and from 10 to 15 teeth in each vertical row. These were self-adjusting, and as one was lost or worn out another pushed up to take its place.

As in Morrison time, so in the very much later Lance epoch there were armored and flesh-eating reptiles, and some of these were even more ugly than their Morrison progenitors. Ankylosaurus was an armored dinosaur whose entire back was covered by flattened ridged-skin plates of bone. The animal was low of stature, had a short, blunt head, and carried on the end of its stout, heavy tail a great triangular club of bone. Even the eyes were provided with a cup-shaped bony shutter, like the visor of a helmet, which could be closed over the eyeball, so that all the vulnerable parts of this animated fortress were protected by bony armor. The "horned toad," one of the small modern lizards of the western plains, is not very different from the armored dinosaurs except in size. (See Pl. XI, *A*, p. 53.)

The most striking of the flesh-eating dinosaurs was the Tyrannosaurus, or tyrant lizard, the largest carnivorous animal that ever lived on land. It was 40 feet in length, and when it stood erect the top of its head was 18 to 20 feet above the ground. The fore limbs were small, and it must have walked entirely upon its powerful hind legs. A perfect skull of this animal is exhibited in the American Museum of Natural History in New York City. The jaws are 4 feet in length and bristle with sharp-pointed teeth, several of which project 6 inches from their sockets. It is with a feeling of awe that one standing before the huge head contemplates a beast of such terrible ferocity.

These rocks contain fossil plants and shells of fresh-water mollusks, although brackish-water and marine fossils occur near their base.

Between Dana and Walcott the strata are bent up in one of the great arches or anticlines of this much-disturbed region. Edson is on the Lewis shale, but the beds of the North Park formation (Tertiary) extend to the railroad from the south. A mile farther southwest, beyond a short tunnel, is a deep cut through the crest of the St. Mary anticline, which consists of the arched sandstone of the Mesaverde formation. The crest of the ridge is formed of this sandstone, which is harder and has therefore resisted erosion better than the shaly beds that originally covered it.

Edson.

Elevation 6,720 feet.
Omaha 664 miles.

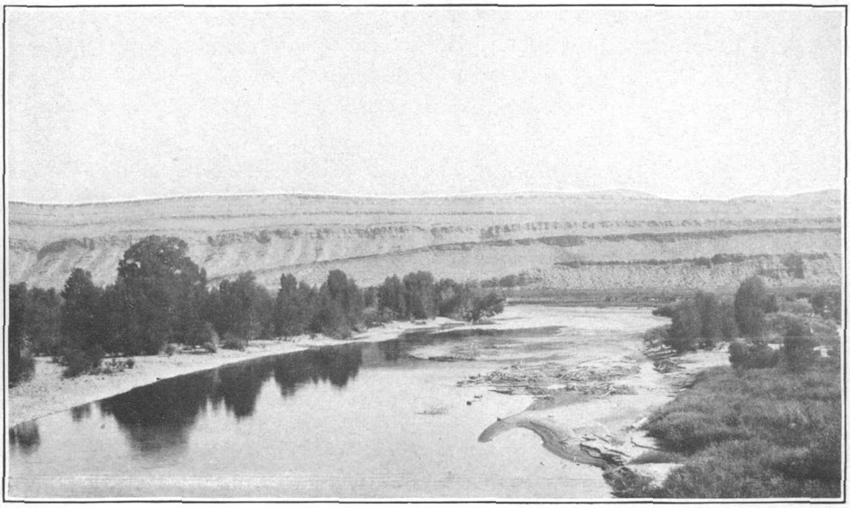
South of the tunnel the train again crosses the Lewis shale and the "Lower Laramie" formation before it reaches Walcott. The town of Walcott is built on the North Park formation, which here covers the older strata. This formation takes its name from North Park, Colo., where it occupies an extensive area and contains thick beds of coal. From Walcott a branch road runs south to Saratoga and Encampment. Saratoga is on Platte River and is well known to sportsmen for its hunting and fishing. Here are some hot sulphur springs and a well that furnishes a mineral water sold under a distinctive name. Encampment, 43 miles south of Walcott, at the end of the branch line, is the center of a copper-mining district which formerly produced considerable ore but is not now very active. This district is in the Sierra Madre. Copper was discovered here in 1868, but not until 1881 did the district become productive. Altogether it has yielded over 20,000,000 pounds of copper. Gold, silver, and other metals have been found in small quantities. The mines are in crystalline and metamorphic rocks, of pre-Cambrian age, cut by intrusive rocks, including gabbro, which is supposed to be the source of the copper ore.

Walcott.

Elevation 6,618 feet.
Omaha 669 miles.

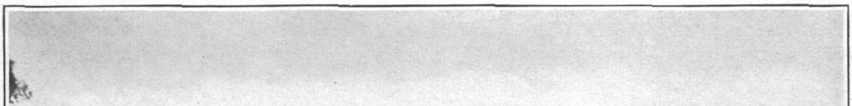
About 2 miles due north of Walcott is a prominent hill known as St. Mary Peak, which rises 7,496 feet above sea level. This peak and the ridge extending northwestward from it are composed of upfolded beds of the Mesaverde formation. The strata, during the process of folding, were broken and thrust upon one another in such a way that those east of the fracture were pushed up over those west of it, so that certain beds of the Mesaverde formation now rest upon younger beds that were originally laid down on top of that formation.

Two miles west of Walcott the railroad leaves the nearly horizontal beds of the North Park formation and reaches the steeply inclined massive yellow sandstones of the Mesaverde formation, which are carved by erosion into a great variety of forms. These sandstones make a conspicuous ridge that extends northwestward for many



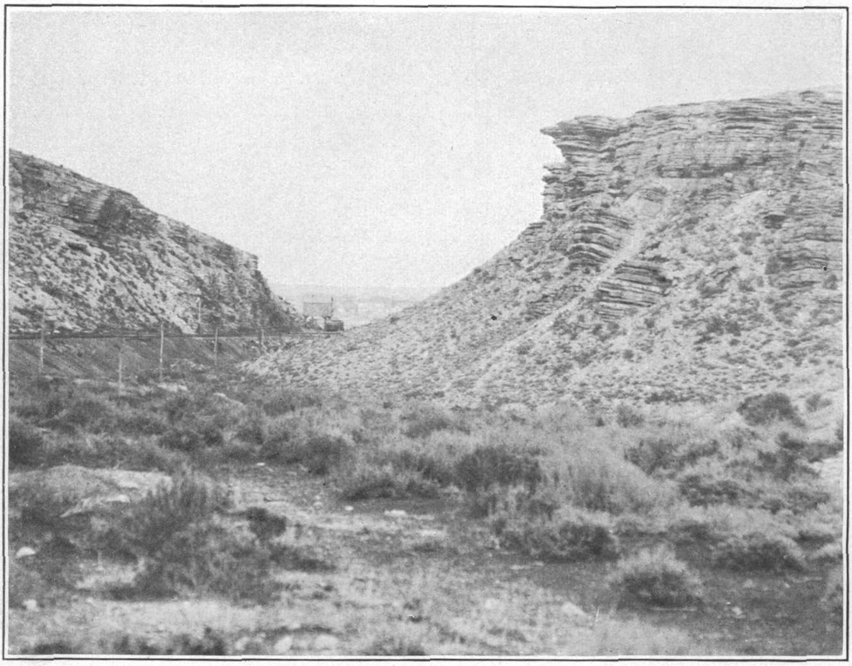
A. PLATTE RIVER AT FORT STEELE, WYO.

A characteristic view of the Cretaceous rocks in central Wyoming. Photograph furnished by Union Pacific Railroad Co.



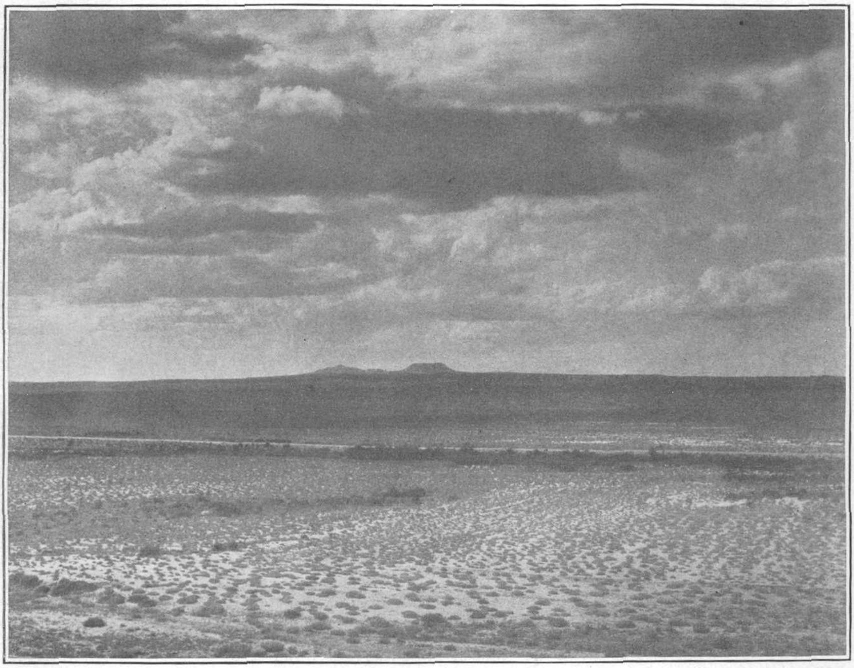
B. ELK MOUNTAIN, THE NORTH END OF THE MEDICINE BOW RANGE.

This mountain may be seen during nearly 150 miles of the journey over the Union Pacific Railroad. Photograph furnished by Union Pacific Railroad Co.



A. GAP IN THE CAMBRIAN QUARTZITE THROUGH WHICH THE WESTBOUND TOURIST PASSES AFTER LEAVING RAWLINS, WYO.

Sagebrush in the foreground.



B. CHARACTERISTIC VIEW OF THE RED DESERT.

The plain is formed on Tertiary beds and covered with sand and sagebrush. The distant buttes are capped with harder beds, which have prevented the rain and wind from wearing them down to the general level of the plain. Photograph furnished by Union Pacific Railroad Co.

miles. The part of the ridge between Walcott and the point where North Platte River crosses the formation is known as the Rattlesnake Hills; the part north of the river is called the Haystack Hills.

Three miles east of Fort Steele the railroad leaves the Mesaverde beds and reaches a formation which has been named the Steele shale,[1] from its occurrence here. This shale is the same as that which crops out near Medicine Bow and extends westward from that place beneath the coal-bearing rocks of the Hanna Basin.

Fort Steele.
Elevation 6,505 feet.
Population 699.
Omaha 675 miles.

The town of Fort Steele derives its name from Fort Fred Steele, an army post established here in 1866 to guard the Union Pacific Railroad against Indians. At the time of the Meeker massacre, in the early eighties, it was from Fort Fred Steele that the unfortunate force commanded by Maj. Thornburg was sent to put down the uprising. Maj. Thornburg and most of his command never returned. That any of them survived was due to the dispatch of a second expedition from the fort to their relief. There is little about the town now to suggest the troublous Indian times. It serves as a place of supply for sheep herders and for the farms scattered up and down North Platte River wherever the valley is wide enough to be cultivated. The North Platte, from which the railroad diverged at the city of North Platte, 291 miles west of Omaha, is reached again at Fort Steele, 384 miles west of North Platte and 3,705 feet higher.

From its source in North Park, Colo., the North Platte follows a circuitous route to the north until it reaches a point nearly halfway across the State of Wyoming. In this part of its course it cuts through the Seminoe Mountains and passes completely around the north end of the Laramie Range. In the Seminoe Mountains the river has cut some remarkably picturesque gorges. Across one of these the United States Reclamation Service built the Pathfinder dam, 218 feet high, creating a reservoir having a capacity of 1,100,000 acre-feet—that is, enough water to cover that number of acres to a depth of 1 foot. In this reservoir flood waters that formerly went to waste are stored, to be released as needed to irrigate 130,000 acres in eastern Wyoming and western Nebraska. This project, which is not yet completed, will cost nearly $7,000,000.

To the left (south) as the train crosses the bridge over the North Platte at Fort Steele may be seen a sawmill which works timber cut in the mountains and floated down the river. This mill produces many railroad ties and mine props from timber grown in the Medicine Bow and Hayden national forests.

[1] The upper part of the Steele shale is much more sandy near Fort Steele than it is farther east, and several prominent sandstones lie below the massive sandstone that is here mapped as the base of the Mesaverde.

North of Fort Steele the Rattlesnake Hills rise from the river level by a series of escarpments, and about 2½ miles south of the town there is another series of escarpments, composed also of the Mesaverde formation and the sandstones of the transition beds between the Steele shale and the Mesaverde, which are illustrated in Plate XII, *A*. If the traveler were to make an excursion to these two ridges he would observe that the strata in the Rattlesnake Hills dip toward the northeast, whereas those in the ridge south of Fort Steele dip toward the south. If the strata of these two ridges were projected upward along their dip till they met, they would form an arch whose crest would be a little south of Fort Steele. As a matter of fact the Mesaverde formation did at one time extend over such an arch. When these beds were bent up by the development of the fold they were probably fractured at its crest. Along this line of fracture the hard sandstones were more easily eroded than elsewhere and were finally cut through by the streams. The underlying soft shale was then rapidly eroded along the crest of the fold, so that in time the axis of the arch, which was originally a ridge, was reduced to a valley bordered on either side by flaring walls of sandstone. This valley, now several miles wide, is followed by the railroad from Fort Steele to Rawlins.

Grenville.

Elevation 6,580 feet.
Omaha 683 miles.

The station at Grenville (see sheet 11, p. 68) is little more than a pump house. Water from the wells that furnish the domestic supply for the town of Rawlins is not suitable for use in locomotives because it contains mineral matter that incrusts the boilers. Consequently water for generating steam is pumped to Rawlins from North Platte River at Fort Steele, a distance of 15 miles, with a lift of 236 feet.

Far to the north may be seen the Seminoe Mountains, named for Seminoe Lajeunesse,[1] a French trapper and fur trader. In plain

[1] It is said that Lajeunesse's real name was Basil and that the name Seminoe was corrupted from a French nickname, "Cimineau," although some reports have it that Seminoe was the name given to him by his Snake squaw. Lajeunesse established a trading post on the Overland Trail above Devils Gate. Early in the sixties, with two men and fifteen pack animals loaded with goods, he started out to trade with the Sioux. On the way the party was attacked by Indians in Bates Hole, southwest of Casper, and Lajeunesse was killed. Lajeunesse was a successful hunter and trapper, and the old settlers who remember him say that the mountains were called Seminoe to perpetuate the name of one of the bravest and truest pioneers of Wyoming. He accompanied Frémont on the first expedition into Wyoming, and was one of those chosen to make the ascent of Fremont Peak. He is reported to have accompanied United States troops as a scout on a number of expeditions. His uncle, Gabriel Lajeunesse, was, so tradition says, the hero of Longfellow's "Evangeline."

It is interesting to note that some recent maps show these mountains as the Seminole Mountains, the compilers of the maps evidently assuming that they were named for the Seminole Indians and that the "l" had been omitted by mistake from the maps on which they were shown as Seminoe.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
OVERLAND ROUTE
From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

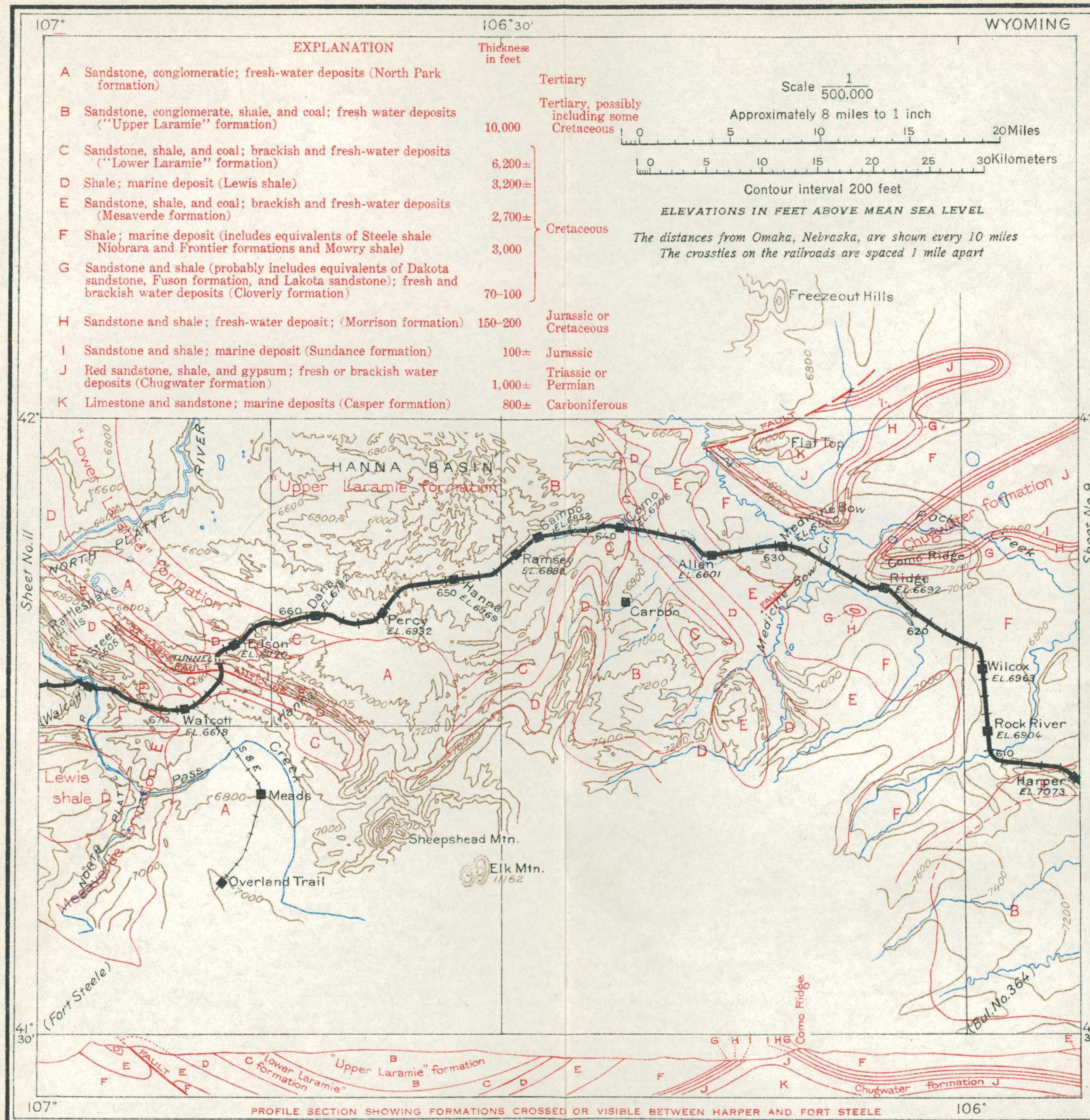
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist   R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.



sight also north of Grenville, although about 30 miles away, is a range of mountains with striking white scallops on their southern flank. These are the Ferris Mountains, lying just west of the Seminoe Range. The white scallops are vertical beds of limestone which have resisted erosion while the softer beds around them have been worn away. These mountains were named for George Ferris, one of the early settlers in this region, whose name has been applied to several of its natural features and many of its enterprises.

South of Grenville the rocks, which have been domed, are eroded so deeply that the Mowry shale is exposed at the surface in the center of the dome and the several sandstones of the Frontier formation lie in concentric ridges around it. The shale between these sandstones contains limestone concretions in which are shark teeth, ammonites, scaphites, and other fossils of marine animals that indicate Upper Cretaceous (Benton) age. These sandstones contain oil in some places, and for the purpose of ascertaining their depth south of Rawlins, where a well was started near the base of the Mesaverde formation, the shale was carefully measured at a favorable exposure south of Grenville, where it was found that the sandstone lies 2,200 feet below the lowest sandstone ledge of the transitional zone between the Mesaverde and the Steele shale. The shale between the base of the Mesaverde and the Frontier is therefore somewhat more than 2,200 feet thick.

A few miles east of Rawlins the outcropping edges of the several formations are passed over in rapid succession. These strata are upturned around the Rawlins dome [1] and range in age from Cambrian up to Cretaceous. (See table on p. 2.) Some of these formations can not be seen to advantage from the train. From the geologist's point of view it is unfortunate, though inevitable, that railroads are built where the easiest grades can be obtained rather

[1] The center of the Rawlins uplift consists of granite which reaches an altitude of more than 7,600 feet in the hills north of the railroad. Around this granite core and sloping away from it are the sedimentary rocks. The oldest, the Cambrian quartzite, is very hard and forms conspicuous slopes. The railroad is built through a narrow gap in these rocks west of Rawlins. (See Pl. XIII, *A*, p. 61.) The Carboniferous limestone lies in general unconformably on the Cambrian quartzite, but is separated from it in some places by beds of iron ore. Red sedimentary rocks that lie above this limestone are separated into two parts by a layer of similar limestone. It is possible that the upper part represents the Chugwater red beds and the lower part the Casper formation of the Laramie region.

The Sundance formation comes next, with its characteristic marine Jurassic fossils, and above it lie the variegated Morrison beds. These are succeeded by the Cloverly, which here, as elsewhere, consists of two sandstones, the lower one conglomeratic, separated by dark shale. Above the upper sandstone is the Mowry shale, the sandstone of the Frontier formation, and a body of shale which includes equivalents of the Steele shale and the Niobrara formation.

than where the rocks are best exposed. The sandstone of the Frontier formation may be recognized by low ridges through which shallow cuts have been made, and the Cloverly forms a prominent ridge seen to the right (north) of the track. The pink beds of the Morrison formation appear to the south and the brick-red beds of the Chugwater formation to the north.

The spring from which the town of Rawlins took its name was so designated in honor of Gen. J. A. Rawlins, Secretary of War under President Grant. The town is a shipping point for a large area both north and south of the railroad. It is the connecting station for Baggs and Dixon, in southern Wyoming, 70 miles to the south, and before the building of the "Moffat road" (Denver & Salt Lake) it supplied Craig, Hayden, and other places still farther south in northwestern Colorado. It is also a railroad division point.

Rawlins.
Elevation 6,741 feet.
Population 4,256.
Omaha 690 miles.

In the old days a Government road ran southeastward from Rawlins to the White River Indian Agency, in what is now Rio Blanco County, Colo. Mail service was maintained on this road, and the bridge which the Government built across Snake River at Baggs is still in good condition.[1]

The dark-colored Cambrian quartzite is conspicuously exposed north of Rawlins, where it is overlain by light-colored Carboniferous limestone. The red oxide of iron at the base of the Carboniferous was formerly mined north of the town for paint.

West of Rawlins the formations on the Rawlins dome that were crossed east of the town are passed over in reverse order.

From points west of Rawlins the Ferris Mountains are again plainly visible far to the north, and a noticeable notch, called Whisky Gap, may be discerned at the west end of the range. Through this gap runs the old Rawlins-Lander stage road. West of this range are the Green Mountains, which are terminated on the west by a pass known as Crooks Gap, named for Gen. George H. Crook, a noted Indian

[1] When the White River Utes massacred Indian Agent Meeker and his family the command sent south from Fort Steele under Maj. Thornburg followed the Government road as far as Baggs, then swung west, crossing Little Snake River about 12 miles farther down and striking out southwest across the great rolling sagebrush country which lies between Little Snake and Bear rivers. Their guide must have known the country thoroughly, for their route, still known as the Thornburg road, takes advantage of every topographic feature and every safe watering place. Some miles after crossing Bear River Maj. Thornburg decided, it is said against the remonstrances of his subordinates, to lead his command through a narrow valley. Here they were ambushed, and for three days and nights defended themselves as best they could, using the few wagons which they could get together and the bodies of dead horses as barricades. Two of the number escaped during the first night and brought word to Rawlins. When the relief expedition reached the scene, Maj. Thornburg and more than two-thirds of his command were dead.

fighter, whose name was given also to the creek that flows through the gap and to the mountain that lies just west of it.

Ferris.

Elevation 6,869 feet.
Omaha 693 miles.

Near Ferris siding the railroad crosses a low ridge of hills formed by the upturned sandstones of the Mesaverde formation, which constitute the eastern rim of the Great Divide Basin, a great depression in the older rocks filled with younger sediment. West of the ridge are the younger Cretaceous rocks, which are here steeply upturned, but which flatten out as they extend westward under this basin. About 2 miles east of Knobs siding the road reaches Tertiary beds, also steeply upturned here, but flattening out farther west. They consist of conglomeratic sandstone alternating with dark-colored shale, and in some places contain beds of coal. These rocks contain some fossil plants and shells of fresh-water mollusks.

Daley's Ranch.

Elevation 6,684 feet.
Omaha 704 miles.

Near the station called Daley's Ranch the train crosses the wide valley of Separation Creek, which, after following an erratic course for 60 miles, is lost in the Great Divide Basin. North of the railroad (to the right) may be seen in this valley the barns and corrals of a large sheep ranch. Less than 30 years ago the owner of this ranch was a section hand on the Union Pacific, but he is now a large property owner and has been a member of the State legislature. Many tales might be told of sudden rise to fortune in the early days of the sheep industry, before the ranges had been overstocked and depleted.

Cherokee.

Elevation 6,828 feet.
Omaha 712 miles.

In Wood's cut, about 2 miles west of Cherokee, there is a poorly consolidated yellow conglomeratic sandstone resting with uneven base on dark-colored shale. This cut was made through a rise in the rolling plain, and here, as at hundreds of other places along the Union Pacific, the road needs protection against drifting snow. The windbreaks for this one cut cost $3,500.

Creston.

Elevation 7,102 feet.
Omaha 719 miles.

At Creston siding the train crosses the divide between the Atlantic and Pacific slopes and a sign south of the track reads: "Divide of the Continent." As a matter of fact, the traveler is also within the Great Divide Basin. The ordinary conception of a divide is that of a mountain crest, but here is the anomaly of a continental divide passing through an undrained basin that is about 60 miles across from north to south and 100 miles from east to west. This basin contains numerous salt and alkaline lakes, mud flats, and mud springs. Hayden, one of the earlier Government geologists, states that in the region between the Seminoe Hills and Rawlins he saw an interesting group of mud springs, analogous to the mud puffs of the geyser region in Yellowstone Park. About 400 of these curious springs were found and examined.

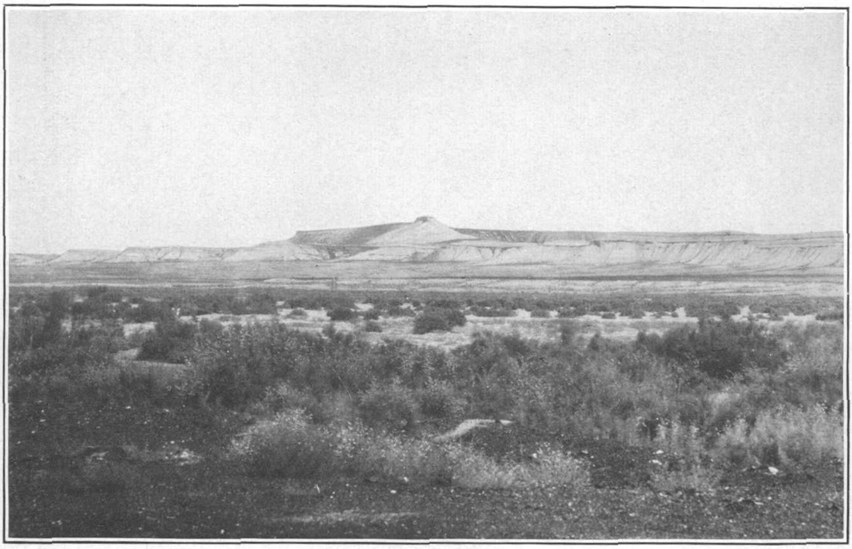
Throughout this part of the route the strata lie nearly horizontal, but there are long stretches of desert on which little can be seen except the bunches and tangled growths of stunted sagebrush and greasewood. (See Pl. XIII, *B*, p. 61.)

Red Desert.

This part of the Great Divide Basin is called the Red Desert. Coal beds crop out in it west of Latham siding, about 5 miles beyond Creston, but the coal is of poor quality and little use has been made of it. West of Creston is obtained the first comprehensive view of the Red Desert. A few miles north of the track is a great stretch of sand dunes, which extends 100 miles, from Green River to North Platte River. The dunes, many of them more than a hundred feet high, are constantly traveling with the prevailing winds in a direction a little north of east. If a few camels and an Arab or two were added to the scene, the spectator could easily imagine himself in the Sahara Desert. Frequent mirages, endless variety of feature, and wonderful coloring make the desert far from the monotonous stretch it may seem to be at first glance. As the name suggests, the dominant colors are red—russet, brick-red, and vermilion—but there is every tone of gray and brown, with not a few shades of green, purple, and yellow. Unlike the colors of an eastern landscape, those of the Red Desert are not dependent on the season, for there is little vegetation to hide the coloring of the rocks and soil.

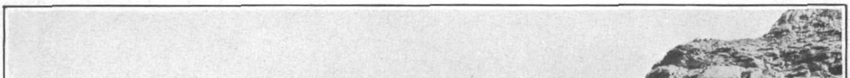
Despite the sparsity of vegetable growth, the Red Desert is a winter sheep range. The scattered "bunch grass," which looks so meager and dry, is in fact excellent forage, curing into hay where it grew and having a high nutritive value. In summer, when the desert is dry and water holes are few, the sheep are herded in the mountains, where water is abundant and grass is green and tender. The early snows, falling first in the higher mountains and extending week by week to lower altitudes, drive the flocks into the rough fall range between the mountains and the desert. Here they are held until the snow falls on the desert itself, but with the first heavy snowfall they are driven from the foothills to spend the winter in the open, where they find pasture in the spaces cleared of snow by the winds. The winds are not tempered here, but neither is the lamb shorn, and Wyoming winter winds make heavy wool when shearing time comes.

It may be noted that the great problem of stock raising in this western country is not so much to find pasturage—although the range has been greatly overstocked—as to find water. This is true not only in the Red Desert but in almost every grazing area throughout the semiarid States. Places at which stock may be watered are so few that control of them in general means control of the entire pasture range. In years gone by it was the custom for large stock owners to acquire a number of water holes and so possess themselves of great



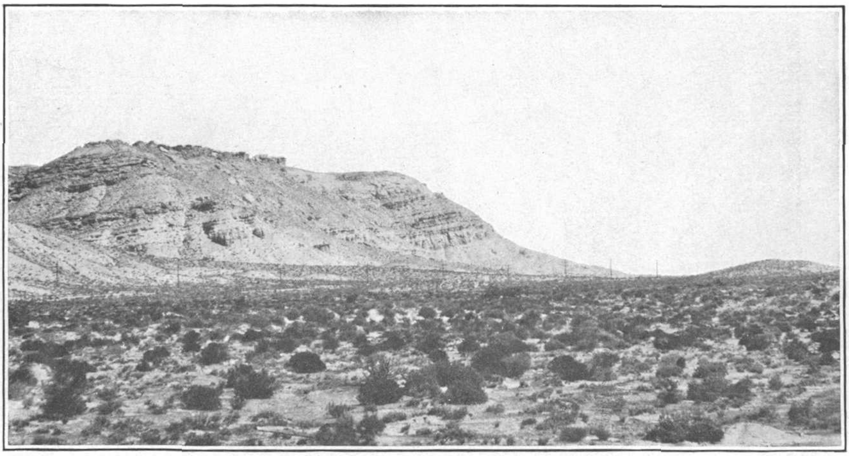
A. TABLE ROCK NEAR BITTER CREEK, WYO.

This rock is composed of alternating hard and soft Tertiary beds. The hard beds form the top of the table and of the benches.

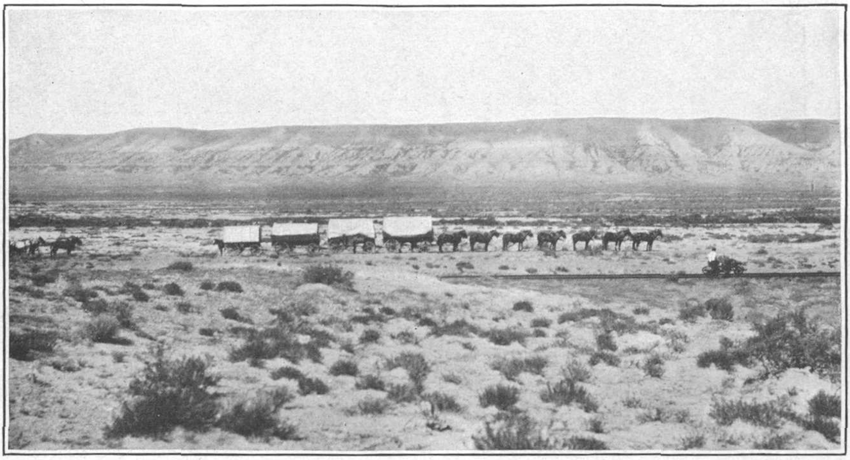


B. CHARACTERISTIC VIEW OF THE NORTH WALL OF THE CANYON THROUGH WHICH THE TOURIST PASSES NEAR POINT OF ROCKS, WYO.

The bluffs are composed of the coarse sandstone which separates the two groups of coal beds of the Mesaverde formation. The Rock Springs coal group lies below this sandstone and the Almond coal group above it.

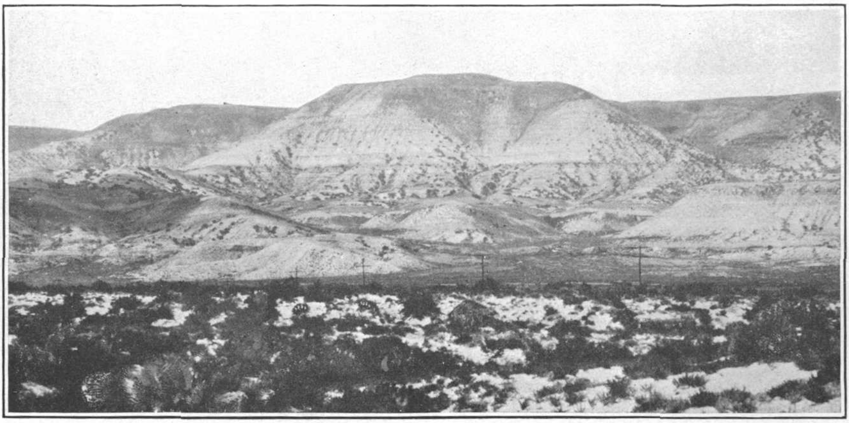


A. COAL-BEARING SANDSTONE OF MESAVERDE FORMATION IN THE WESTERN PART OF THE ROCK SPRINGS DOME EAST OF ROCK SPRINGS, WYO.



B. TRANSPORTATION, OLD AND NEW.

A 14-horse team hauling freight from the railroad (in the foreground). The bluff in the distance is White Mountain and is composed of Tertiary beds.



C. NEAR VIEW OF WHITE MOUNTAIN.

grazing areas as effectively as if they owned every acre of them. In recent years the Government has attempted to break up this practice by creating public water reserves which are open to the use of all comers, thus giving the small stock grower an equal chance with his more powerful rival.

In the Indian days the southern Red Desert constituted a more or less neutral territory among the numerous tribes. To the north were the Shoshones or Snakes, to the northeast the Crows, and to the south the Utes, but this territory was the common hunting ground and battle ground of all. In 1906, when the Uncompahgre Utes jumped the reservation in northeastern Utah and ranged northeastward across Wyoming, they held a great antelope round-up in the Red Desert, forming in genuine Indian style a great circle of riders which gradually drew in until the frightened antelope were concentrated in the center and killed. About 400 Indians took part in this round-up. Although they traveled several hundred miles from their reservation, and although it required a regiment of United States troops to awe them into surrender, no one was killed.

Wamsutter.
Elevation 6,702 feet.
Omaha 731 miles.

Wamsutter, formerly called Washakie, is a division point on the railroad. It is the site of old Fort Washakie, built for the protection of railroad employees and emigrants from the Shoshone and Arapahoe Indians. Three deep wells have been sunk to water here by the railway company, the deepest boring going down 1,900 feet. The coal beds of the Wasatch group (Tertiary) were penetrated near the surface, and those in the undifferentiated Tertiary at several lower levels. The color and lithologic character of the beds penetrated indicate that the well probably did not go entirely through the Tertiary beds. Similar beds were struck in a well 1,115 feet deep at Red Desert station, 9 miles west of Wamsutter.

West of Red Desert station is Hillside.

Tipton.
Elevation 6,993 feet.
Omaha 747 miles.

To the left (south), about 4 miles south of Tipton station is a prominent escarpment known as Laney Rim, formed by the beds of the upper part of the Wasatch group. To the right is an uninterrupted view of the Green Mountains, more than 50 miles away. In the distance toward the northwest may also be seen the Leucite Hills. Toward the west is a conspicuous dark-colored knob called Black Butte, which has served as a prominent landmark since the days of the earliest pioneers.

The stratified rocks, which are nearly horizontal in the center of the Great Divide Basin, have here a gentle inclination toward the east. The softer layers have been eroded away faster than the harder ones, which now appear as prominent shelves. Near Tipton (see sheet 12, p. 70) the train crosses one of the harder layers of the Wasatch beds, a shelf-making sandstone, which may be seen to the left, south of the railroad, rising higher and higher toward the west until, on Table Rock (see Pl. XIV, *A*), south of Table Rock station, it is about 800 feet above the level of the track. These rocks near Tipton contain great numbers of shells of fresh-water mollusks and some fossil bones.

Bitter Creek.

Elevation 6,692 feet.
Omaha 764 miles.

Toward the east from Bitter Creek station may be obtained a good view of Table Rock, a prominent point in the eastward-sloping shelf just mentioned. The low hills south of the station are covered with gravel deposited by Bitter Creek before that stream had eroded to its present depth. The gravels contain many agate pebbles, some of them beautifully colored. A well drilled at this station years ago to a depth of 1,300 feet found water under sufficient pressure to flow at the surface, but too alkaline to be of much use.

West of Bitter Creek station the railroad crosses the eroded edges of eastward-dipping strata that range in age from middle Eocene to Cretaceous. At Patrick siding these strata have the same general appearance as the Wasatch beds farther east, but west of this siding the hard layers are closer together and outcrop in numerous ridges. These ridges are parts of the east limb of the Rock Springs dome.[1]

[1] The Cretaceous rocks that are covered by the Tertiary beds of the Great Divide Basin on the east and those of the Bridger Basin on the west are exposed between Black Buttes and Rock Springs because they have been arched up into a great dome from the top of which the younger beds have been removed by erosion. The major axis of this dome is about 90 miles long and trends nearly north and south close to the west limb of the dome. The beds on the west dip 15° to 30°; those on the east dip 5° to 10°. The minor axis is about 40 miles long and passes through the dome south of Rock Springs. The oldest rocks exposed are the shales near Baxter siding, which correspond to the Steele shale seen farther east. Around this shaly center outcrop in concentric zones (1) a series of non coal-bearing sandstones; (2) the Rock Springs coal group, 600 to 2,400 feet thick, of lower Mesaverde age; (3) a massive sandstone, 800 feet thick, of middle Mesaverde age; (4) the Almond coal group, 900 feet thick, said to be of upper Mesaverde age; (5) the Lewis shale, 750± feet thick; (6) the Black Buttes coal group; and (7) the Black Rock coal group, of Tertiary age.

It has been estimated that the amount of coal in the Rock Springs field available for mining—that is, within 3,000 feet of the surface and in beds 2½ feet or more in thickness—exceeds 142,000,000,000 tons. As coal is fossilized vegetal matter, the traveler, as he views the barren hillsides where now scarcely a living thing can be seen, may well wonder how all this great store of carbonaceous matter came there. These coal beds are mute but forceful reminders that desert conditions have not always prevailed in this region. Fossil plants, such as palms, figs, and magnolias, found at many places in these coal beds prove that the carbonaceous matter of the coal accumulated in swamps at a time when the climate was as mild as that of Florida at present.

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

OVERLAND ROUTE

From Omaha, Nebraska, to San Francisco, California

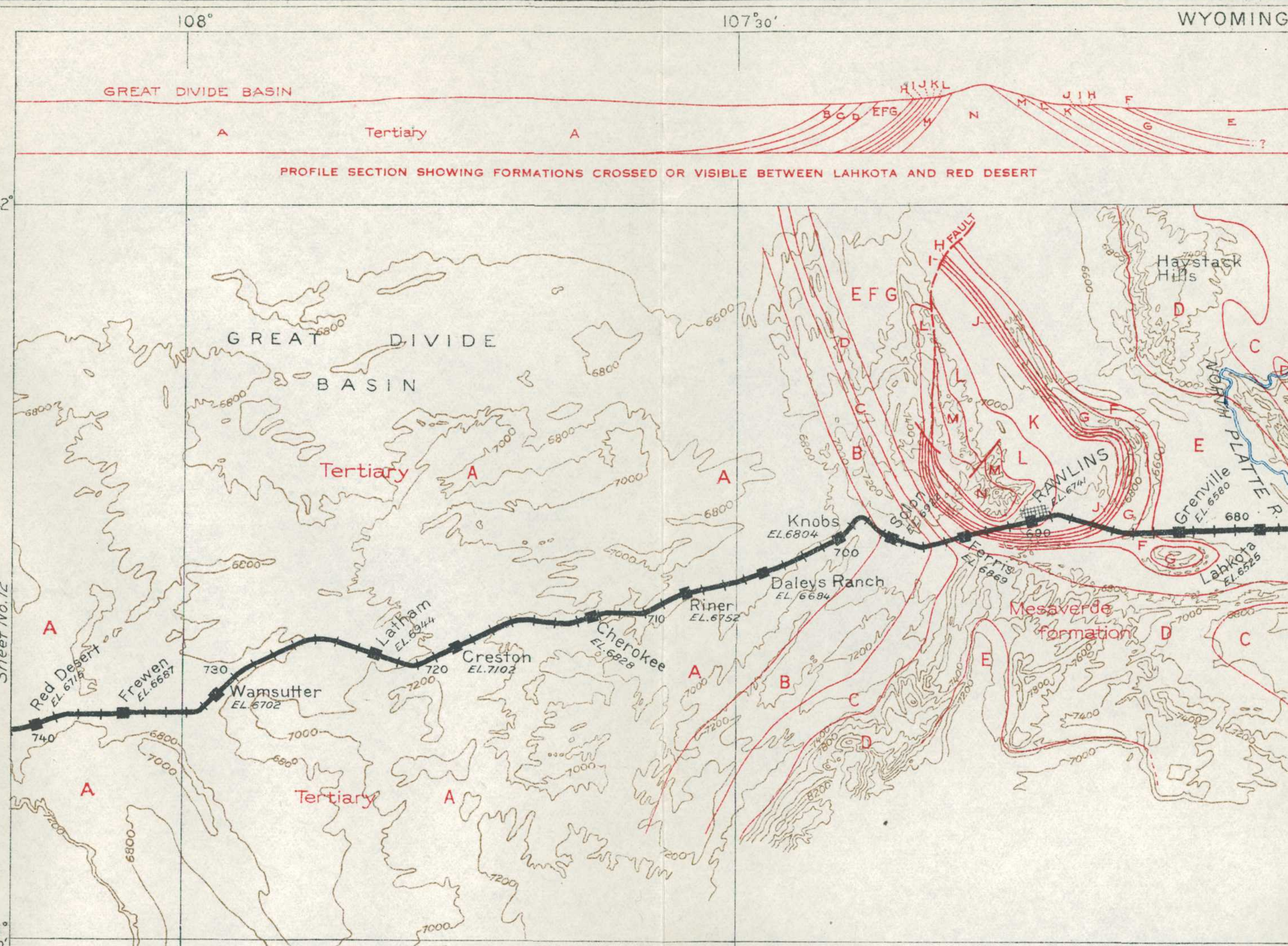
Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915



EXPLANATION

		Thickness in feet	
A	Sandstone and shale; fresh-water deposits (Wasatch group and older Tertiary formations)	6,000 - 13,000	Tertiary
B	Sandstone, shale, and coal; fresh and brackish water deposits ("Lower Laramie" formation)	1,000 - 4,000	Cretaceous
C	Shale; marine deposit (Lewis shale)	500 - 1,500	Cretaceous
D	Sandstone, shale, and coal; fresh and brackish water deposits (Mesaverde formation)	2,000 - 3,600	Cretaceous
E F G	Shale and sandstone; including equivalents of Steele shale (E), Frontier formation, (F), and Mowry shale (G)	6,000 ±	Cretaceous
H	Sandstone (Cloverly formation)	100 ±	Cretaceous
I	Sandstone and shale; fresh-water deposit (Morrison formation)		Jurassic or Cretaceous
J	Sandstone and shale; marine deposit (Sundance formation)		Jurassic
K	Red sandstone and shale; fresh or brackish water deposits (Chugwater formation)		Triassic or Permian
L	Limestone and red sandstone; marine deposits (Casper formation)		Carboniferous
M	Quartzite		Cambrian
N	Granite		Archean(?)

Scale $\frac{1}{500,000}$

Approximately 8 miles to 1 inch

1 0 5 10 15 20 Miles

1 0 5 10 15 20 25 30 Kilometers

Contour interval 200 feet

ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

The distances from Omaha, Nebraska, are shown every 10 miles

The crossties on the railroads are spaced 1 mile apart

Just before reaching Black Buttes station the train crosses the youngest of the three groups of Cretaceous coal beds that are exposed around the Rock Springs dome. This is called the Black Buttes coal group. The coal of the Black Buttes group has been mined to some extent. An abandoned mine may be seen to the right (north) of the railroad half a mile east of Black Buttes station, where also a spur runs to an active mine a mile farther south.

Black Buttes.

Elevation 6,610 feet.
Omaha 773 miles.

West of Black Buttes the route follows a valley eroded mainly in the Lewis (Upper Cretaceous) shale. The rocks have been displaced by faulting here, so that individual beds are not easily traceable by one passing rapidly over them. At Hallville siding the road crosses one of the faults or displacements of the strata that are so numerous in this region and enters a narrow canyon whose steep, craggy walls display the hard rocks of the upper part of the Mesaverde formation. From this siding is obtained a good view of the Almond coal group,[1] which crops out north of the railroad (to the right) and is underlain by the white sandstone of the middle part of the Mesaverde.

Hallville.

Elevation 6,554 feet.
Omaha 778 miles.

The light-colored sandstone near the middle of the Mesaverde formation makes prominent cliffs at the town of Point of Rocks. (See Pl. XIV, *B*.) It is an important water-bearing sandstone and yields mineral waters. This sandstone is slightly conglomeratic, is irregular in texture and hardness, and has been eroded into many fantastic and curious forms. To some of the cavernous hollows in it have been given names, such as "Hermit's Grotto," "Cave of the Sands," and "Sancho's Bower." Three wells that have been drilled here to depths of a little more than 1,000 feet have obtained an abundant supply of water. The water is strongly charged with sulphureted hydrogen (H_2S), which soon escapes or is oxidized on exposure to the air. From Rawlins to Green River, a distance of 134 miles, there is scarcely a place where water fit to drink can be found at the surface. The springs and the streams are alkaline, and water from the wells at Point of Rocks is hauled for domestic and railroad use over much of this distance.

Point of Rocks.

Elevation 6,503 feet.
Omaha 784 miles.

The coal beds of the Almond group are conspicuously exposed above the conglomeratic sandstone, and certain fossil oysters and other brackish-water shells are abundant in the rocks above the coal. The coal was mined about a mile east of the town, where the dip of the strata brings the coal beds to the level of the valley floor.

[1] The coals of the Almond coal group are of poorer quality than those of the Rock Springs coal group and as they occur close to the abundant supply of high-grade coal mined at Rock Springs they have not been much exploited. The only place where they have been mined is Point of Rocks, formerly called Almond.

About 2 miles west of Point of Rocks the route leaves the massive cliff-making sandstone and comes to the relatively soft yellow sandstone and shale of the Rock Springs coal group,[1] which contains the principal coal beds of this region.

Just east of Thayer Junction the railroad crosses the massive sandstones that occur near the base of the Mesaverde formation and emerges into an open space occupied by the marine shale which farther east is called the Steele shale. This is separated from the younger massive sandstones of the Mesaverde formation by a thick zone of shaly yellow sandstone that forms prominent benches and "badland" slopes.

The coal of the Rock Springs group is mined at Superior, about 7 miles north of Thayer Junction. About 2 miles northeast of Superior are the Leucite Hills, which are made up largely of igneous rocks in the form of volcanic necks, sheets intruded into the stratified rocks, and dikes cutting across the sedimentary strata. Associated with these intrusive rocks are volcanic cones and lava flows. These rocks have long been objects of scientific interest because of their unusual character. Lately they have attracted additional interest by reason of the potash-rich mineral, leucite, they contain, which may some day be utilized if a process can be found for extracting the potash cheaply. It has been estimated that the igneous rock of the Leucite Hills contains more than 197,000,000 tons of potash.

Thayer Junction.

Elevation 6,434 feet.
Omaha 791 miles.

Baxter siding is near the center of the Rock Springs dome. The several eastward-dipping formations crossed between Bitter Creek station and Thayer Junction once arched over the top of this dome and now dip in the opposite direction on its western slope, as is indicated in the profile on the accompanying map (sheet 12). A mile west of Baxter siding a branch line runs northward 3 miles to Gunn, where mines have been opened on the lower beds of the Rock Springs coal group. Two miles west of the siding the route enters a

Baxter.

Elevation 6,303 feet.
Omaha 803 miles.

[1] The Rock Springs group of coal beds is of lower Mesaverde (middle Upper Cretaceous) age and is the most important group of coals in Wyoming, for it contains many beds of bituminous coal of higher grade than that of the other groups of this region. The basal portion of the group of rocks consists of heavy ridge-making coal-bearing sandstones (Pl. XV, *A*, p. 67), and the remainder of brown, yellow, and white sandstones, shale, clay, and interbedded coal. The group is about 2,400 feet thick and contains at least twelve coal beds that range from 2 to 10 feet in thickness and many other beds less than 2 feet thick. These beds are somewhat regularly distributed through the group and are fairly persistent along the strike. They have been prospected from Sweetwater, south of Rock Springs, northward around the end of the dome to Superior. Very little prospecting has been done south of Superior, as in this locality the coal beds are somewhat thinner and are fewer in number than between Superior and Rock Springs.

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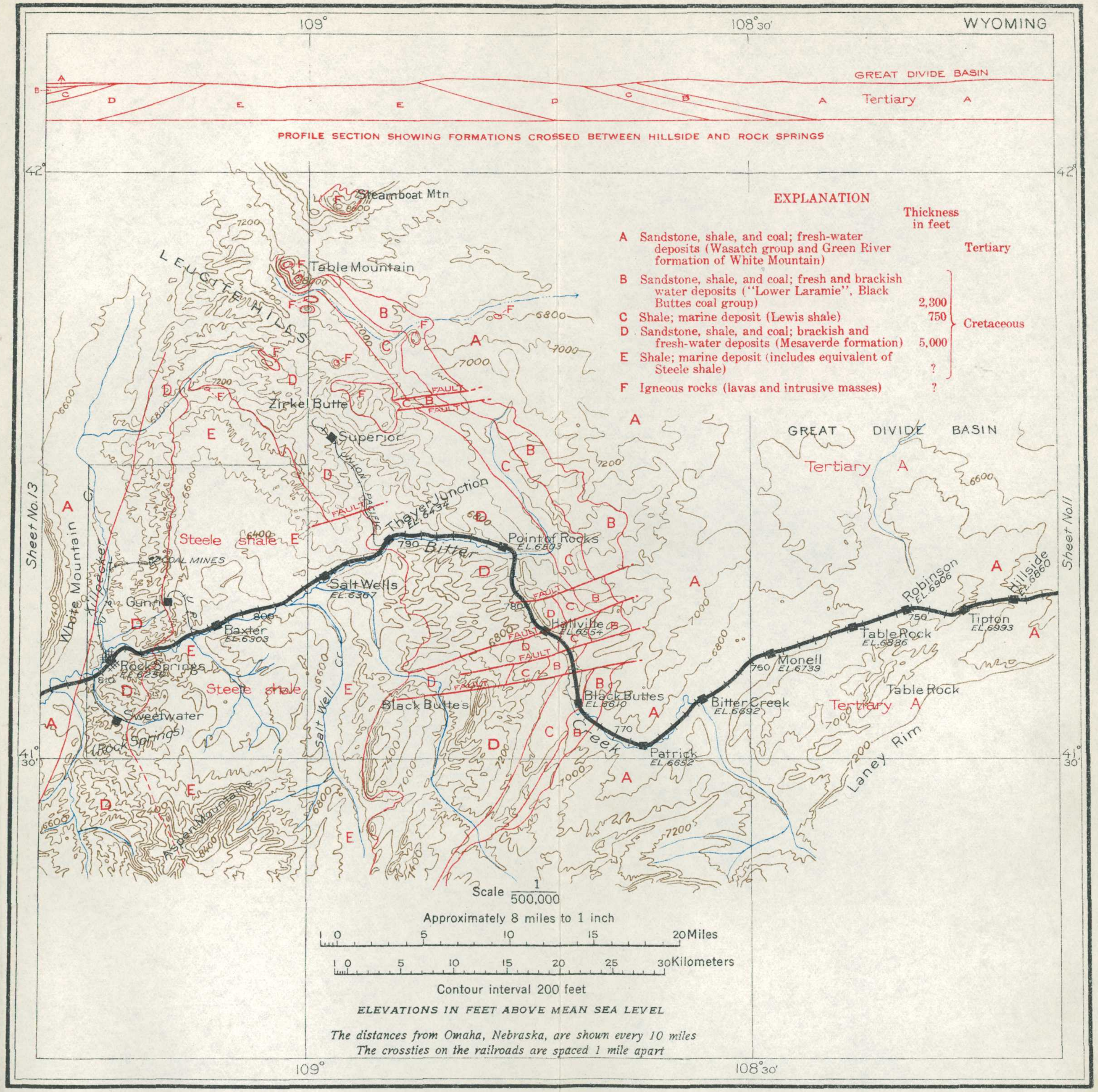


picturesque gorge eroded by Bitter Creek through the ridge formed by the hard sandstone of the Mesaverde formation (Pl. XV, *A*, p. 67). Coal is mined from one of the beds that outcrop in the north wall of this gorge. From the west end of the gorge, just before the train enters Rock Springs, the traveler gets a magnificent view of White Mountain (Pl. XV, *C*), to the right, northwest of the town. This is the eastern escarpment of the plateau, made up of beds of Eocene (Tertiary) age that occupy the Bridger Basin. The rocks are the same as those that will be seen at close range from the town of Green River.

Rock Springs.
Elevation 6,256 feet.
Population 5,778.
Omaha 809 miles.

The city of Rock Springs derives its name from a large spring of saline water that issues at the base of a bluff of the water-bearing sandstone previously described as occurring between the Rock Springs and Almond groups of coal beds near Point of Rocks. However, water for domestic use as well as for use at the mines in this vicinity is pumped from Green River, a distance of 15 miles, with a lift of 179 feet.

Rock Springs is one of the most important coal-mining centers of the West and ships each year nearly a million tons of high-grade bituminous coal. The mines have been operated since 1868, when the Union Pacific Railroad reached this point, and some of the older workings extend for miles underground. Mine openings may be seen to the right (north) of the railroad east of the city. A branch line runs north to Reliance and another runs south to mines at Sweetwater. All the mines are in beds of the Rock Springs coal group.

West of Rock Springs the road passes from the Cretaceous formations to the Tertiary beds that occupy the Bridger Basin. The Tertiary rocks are conspicuous to the right (north) of the railroad, in White Mountain (see Pl. XV, *C*), which here forms the eastern rim of the basin. The mountain is made up of stratified rocks consisting of the light-pink beds of the Wasatch group and the white to light-blue and greenish rocks of the Green River formation. These beds are inclined gently toward the west, so that the light-colored beds of the middle portion of White Mountain descend to the river level at the town of Green River.

Kanda.
Elevation 6,204 feet.
Omaha 816 miles.

Near Kanda (see sheet 13, p. 76) the train enters a narrow winding gorge which was eroded by Bitter Creek and whose walls show the westbound traveler first the pink beds of the lower part of the Wasatch group and then the harder sandy shales of the Green River formation. These beds are made up of a countless number of very thin and sandy calcareous layers separated by equally thin layers of shale, so that the cliffs of this formation have a wonderfully banded appearance.

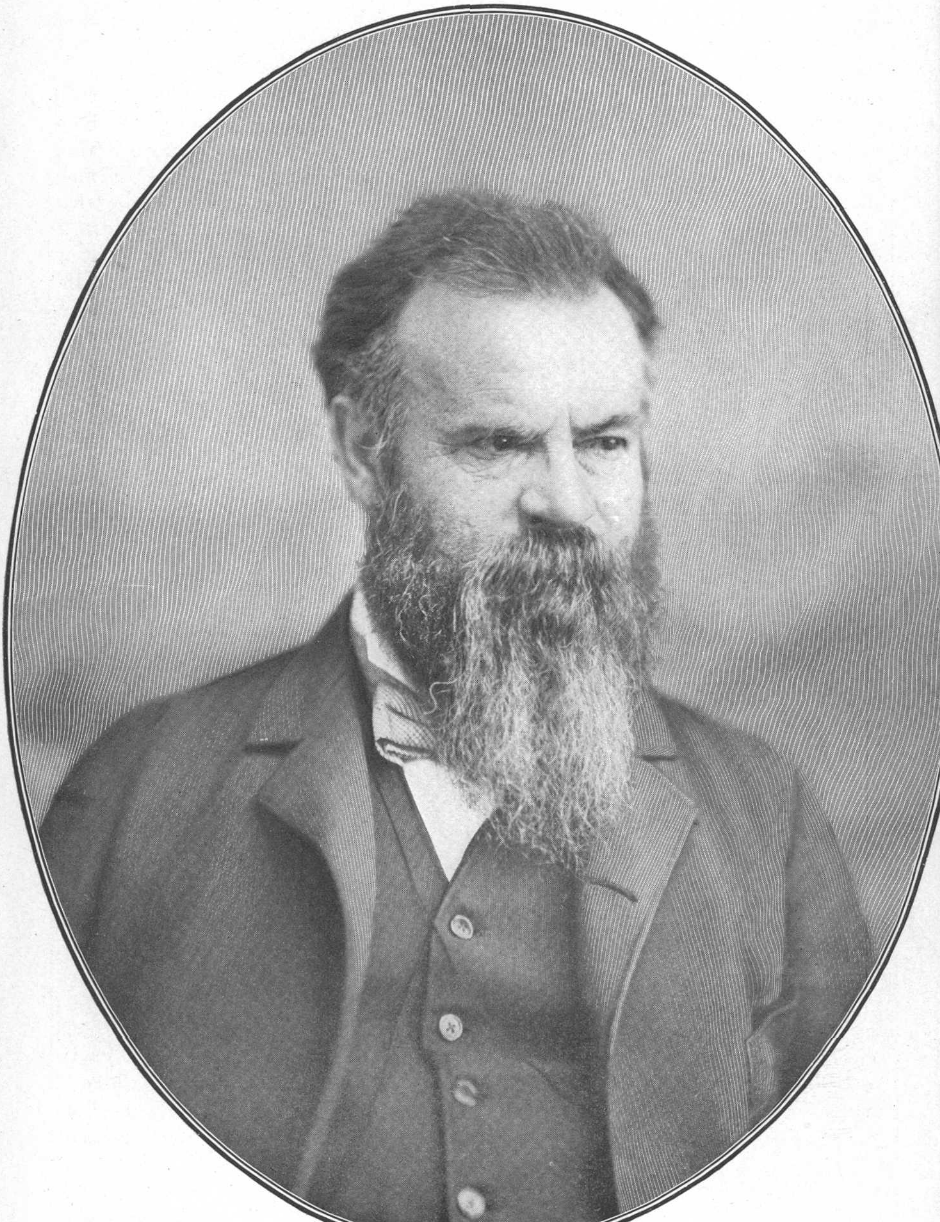
The gorge extends to the mouth of Bitter Creek,[1] where the train suddenly emerges from its narrow confines directly into the broad valley occupied by Green River.

[1] In order to understand why Bitter Creek established itself in its present course, we must consider conditions that existed here millions of years ago. This stream cuts its way directly across the Rock Springs dome instead of flowing around it and then, seemingly regardless of what would be easy lines of erosion, flows across the broad valley west of Rock Springs and plunges through White Mountain, in which it has cut a gorge 1,000 feet or more in depth. This apparently unreasonable course was established long ages ago, when this part of the country was lower than it is now and the distant mountains, then newly formed and rugged, supplied the streams with more sediment than they could carry. This material was deposited on the lower lands, building them up just as flood plains and deltas are being built up in some places at the present time. The resulting accumulations of sediment constitute the Wasatch, Green River, Bridger, and other formations of Tertiary age.

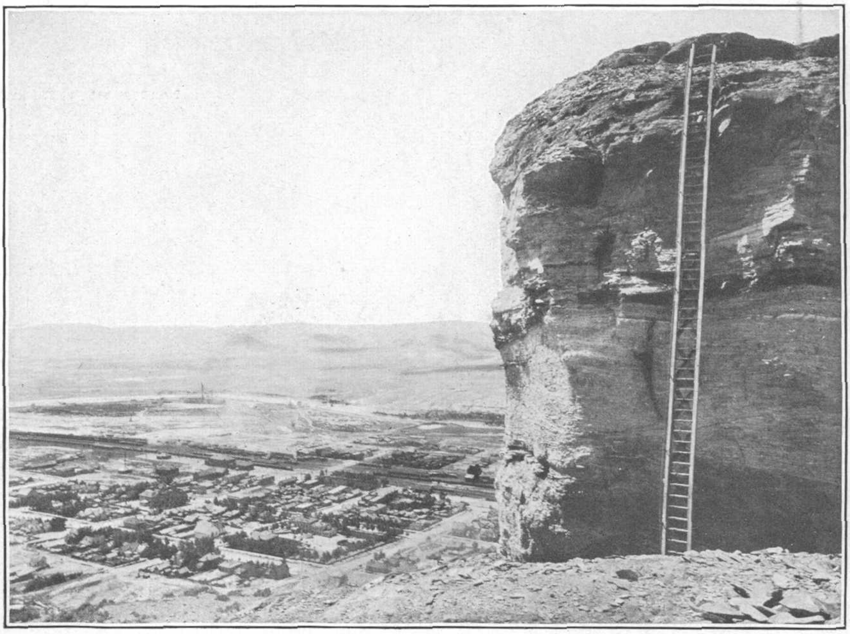
There came a time, however, when the region thus built up was uplifted so much as not only to stop deposition but perhaps also to divert the streams to new courses and cause them to cut downward into the beds of sediment which they had previously deposited. The surface was not raised the same amount in all places and the uplift was accompanied by warping and fracture of the rocks. East of Rock Springs the upheaval produced a great dome. In other fractured places the rocks slipped past each other and produced faults. These movements were very slow, and for this reason Bitter Creek maintained itself even while the great dome rose across its course. Doubtless similar movements are in progress now, but they are so slow that the lifetime of a man is not long enough to enable him to detect a change. The oldest inhabitant of Bitter Creek valley would probably insist that the creek had not deepened its channel during his lifetime, yet it cut its channel as fast as the dome rose, or it would have been deflected.

A similar explanation accounts for the behavior of this stream west of Rock Springs. Its course was established when the surface was a thousand feet or more higher than it is now—that is, higher than the present top of Table Mountain. As the master stream, Green River, cut its course lower and lower, the smaller stream, Bitter Creek, cut the narrow gorge through Table Mountain. But farther east, where the same sedimentary rocks that compose this mountain were more steeply upturned and more easily eroded, Bitter Creek and its tributaries cut down a vast area to a level much lower than the top of Table Mountain.

The volume of rock removed by this small stream alone would probably be reckoned in hundreds of cubic miles, and all of it found its way through the narrow gorge to Green River. Hundreds of other streams delivered similar amounts to the same river, and the question may well be asked, What became of it all? Those who have visited the Grand Canyon of the Colorado in Arizona have noted the muddy waters of that river and wondered where the mud came from. Some of it came from Wyoming. Those who have visited the built-up plains and filled basins that mark the ancient course of Colorado River in western Arizona have wondered where the material came from to fill these enormous basins. Some of it came from the valleys through which the Union Pacific Railroad is built. Those who have traveled over the Southern Pacific line in southern California, where it crosses the broad delta which the Colorado built out across the Gulf of California so far that the north end of the gulf—now the Salton Sink—was completely cut off from the main part of the gulf, have wondered where all the sand and silt of that great delta came from. Some of it once rested on the arch of the Rock Springs dome.

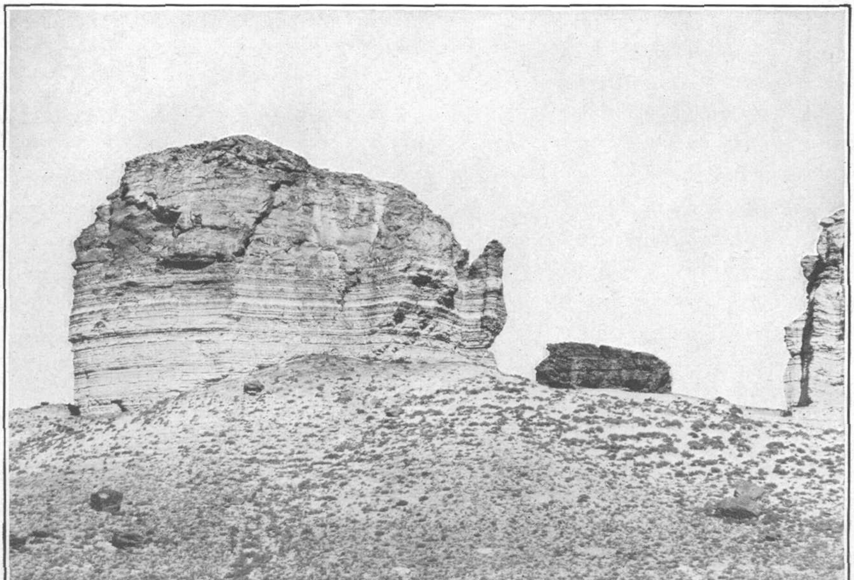


MAJOR J. W. POWELL.



A. GREEN RIVER CITY, WYO., AS SEEN FROM CASTLE ROCK.

Photograph furnished by Union Pacific Railroad Co.



B. NATURAL MONUMENTS WEST OF CASTLE ROCK.

Some of these monuments have assumed curious shapes, like the "teapot and cup," shown above. They are composed of the regularly laminated Green River shale capped by hard brown sandstone.

The town of Green River (see Pl. XVII, *A*) is a division headquarters of the Union Pacific Railroad and the point at which passengers for Oregon and Washington change to the Oregon Short Line. The Short Line trains, however, use the main line as far west as Granger.

Green River.
Elevation 6,077 feet.
Population 1,313.
Omaha 824 miles.

Green River is picturesquely situated between the river and the precipitous bluffs which rise 700 feet or more above the water. Like most of the other towns along the route throughout Wyoming it has little aside from the immediate business of the railroad to maintain it. An attempt has been made here to manufacture soda from alkaline water pumped from wells about 250 feet deep, but the long haul to market renders profitable operation difficult.

The town of Green River is on one of the most interesting drainage systems in America. The river rises about 200 miles farther north and at the railroad crossing is a stream of considerable size, having an average flow of 2,200 cubic feet a second. About 540 miles farther south it joins Grand River to form the Colorado, which, after winding through more than a thousand miles of the most wonderful canyon scenery in the world, reaches the Gulf of California.

From the town of Green River, Maj. J. W. Powell, afterward Director of the United States Geological Survey, started May 24, 1869, with his little company of daring associates to explore the canyons of the Colorado. The story of the trip is well known, but from the simple, unimpassioned language in which Major Powell (see Pl. XVI) himself tells it, the reader might not realize that this was one of the most hazardous undertakings in the history of modern exploration. Few have cared to undertake the adventure since, and some of those have paid for their temerity with their lives. The journey has recently been successfully repeated, however, by two photographers, Ellsworth and Emery Kolb, who on September 8, 1911, also started from Green River and, after numerous adventures, emerged from the canyons with a valuable collection of negatives and moving-picture films.

The Green River beds, which form the bluffs near Green River, are carved into many curious and picturesque forms—natural monuments (Pl. XVII, *B*) and castle-like structures. The bluffs are light green in the lower part and dark brown above. The upper beds are harder than the lower ones and form the protecting caps of the pinnacles. These bluffs have been a source of interest to geologists and travelers ever since they were examined by F. V. Hayden more than 40 years ago, and they have been described and illustrated many times. Their character is indicated by the accompanying illustrations much better than by any word pictures.

Three miles west of Green River the railroad passes through Fish Cut (Pl. XVIII, *A*), so named because of the large numbers of fossil fishes (Plate XIX, *A*), taken from it. Fossils are obtained from this same formation at Fossil, Wyo., a station on the Oregon Short Line, and sold as curios. On the side of the river opposite Fish Cut the Green River shale has been eroded into a variety of picturesque forms, such as are illustrated in Plates XVII, *B*, and XVIII, *B*. These may be seen to the right from the train.

On the old grade just below the present road in Fish Cut there are several oil seeps, where the surface is kept moist by oil that oozes from the shale. Little oil occurs in the Green River formation. Its carbonaceous content consists of partly decomposed vegetal matter (see Plate XIX, *B*), which, when the rock is heated, yields petroleum and ammonia. Rock from Fish Cut that gave no outward sign of the presence of oil yielded, on distillation, 31 gallons of oil to the ton and an amount of ammonia equivalent to 34 pounds of ammonium sulphate, a product that is nearly as valuable as the oil.

Just above the horizon at which the fossil fishes occur the shale gives place to brown coarse-grained cross-bedded sandstone, which occurs in such a way as to suggest that it fills old river channels. It is this channel sandstone that caps the curious pinnacles which are so conspicuous near Green River. The softer shale surrounding and underlying the masses of hard sandstone softens and crumbles under the influence of the weather and is washed by the rain or blown by the wind from the bluffs, the portions that are protected by the hard capping standing as isolated monuments or precipitous cliffs.

From Peru station the traveler may catch glimpses toward the southwest of the high peaks of the Uinta Mountains, in northwestern Colorado. These appear more conspicuous from points farther west.

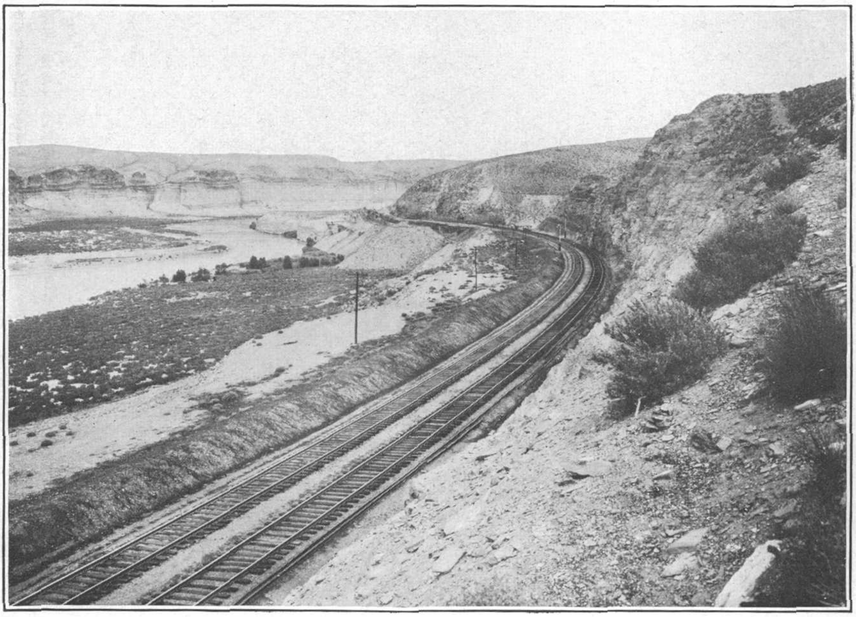
Peru.
Elevation 6,381 feet.
Omaha 831 miles.

From Green River the road rises by a relatively steep grade over strata that dip slightly to the west, and at Peru the younger Eocene or Bridger beds [1] occupy the surface. Where they are cut by the railroad these beds consist of brown shaly or limy sandstone.

Great numbers of fossil bones, most of them representing primitive or unspecialized types of mammals, have been collected from the

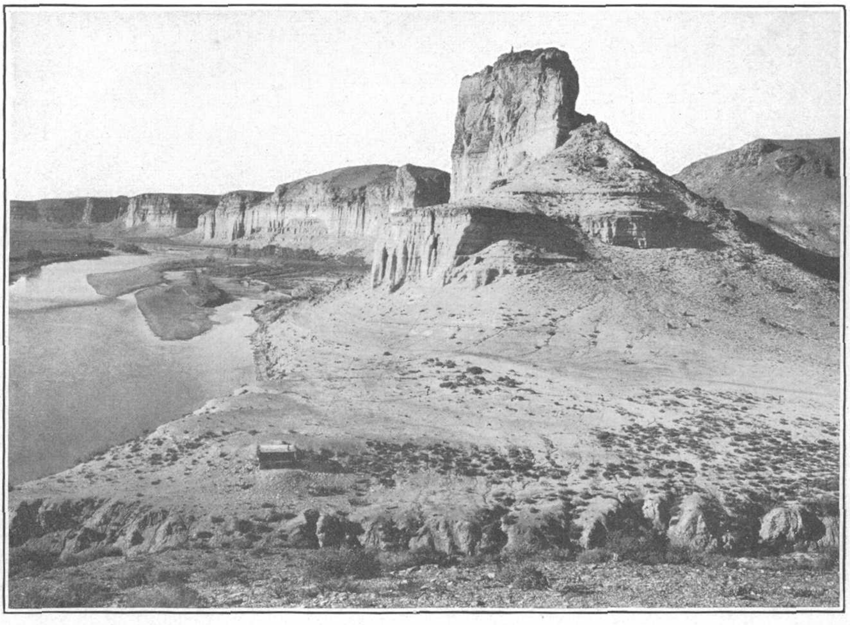
[1] The Bridger formation takes its name from Fort Bridger, which stands in the valley of Blacks Fork about 10 miles south of Carter station. To the traveler on the train this formation is not readily distinguishable from the underlying beds, but many of the prominent buttes in this vicinity, especially those south of the track, are composed of rocks belonging to this formation. Probably those most noticeable from the train are the buttes near the station of Church Butte, which takes its name from the largest of this group.

Most of the formations exposed in western Wyoming and eastern Utah are



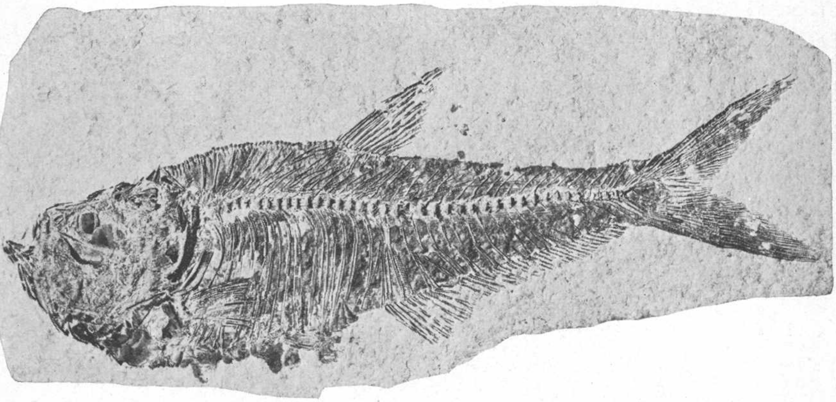
A. "FISH CUT," WEST OF GREEN RIVER CITY, WYO.

Many fossil fishes were found in the Green River formation at this locality. Photograph furnished by Union Pacific Railroad Co.



B. BLUFFS OF THE GREEN RIVER FORMATION NEAR GREEN RIVER CITY, WYO.

Photograph furnished by Union Pacific Railroad Co.



A. FOSSIL FISH (DIPLOMYSTUS DENTATUS), SHOWING THE BONES, FIN RAYS, ETC., EMBEDDED IN A SLAB OF ROCK TAKEN FROM THE QUARRY.

B. FOSSIL LEAF OF THE SWEET-GUM TREE (LIQUIDAMBAR) AS IT APPEARS ON A SLAB OF ROCK TAKEN FROM THE QUARRY.

FOSSILS FOUND IN THE GREEN RIVER (TERTIARY) FORMATION.

Eocene beds of the Bridger Basin. It was during the Eocene epoch that the great development of mammalian life took place. The small

designated by other names than those used for beds of essentially the same age that lie farther east. The following table shows the relations of these formations:

Succession of the rock formations exposed along the Union Pacific Railroad in western Wyoming and eastern Utah.

Period.	Epoch.	Group and formation.
Tertiary.	Eocene.	Bridger formation. Green River formation. Wasatch group: Knight formation. Fowkes formation. Almy formation.
Cretaceous or Tertiary.	(?)	Evanston formation.
Cretaceous.	Upper Cretaceous.	Adaville formation. Hilliard formation. Frontier formation. Aspen formation. Bear River formation.
Jurassic.		Beckwith formation (possibly including some Cretaceous). Twin Creek limestone.
Jurassic or Triassic.		Nugget sandstone.
Triassic.	Lower Triassic.	Ankareh shale. Thaynes limestone. Woodside formation.
Carboniferous.	Permian (?).	Park City formation.
	Pennsylvanian.	Weber quartzite. Morgan formation.
	Mississippian.	Limestones.
Devonian.		
Silurian.		
Ordovician.		
Cambrian.		
Algonkian.		
Archean.		Granite, etc.

primitive mammals of earlier epochs were succeeded by a great variety of forms, some of which are the ancestors of animals now living, though others seem to have left no descendants. Two of the common forms are illustrated in Plate XX (p. 80).

Bryan, the home of 3,000 people during the construction of the Union Pacific Railroad, is now little more than a name in the desert.

Bryan.
Elevation 6,173 feet.
Omaha 837 miles.

Toward the southwest, 60 miles away, may be seen the snowy summit of Gilbert Peak, one of the monarchs of the Uinta Mountains, rising 13,422 feet above sea level, named after G. K. Gilbert, one of the original members of the United States Geological Survey.

Granger.
Elevation 6,279 feet.
Omaha 854 miles.

At Granger the Oregon Short Line branches off to the right from the Union Pacific, turning northward up Hams Fork. West of this station the Tertiary strata dip slightly toward the east, so that the westbound traveler passes gradually from younger to older beds.

Hampton.
Elevation 6,396 feet.
Omaha 873 miles.

From points between Granger and Hampton some of the distant summits of the Salt River Range may be seen on the right, far to the northwest, and the rugged, snowy peaks of the Uinta Mountains on the left, far away to the south. The hill south of the railroad, half a mile west of the station, contains great numbers of fossil shells. One layer of rock here, about 4 feet thick, consists almost wholly of coiled shells, of Eocene age, and another layer just below it contains numerous clamshells in an almost perfect state of preservation.

Carter.
Elevation 6,507 feet.
Omaha 882 miles.

Carter consists of only a few houses but is the center of an extensive sheep-raising industry. During the summer the sheep are pastured on the distant mountains, but when the snow falls they are driven down to the desert plains, where they pass the winter.

West of Carter the red sandstone and shale of the Wasatch (Tertiary) group are again reached. These beds underlie the surface rocks that occupy the center of the Bridger Basin. Their material here is much coarser and of a deeper-red color than it is east of Green River. This change in character becomes more and more conspicuous toward the west, and near Evanston these rocks are markedly conglomeratic. Farther west, near the Wasatch Mountains, they are made up largely of a still coarser red puddingstone.

Between Carter and Bridger is Antelope station, at which the traveler will be nearly halfway from Omaha to San Francisco.

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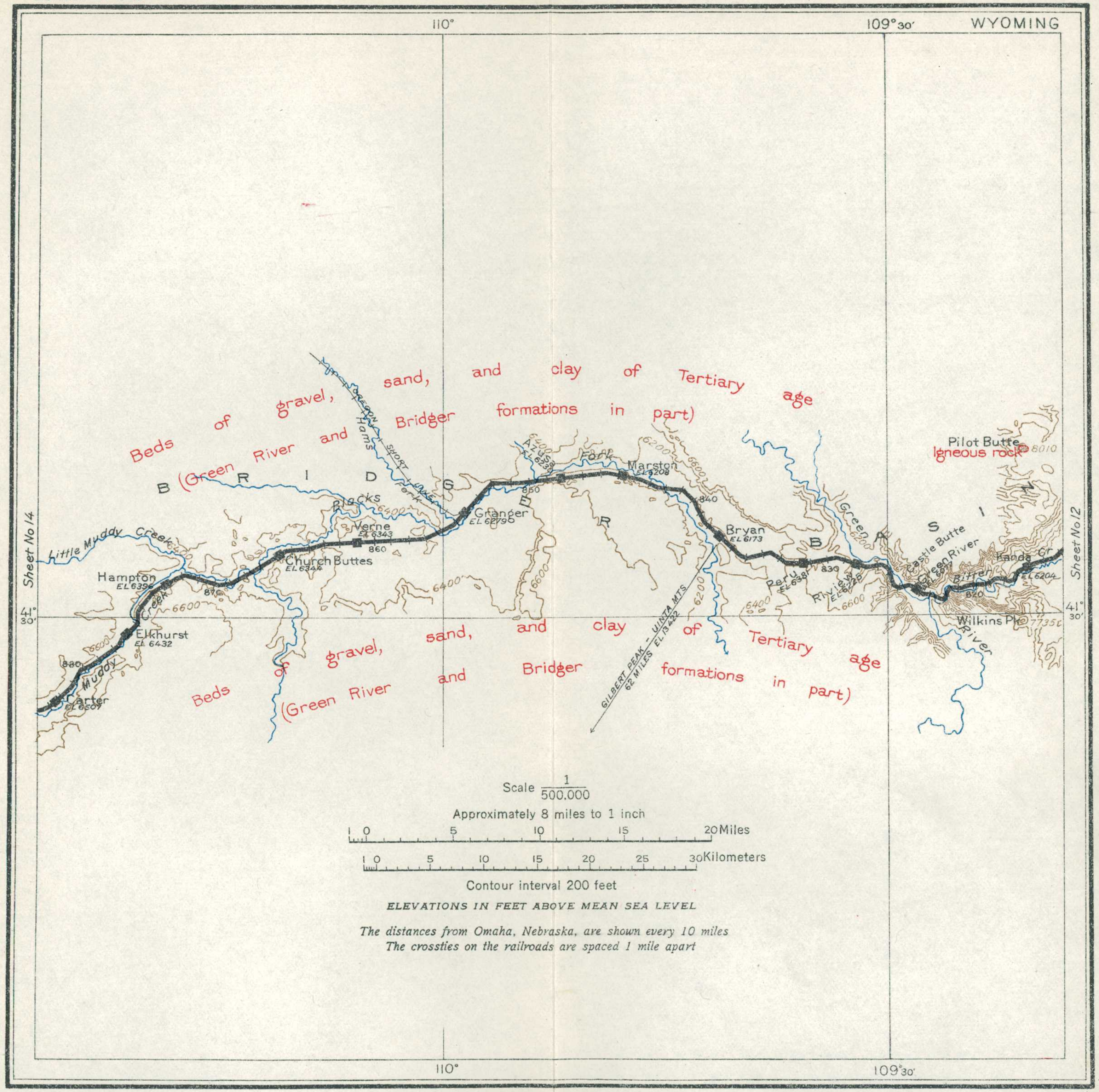

Bridger.
Elevation 6,622 feet.
Omaha 893 miles.

Bridger station (see sheet 14, p. 88) was named for James Bridger,[1] the first white man to settle in this section. Near the station the rocks of Upper Cretaceous and Jurassic age that underlie the Tertiary beds of the Bridger Basin begin to appear at the surface. About 3 miles north of the station, where the railroad turns south, the hills formed by these older rocks are visible at the right (west), and the ridges formed by them lie nearly parallel to the road as far south as the Aspen tunnel. Throughout this distance the route traverses the valley eroded by Muddy Creek, mainly in the Wasatch red beds, which here dip gently to the east.

Leroy.
Elevation 6,702 feet.
Omaha 898 miles.

The original route of the railroad from Leroy up the valley of Muddy Creek and over the divide near old Bear River City has been abandoned. It was difficult to operate because of curves and grades that necessitated helping engines for all heavy trains. The new route follows the valley used by the Mormon pioneers in crossing Aspen Ridge.[2] This ridge is pierced by the Aspen tunnel, which is 5,900 feet long and is the largest single piece of tunnel work performed by the Union Pacific Railroad Co. In order to hasten

[1] James Bridger was a well-known pioneer who did much toward taming the "wild West." Although he called Fort Bridger his home, he may more properly be spoken of as a citizen of the West, for he was at home beside the camp fire wherever night overtook him, whether on the plains or in the mountains, whether alone or surrounded by hostile savages.

He was born in Richmond, Va., in 1804, but soon drifted to the West, where he was employed by the Rocky Mountain Fur Co. So rapidly did he become familiar with the wilderness and with its savage inhabitants that before he was 30 years of age he was known as "the old man of the mountains." He discovered Great Salt Lake in the winter of 1824–25, and, because of the salinity of its waters, thought it was an arm of the Pacific Ocean. Two years later men under his direction explored the lake, passing completely around it in boats made of skins.

At his trading post on Black Fork, 10 miles southeast of the Bridger station, he built the fort that bore his name and which was later used by United States soldiers. Bridger was long employed as a guide for the Army in the several campaigns against hostile Indians, and also by companies of emigrants, especially by the gold seekers of 1849. He was in western Wyoming when the advance company of Mormons, led by Brigham Young, were on their way to the "promised land" and urged them not to settle in Salt Lake Valley, because of the supposed difficulty of ripening crops there. He said to Young: "I will give you a thousand dollars for the first ear of corn that ripens there." Young, who claimed divine guidance, replied: "Wait and we will show you."

[2] Aspen Ridge is the easternmost of a series of north-south ridges that are separated by troughlike depressions, of which Mammoth Hollow is a type. These ridges originated in mountain-making movements which probably began at the close of the Cretaceous period and resulted in the upheaval of the Uinta and Wasatch mountains on the south and the group of mountains extending southward from Yellowstone Park on the north. These ridges connect the groups of mountains and may be regarded as incipient mountain ranges. The rocks were broken or

the work of construction a central shaft was sunk, the top of which was 331 feet above track grade. From the bottom of the shaft headings were started east and west to connect with the end headings. The greatest depth reached below the surface is 456 feet; the highest point above sea level 7,296 feet. The tunnel accommodates a single track and is lined with timber and concrete. The new route was completed in 1901, at a cost of $12,000,000, and shortens the line 10 miles:

At the point where the road leaves the main branch of Muddy Creek, 2½ miles south of Leroy, the traveler may obtain a view, toward the left (east), of the edge of the plateau of Bridger beds on which stands Bridger Butte. A mile west of Ragan may be seen, to the right (north), a group of derricks where oil wells have been sunk into the Aspen shale,[1] which includes the oil-bearing rocks of this region. A small refinery was built at Leroy, but it was not in operation in 1914.

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faulted and upturned in ridges, but the movement was arrested before high mountains were formed here.

Two main groups of fault lines are crossed by the Union Pacific in this general region. The Absaroka fault and the Oil Springs faults are crossed at the Aspen tunnel and the Almy and Medicine Butte faults at Evanston. The Absaroka is a thrust fault by which the rocks on the west have been pushed eastward and raised more than 15,000 feet, some of the older sedimentary rocks being brought to altitudes much greater than those of the younger rocks of this region. This relation is conspicuous west of the Aspen tunnel, where rocks of early Tertiary age abut against some of Jurassic age. The Medicine Butte fault, which the road crosses at Evanston, is also an overthrust, but the Almy is a normal or gravity fault—that is, the rock mass here has dropped instead of being pushed upward.

Erosion, which followed the initial mountain-forming disturbance, carved the older rocks into low hills and shallow valleys, and these in turn were buried by accumulations of sediment in early Eocene time. Later the rocks were again upheaved, erosion was renewed, and other hills and valleys were carved out. These also were buried by the red sands and gravels of the Wasatch group, which recent erosion has removed in some places, exposing again the pre-Wasatch hills, but which still remain as the surface rocks over large areas of western Wyoming and eastern Utah.

[1] The Aspen formation consists of shale 1,500 to 2,000 feet thick, in which are layers of sandstone that contain oil. Near the top of the formation occurs the "Spring Valley oil sand," which contains the principal oil pools, although some have been found in lower sands. The formation is of marine origin, and the shaly parts contain numerous scales of fishes, from which they have been called the "fish-scale shales." Certain fossils found in the formation prove that it belongs in the lower part of the Upper Cretaceous series.

Although most of the oil of this region has been found in the Aspen formation, some comes from the Bear River formation, which immediately underlies the Aspen. The occurrence of oil in this region was known to James Bridger and other early trappers, but the first published account of it resulted from a visit made by the Mormon pioneers in 1847 to the natural oil spring, known as the Brigham Young oil well, 6 miles southwest of Spring Valley. Small quantities of oil were collected from this and other springs, and prospecting was carried on intermittently until 1900, when high-grade oil was struck in a well near Spring Valley. Since that time several pools have been found, but the yield is small, the best wells producing only a few barrels a day.

Just west of Spring Valley station the train crosses a small exposure of the Frontier formation.[1] These coal-bearing rocks are of Upper Cretaceous age and have been exposed because of the removal of the red beds of the Wasatch group that once covered them. Several abandoned prospects and old coal mines may be seen on each side of the track, but no coal is mined here now.

Spring Valley.
Elevation 7,003 feet.
Omaha 905 miles.

Aspen is a small station at the east end of the Aspen tunnel. From Granger the train has been ascending Muddy Creek and here reaches the head of one of its tributaries. In going through the tunnel the train passes from the area drained by Colorado River to the Great Basin—that portion of western North America which has no outlet to the sea. The waters east of Aspen Ridge find their way down Muddy Creek and Black Fork to Green River and thence through the Grand Canyon of the Colorado to the Gulf of California. Those west of this ridge find their way to Bear River and flow by a circuitous route into Great Salt Lake, from which they can escape only by evaporation.

Aspen.
Elevation 7,175 feet.
Omaha 909 miles.

The rocks at the east end of the tunnel are the red beds of the Wasatch group, but the Oyster Ridge sandstone may be seen in the ridge just above the mouth of the tunnel. The tunnel pierces this sandstone and also part of the Hilliard formation of Upper Cretaceous age, next younger than the Frontier.

West of Altamont the route passes for about 2 miles through an open valley occupied by the soft Hilliard shale, then crosses the fault line that separates this shale from the Beckwith formation,[2] the oldest formation exposed near the Union Pacific Railroad in western Wyoming, and enters a narrow gorge carved out of the hard conglomeratic sandstone of that formation. This sandstone, upturned to a nearly vertical position, now crops out in sharp ridges composed of

Altamont.
Elevation 7,217 feet.
Omaha 911 miles.

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[1] The Frontier formation consists of coal-bearing sandstone and shale of Benton (Upper Cretaceous) age. Its name is derived from Frontier, Wyo., where the coals are well developed. The formation contains near the top a prominent sandstone about 200 feet thick, which usually forms a ridge at the outcrop and is characterized by the presence of fossil shells of a long, slender oyster (*Ostrea soleniscus*). Since 1858, when Engelmann collected fossils from this sandstone on Sulphur Creek, it has been a favorite collecting ground for geologists, and from the time of the Hayden Survey, in 1872, it has been known as the Oyster Ridge sandstone. Fossil plants also have been collected from the Frontier formation.

[2] The Beckwith formation comprises two members. The lower member consists of conglomerate, sandstone, and sandy clay 2,500 feet thick, light colored near the railroad, but red farther north; the upper member consists of light-colored sandstone and clay about 3,000 feet thick well exposed west of the railroad from Bridger to Leroy and in the ridges west of the Aspen tunnel.

coarse red conglomerate that is seen to best advantage toward the right (north). These ridges were formed by mountain-making movements which fractured the once horizontal layers and shoved them up to a vertical position, and by erosion, which carved them into the present forms.

Beyond this series of sharp ridges and well exposed in the gorge, on either side of the road, is the Bear River formation,[1] which is here about 1,100 feet thick. In the lower part of this formation north of the track were found great numbers of fossil shells of clams and snails.

Knight.
Elevation 7,043 feet.
Omaha 916 miles.

West of the narrow gorge in the Beckwith and Bear River formations is a small open space in which the Aspen shale crops out. Still farther west the route again enters an area occupied by the red beds of the Wasatch group. The Wasatch of this region consists of the Almy, Fowles, and Knight formations, the last having been named from Knight station.

About 2 miles west of the station the train reaches the open valley of Bear River, a broad marshy flood plain over which the river meanders in a serpentine course and which at times of high water is completely flooded. Bear River rises in the Uinta Mountains, about 50 miles to the south, and flows in a circuitous route, first northwestward and then westward, around the north end of the Wasatch Mountains, and finally doubles back upon itself in a general southerly course and empties into Great Salt Lake. Measurements of its flow show that on the average 375 cubic feet of water passed Evanston every second in 1914. The current is swift in some places, and from this point in its course to its mouth the river falls about 2,500 feet. Water from Bear River and its tributaries is utilized for irrigating about 75,000 acres of land.

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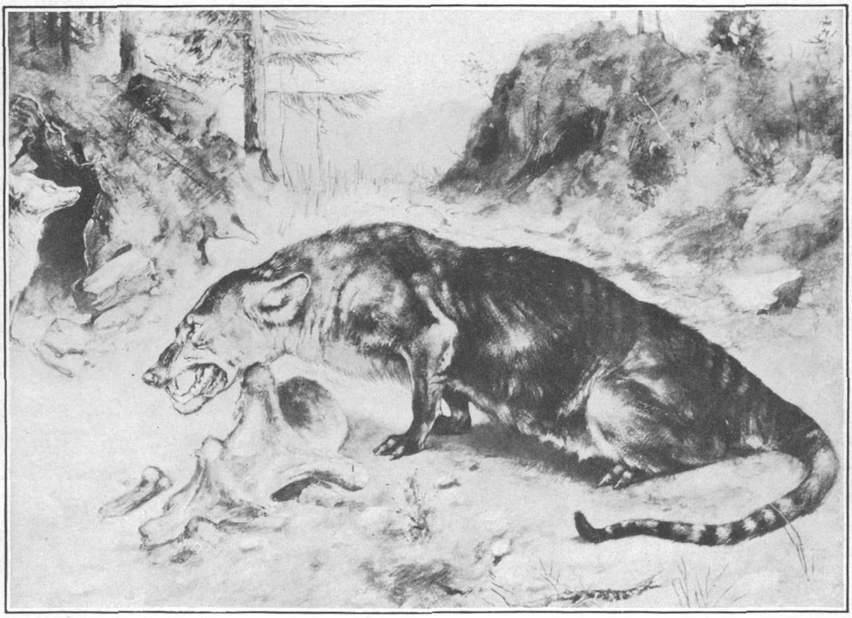
[1] The Bear River formation consists of dark shale, some of it carbonaceous, and thin layers of sandstone and limestone, and in some places it includes beds of coal. It may be distinguished from the older, unfossiliferous Beckwith beds by its darker color and by the fossils near its base.

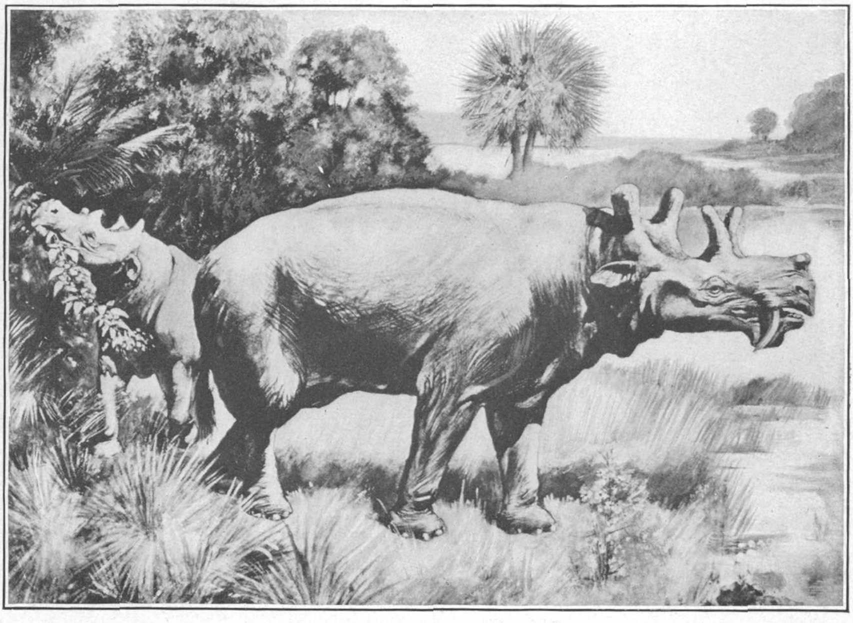
Some parts of the formation contain numerous fossil plants, as well as shells of fresh-water and brackish-water mollusks, unlike those found in Cretaceous beds elsewhere. The formation is not widely distributed, being known only from Bear River City—an early construction camp of the Union Pacific near Bear River on the line now abandoned—northward to the Salt River Range. Its thickness ranges from 500 to about 5,000 feet.

The Bear River beds were formed not far from the continental land mass that remained above water throughout Upper Cretaceous time, west of the interior sea, and it probably represents a delta at the mouth of a river that drained this old continent. The presence of fossil plants, coal beds, and fresh-water invertebrates in the Bear River formation, together with its stratigraphic position beneath the Aspen formation, which is known from fossils contained in it to be of Benton (Upper Cretaceous) age, has led to the somewhat persistent suggestion that the Bear River may be the time equivalent of the Dakota sandstone, although its maximum thickness is about 50 times that of the Dakota.



A. A CREODONT, AN ANCIENT DOGLIKE ANIMAL, ONE OF THE ANCESTORS OF THE CARNIVOROUS MAMMALS OF TO-DAY.

After Osborn. Published by permission of The Macmillan Co.



B. EOBASILEUS, ONE OF THE TYPES OF ANIMALS THAT BECAME EXTINCT AGES AGO.

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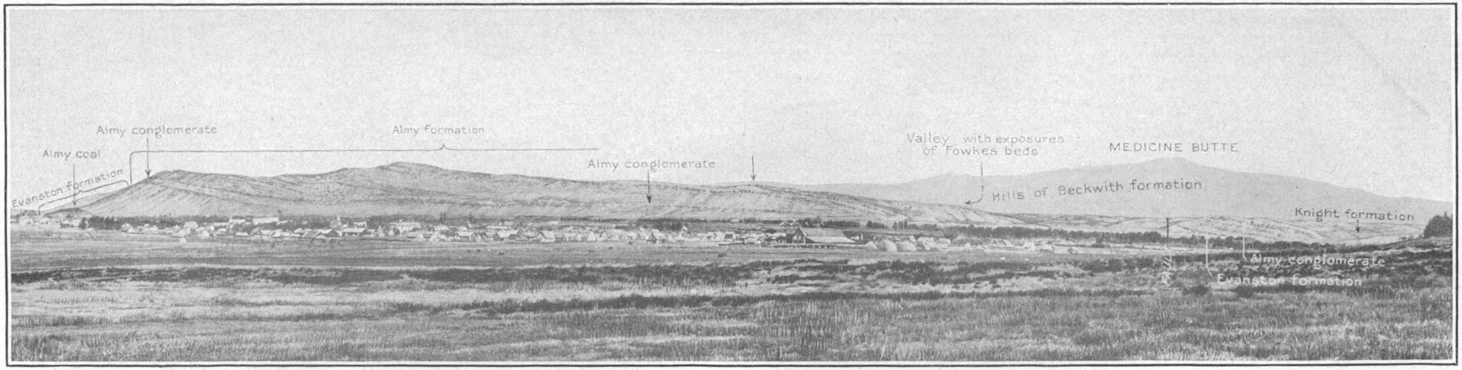
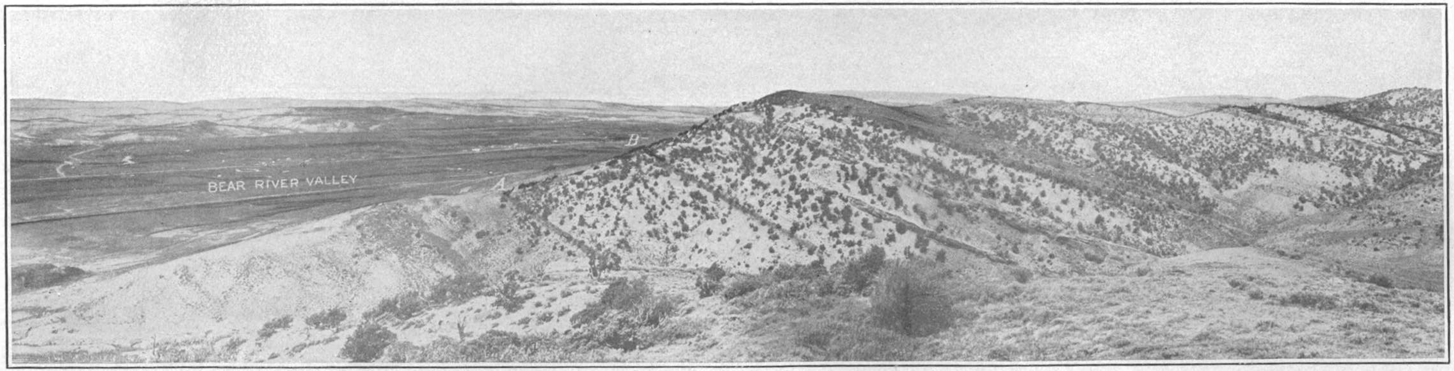


A. GEOLOGIC FEATURES SEEN FROM EVANSTON, WYO., LOOKING NORTH.



B. DETAILS OF PROMINENT HILL AT LEFT OF VIEW SHOWN IN *A.*

The line of parting between the Evanston and Almy formations lies between the points A and B. Upper beds are conglomeratic Almy; lower are Evanston. The hills across the irrigated valley of Bear River are composed of nearly horizontal strata belonging to the Knight formation.

Millis.
Elevation 6,883 feet.
Omaha 920 miles.

Near Millis station may be seen to the right (north) great piles of railroad ties that were cut in the mountains many miles to the south and floated down Bear River at times of high water. To the left (south) are bluffs formed by beds of gravel lying horizontally over the eroded edges of the upturned red beds of the Knight formation. These gravels were deposited by the river ages ago, before it had cut its valley down to the level of the present flood plain.

Just before entering Evanston the road crosses the lines of the Almy and Medicine Butte faults. Between these two faults the rocks are steeply tilted, and to the left (south) may be obtained a glimpse of the Almy conglomerates and the Evanston formation, a coal-bearing formation that is best exposed north of the city.

Evanston, Wyo.
Elevation 6,739 feet.
Population 2,583.
Omaha 925 miles.

Evanston is the seat of Uinta County and takes its name from John Evans, a civil engineer, who founded it in 1869. It is a coal-mining and commercial center and a division point of the Union Pacific Railroad, with machine shops, icing plants, and other buildings. A branch road connects the city with several mines, some as far north as Almy. The Evanston formation, which contains the principal coal beds of this region, is well exposed in a hill that may be seen to the right, about 2 miles north of the city. Plate XXI, *A*, shows the relations of this formation as seen from Evanston. The type locality of this formation is east of Bear River, just north of the city, at the locality shown in Plate XXI, *B*. Its rocks consist of conglomeratic sandstone, shale, and thick beds of coal. It lies on the eroded edges of several older formations, indicating that its deposition followed a long period of erosion. (See table on p. 75.)

Six miles west of Evanston the railroad crosses from Wyoming into Utah.

Utah.

Utah has an area of 82,184 square miles and a population of 373,351. The eastern part of the State consists of high plateaus; the western part, which lies in the Great Basin,[1] consists of ranges of rugged mountains trending in general from north to south, sagebrush-covered hills, wide, nearly level valleys, clear mountain streams, and fresh and salt lakes. The floor of the Great Basin is formed of alluvium washed from the plateaus and mountains.

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[1] As a general rule continental surfaces are drained by streams flowing to the ocean, but there are some exceptional areas which have no outward drainage. The Great Basin (fig. 10) is such an area. It was so named by Frémont, who was the first to gain an adequate conception of its character and extent. It lies near the western margin of the continent and is surrounded by the headwater divides of rivers tributary to the Pacific Ocean.

Roughly, the Great Basin is bounded by the Rocky Mountains on the east and by the Sierra Nevada on the west. It

The great mineral wealth of the State is shown by its record of mineral production, which in 1913 amounted to more than $53,000,000. The five leading products in that year were copper, $25,024,124; silver, $7,903,240; lead, $7,309,579; coal, $5,384,127; and gold,

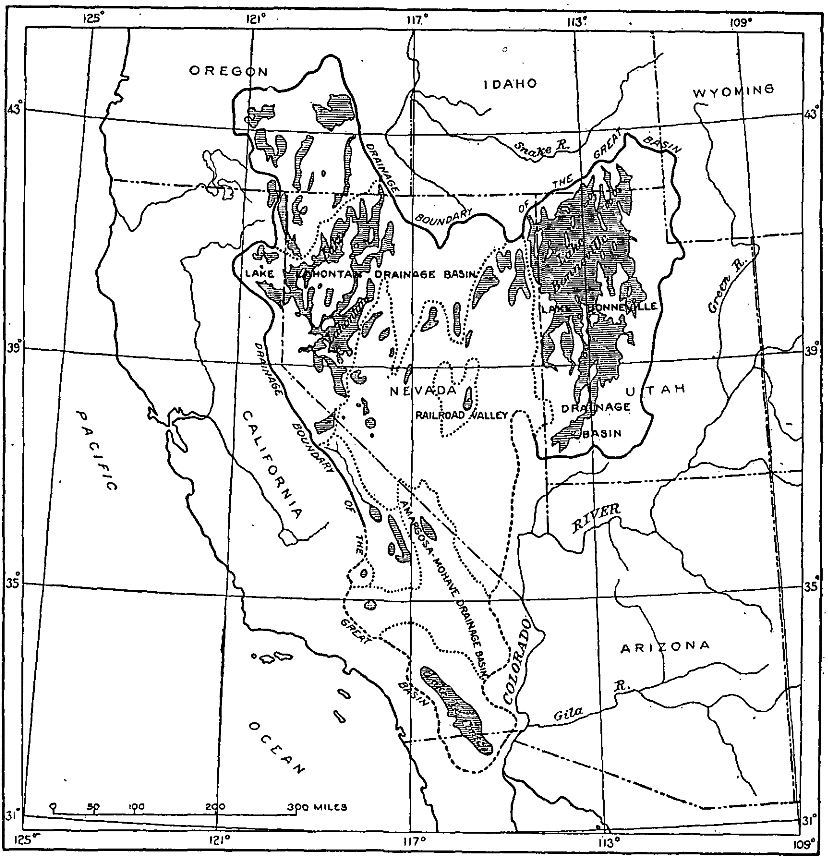

FIGURE 10.—Map showing outline of the Great Basin and the lakes it once contained. Shaded areas show Quaternary lakes; dotted lines show boundaries of drainage basins.

$3,565,229. Utah is third among the States in the Union in the production of silver and lead and fourth in the production of copper.

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extends from Oregon on the north to and beyond the Mexican boundary, but is limited by the drainage system of Colorado River on the southeast. The area thus defined is 800 miles long from north to south, and nearly 500 miles broad in its widest part. It contains 200,000 square miles, an area about equal to that of France.

The Great Basin is a region of diversified surface features, including flat desert valleys and rugged mountain ranges containing lofty peaks. It is not, as its name might suggest, a single pan-shaped depression, gathering its waters to a common center, but is divided into a large number of independent drainage areas. Both the mountains and the valleys are of types more or less peculiar to the region.

The mountains are long, narrow ridges, most of which extend from north to south and project abruptly out of the plains, there being a noticeable absence of foothills. Many of them terminate at the ends as abruptly as their side slopes join the surrounding plains.

Arid plains are abundant in this region and some are so extensive that they appear

Among the State's nonmetallic mineral resources are coal, which underlies large areas, and phosphate rock.

Although the average annual rainfall in Utah is only 11 inches, large crops are grown, chiefly by irrigation, and great numbers of live stock are raised. The value of the sugar made from sugar beets in 1914 amounted to more than $10,000,000. Wheat, oats, and potatoes are raised in large quantities, the value of these products in 1913 having been more than $8,000,000. The live stock in Utah in 1914 was valued at $18,000,000, and the value of the wool clip was $7,000,000. The value of the manufactures of the State in 1914 amounted to about $76,000,000.

To the geologist Utah is an interesting field of work and study. Its peculiar mountain ranges, the record of its extinct lakes, the deposits in its present lakes, its coal beds, its possible gas and oil fields, and its diverse and abundant mineral deposits, as well as its underground water and its available water powers, have long commanded attention and have been the subjects of many reports.

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almost boundless. They present many of the features generally supposed to characterize a desert, such as deep drifting sands and broad stretches of wholly barren mud plains, and in the heat of the midday sun they exhibit all the tricks of the mirage.

The climate of the region is very dry, the average annual rainfall varying from 10 or 12 inches in northern Nevada to less than 3 inches in the south and southwest. In northern Nevada the plains are in general covered with scattered clumps of brush, of which greasewood (Sarcobatus) and numerous varieties of sage (Artemisia) are most common. In the spring the barren-looking soil brings forth a surprising variety of beautiful and delicate flowers, most of which disappear entirely as the parching heat of summer comes on. Timber or even trees of any kind are, as a rule, exceedingly scarce. Cottonwoods and willows grow in patches or line some of the more permanent watercourses, and more or less scrubby pines and cedars are scattered on some of the higher mountain slopes. Herds of small wild horses, or mustangs, roam over some of the less frequented mountain ranges, but, like the ubiquitous coyotes, they are shy and are not likely to be seen from the train.

Agriculture is almost wholly restricted to a few areas that can be irrigated, although dry farming is being tried in some localities. A more common industry is the grazing of sheep and cattle on the bunch grass that grows in the shade of the sagebrush.

The mines of the precious metals are the principal source of wealth in the Great Basin, and in connection with their development towns have been built in out of the way places, many of them high on the bare mountain sides and far from water and food supplies.

Since the completion of the first transcontinental railroad, in 1869, settlement of the region and development of its resources have progressed enormously. Now several transcontinental railroads cross it and numerous branches extend through the desert valleys north and south from the trunk lines; towns and mining camps have sprung up along these highways, and almost every acre of easily irrigable land has been appropriated by settlers. Herds of cattle and sheep find sustenance on the mountains and in the sagebrush-covered valleys that were once thought to be too barren ever to become of service to man. Throughout the eastern border of the Great Basin, in Idaho and Utah, the followers of the Mormon faith have found a "promised land" which, by great industry, they have reclaimed from its primitive desolation and made the home of thousands.

Wahsatch, which consists of little more than a station house, stands at the crest of the divide between Bear River and Weber River. The name of the station retains the old spelling, which has been simplified for the name of the mountains. From many points west of this station may be had glimpses of the Uinta Mountains, to the southeast, and of the Wasatch Mountains, to the southwest. Toward the west may be seen the northward extension of the Wasatch Range. The hills near by consist of the red and yellow sandstone, shale, and conglomerate of the Wasatch group, which occurs here in typical development. It was from this region that Dr. Hayden, Director of the United States Geological and Geographical Survey of the Territories, named these strata.

Wahsatch, Utah.
Elevation 6,824 feet.
Omaha 935 miles.

A short distance west of the station the railroad passes through a tunnel in these red rocks and enters Echo Canyon, which is famous for the curious forms carved by erosion from the red conglomerate of its walls.

The first station in this canyon has been named Curvo, because of the route taken by the railroad in its vicinity. Many of the sharp curves and steep grades of the Union Pacific as first built have been eliminated by recent improvements, but it is not easy to smooth out all the rough places, especially where the road is confined in a narrow valley.

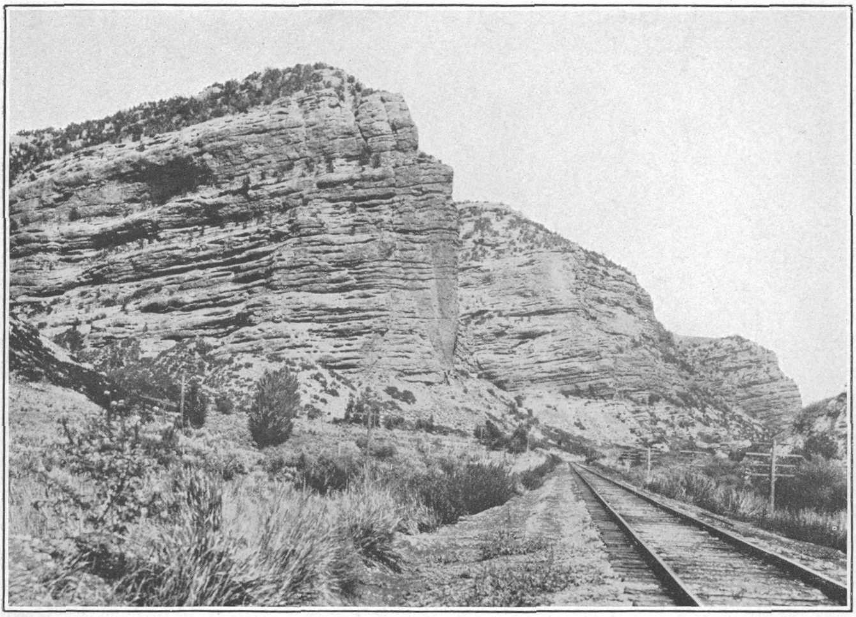
Curvo.
Elevation 6,824 feet.
Omaha 939 miles.

The station of Castle Rock takes its name from the castellated form of the north wall of the canyon which overlooks it. The red beds are here carved by erosion into many fantastic shapes, and the peculiar forms seen here become more numerous farther west and culminate in grotesqueness near Echo.

Castle Rock.
Elevation 6,240 feet.
Population 131.
Omaha 944 miles.

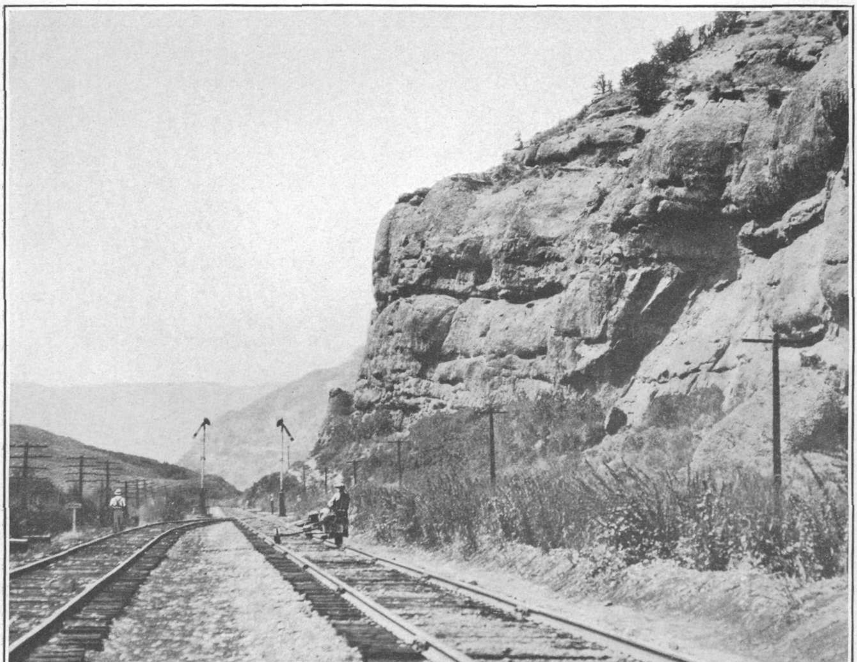
Some of the most productive gold and silver mines in the world have been developed in this inhospitable region. With all this advancement, however, the Great Basin is still very sparsely settled.

Although not generally attractive to the pleasure seeker, the Great Basin appeals especially to the geologist, both because the absence of vegetation gives unusual facilities for investigation and because the problems to be solved are peculiarly interesting and economically important. There is, moreover, an attraction in the region that grows with more intimate acquaintance, and that is due partly perhaps to its vastness, its clear dry air, and the free and healthful life that it seems to induce. Although the region is generally called a desert, its climate compares favorably with that of many other parts of the country. The low humidity prevents the high temperatures of summer from being oppressive, except possibly in some of the low-lying southern valleys where the heat is almost unendurable. It is true that the wind blows fiercely at times, so that the air is filled with flying dust and sand, but these storms are infrequent. The country probably appears to least advantage viewed from the windows of a Pullman car. From such a position of comfort the heat and dust of a summer's day appear unnaturally intensified and the apparent lonesomeness of a strange and unknown country is likely to be repellent.



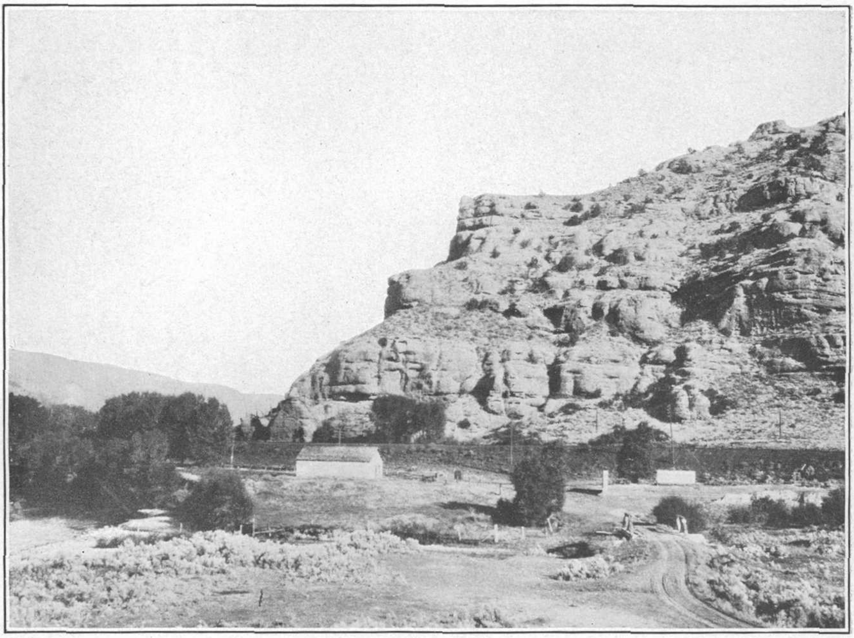
A. "STEAMBOAT ROCK," IN ECHO CANYON, UTAH.

Name is applied to rock mass in foreground because seen at some angles it resembles the bow of a steamship. It consists of red conglomerate of Tertiary age.



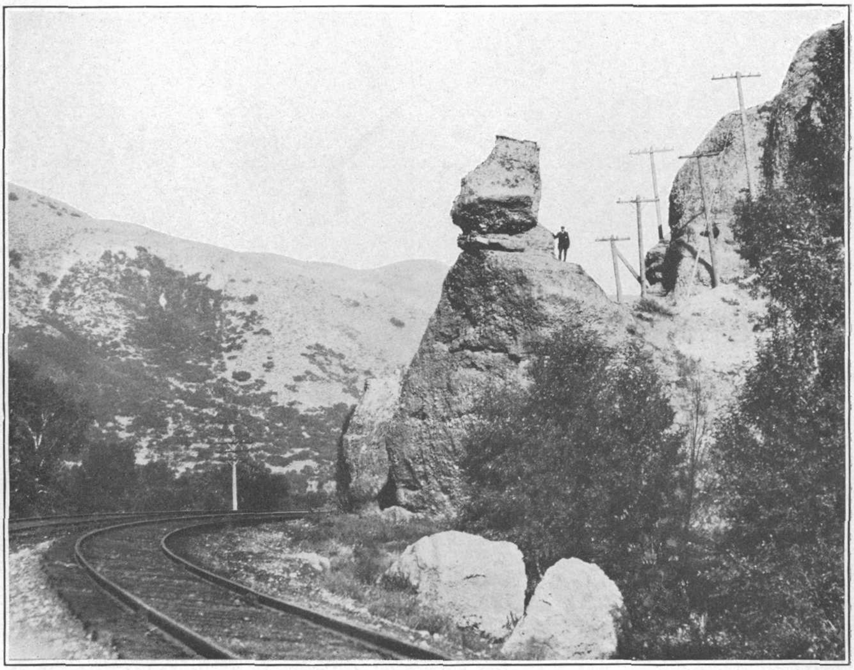
B. THE NARROWS, IN ECHO CANYON, UTAH.

Fortifications were constructed by the Mormons in these narrows during the so-called Mormon war of 1857. The walls are composed of coarse red conglomerate of the Wasatch group.



A. NORTH WALL OF ECHO CANYON, UTAH, AT ITS JUNCTION WITH WEBER CANYON, NEAR THE TOWN OF ECHO.

The rocks consist of coarse red conglomerate of the Wasatch group.



B. PULPIT ROCK AT ECHO, UTAH.

Composed of red conglomerate.

Two miles east of Emory light-colored conglomeratic sandstone appears in the canyon wall to the right (north), steeply inclined beneath the red beds of the Wasatch group. These tilted beds contain fossil plants that indicate Cretaceous age. Near Emory station a thickness of several thousand feet of these beds is exposed. The conglomerates are very coarse near the top and are colored light red, so that they can not always be distinguished from the overlying conglomerates of the Wasatch group.

Emory.

Elevation 5,925 feet.
Omaha 950 miles.

In Echo Canyon west of Emory there is some of the most picturesque scenery on the Overland Route. After passing over the great stretches of flat, unbroken desert farther east, where little but sagebrush and sand can be seen, the traveler is here refreshed by seeing something that has a vertical dimension. Some of the cliffs are nearly 1,000 feet high. The canyon has been carved by the stream, the rains, and the wind, working through long ages on the red conglomerate, which, because of inequalities in hardness, has been worn into many a curious and fantastic shape whose general effect can not be adequately described and is only poorly represented by the camera. Many of the forms have received fanciful names suggested by their shapes, such as "Jack in the Pulpit," "the Sphinx," "the Giant's Teapot," "Steamboat Rock," and "Gibraltar." (See Pl. XXII, *A*.) The imaginative spectator may be able to distinguish the forms suggested by these names, but the more observant will rather be impressed by the evidences of the working of the great forces of nature here so conspicuously displayed.

Echo Canyon is in places very narrow and long stretches of its north wall are almost vertical. (See Pl. XXII, *B*.) On top of this wall may still be seen the rude fortifications built by the Mormons during the so-called Mormon war of 1857 to prevent the entrance of United States soldiers into Salt Lake valley. Here the defenders watched and waited for the battle that was never fought, for the misunderstanding—or worse, according to Bancroft's "History of Utah"—was adjusted before the troops reached the canyon.

Just before entering the town of Echo the train passes close to Pulpit Rock (see Pl. XXIII, *B*) which may be seen on the right. As the name implies, this rock bears some resemblance to a pulpit, and the story has been somewhat widely circulated that from it Brigham Young preached his first sermon on entering the "promised land" in 1847. However, those in position to speak with authority on this subject say that the first company of Mormon emigrants did not stop at Pulpit Rock and that Young was sick with mountain fever during this part of the journey.[1]

Echo.

Elevation 5,471 feet.
Population 144.
Omaha 960 miles.

[1] Many of the facts relating to the Mormon immigration have been kindly furnished by Mr. Andrew Jensen, of Salt Lake City.

At the town of Echo the canyon opens into Weber Valley, up which a railroad spur extends through the coal-mining town of Coalville to the metal-mining district surrounding Park City.[1] Coal was found by the Mormon settlers near Coalville long before the Union Pacific was built and has been mined more or less continuously ever since its discovery. The mines of the Grass Creek valley, in the Coalville field now furnish fuel for the mining operations at Park City and for the manufacture of Portland cement at Devils Slide.

At Echo the red conglomerates (Wasatch) form cliffs 500 feet or more in height (Pl. XXIII, *A*). South and west of the town the rocks of Cretaceous age reappear at the surface where the Wasatch beds have been eroded away. About 2 miles west of Echo a group of curious monument-like rocks, some of which are more than 100 feet high, may be seen to the right (north) of the track, well up the slope. These are known as The Witches (Pl. XXIV, *A*) and are remnants formed by the erosion of a coarse conglomerate. Although any rock that has a fancied resemblance to some familiar shape is likely to attract greater attention than many a more significant feature of the landscape, these bizarre monuments are well worthy of more than a passing glance. The name "The Witches" is suggested by the form of the cap rock of one of the monuments, which is shaped something like the fabled witch's hat. (See Pl. XXIV, *B*.) The caps are formed from a light-colored band of conglomerate that is cemented into a harder mass than the underlying pink conglomerate. This hard cap rock protects the underlying beds from the rain until the supporting column, by slow crumbling, becomes too slender to hold it. When the cap falls off the monument soon becomes pointed at the top and is finally reduced to the level of the surrounding country.

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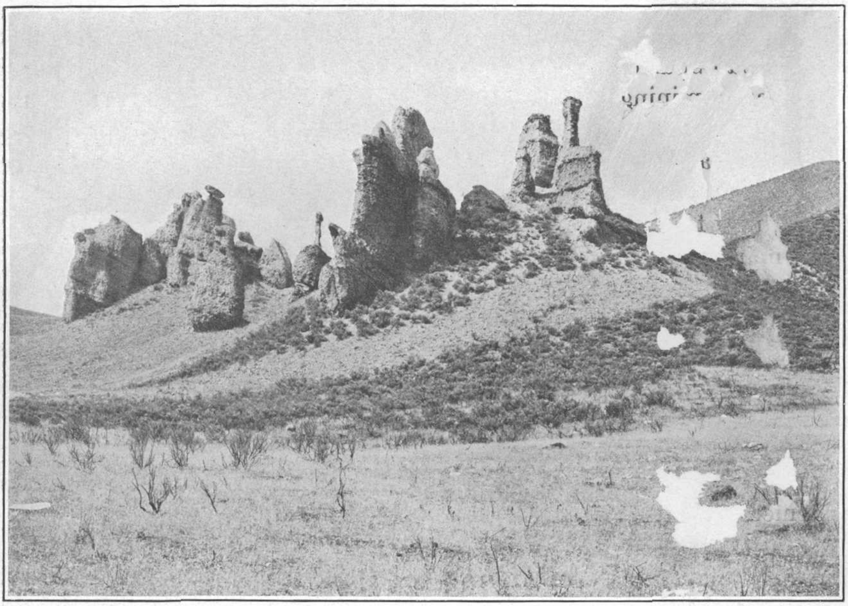
[1] The mining camp at Park City is on the east side of the Wasatch Range at an altitude of 7,200 feet, but some of the mines are nearly 2,000 feet higher. The sedimentary rocks of this district, ranging in age from Carboniferous to Triassic, were long ago compressed into a series of folds and broken by mountain-making forces and large portions of them were greatly displaced. Masses of molten rock known as quartz diorite and quartz diorite porphyry were then forced up into them from below. Later other masses of molten rock called andesite flowed over the surface.

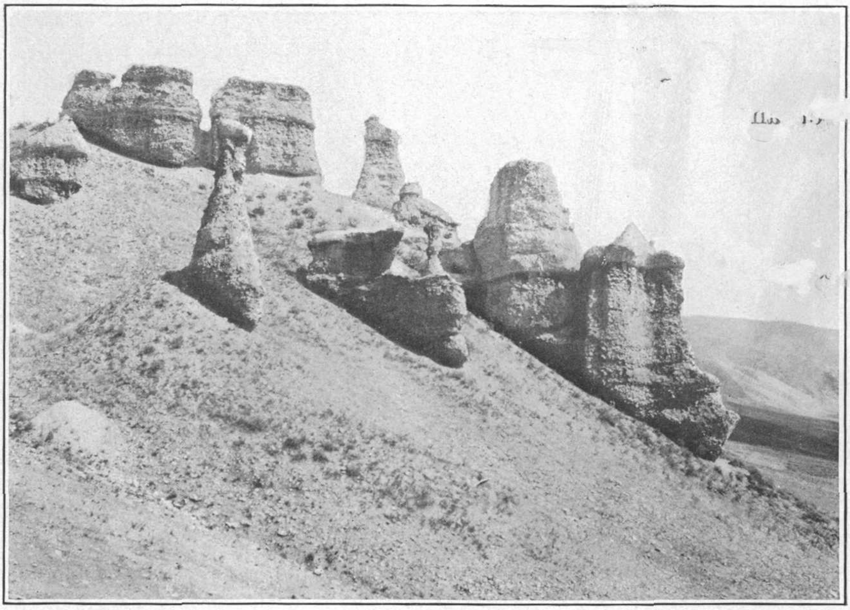
The ores result from the older intrusions and occur as compounds of lead, silver, copper, zinc, and other metals in lodes and fissure veins and as bedded deposits in the sedimentary rocks. The more important lode deposits occur in two zones about a mile apart, known as the Ontario and Daly West zone and the Silver King and Kearns-Keith zone. These have been explored for several thousand feet (in length), and in the Ontario mine a fissure containing much valuable ore has been explored to a depth of 2,000 feet or more.

Ore was discovered in this district in 1869, but not until 1877 did the camp become an important producer. Since that time production has been continuous. The total reported output to the close of the year 1913 was gold $3,959,132; silver, $91,336,065; lead, $47,602,156; copper, $3,587,247; zinc, $2,606,770—a total value of $149,091,370, of which $38,753,126 has been distributed as dividends.

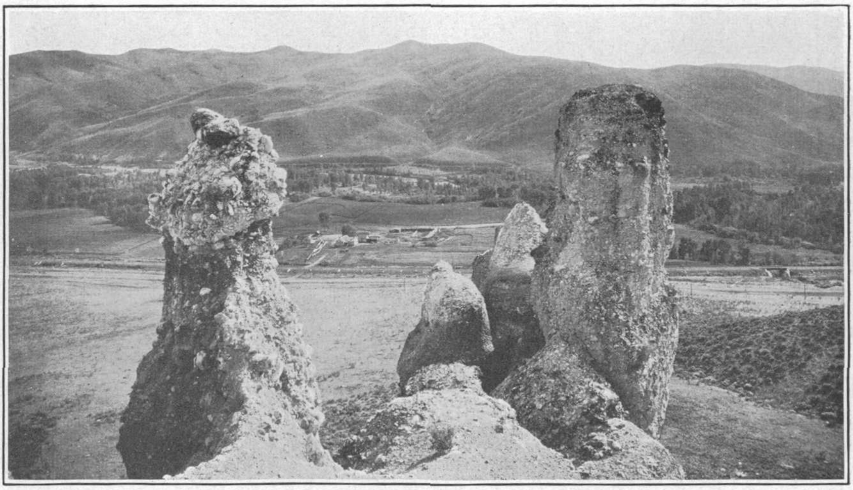


A. THE WITCHES, NE...

A group of natural monuments carved by wind and rain from cong... furnished by Union Pacific Railroad Co.

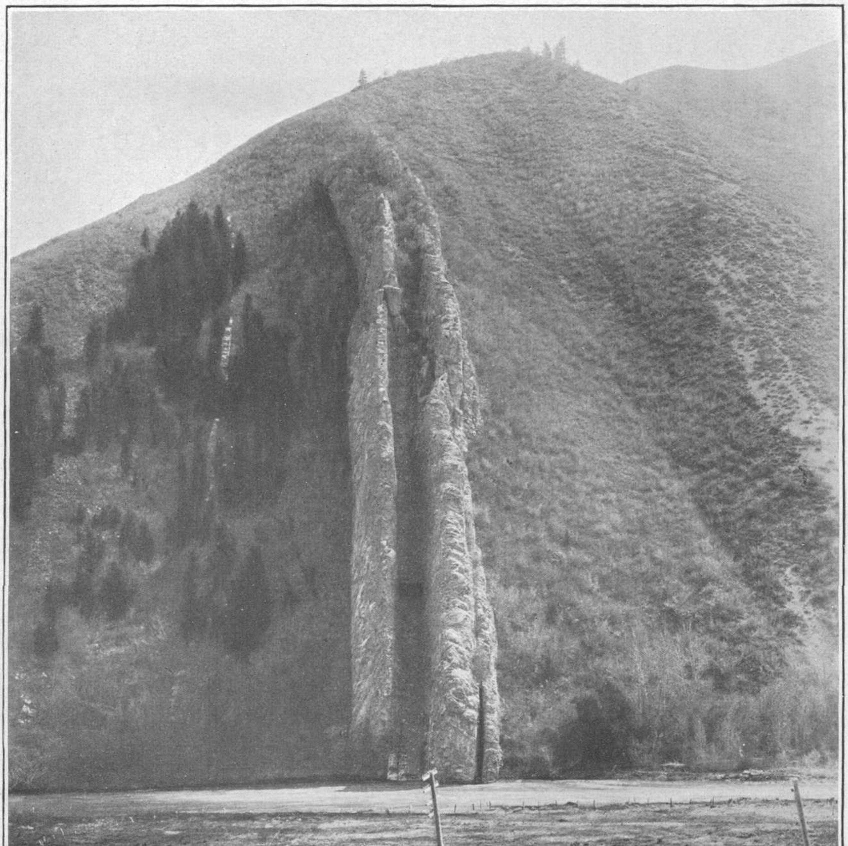


B. SIDE VIEW SHOWING, ON THE BUTTE TO THE RIGHT, THE "WITCH'S CAP," WHICH SUGGESTED THE NAME FOR THE GROUP.



A. VIEW OF THE VALLEY OF WEBER RIVER FROM WITCHES ROCKS.

On the monument at the left is a cap which protects the rock under it because its pebbles are cemented together more firmly than those below.



B. THE DEVILS SLIDE.

These beds consist of layers of hard limestone separated by soft shale of the Twin Creek formation, of Jurrassic age, and were originally formed in a horizontal position but during one of the mountain uplifts were upturned to a vertical position.

Plate XXIV, *A*, shows a monument (in the center of the group) that is lower than the others and worn to a sharp point at the top. The cap that once protected this "witch" now lies in a gulch at her feet. The other caps will fall in time—probably after the lapse of centuries—and The Witches, like their mythical prototypes, will disappear from the face of the earth.

Near Henefer the first company of Mormon emigrants, for some reason that is now hard to understand, left the Overland Trail and chose the very difficult route up the creek that enters the Weber from the south. After crossing the mountains, they passed down Emigration Canyon to Salt Lake City.[1]

Henefer.

Elevation 5,409 feet.
Population 413.
Omaha 964 miles.

To the right (north), near Henefer station, may be seen a gravel terrace rising 25 feet or more above the level of the roadbed. This was formed by the river at some former stage, probably during the time of high water in Lake Bonneville. (See pp. 97–99.) Although the gravels here are more than 200 feet above the highest terrace of the old lake, it seems likely that the diminished slope of the river during high water then caused the stream to deposit in this part of its course the beds of gravel that now form the shelf on which the railroad is built west of Echo and that form the protecting cap of the bluff at Henefer.

The Cretaceous rocks which in Echo Canyon dip steeply toward the west under the red beds of the Wasatch group reappear with opposite dip west of Echo, but owing to the great quantities of gravel that cover the hillsides, derived by disintegration from the older conglomerates, these rocks can be seen from the train at only a few places. However, the broad, open valley that the route crosses west of Henefer is due to erosion of the soft Cretaceous shales.

Three miles west of Henefer the coarse red puddingstone of the Wasatch beds extends down to the river level, and the broad basin-

[1] It is possible that a little study of the earlier history of the Mormons may throw some light on this strange procedure. They had been driven from place to place in the States until they had decided to seek a place so far from settled districts that they would not be molested. When this first company, consisting of 140 men and 3 women, started westward in April, 1847, one purpose of their leader, Brigham Young, was to mark out a trail for the use of later emigrants. Rather than follow the Overland Trail, which had become fairly well known by this time, he chose a new and untraveled route that came later to be called the Mormon Trail. The beaten path was avoided for two reasons. First, they wished to avoid their enemies, some of whom they would be sure to find on the older trail, and second, they never traveled on Sunday and they made religious worship as much a part of their daily program as the travel itself. In order to avoid trouble, as well as for the sake of being unmolested in their devotions, this first company marked out a new route through 1,000 miles of wilderness. The Mormon Trail parallels the Overland Trail and in some places where a different route was impracticable joins it, as, for example, at river crossings and in the mountain passes and canyons.

like valley suddenly narrows to a gorge barely wide enough for the river to pass through. The road bed has been cut in the side of this gorge, and in the cuts may be seen great bowlders of quartzite, some of them 4 feet in diameter, with smaller bowlders, pebbles, and sand filling the space between them. These materials are cemented into a resistant mass by red oxide of iron, which gives a brilliant color to the whole mass. At the west end of this short gorge the red conglomerate overlaps rocks of Jurassic age, which have been upturned to a vertical position.

On emerging from the gorge, just before entering the town of Devils Slide, the train passes through a long cut in the shale of the upper part of the Jurassic and crosses Weber River at the point where Lost Creek enters it from the right (north). To the right also, in the Lost Creek valley, may be seen a large mill where limestone and shale are manufactured into Portland cement.[1] These stratified rocks are all turned up into a vertical attitude. The soft shale is worn away by rain and wind faster than the limestone, which is left standing out as ragged vertical walls. The Devils Slide (Pl. XXV, *B*) is formed by two of these limestone reefs, about 20 feet apart, from which the shale has been eroded away, leaving them standing about 40 feet above the general slope of the canyon side. Many other reefs in this vicinity are equally prominent, but no others are so conspicuous from the train.

Devils Slide.
Elevation 5,314 feet.
Omaha 969 miles.

From Devils Slide westward to Morgan Weber River has cut a canyon through the Bear River Range. This broad range is by some geographers included in the Wasatch Mountains, into which it passes farther south. The sedimentary rocks of the Bear River Range consist of steeply inclined beds of limestone and sandstone and a subordinate amount of shale, ranging in age from Jurassic on the east to Ordovician on the west. (See table on p. 2.) The formations are all conspicuously exposed in the precipitous craggy sides of the canyon and may be seen to best advantage toward the right, in the north wall of the canyon. West of the town of Devils Slide the gray beds of the Jurassic Twin Creek limestone give place to a massive salmon-colored sandstone (Nugget sandstone) of Jurassic or Triassic age, west of which, and next older, are thin-bedded bright-red shales and sandstones (Ankareh shale), fossiliferous shaly limestone (Thaynes

[1] The Jurassic limestone and shale of this locality are utilized in the manufacture of cement, for which they are well adapted and conveniently located. The rock is blasted from the mountain side in quarries plainly visible from the train to the right (north) and passed downward through the mills, coming out at the bottom in the form of cement at the rate of about 2,500 barrels a day. The fuel used for the kilns is coal, mined on Grass Creek. Electric power is furnished by streams on the western slope of the Wasatch Mountains and transmitted from generating plants near the base of the range.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
OVERLAND ROUTE
From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

UNITED STATES GEOLOGICAL SURVEY

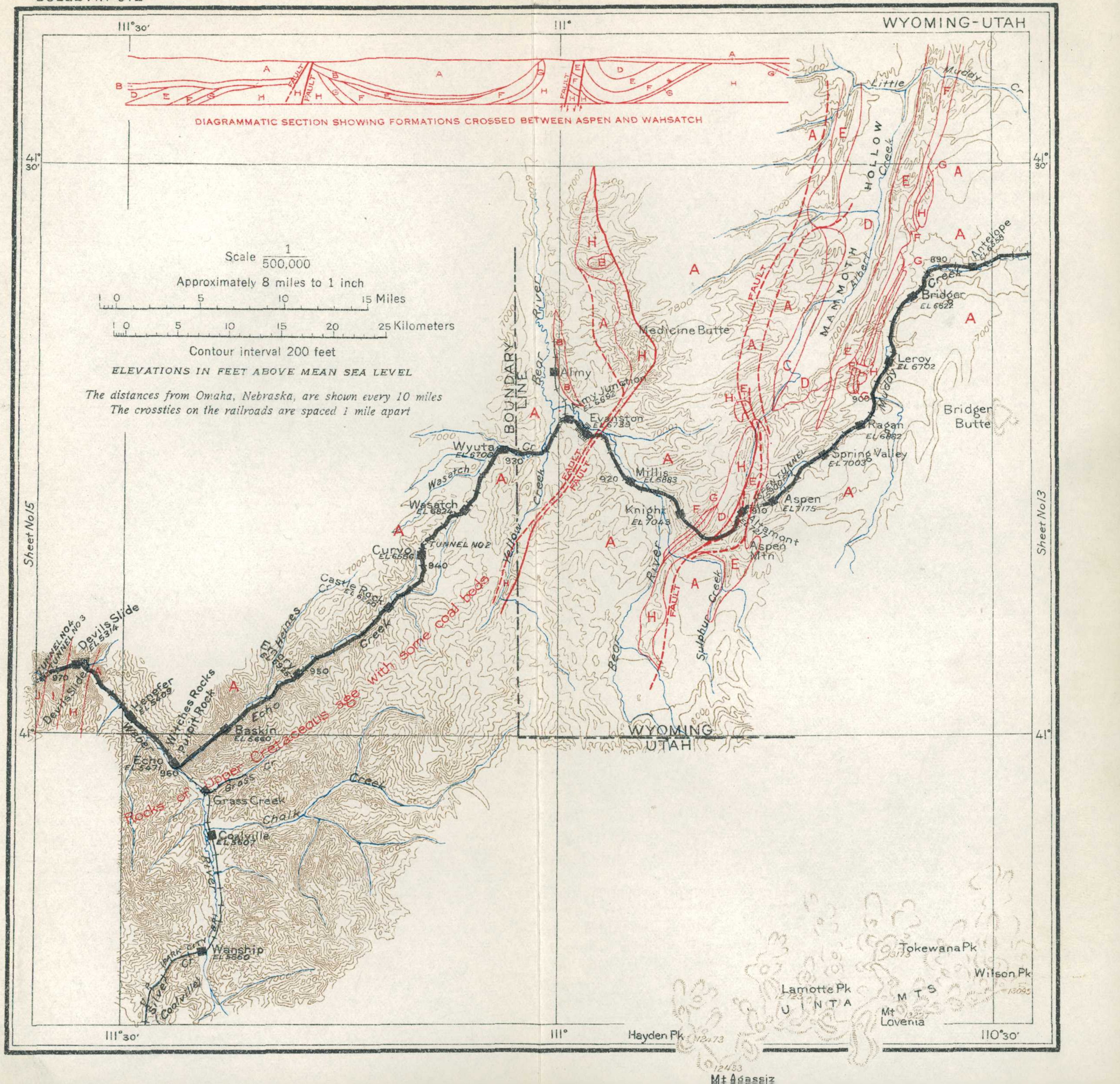
GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.

EXPLANATION

		Thickness in feet	
A	Sandstone and conglomerate; fresh-water deposits; includes Knight, Fowkes, and Almy formations (Wasatch group)	2,600 - 6,200	Tertiary
B	Sandstone, shale, and coal; fresh-water deposits (Evanston formation)	0 - 1,600	Cretaceous or Tertiary
C	Sandstone and shale; brackish and fresh-water deposits (Adaville formation)	4,000	Cretaceous
D	Shale; marine deposit (Hilliard formation)	5,500 - 6,800	
E	Sandstone, shale, and coal, (includes Oyster Ridge sandstone member); marine and brackish water deposits (Frontier formation)	2,200 - 2,600	
F	Shale; marine deposit (Aspen formation)	1,500 - 2,000	
G	Sandstone and shale; fresh and brackish water deposits (Bear River formation)	500 - 5,000	
H	Sandstone, conglomerate, shale, and limestone; marine and fresh-water deposits (Beckwith and Twin Creek formations)	3,800 - 5,500	Jurassic possibly some Cretaceous
I	Sandstone and shale; marine deposits (Nugget (1,700 ±), Ankareh (1,500 ±), Thaynes (1,700 ±), and Woodside (1,000 ±) formations)	5,900	Triassic may include some Jurassic
J	Limestone; marine deposit (Park City formation)	1,500±	Carboniferous
J	Quartzite; marine deposit (Weber quartzite)	4,000±	Carboniferous



limestone), and red sandstone and shale (Woodside formation), all probably of Lower Triassic age. The purplish-red sandstone layers of the Ankareh are beautifully ripple marked.

Still farther west appears the fossiliferous limestone of the Park City formation, of Pennsylvanian or Permian age. In the lower part of this formation are beds of black phosphate rock interstratified with beds of shale and limestone. The traveler can see some old prospect openings in the phosphate beds to the left, in the south wall of the canyon, just before the train enters the tunnel. These beds are portions of the great phosphate deposits of Utah, Idaho, Wyoming, and Montana, which form a large part of the nation's store of material available for making phosphatic fertilizers. (See pp. 127–129.)

West of the phosphate beds is the Weber quartzite, a thick formation of Pennsylvanian age which, because of its superior hardness and resistance to erosion, forms the crest of the Bear River Range. Most of the rounded quartzite bowlders and pebbles in the red conglomerate of Echo Canyon and of the gorge east of Devils Slide were derived from this formation.

The river has cut a winding gorge through the quartzite, and two of the projecting spurs of the craggy walls are pierced by short tunnels. At the eastern tunnel the strata, which farther east are nearly vertical, are bent into a knee-shaped fold that brings the beds west of the axis to an inclination of scarcely 15°.

The second tunnel in the Weber quartzite opens on the west into Round Valley, a circular basin hollowed out by the river in the relatively soft red sandstone and shale of lower Pennsylvanian age, known as the Morgan formation, because of its occurrence near the town of Morgan. These red beds are well exposed in the north wall of Round Valley and also south of the railroad between this valley and Morgan.

Morgan.

Elevation 5,080 feet.
Population 756.
Omaha 976 miles.

Morgan is the center of a rich agricultural district that is especially noted for the fine quality of the peas which are raised here. From Morgan (see sheet 15, p. 102) about 90 carloads of canned peas are shipped each year. The broad valley which makes this industry possible is due to the presence of soft rocks, in which the river has greatly widened its valley while it was cutting the narrow gorges in the hard rocks both east and west. These rocks once filled a basin lying between the two ranges of the Wasatch Mountains. East of Morgan rise the craggy slopes of the Bear River Range, through which the train has just passed, and which attains an altitude of 9,245 feet in Mount Morgan, north of the town. To the west may be seen the rugged crest of the main range of the Wasatch Mountains, which in this latitude consist entirely of granitic rocks of Archean age—that is, rocks which are older than the oldest sedimentary rocks that contain remains of plants or animals. (See table on p. 2.)

Just before entering Morgan the train passes close to the foot of a slope on the right (north) in which dark-colored limestone containing fossil corals and shells of early Carboniferous (Mississippian) age is well exposed. Farther west rocks of Ordovician and Cambrian age are exposed north of the track, but these can not be readily distinguished from the train.

The soft Tertiary rocks that occupy the basin west of Morgan may be seen to the right from the train, north of Peterson, where they appear as light-green to pink strata, slightly conglomeratic and inclined toward the east.

Peterson.

Elevation 4,892 feet.
Population 277.*
Omaha 983 miles.

The station at Peterson is near the center of the basin just described. The basin was formerly occupied by a bay of the ancient Lake Bonneville, whose waters backed up through Weber Canyon. (See pp. 97–99.) Along the margin of this bay, which was 300 feet or more in depth, sand and gravel accumulated in large quantities. When the water withdrew from the basin these beach accumulations were left as a shelf, remnants of which lie about 300 feet above the railroad at many places on the slopes.

Strawberry.

Elevation 4,842 feet.
Omaha 985 miles.

Many a "station" along the Union Pacific Railroad consists of nothing more than a signpost, but at Strawberry not even a post is visible. It is a switch for sidetracking cars to gravel pits, which may be seen to the right, north of the railroad, and which furnish gravel for ballast. From many places near Strawberry the traveler may get good views of Mount Morgan, to the east, and of Observation Peak (over 10,000 feet above sea level), which lies to the north (right) and is here the most prominent mountain north of the railroad. To the left (south) rises the main mass of the southern part of the Wasatch Range.[1]

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[1] The Wasatch is the easternmost of the basin ranges. Although very complex in structure, it may be described briefly as a great block of the earth's crust that has been elevated at its western margin, so that it inclines eastward. Its tilting was made possible by a break of the crust in a north-south direction along what is now the western base of the range. The rocks that lie east of this line of fracture were pushed up many thousands of feet higher than those that lie west of the line, thus producing a great fault. Later the elevated part of the block was eroded, so that now its surface is a complicated mass of rugged mountains, separated from one another by valleys, canyons, and gorges. The western face of the range which was originally nearly straight and might have been a single cliff had it not been eroded, is still very precipitous and forms what is known as a great fault scarp. It is this western fault scarp that is so impressive as seen from Ogden and other points in the valley of Great Salt Lake.

The Uinta Mountains differ from the Wasatch Mountains in that they have resulted from the erosion of a broad arch whose axis trends east, nearly at right angles to the Wasatch axis. The Uinta is the westernmost of the Rocky Mountain ranges, which reach their maximum development farther east in central Colorado. The junction of this range with the

Gateway.

Elevation 4,804 feet.
Omaha 988 miles.

Just before reaching Gateway station the route passes abruptly from the open valley into the narrow V-shaped gorge cut by Weber River through this great range of mountains. Precipitous, craggy slopes rise on both sides and the scenery is varied and impressive. The river descends rapidly in this canyon and the power furnished by it is utilized by hydroelectric plants. Soon after entering the canyon the train passes to the left (south) of a diversion dam at which a large part of the water is turned into a pressure pipe 6 feet in diameter. From this pipe it emerges about 2 miles downstream, at an altitude 172 feet below the intake, at the power house of the Utah Light & Railway Co., from which 5,000 horsepower is transmitted 35 miles to Salt Lake City. From the power house the water is carried by a canal along the south wall of the canyon to the turbines of a second power house, from which it is distributed for irrigating the lands of the valley below. The once worthless desert has thus been transformed to green fields and fruitful orchards which support a thriving community.

Toward the lower end of the canyon the river makes a sharp turn to the right through a rocky defile called Devils Gate. Instead of passing through this defile, the railroad is built through a cut made in unconsolidated gravel which fills a former channel of the river. Apparently this old channel was filled during one of the stages of high water in Lake Bonneville (see pp. 97–99), and when the lake water withdrew the river was deflected to the right at this point and cut a new channel in the solid rock, making what the physiographer calls a young channel due to superimposed drainage.[1]

Wasatch constitutes the transition between the Rocky Mountain ranges—modified arches whose axes have a northerly trend with a marked tendency toward westward deflection—and the Basin Ranges—tilted blocks, whose axes have a regular northerly trend.

[1] The behavior of the river at this point gives the key to an understanding of its course across the Wasatch Range. The river rises east of this range, but instead of taking the seemingly easier course around the mountains, as Bear River did, it has cut its way directly through them. West of Echo it leaves the open basin-like valley and enters a narrow gorge nearly 2,000 feet deep. West of Devils Slide it enters a canyon cut to a depth of 4,000 feet or more through the Bear River Range. West of this range it crosses another open space and once more enters a narrow canyon within which it passes through the main range of the Wasatch Mountains.

In Tertiary time such valleys as may then have existed in this region were filled with gravel, sand, and silt, and practically the whole region was aggraded or built up to nearly a common level. Over this plain the streams established their courses without regard to the kind of rock beneath the surface. Weber River chose the course of least resistance at that time, and when it deepened its channel and found itself flowing directly across the ridges of hard rock that now form the Wasatch Mountains it was too late to change. The energy of the stream has been sufficient to cut only narrow gorges in the hard rock, but in the softer rock it has excavated the broad valleys west of Echo and near Morgan.

On emerging from Weber Canyon the train crosses the line of the great fault by which the rocks on the east were uplifted many thousands of feet relative to those on the west. Here we enter a broad, fertile valley that is well watered by the river. If the traveler covered with alkali dust from the deserts farther east reaches this valley when the orchard trees are bending to the ground under their burden of ripening fruit he will not wonder that some of the inhabitants call it "Zion."

Uinta.

Elevation 4,497 feet.
Population 178.*
Omaha 993 miles.

This valley has been eroded from a broad delta of gravel, sand, and silt built up by the river during the Pleistocene epoch, when the waters of Lake Bonneville covered the region. The form of the delta is not visible from the train, because the railroad follows the trench that the river subsequently cut in the old delta. The accompanying map (sheet 15, p. 102) shows that a gently sloping surface with Ogden near its center extends from Farmington nearly to Brigham, a distance of 30 miles, and from the foot of the mountains westward to the lake, a distance of 17 miles. This is the delta built by Weber and Ogden rivers and several smaller streams.

Two prominent beach lines are plainly visible on either side of the canyon. The higher one, known as the Bonneville terrace, is nearly 1,000 feet above the river and marks the level reached by the water when the lake was at its maximum height. The lower one, known as the Provo terrace, is 375 feet below the Bonneville terrace and denotes a later stage of the lake. From points at a considerable distance these so-called "water lines," some made by deposits of gravel and others by notches cut by the waves of Lake Bonneville in the hard rock, may be seen all along the western face of the mountains. (For a description of these terraces and the phenomena associated with them see pp. 97–99.)

The valley of Weber River, which appears so attractive in the vicinity of Uinta, is a small part of the Great Salt Lake valley, which includes a large part of northern Utah. This is the home land of the Mormons, and according to the historian Hubert H. Bancroft it is "a new Holy Land, with its Desert and its Dead Sea, its River Jordan, Mount of Olives, and Galilee Lake, and a hundred features of its prototype of Asia."

Ogden.
Elevation 4,301 feet.
Population 25,580.
Omaha 1,000 miles.

Ogden is the western terminus of the Union Pacific system. Through passengers on the Overland Route here pass without change of cars to the Southern Pacific line which connects Ogden with San Francisco. Passengers for Yellowstone Park change to the Oregon Short Line, and those for Salt Lake City [1] have the choice of the Salt Lake & Ogden electric road, the Oregon Short Line, or the Denver & Rio Grande. The railroad time changes here from mountain to Pacific time, and the westbound traveler should set his watch back one hour.

Ogden is the county seat of Weber County and the second largest city in Utah. It is said to have been named for an old trapper and was laid out under the direction of Brigham Young in 1850. Ogden has a variety of industries, owing in part to its good transportation facilities and cheap electric power. Canning is one of the most important. In 1913 canneries adjacent to the city made an output of nearly a million cases (approximately 24,000,000 quarts) of fruit and vegetables, of which more than half was tomatoes.

Ogden lies at the foot of the Wasatch Mountains, which rise abruptly just east of it, and is on the border of the flat floor of Great Salt Lake valley, stretching away to the west. The business part of the city is on one of the later terraces cut by the waves of the

[1] Salt Lake City, 37 miles south of Ogden, is the capital of Utah and the seat of government of the "Church of Jesus Christ of Latter-Day Saints," whose adherents are commonly called Mormons. It is a city of 92,777 inhabitants, beautifully situated between the shore of Great Salt Lake and the lofty and precipitous front of the Wasatch Mountains. Many of the natural features are unique, especially the great lake of brine so salty that no fish can live in it and so dense that the bather floats on it like a cork on ordinary water. But this city is of interest mainly as the headquarters of the Mormon Church, which has grown so rapidly that in place of the 40 who organized it in 1830 it now has a membership of about 500,000. Here are the Temple, the Tabernacle, and many other objects of interest. The city was founded in 1847 by the first company of Mormon emigrants under Brigham Young and was the point to which later companies came and from which they went out to possess the land. The story of this migration and the establishment of the new sect in the wilderness is of absorbing interest. The fortitude with which these people endured hardships and suffering and their unwavering devotion to a fixed purpose compel admiration.

Bingham Canyon, the principal copper district of Utah, is easily reached from Salt Lake City. The ores occur mainly in limestone of Carboniferous age and in an intrusive igneous rock (monzonite porphyry) which cuts the limestone. The low-grade disseminated ores in porphyry are now more important than the ores in the limestone. In 1913 the disseminated ore mined, chiefly by steam shovels, amounted to 8,300,000 tons, yielding about 0.75 per cent of copper and some gold and silver.

The Park City and Tintic districts, which produce large quantities of ores carrying chiefly lead and silver, can also be visited from Salt Lake City.

ancient Lake Bonneville, described below by G. K. Gilbert,[1] in an apron of mountain waste; the main residence section rises eastward

[1] At Ogden the traveler is fairly within the Great Basin, and for 590 miles, until he reaches the crest of the Sierra Nevada, his course traverses a series of closed valleys—valleys which resemble basins in the fact that all parts of their rims stand higher than their middle parts. All streams of this region either lose their water by direct evaporation or discharge it to some lake that serves as an evaporation pan. Some of the lakes have outlets, but every such outflowing stream flows into another lake, and the final receptacle has no outlet, all the water it receives escaping upward, into the air. No stream in the Great Basin finds its way to the ocean.

Great Salt Lake has no outlet. Jordan River, which enters it from the south, is the outlet of Utah Lake. Bear River, coming from the north, carries the outflow from Bear Lake. The waters of Utah and Bear lakes and of Jordan and Bear rivers are fresh, and so is the water of Weber River, the third great tributary of Great Salt Lake, but the lake into which the three rivers flow is saline. It is saline because it has no outlet. The fresh waters of the rivers contain some saline matter, but the quantity is too small to be discovered by taste. As stated by the chemist, in parts per million, the quantity seems minute, but when account is taken also of the total volume of water brought by the streams to the lake in a year their burden of saline matter is found to be really great, amounting annually to more than 500,000 tons. Year by year and century by century the water which they pour into the lake is evaporated, but the dissolved solids can not escape in that way and therefore remain. They have accumulated until the lake water is approximately saturated, holding nearly as much mineral matter as it can retain in solution. The lake contains over 5,000 million tons of common salt and 900 million tons of Glauber's salt, or sodium sulphate, as well as other mineral matter.

Another consequence of the lack of outlet is that the lake varies from time to time in size. Whenever the gain from inflow is greater than the loss from evaporation the level of the water surface rises; when the loss is greater it falls. Each year there is a rise, beginning in winter, when the cool air has little power to absorb moisture, and continuing through spring, when the rivers are swollen by the melting of snows in the mountains. Each year there is a fall, beginning in summer, when the hot air rapidly absorbs the water, and continuing in autumn, when the rivers are smallest. This annual oscillation amounts on the average to about 16 inches.

In some years the rainfall and snowfall are greater than in others, and then the lake usually receives more water than it parts with, so that the surface is left higher than it was before. In a series of wet years the lake level progressively rises; in a series of dry years it progressively falls; and as the rainfall is irregular the fluctuations of the lake are conspicuous. Since definite knowledge of the lake began, in 1850, there have been five periods of increase and four of decrease. (See fig. 11.) The summer levels of 1868 and 1877 were more than 10 feet above the summer level of 1850, and those of 1903 and 1905 were 4 feet below that of 1850. The level of 1914 was 6 feet above that for 1905.

The land bordering the lake has in many places a slope so gentle that a small change in the height of the water surface makes a great change in the area of the lake. On a map completed in 1850 the area shown is 1,750 square miles; on a map made in 1869 it is 2,170 square miles. In the interval between the two surveys the lake had risen 10 feet, and this rise enlarged the area about 24 per cent. From the greater surface the evaporation was of course greater, and the dependence of evaporation on area is thus an important factor in regulating the size of the lake. The effect of a long series of wet years is somewhat reduced

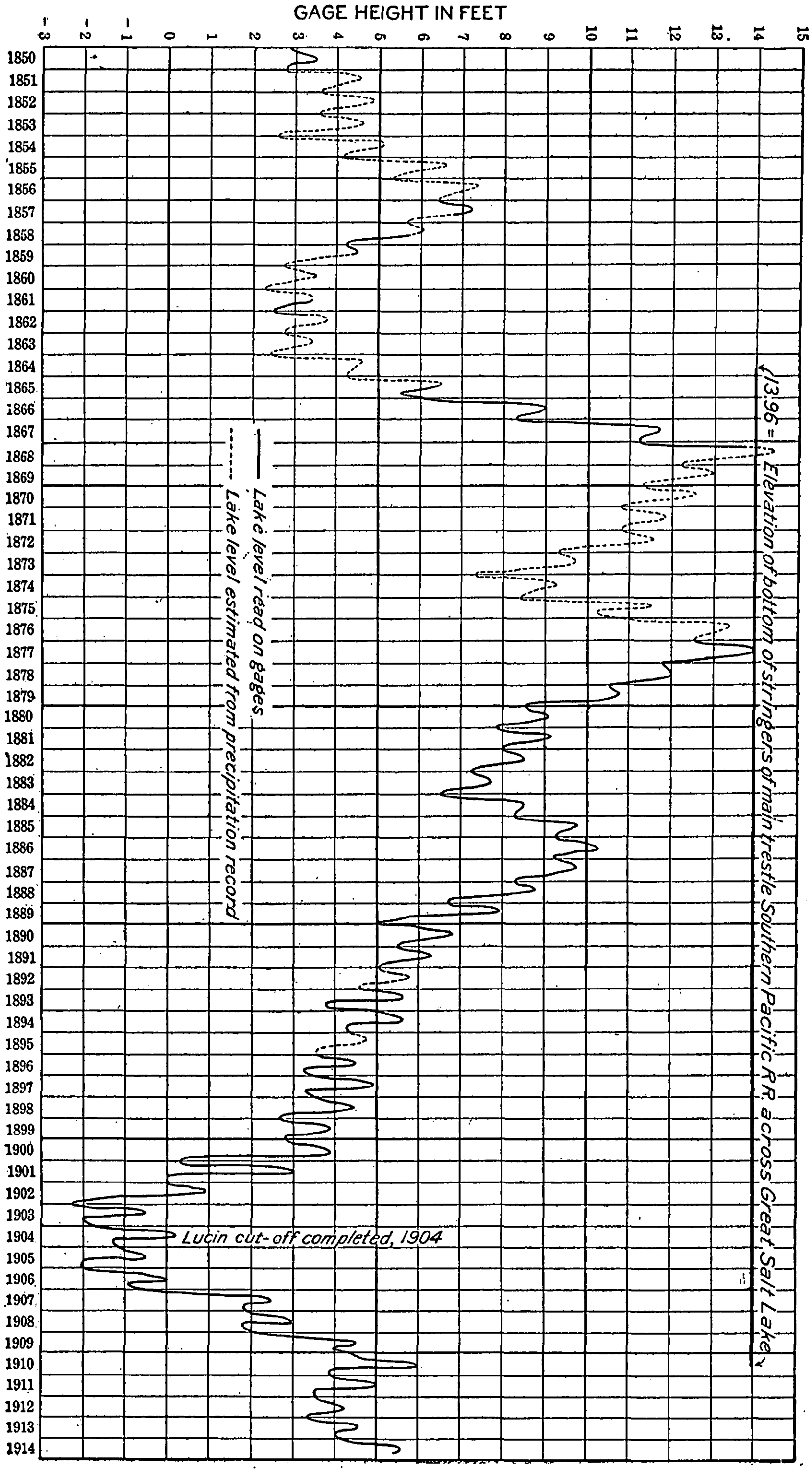

FIGURE 11.—Diagram showing fluctuations of water surface of Great Salt Lake, Utah, from 1850 to 1914.

to the level of the Provo terrace, which was built by this lake when its surface remained for a long time at an elevation about 625 feet higher than the present lake.

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by the resulting increase of evaporation surface, and the effect of a series of dry years is lessened by the resulting reduction of surface exposed to evaporation. This natural and automatic control limits the range of oscillation and gives a certain permanence to what may be called a normal or average level. A change in the normal can occur only when some new factor is introduced.

Both man and nature have introduced new factors and thus have produced changes in the normal level. The occupation of the surrounding region by white men has recently modified the face of the land in ways that have a recognized influence on the water level; and the ancient history of the lake includes enormous modifications in response to changes of climate.

Of human influences the most telling has arisen from the development of agriculture with irrigation. In irrigation the water of rivers and creeks is diverted to cultivated fields, which first absorb it and then through evaporation feed it to the air; and the water thus consumed by utilization is lost to the lake. With the gradual enlargement of the irrigated area the normal level of the lake is inevitably being lowered, and engineers are already confident that the high-water mark of 1877 will never again be reached. On the other hand, there is no reason to expect the lake's extinction, for there is a limit to the possibilities of irrigation.

The fresh water brought by the rivers mingles gradually with the brine, and as the river mouths are on or near the eastern shore, the brine is not so strong at the east as at the west. Analyses from samples of the brine gathered at different points and in different years report the dissolved solids as from 13.7 to 27.7 per cent, by weight. A sample taken in August, 1914, contained 18.9 per cent of solids. At the present time the average salinity of the lake is about 5½ times that of the ocean, and its density is 14.5 per cent greater than that of fresh water. Only with difficulty can the bather keep his feet from rising to the surface, and if he balances himself in an upright position his head and shoulders are above the surface.

The brine is weakest in the northeastern arm, the portion visible from the train near Brigham. This arm has been partitioned from the main body by the embankment of the Southern Pacific Co. and is continuously supplied with fresh water by Bear River. Ice can form on the stronger brine only in zero weather, but this arm is frozen from side to side every winter and sleighs have been driven across it.

The only climatic element with which the lake oscillations have been connected by direct observation is precipitation—the lake rises or sinks as the fall of rain and snow is great or small—but it is easy to understand that the balance between supply and loss of water may also be disturbed by any change of climate which affects the rate of evaporation. As every laundress well knows, evaporation is favored by heat, by dryness of the air, and by strength of wind and is retarded by cold, by moisture in the air, and by calm. So there are at least four ways in which changes of climate may cause the lake to expand or contract. The latest of the periods into which geologists divide past time witnessed a series of climatic changes which affected the whole earth, and though all the elements just mentioned were doubtless involved, the element which recorded its changes most clearly was temperature. There were several epochs of cold, and they were separated by epochs of warmth. During the cold epochs the high parts of the Wasatch Range held a system of glaciers, and in one of them several ice tongues protruded so far beyond the mouths of the mountain canyons that they heaped their moraines on the floor of Jordan Valley, only a few miles from the place where Salt Lake City now stands. In that epoch of cold the rate of evaporation was far slower than now, and evaporation was at so great a dis-

From the station at Ogden may be seen Observation Peak, 6 miles to the east, its top over 10,000 feet above sea level and more than a mile

advantage in its contest with precipitation that there was immense expansion of the water surface. When the lake was largest it was comparable in area and depth with Lake Michigan; it had eleven times its present extent. In attaining this great expanse the water surface rose to a position more than 1,000 feet above its present level.

To this great body of water geologists apply a distinctive name, Lake Bonneville, and they have given much attention to its history, which is written in shore lines, deltas, channels, deposits, and fossils. The shore lines appeal most to the traveler, and may be seen from car windows at several points.

As a matter of definition a shore is merely the meeting place of land and sea or of land and lake, but as a matter of land form it is much more. At the shore the lashing of storm waves works changes in the land, giving it new shapes. At some places the land is carved away; at others it is made to encroach on the water. Where it is eroded the limit of erosion is marked by a cliff, and below the water is a shelf of gentle slope. Where additions are made they take the form of beaches or bars, which rise little above the water level and are composed of sand or gravel. At some places a bar spans a bay from side to side; elsewhere it is incomplete, projecting from a headland as a spit.

The waves of Lake Bonneville were as powerful as those of Lake Michigan and fashioned the shore into an elaborate system of cliffs, beaches, and spits; and when the waters finally fell to lower levels they left behind the shapes their waves had made. The base of each surviving shore cliff is a horizontal line, and so is the crest of each beach, bar, and spit, and these features in combination trace the outline of the old lake as a level contour about the sides of the basin and the faces of mountains that were once islands in the lake.

In rising and falling the waters lingered at many levels, and so there are many ancient shore lines, but two of them are more conspicuous than the rest and have been named. The highest of all is the Bonneville shore line, and 375 feet lower lies the Provo shore line. The Bonneville line represents a relatively short stand of the water and is conspicuous chiefly because it marks the boundary of wave action. All the slopes below it have been more or less modified by the waves, but the slopes above it retain the shapes which had been given them by other agencies. The Provo line represents a long stand of the water and is conspicuous because it is strongly sculptured.

In all the early history of the great lake its basin was closed, like that of the modern lake. The water surface rose and fell in response to climatic changes, like that of its modern remnant. The last great rising was the highest and terminated the series of oscillations by creating an outlet. The lowest point of the basin's rim was at Red Rock Pass (90 miles by rail north of Ogden), and when the water rose above that level the stream which began to cross the pass descended to Portneuf River, a tributary to Snake River, the chief branch of the Columbia. Through the creation of this outlet the Bonneville Basin, which had previously contained an independent interior drainage system, became part of the drainage system of the Pacific Ocean.

Red Rock Pass was not a mountain pass, a notch in a rocky crest; it was merely the highest point on the axis of a valley between two mountain ranges. Valley and ranges ran north and south and the valley was floored by alluvium washed from the ranges. From the Red Rock summit the valley sloped gently northward toward the Portneuf and southward toward Bear River. The formation at the summit consisted of soft earth, and as soon as overflow began a channel was formed. The deepening of the channel increased the volume of the stream by lowering the outlet of the lake, the greater stream was more efficient in deepening the channel, and these two causes interabove the railroad. This is the culminating peak of the Wasatch Mountains (Pl. XXVIII, p. 104), a range that came into existence

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acted until the stream became a stupendous torrent. The volume of water discharged before the flow became steady was enough to supply Niagara River for 25 years, but the record of the torrent's violence leads to the belief that it lasted for a much shorter period.

The rapid deepening of the outlet channel was finally checked when the stream reached a sill of solid rock beneath the soft alluvium of the pass, and upon this sill the outlet rested for a long period. The lake surface then no longer oscillated in response to varying climate but held a constant level, and it was the long maintenance of this level which enabled the waves to carve and construct the Provo shore line.

The draining of the lake down to the Provo level reduced its area by one-third and correspondingly reduced the quantity of water annually evaporated. Two-thirds of the inflowing water was then disposed of by evaporation and the remainder was discharged through the outlet. Only a great change of climate could restore the balance between inflow and evaporation, and the change was slow in completion. At last, however, the pendulum of temperature swung far enough on the side of warmth. The outlet channel ran dry, the lake basin was again separated from the drainage system of the Pacific, and the lake began to shrink. So long as there was outflow the water was fresh, but when the outflow ceased there began that accumulation of salt which has made the water of the present lake a concentrated brine.

At times in the history of the lake, especially while the Provo shore line was being formed, the tributary streams brought down sand and gravel, which they dropped at their mouths, building deltas. When the water fell these deposits remained as fan-shaped benches having steep fronts. The streams that built them then dug channels through them. Part of the city of Ogden stands on a delta bench built by Ogden River. Between Weber Canyon and Ogden the railroad follows the channel that was opened by Weber River through its former delta.

The climatic revolutions which created and destroyed Lake Bonneville wrought similar changes in all parts of the Great Basin. In Western Nevada the traveler sees the shore lines of another ancient lake, known to geologists as Lake Lahontan. It did not rise high enough to establish an outlet, but its water was so nearly pure as to be inhabited by fresh-water shells. Some of its shores are marked by heavy deposits of travertine. When it died away there remained in its basin a group of smaller lakes, some salt and some fresh, but only one—Humboldt, a fresh lake—can be seen from the train.

The view from Ogden station is obstructed by buildings and trees, but by climbing to a near-by viaduct one may see the bold face of the Wasatch Range, across which the line of the Bonneville shore is drawn as a narrow pale band. On the shore bench grow the ash-green sage and other light-colored bushes, and the steeper slopes are mottled by dark-green thickets of dwarf oak. The west-bound traveler obtains a better view by looking backward just after leaving Ogden, and may probably recognize the Provo shore line as well as the Bonneville. These traces of old shores appear on Promontory Range and Fremont Island; and if the air is clear the traveler will have the old shore lines in view until he leaves the Bonneville Basin near Montello, 130 miles from Ogden.

On the route from Ogden to the Yellowstone National Park the old shore lines are prominently and almost continuously in sight until the train enters Bear River Canyon and may also be seen on a distant range to the left. They reappear in Cache Valley, beyond this canyon, and are especially conspicuous at the left where their terraces surround a range of hills. At the Provo stage of the lake these hills projected above the water as in comparatively recent geologic time and that has an interesting origin.[1]

[For continuation of itinerary to San Francisco, see p. 148.]

a long island, and at the Bonneville stage as a chain of smaller islands. Between Oxford and Downey the railroad traverses the Red Rock outlet channel, one of the stations, Swan Lake, being within the channel. The modern streamlets, flowing from neighboring hills, have brought down enough gravel and sand to build alluvial dams and have thus obstructed the drainage of the old river bed, so that it now contains a series of ponds and marshes.

In quality of water and in temperature Lake Bonneville was as well fitted for abundant and varied life as the Bear Lake of to-day, and though the only remains yet found in its sediments are fresh-water shells, we need not doubt that its waters teemed with fish. We may confidently picture its bordering marshes as fields of verdure and its bolder shores as forest clad; and we may less confidently imagine primitive man as a denizen of its shores and an eyewitness of the spectacular deluge when its earthen barrier was burst.

The only permanent animal inhabitant of Great Salt Lake is a tiny "brine shrimp," a third of an inch in length. A more conspicuous temporary resident is a minute fly which passes its larval stage in the water, and when its transformation takes place leaves behind it the discarded skin. These flies are so numerous in their season that even the passing tourist should feel grateful that they do not bite. Their brown exuviæ darken the water edge and often sully broad belts of the lake surface. More decorative denizens are gulls and pelicans, which find safe nesting ground on some of the smaller islands. There are no shoal-water plants, and the salt spray of the beach is fatal to all land vegetation along the shores.

When the lake is low its salt is segregated and deposited in shallow lagoons at its margin, to be redissolved when the water rises. Each autumn, as the water cools, deposits of hydrated sodium sulphate (Glauber's salt) coat piles and other fixed objects near the water surface, and the deposits increase as the temperature falls. In the depth of winter large masses of this salt may be seen along the embankments and trestles of the Lucin cut-off. Calcium carbonate, the mineral constituting limestone, travertine, and chalk, is continuously and permanently separated from the water, which is unable to retain that which is brought to it by the rivers. Along the shores it forms minute balls, which together constitute sand, a sand quite distinct from the siliceous sand of ordinary beaches.

Man makes little use of the lake. On its shores there are neither fisheries nor ports, and commerce finds it an impediment rather than an aid. Its deposits of Glauber's salt, which it offers for the gathering, are neglected because the world's demand is small and is cheaply met in other ways. Its common salt is harvested with great economy of effort, for impurities are easily excluded and the work of evaporation is performed by the sun. The present annual output of 40,000 tons must be multiplied fivefold before it can commence to weaken the brine. For the rest man is content to resort to its shore for bathing and to realize a new sensation as he floats upon its surface.

[1] Most of the rocks in the Wasatch Range were laid down as sand and mud on the bottom of the ancient sea, where they became compacted and hardened into sandstone, shale, and limestone. The sea bottom eventually became land. As mother earth has aged her skin has cracked and wrinkled. In the Utah-Nevada region many long cracks were formed and the rocks on one side or the other were moved slowly upward or downward, forming long ridges along the cracks, steep on one side and gently sloping on the other. Such breaks in the earth's crust are called faults. A fault may be a few feet or hundreds of miles long, and the distance which the rock beds on one side slip past those on the other may range from a fraction of an inch

To see the structure of the Wasatch Mountains, the traveler should make a side trip to the local scenic attraction, Ogden Canyon, which can be reached by street car from Ogden station. In bright afternoon sunlight it can easily be seen that the face of the range is divided into bands of different rock formations. (See Pl. XXVIII, *B*, p. 104.) Observation Peak itself is a mass of pink rock called quartzite. This rock was a widespread bed of sand which was laid down on the bottom of the sea about the time the earliest forms of life appeared on the earth. How it reached its present position has been explained in the preceding footnote. A dark band of rocks, partly concealed by brush and timber, lies below the peak. In a spur much lower down the mountain is another band of pink quartzite which makes a 1,000-foot wall and rests on a dark band similar to the one above it. This pink rock is a part of the same formation as that at the peak, the repetition being due to breaking of the earth's crust and piling up of the fragments. In fact the structure of the mountains at Ogden is not unlike that of the cakes of ice in an ice jam.

Ogden Canyon.

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to thousands of feet. When the rocks on one side are shoved up over those on the other side. The break is called a reverse or overthrust fault. (See fig. 12.) In the region now occupied by the Wasatch Mountains a number of parallel faults were developed close together and the broken pieces of the earth's crust between them were pushed up, the rocks on one side of each crack riding up over those on the other side until a great mountain range was formed where once lay a plain. The accompanying diagram (fig. 13) illustrates the structure of the Wasatch Range in cross section. During the long period of slow earth movement which made these mountains flat-lying parallel beds of rock were locally turned on edge, crumpled, and folded in a wonderfully intricate manner. These upturned and crumpled rocks are well exposed in Ogden Canyon. The west face of the Wasatch Range is believed to mark the plane of a normal fault (fig. 12) at a nearly vertical crack in the earth's crust, the rocks on the east side of which went up or those on the west side went down. The forces which have raised these mountains are still active, for movement along this fault has disturbed the surface recently.

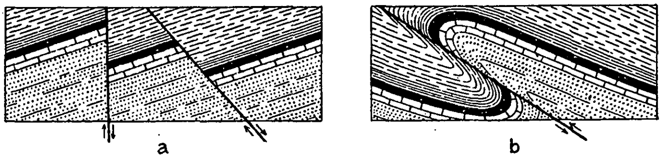


FIGURE 12.—Diagram showing normal faults (a) and a reverse or overthrust fault (b).

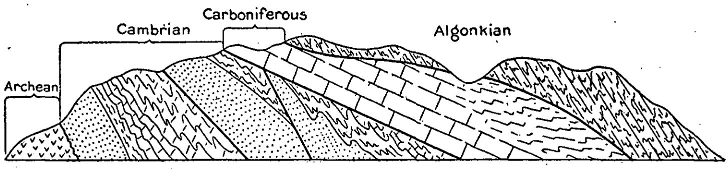
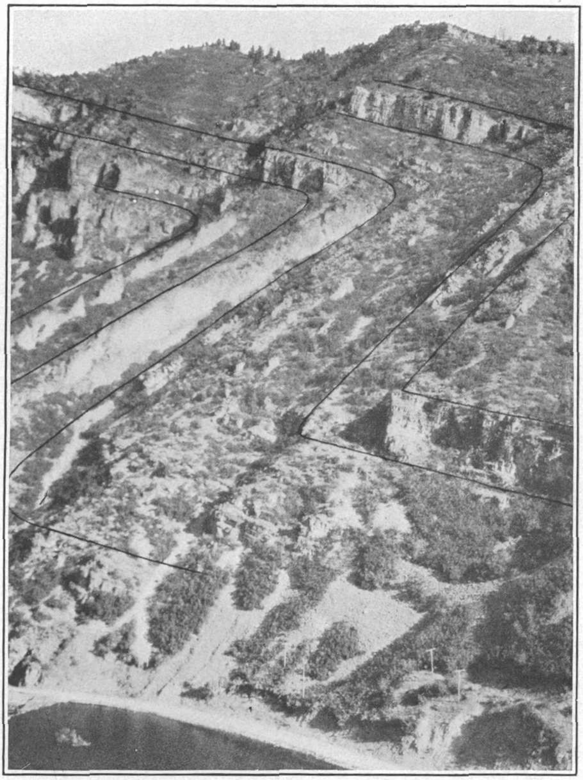
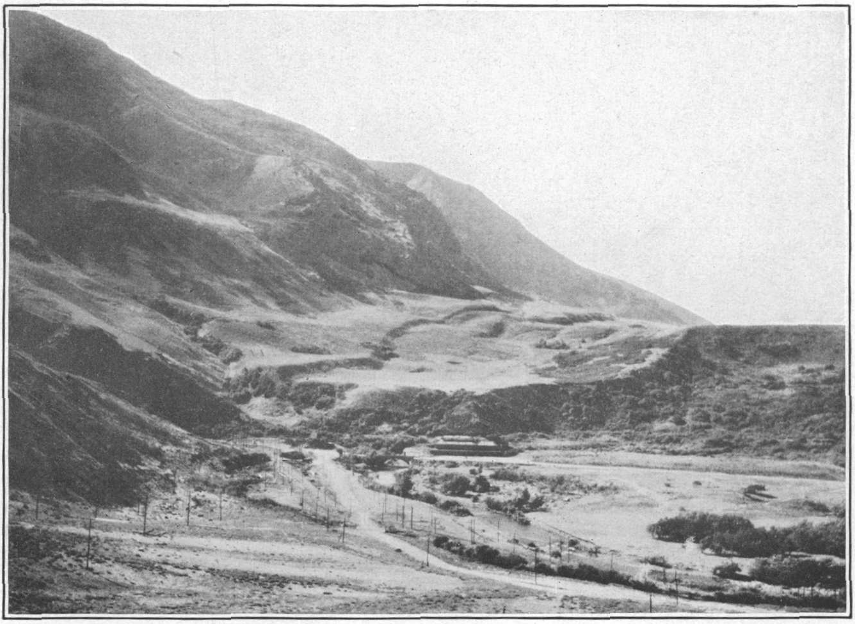


FIGURE 13.—Diagrammatic structure section of the Wasatch Range in Ogden Canyon.

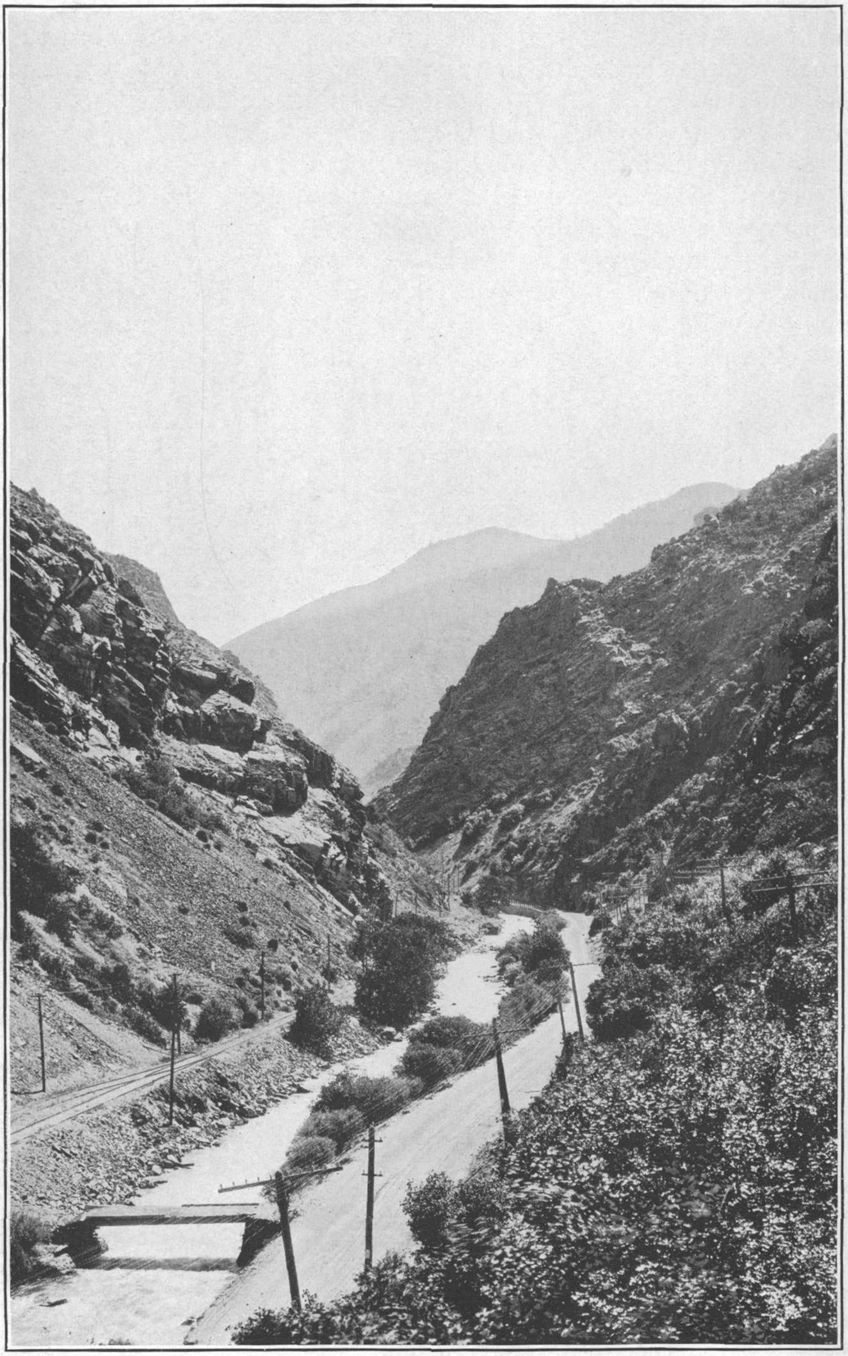


A. Z-SHAPED FOLDS NEAR EAST END OF OGDEN CANYON.

The lines follow the outcrops of the folded beds.



B. RECENT FAULT SCARP AT THE MOUTH OF OGDEN CANYON.



VIEW IN OGDEN CANYON BELOW THE NARROWS.

Just before reaching the mouth of the canyon the traveler may see a nearly perpendicular bluff or scarp, a few feet high, at the top of the bank above a gully a few rods southeast of a single-arch concrete bridge. This small bluff, which was made by recent uplift along the side of a great fault that parallels the mountain front, is best seen from the higher bench land. (See Pl. XXVI, *B*.)

The steep face of the mountain range represents the exposed edges of geologic formations whose continuation west of the fault is now far below the level of the plain. The mouth of the canyon is in very old, greatly distorted rocks (Archean gneiss and schist) which were formed before life began on the globe. Warm springs issue near the bridge below the mouth of the canyon, and where the trolley road passes over a steel bridge just inside the canyon a warm spring in the south bank of the river steams forth from the contact between pink quartzite and somber-colored gneiss. The water is salty, contains iron, and has a temperature of about 136° Fahrenheit. Rounding a curve brings into view a waterfall which shoots out from the rocks several hundred feet above the track and turns to spray. The water collects on the rocks below and cascades into the river. This is an artificial fall, made by a hole in a flume that carries water to a hydro-electric plant. Close to the foot of this fall the bedrock wall of the canyon is plastered by a deposit of thoroughly cemented gravel, a remnant of the material that choked the canyon when Lake Bonneville backed up into it.[1]

The canyon at this point is very narrow, and there is barely room for the highway on one side and the trolley-car tracks on the other side of the river (Pl. XXVII). The mountain walls that rise thousands of feet above appear almost insurmountable, and directly ahead they seem to completely block further passage upstream. But a little turn shows a thin notch cut by the river through a great mass of quartzite beds standing nearly on edge. This is the same pink formation as that in Observation Peak, and its presence and position

[1] G. K. Gilbert describes this material as follows:

"The lower part of the canyon through its length, but especially near its mouth, is more or less lined with heavy beds of coarse gravel, thoroughly consolidated by a ferruginous cement. In some places this forms the bed as well as the banks of the stream; but at others it is cut through, and the original well-worn rock bottom of the old channel is exposed beneath the gravel by the side of the road. It is evident that when this canyon was originally excavated the Great Salt Lake was not far if at all above its present level; so that the rushing torrent which wore out this old rounded bottom met no check until it had passed entirely beyond the mouth of the canyon. There followed a time when the lake filled nearly or quite to its highest terrace; and meanwhile the Ogden River continued to bring down the sand and pebbles which it had before been accustomed to sweep out upon the lower terrace, but now, checked by the rising lake, deposited them in the lower parts of its old channel, until they accumulated to a very high level, not yet accurately located. Again the lake retired and the stream again cut down its channel, sometimes reaching its old level and sometimes not."

here show how much these rocks have been turned from their original flat-lying position. The nearly vertical slitting or gashing of the rocks is merely the result of weathering between the original beds of sand as laid down on the sea bottom. The passage is narrow because of the great hardness of the rocks, for the whole valley, like most other valleys, has been made by the gradual washing away of material by its stream and is narrowest where the rocks are hardest. Above the narrows the valley walls are limestone and shale, which are more easily worn away than the quartzite. A limestone quarry and kilns are situated just above the narrows on the south side of the river.

Farther up Ogden River (which, by the way, would be called a brook or run in some parts of the country) city people have built summer homes along the stream bank.

In 1914 the trolley line ended 7 miles from Ogden at The Hermitage, a rustic hotel built of logs and stone. The verandas of this hotel afford a vantage point for enjoying the rugged canyon scenery.[1]

About a quarter of a mile east of The Hermitage, in the south wall of the canyon, a few feet above the river, the limestone is folded. The position of the thin strata, once nearly horizontal throughout but now turned abruptly back on themselves, suggests something of the stresses that have had a part in forming these mountains. A mile farther along in the road cut, near a flume that crosses the river, there is a very distinct S fold in black shales that indicates even more vividly the complexity of the mountain-making process. Some of this black shale contains phosphate.[2]

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[1] Ogden Canyon was cut in the solid rock by the river which now flows through it. Running water carrying sand and gravel acts as a saw or file and, given time enough, can cut through the hardest rocks. Ogden River was flowing west along its present course before the Wasatch Mountains came into existence. The raising of the mountains went on slowly for ages, so slowly that the river kept its place by cutting down its ever-rising bed, carving a deep and narrow canyon straight through the block of the earth's crust as it rose. In no other way can we account for a river rising on one side of the range and flowing directly across it. Movement of the mountain mass has continued down to the present time—at least there has been recent disturbance along the base of the Wasatch Range, as is shown by faults which traverse the lake deposits and the modern alluvial aprons. Some of the breaks are so new as to be devoid of vegetation. Furthermore, the main stream channels crossing from the uplifted fault block to the undisturbed rocks on the west have abnormal profiles. Ogden River has a high gradient within the canyon, but on crossing the fault and emerging on the gravel fan at its mouth at once loses grade. The upward movement of the mountains has been so continuous that the river has had no opportunity to widen its valley, a task which it will begin as soon as the mountains cease rising.

[2] In a roadside ledge about 2 miles below the upper end of Ogden Canyon there is some black shale and limestone, which proves on analysis to be decidedly phosphatic. The richest material is contained in two beds of black shaly rock, each about 2 feet thick. Analysis of a random sample gives 42.5 per cent of bone phosphate. This deposit is too low in grade and too broken to be of value.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE

OVERLAND ROUTE

From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

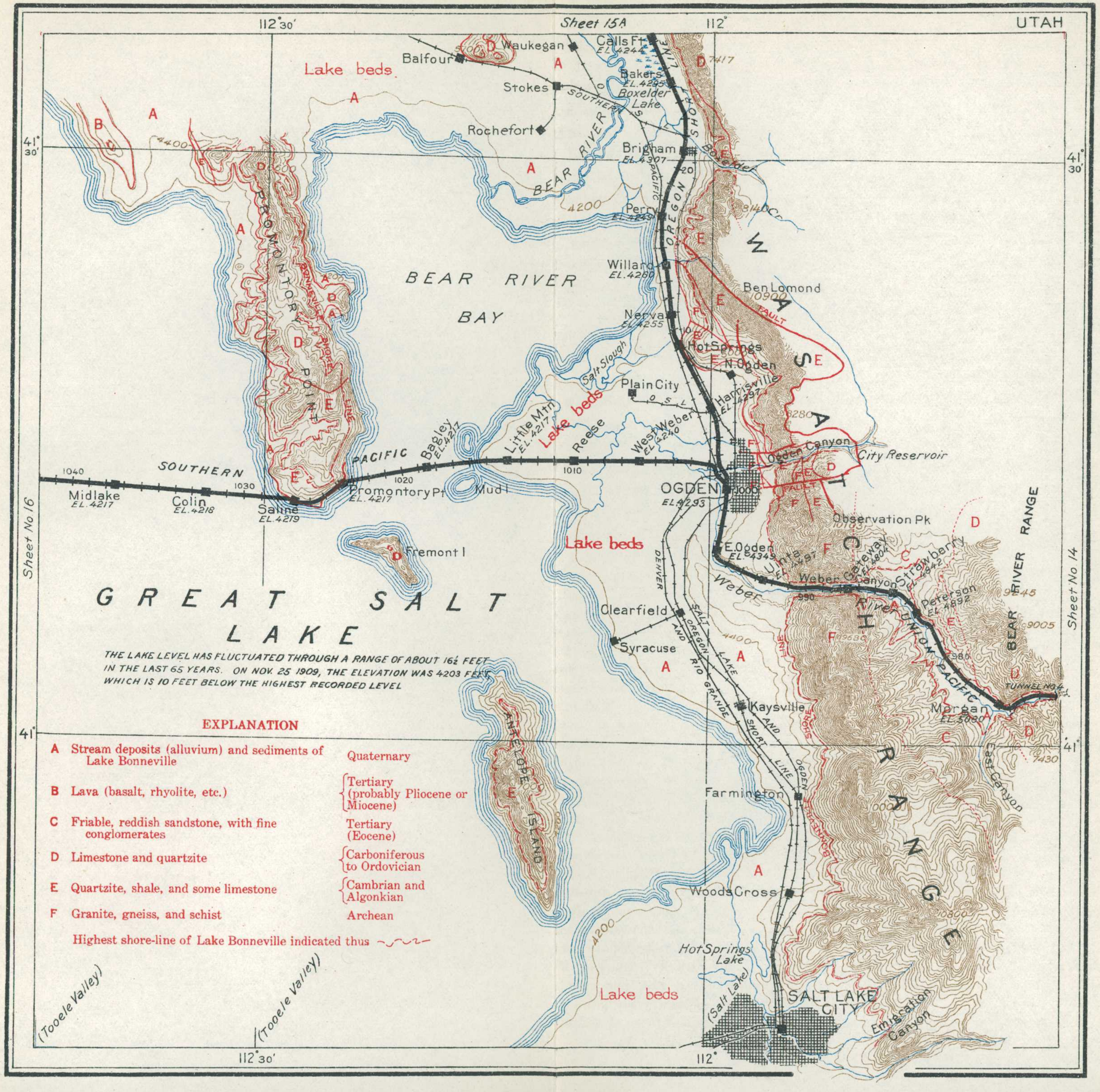
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist   R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.



The most prominent rock folding in the canyon is at the reservoir about 2½ miles above The Hermitage. Here a thick bed of limestone is crumpled into a Z fold, measuring 1,000 feet between the top and bottom bars, which are about half a mile long. It can be seen plainly from the south bank of the reservoir. (See Pl. XXVI, *A*, p. 100.) This great wrinkle was made by the shoving of one mass of rocks over another during the formation of the mountain range.

At the upper end of Ogden Canyon, 10 miles from the city, is Ogden Hole or Ogden Valley, which, when Lake Bonneville reached its highest stage, was a small bay connected with the lake by a strait in Ogden Canyon.

OGDEN, UTAH, TO YELLOWSTONE, MONT.

The route described in the following pages covers a distance of 291 miles on the Oregon Short Line Railroad from Ogden, Utah, across southeastern Idaho to Yellowstone, Mont., the west entrance to Yellowstone National Park,[1] a public playground covering about 3,348 square miles. For 40 miles north from Ogden the road lies along the boundary between the Wasatch Mountains and the region once known as the Great American Desert, following the shore line of Lake Bonneville, a great body of fresh water that in geologically recent time covered a large part of Utah (pp. 97–99); then after turning eastward and passing through the range in a rocky canyon, it goes northward across a flat stretch of country which was the floor of a bay of the former lake. This bay was surrounded by mountains, and the railroad follows the foot of a north-south range to the head of an arm of the bay.

About 90 miles from Ogden the railroad crosses Red Rock Pass, through which for a time Lake Bonneville drained to the north, and then runs down a valley between two mountain ranges. In this valley the track for miles is on the surface or along the edge of a black lava flow. Turning west and passing through a notch in the Bannock Range, it comes out at Pocatello, 134 miles from Ogden, on the great Snake River plain. From Pocatello north for 100 miles the way leads across another lava flow, once a sagebrush waste, now an agricultural paradise. The last 50 miles of the route is through forests and finally over the Continental Divide, in mountains of volcanic rock poured out in the vicinity of Yellowstone Park.

The northbound trains, on leaving Ogden, cross Ogden River and come at once into orchards and into fields of sugar beets, hay, corn,

[1] Mileposts from Ogden to McCammon and from Pocatello to Idaho Falls give the distance north of Ogden; from McCammon to Pocatello, the distance west of Granger, Wyo.; and from Idaho Falls to Yellowstone, the distance north of Idaho Falls.

and garden truck. From the outskirts of the city an uninterrupted view of the Wasatch Range can be had (Pl. XXVIII). Ogden Canyon is seen as a great notch with bare cliffs of pink quartzite on both sides, and tier on tier of gray limestone farther up the canyon.[1] In the distance on the west is the hazy blue outline of Promontory Range, a long point extending from the north out into Great Salt Lake.

The traveler who is for the first time west of the Rocky Mountains and wonders if the melodramatic activities of western life he has seen quivering on the "movie" screen really exist to-day along the route between Ogden and Yellowstone Park should remember Francis Parkman's introduction to "The Oregon Trail":

> The buffalo is gone, and of all his millions nothing is left but bones. Fences of barbed wire supplant his boundless grazing grounds. Those discordant serenaders, the wolves, that howled at evening about the traveler's camp fire have succumbed to arsenic and hushed their savage music. The wild Indian is turned into an ugly caricature of his conqueror. The slow cavalcade of horsemen has disappeared before parlor cars and the effeminate comforts of modern travel. The all-daring and all-enduring trapper belongs to the past and the cowboy's star begins to wane. The wild West is tamed.

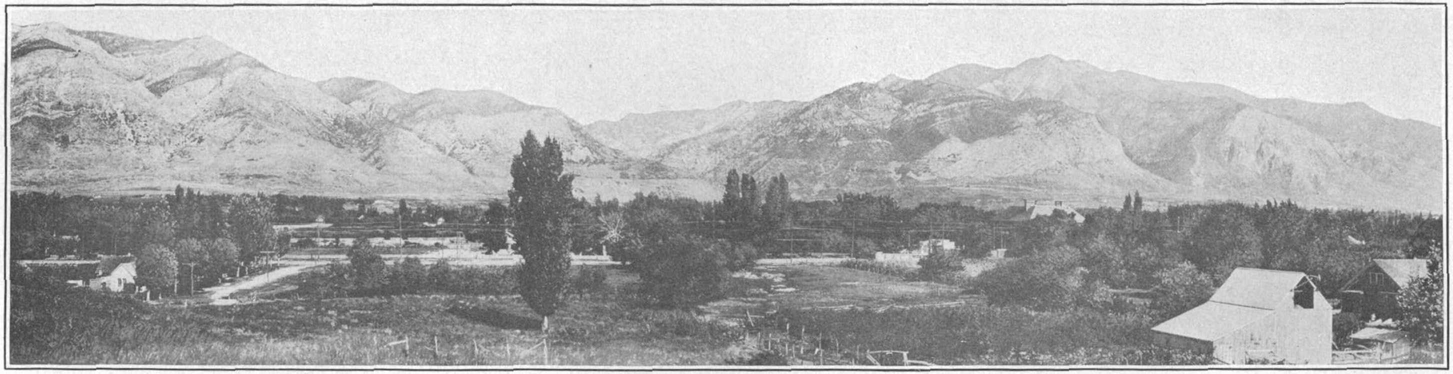
The great desert which Frémont explored in 1842 and to which the Mormons came in 1847 is still a desert, but orchards, gardens, and grain fields now mark its border.

Harrisville.
Elevation 4,297 feet.
Population 395.*
Ogden 5 miles.

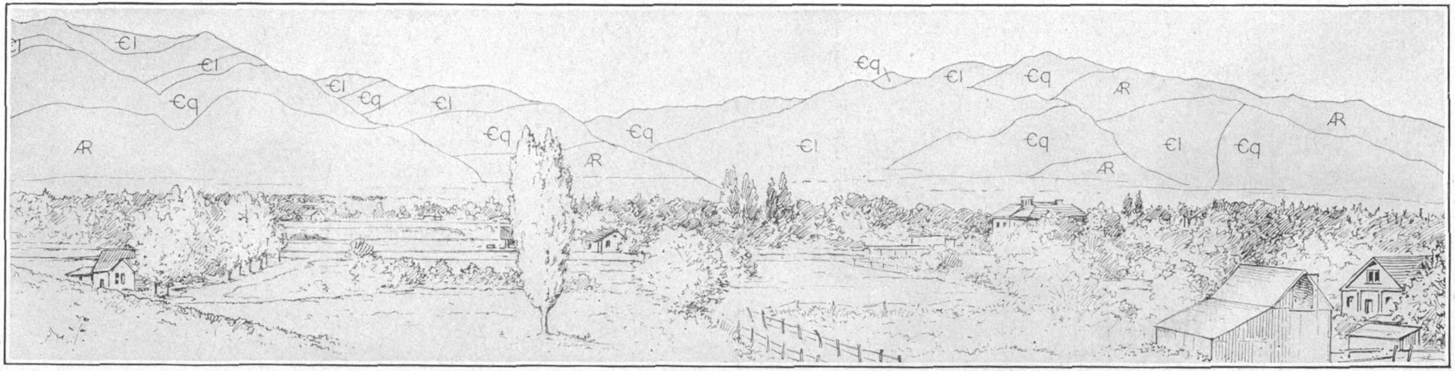
A large brick plant at Harrisville (see sheet 15A, p. 114) is using clay that was deposited as sediment on the bottom of Lake Bonneville. This is one of the few mineral industries along this route. Many years of prospecting in the mountains all the way from Ogden to Yellowstone Park have brought to light a few small metalliferous deposits, but not one from which ore is being shipped. Among the nonmetals clay, sand, gravel, limestone, marl, coal, building stone, and water are utilized. Water is the one mineral to which above all

[1] The geologic structure of the Wasatch Mountains, from Ogden north to Brigham, has been described by Eliot Blackwelder as "shingled structure with overthrust slabs or wedges dipping eastward." (See fig. 13, p. 100.) Although this structure can not be seen from the railroad, the various formations can be distinguished. At the base of the range, showing above the lake benches, is the oldest rock formation here exposed, the Archean gneiss and schist, making dark-colored ragged ledges. (See Pl. XXVIII.) Above this is 1,000 feet of bare rock cliff of pale pink or faded iron-stain color, the Cambrian quartzite. Next higher, under brush and scattered trees, are ledges of gray limestone; then comes the pink quartzite again, and at the top a thick band of gray limestone. In the morning sunlight the west face of the range is somber and does not reveal the striking differences in these formations, but under the light of the afternoon sun they stand out in marked contrast.

The Cambrian quartzite can be traced by the eye from Ogden Canyon northward for several miles, but not continuously, for the rocks are broken by east-west as well as north-south faults.

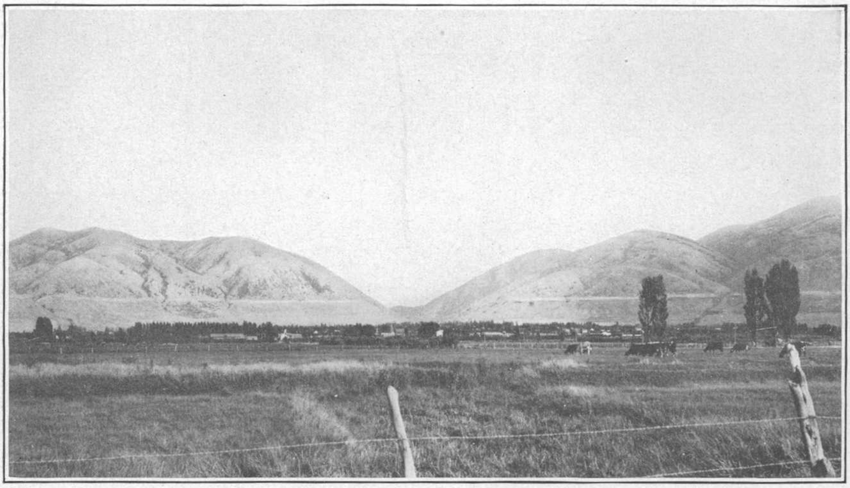


A. WEST FRONT OF WASATCH RANGE AT OGDEN, UTAH.

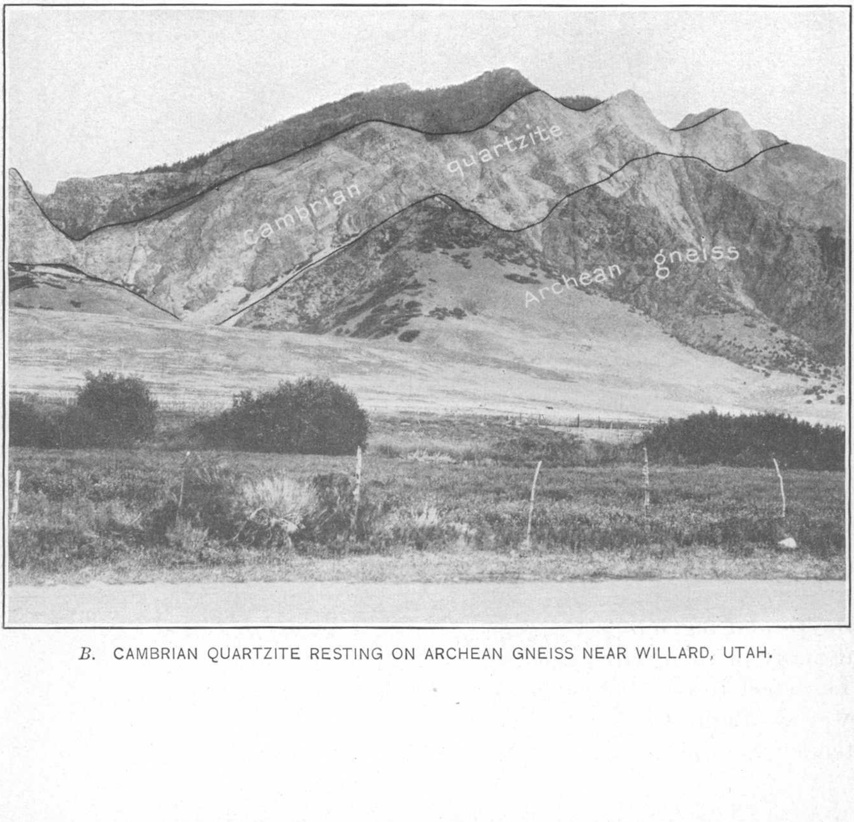


B. DIAGRAM SHOWING GEOLOGY OF MOUNTAIN MASSES IN *A.*

ÆR = Archean gneiss and schist; Єq = Cambrian quartzite; Єl = Cambrian limestone.



A. LAKE BONNEVILLE SHORE AT BRIGHAM, UTAH.



B. CAMBRIAN QUARTZITE RESTING ON ARCHEAN GNEISS NEAR WILLARD, UTAH.

others is due the prosperity of the country traversed by this route. Rock phosphate is a vast potential asset but is not yet used.

North of Harrisville a low ridge, strewn with many large angular blocks of rock, both white and pink, projects from the mountain front nearly to the railroad. This ridge is made of a great block of quartzite and limestone broken in two, the two parts standing on edge. A stone crusher working on one of the limestone ledges makes macadam for the highways.

The electric-car line between Ogden and Brigham and the main highway from Utah to Idaho are east of the track. There is a tomato-canning factory near Harrisville. Tomatoes are grown extensively all along the foothills between Ogden and Brigham, and in 1913 Brigham packed 30,000 cases, 24 cans to the case.

Just before reaching Hot Springs the train passes from Weber to Boxelder County and leaves behind the last saloon on the route, the country from Hot Springs to Yellowstone being "dry."

Hot Springs.
Elevation 4,271 feet.
Ogden 9 miles.

The Utah Hot Springs hotel and sanitarium is a bathing resort that has some reputation for the relief of rheumatism. It is equipped with an open-air concrete pool 125 feet square, two indoor pools 28 by 45 feet, several smaller pools, and private baths. Small circular stone walls inclose the springs, which are just south of the station. The water, which is strongly charged with salt and other minerals, has a temperature of 131° F.

In this region there is a close relation between hot springs and lines of faulting. The temperature of the earth increases about 1° with every 50 feet of depth below the surface. Along the faults rocks which formerly were buried deeply and were therefore hot are now at the surface and water coning into contact with them a short distance below the surface, where they are still hot, is warmed; or the heat of the rocks may be due to friction along the fault plane.

Soon after passing Hot Springs the train runs close to a lagoon on the edge of Bear Bay, the northeast arm of Great Salt Lake. This lake, as is shown on pages 97–99, is a remnant of the much larger Lake Bonneville. Patches of white alkali (sodium sulphate and sodium chloride) may be seen along the edge of the lagoon and are due to the evaporation of salty water rising by capillary attraction.

A belt of land of varying width west of the railroad is in grain and pasture, but a strip close to the water is too salty to cultivate. The lagoon near Willard is often dotted with ducks and a flock of great white pelicans may usually be seen on the shore of the bay. The marshes and lagoons along the edge of the lake afford good hunting and many of them are owned by gun clubs.

The steel towers between the track and the lake carry the Utah Power & Light Co.'s high-power electric-transmission line, which extends from the Grace hydroelectric plant in Idaho to Salt Lake City.

On the east there are peach orchards, and back of them is the Wasatch Range, culminating in Ben Lomond Peak ("Willard Peak" of the Fortieth Parallel Survey). The terraces of Lake Bonneville, carved in mountain waste deposited along the base of the range, are well preserved, and above them is the dark, rough-weathering gneiss. The Cambrian quartzite is very conspicuous here, forming a great pink band that extends far up the mountain side. The overlying limestone and shale, by reason of their softness, have weathered farther back than the much harder quartzite.

Willard.

Elevation 4,260 feet.
Population 577.
Ogden 14 miles.

Willard is a quiet old village, its main streets lined with poplars and its homes surrounded by orchards. The principal industry is the growing of peaches and tomatoes. The traveler who goes north to Yellowstone Park from Ogden will see many villages that were started by Mormon emigrants. Some of them are at the mouths of mountain canyons, where perennial streams afford water for irrigating the arid land near by. Willard was located near such a mountain stream, as were also Brigham, Wellsville, Logan, and other towns in this region.

From Ben Lomond northward the pink Cambrian quartzite slopes down abruptly (Pl. XXIX, *B*), crosses the mouth of a sharp canyon back of Willard, where a stream leaps over it in a beautiful fall, and disappears under the terraces. The crest of the range also becomes lower, and the front of the range as far as Brigham shows older rocks (Algonkian quartzite and slate) thrust over the Cambrian. A short distance north of Willard Canyon the mountain face changes from bare crags to a fairly smooth grassy slope because the underlying rocks decay, so that the bedrock is covered by rubble in which vegetation soon gains a foothold.

North of Willard the old lake terraces are well preserved and peach orchards become more numerous. Among the trees in the distance is seen the white tower of a church in Brigham.

Brigham.

Elevation 4,307 feet.
Population 3,685.
Ogden 21 miles.

The first permanent settlers came to the mouth of Boxelder Canyon in 1853 and named the site of Brigham for their leader, Brigham Young. The Greens, Hunsackers, Johnstones, and Harrises were courageous folk, and although the level country was a great desert covered with sagebrush, they saw the advantages of the location, diverted the mountain stream into irrigating ditches, and transformed the desert into a veritable garden.

Brigham stands on a delta built in Lake Bonneville when the water was rising to the Provo level. (See p. 98.) When the lake was at its greatest height at the Bonneville level, the water extended back through Boxelder Canyon, drowned the river and made a bay of Mantua Valley, which lies within the range. During this time much of the material washed from the mountains around Mantua Valley was deposited in that valley and not carried through the canyon, which at that time held a quiet strait instead of a rapid stream. As the lake dried up the waves on its lowering surface cut terraces on the old delta, and a new Boxelder River came into existence and wore a channel down through the delta its ancestor had built. In summer Brigham, which is sometimes called Peach City, is almost completely hidden in peach orchards. The trees grow luxuriantly, because practically every street has an irrigating ditch for its entire length. About 400 acres of land beyond the reach of ditches from the canyon is irrigated from a score or more of wells pumped by electric motor. Brigham has celebrated Peach Day early in September annually since 1907. Peach Day is to Boxelder County what the 24th of July is to the State of Utah and the 4th of July to the Nation. On that day there are free peaches and plums and melons for all the thousands of people who visit the city. In 1913 this station shipped 467 cars of peaches. Tomatoes also are grown in large quantities. A factory near the station cans in the height of the season 60 to 75 tons of tomatoes every day.

The old transcontinental railroad line of the Central Pacific went west from Brigham over Promontory Range and around the north end of Great Salt Lake. It is little used now, for the trains go from Ogden straight across the lake. Brigham is the southern terminus of the Malade branch of the Oregon Short Line, which serves the west side of the Bear River valley.

As the train leaves Brigham going north the traveler gets a fine view of old lake beaches along the face of the mountain. (See Pl. XXIX, *A*.) The upper or Bonneville terrace is particularly conspicuous on each side of Boxelder Canyon.

A few miles to the west is Little Mountain, an isolated butte composed of limestone containing abundant fossil coral and shells. This butte was a small island when Lake Bonneville was at its greatest height. Six miles west of Brigham is Corrine, a station on the old main line of the Union Pacific Railroad, from which freight was hauled by wagon to the mines of western Montana in the early days. Then it had a population of nearly 5,000, but now it is only a small settlement. From Brigham to Idaho Falls the railroad parallels the road made by the freighters from Corrine. About 4 miles north of Brigham the railroad crosses Boxelder Lake, a small area covered with 1 inch or 2 inches of water, in which gulls, snipe, and plover are usually wading about. A State law prohibiting the killing of sea gulls at any time was passed many years ago, when these birds saved the emigrants' first crops from a scourge of grasshoppers.

Just beyond this lake is Bakers sidetrack and the plant of the Ogden Portland Cement Co. This company owns a large area which was supposed for many years to be worthless on account of alkali, but which on testing by drill holes was found to be underlain by 2 to 8 feet of marl, a limy earth, averaging 85 per cent lime carbonate, beneath which is a bed of clay—an especially valuable combination, for the two materials together have the proper chemical composition for making Portland cement, and for a number of years the plant has been using them successfully. In 1914 it had an average daily production of 700 barrels. The company supplied some of the cement for the Arrowrock dam, built by the United States Reclamation Service near Boise, Idaho.

Bakers.

Elevation 4,222 feet.
Ogden 25 miles.

The broad brown and gray striping of the rugged mountain face north of Brigham is due to alternating shale and limestone formations.

At the 28-mile post the railroad passes under a steel transmission line carrying electric power from the plant of the Utah Power & Light Co. in Bear River canyon.

The residents of Honeyville are principally descendants of Bishop Abraham Hunsacker, the original settler, who was the father of 52 children. The name of the town is a euphonious corruption and shortening of Hunsackerville. About 2 miles north of Honeyville, in fields east of the railroad, are some weed-grown pools formed by hot springs that have been known for many years, though no commercial use of the water has yet been made. The water is salty, and strongly impregnated with iron and is described by a neighboring rancher as being "hot enough to scald a pig." Frémont reported the temperature of these springs at 134° Fahrenheit in 1843, and Gilbert found them varying from 121° to 132° in 1872. The discharge from the hot springs, mixed with water from cold springs in the same gully, is used for power at a gristmill on the bank of Bear River 1½ miles west of Honeyville.

Honeyville.

Elevation 4,266 feet.
Ogden 30 miles.

This part of Bear River valley is a former sagebrush desert that has been changed by irrigation[1] to a thriving agricultural district in which

[1] To readers who are not familiar with irrigation a brief explanation may be of interest. The common practice is to select a site at the edge of the mountains, where, by throwing an inexpensive dam across a stream, the current may be diverted a little to one side, into a ditch where a headgate is placed and made secure by the use of bowlders or concrete. During the winter and high-water seasons the gate is kept closed, so that no water flows into the ditch, but in the dry season the gate is opened and a part of the stream is diverted from its natural channel. The headgate is, of course, far enough upstream to be at a higher altitude than the land to be irrigated, and the course of the ditch is determined by a more or less careful survey, so that it will have a uniform grade of a very few feet to the mile. As many of the streams of this region fall more than 100 feet to the mile, the height

large quantities of grain, alfalfa, sugar beets, potatoes, tomatoes, onions, and other vegetables are raised. It is said that this land has produced, per acre, 15 to 60 bushels of wheat, 65 to 135 bushels of oats, 50 to 95 bushels of barley, 6 to 8 tons of alfalfa, and 10 to 40 tons of beets. Apples, apricots, peaches, and plums are the principal fruits raised.

Madsen.
Elevation 4,298 feet.
Ogden 33 miles.

Madsen is only a siding and beet-loading platform. On the west is the cut bank of Bear River, which has carved a meandering course in the old lake bottom. The river is sluggish here, having nearly reached the level of the present lake, though several miles from it. As the train approaches Dewey prominent lake benches are seen on the mountain side.

Dewey.
Elevation 4,323 feet.
Population 292.*
Ogden 36 miles.

Three excavations on the hill a short distance back of Dewey were made in obtaining limestone for a million-dollar beet-sugar factory. Lime is used for removing various impurities from the beet-sugar juice. The four smokestacks of the factory can be seen about 3 miles to the west. To serve this sugar factory was the purpose of the branch railroad from Brigham to Malade. Sugar-beet growing is a large industry in this part of the valley, the area cultivated being 5,000 to 7,000 acres and the average production per acre 18 tons of beets. The factory can handle 600 tons of beets daily. It is on the edge of Garland, a village with a population of 800, which

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of the ditch above the valley bottom increases downstream, and for this reason in many ditches the water seems to be running uphill. As the upland inclines in the same direction as the stream, it is possible, without using any hoisting device, to locate the ditches so that water diverted from the stream at a certain point will flow out on the upland farther downstream—indeed, water can be carried in this way from one stream over a divide and down into another valley.

At the place where the water is to be used an opening is made in the downhill side of the ditch and the water is allowed to flow out over the land. In grain and hay fields care is taken to keep the water spread out in very thin sheets, by throwing earth in its pathway wherever there are little depressions in the surface and the water shows a tendency to get deep. In gardens and orchards the water is caused to flow down furrows between rows so arranged that it does not flow so fast as to wash away the soil. The immense acreage devoted to potato raising along this route is irrigated in this way.

On a perfectly level field it would be impossible to make use of this method of irrigation, but western fields usually have more or less slope, and hence it is possible, by guiding the water in its natural downward flow, to keep it spread out over the land either as a thin sheet or as little rills in closely spaced furrows. It is customary to allow the water to flow gradually across a field until it reaches the lower side, and then to stop up the opening in the ditch and make a new one near some other place which it is desired to irrigate. The time required for the water to reach the downhill side of a field is commonly several days, because the land absorbs so much of it.

In actual practice the method of irrigating is more complicated than that outlined here. According to the practice generally followed the water is not taken directly from the main ditch but from a branch.

was named for William Garland, of Kansas City, the contractor for the construction of the irrigating canal through Bear River canyon.

The red color on the mountain side opposite Dewey is produced by a mixture of blue, gray, red, and pink limestone and limy sandstone. Just north of Dewey the traveler gets the first glimpse of Bear River, the largest stream draining into Great Salt Lake. This river has an interstate habit; it rises in southwestern Wyoming and is crossed by the Union Pacific Railroad near Evanston, flows northwestward into Utah, back into Wyoming, crosses into Idaho, and eventually turns southward to empty into Great Salt Lake. It also drains Bear Lake, a body of water 20 miles long lying across the Utah-Idaho boundary near the Wyoming line.[1]

Irrigation is practiced throughout the length of Bear River valley wherever it has been possible to divert water from the stream at a reasonable cost.

Between Dewey and Collinston may be seen three conspicuous wave-cut terraces 300, 500, and 640 feet above the track; the uppermost one is the Bonneville and the lowermost the Provo terrace. Several miles to the west on a clear day the parallel beaches can be seen on the lower gentle slope of Blue Spring Ridge. Just before reaching Collinston the train leaves the flat lake floor and ascends through gravel cuts in an uneven surface to a slightly higher level.

Collinston.
Elevation 4,416 feet.
Population 114.*
Ogden 40 miles.

Collinston is a small settlement surrounded by grain fields. Lake terraces, like gigantic music staves engraved on the mountain, are beautifully preserved in this vicinity. The rocky knob just beyond the station is gray conglomerate (gravel and sand cemented together) of Tertiary age, carrying an abundance of fossil snail shells. This rock is very young in comparison with those found in the Wasatch Range and is the remnant of a once extensive body of gravel and sand which was deposited in a fresh-water inland sea that covered this area just prior to or during the uplifting of the mountains. Though geologically young, the rock in this knob is nevertheless hundreds of thousands if not millions of years old, and ever since its formation was completed and the lake was drained it has been subjected to the washing of the streams which have crossed it, so that much of it has been worn away. It has also been affected by movements within the earth, as is shown by the fact that its once nearly horizontal layers are now tilted and broken.

North of Collinston the railroad climbs by easy grades still higher above the plain, across which winds the deep-cut trench of Bear River.

[1] The mean discharge of Bear River near Preston, Idaho, is 1,290 second-feet (that is, 1,290 cubic feet of water a second). The total estimated possible power development on Bear River in the State of Idaho with the aid of storage is 81,500 horsepower. Three hydroelectric power plants are in operation on the river.

The broad valley continues northward and is occupied by Malade River, but the railroad turns eastward and goes through a canyon cut by Bear River across a low pass in the Wasatch Range.

The Utah-Idaho Sugar Co.'s canal, which irrigates the west side of the lower Bear River valley, is seen on the far side of the river and the Hammond canal on the near side. Although these canals appear to climb toward the west, they actually descend in that direction, for the irrigator has not yet learned how to get around gravitation without lifting devices, and in Utah, as everywhere else, water runs downhill.

Wheelon.

Elevation 4,499 feet.
Ogden 44 miles.

The Utah Power & Light Co.'s 4,000-horsepower electric plant, with its great flumes taking water from these canals, is on the river bank at the mouth of the canyon. The railroad station was named for John C. Wheelon, a civil engineer who constructed part of the canal.

Such scenery as that for the 2 miles above Wheelon is to be found at no other place on the railroad between Ogden and Yellowstone. Here is one of the two tunnels on the route; here are the highest trestles and the sharpest curves. With a great flume of water just below the track and Bear River roaring over bowlders that impede its progress along the canyon bottom 175 feet below, this is no place for speeding; and yet the time consumed in going through the canyon is so short that one can only glance at the numerous interesting geologic features. It is easy to see that the narrow canyon, with its high precipitous walls, is cut in limestone whose beds dip about 25° to the west; but there is little likelihood that the traveler will notice the cavities made by solution of the limestone or the numerous small faults which break the normal continuity of the rock beds. He will, however, be attracted by a waterfall made by the overflow from a flume below the track and by the low falls in the river.

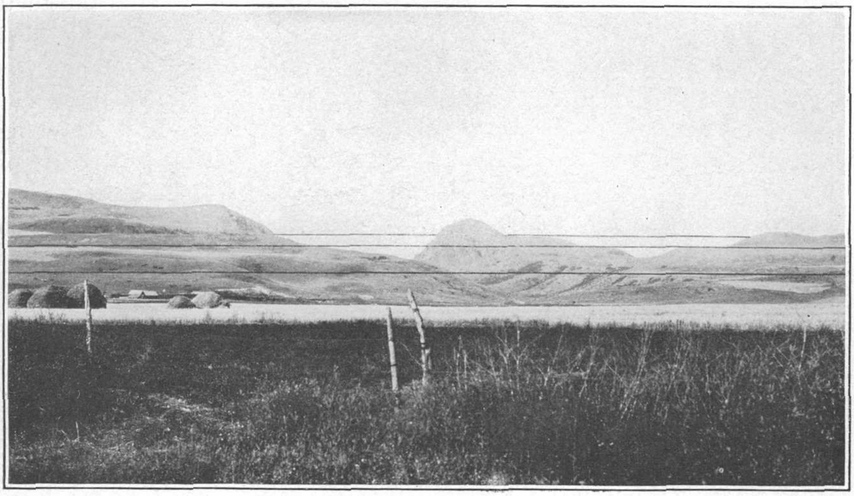
At the upper end of the canyon, just below the dam which diverts the water of the river into flumes, pink quartzite is exposed below the limestone. Above the dam green Tertiary shales are seen in the opposite wall. These shales are the hardened mud which was laid down on the bottom of a lake that covered this area before the mountains were formed or while their elevation was in progress. That they are older than Lake Bonneville is shown by their continuation beneath the silts deposited in that lake, and that they are older than the mountain uplift is proved by the facts that their original continuity is broken by a mountain-forming fault, and that they were hoisted and tilted from their original position along with the mountain block.

The steel-tower transmission line that crosses the hill brings electricity from a power plant in the upper Bear River canyon 20 miles above Preston, Idaho. On leaving the canyon the train swings around a bend and enters the broad Cache Valley,[1] of which the Bear River range, another part of the Wasatch Range, makes the east wall. To the northeast is Newton Hill, which was an island in the great arm of Lake Bonneville that occupied this valley. Wave-cut shore lines are conspicuous on its sides (see Pl. XXX, *A*), showing conclusively that Cache Valley was once occupied by a great body of water several hundred feet deep. It will be easily realized that when Lake Bonneville was at its greatest height the strait between the body of water in Cache Valley and the larger body on the west was about 5 miles wide and was shallow and interrupted by several islands. The cliffs of the narrow canyon reach nearly to the level of the second conspicuous terrace (the Provo), and north of the cliffs, where the highway now crosses the pass, there is a considerable break in the upper (Bonneville) terrace, as there is also south of the canyon. From this it appears that as the lake surface lowered the outlet of Cache Bay dwindled to three channels. One of these whose position may have been determined by a fault or line of fracture across the pass persisted and now carries all the drainage. While the canyon was being cut, the surface of the main lake must have been lower than that of Cache Bay. The smaller body of water, besides evaporating less rapidly, was receiving the largest inflow. When the shore of the main lake had receded a considerable distance, perhaps several miles from the mouth of the canyon, Cache Valley no longer contained a bay connected with the main lake by a narrow strait, but instead a separate lake which drained into Lake Bonneville by a short river. Eventually the lake in Cache Valley was drained out, and the river flowing across the abandoned lake bottom west of the canyon has gradually deepened its channel.

Cache Junction.
Elevation 4,444 feet.
Ogden 49 miles.

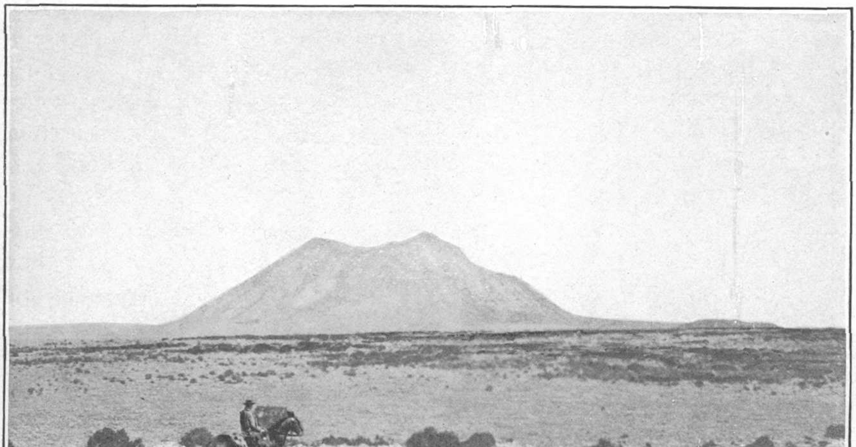
From Cache Junction the Cache Valley branch of the railroad runs to Wellsville, Logan, and Preston. The bottom of Cache Valley has an altitude of about 4,500 feet and presents one of the most beautiful pastoral spectacles in the State. The valley proper is about 35 miles long and in many places 10 miles wide. The settlement of this valley was begun by the Mormons in 1856, when the town of Wellsville was

[1] Cache Valley was formed by faults which broke the earth's crust into blocks and raised some with relation to others. The Wasatch Range has already been described (pp. 99–100) as made of upturned slabs of rock formations shoved up one on another. The Bear River Range had somewhat the same origin. The west face at Logan is believed to be a fault scarp like that at Ogden. Whether the block under Cache Valley remained at a fixed altitude while the surrounding blocks were raised, or whether it sank with relation to them is not known. The surface of the valley block probably was not smooth, but when Lake Bonneville occupied this basin, the sediment brought in by rivers, and the wash from the mountain sides, were deposited on the lake bottom and smoothed over the inequalities, making the present nearly level surface.

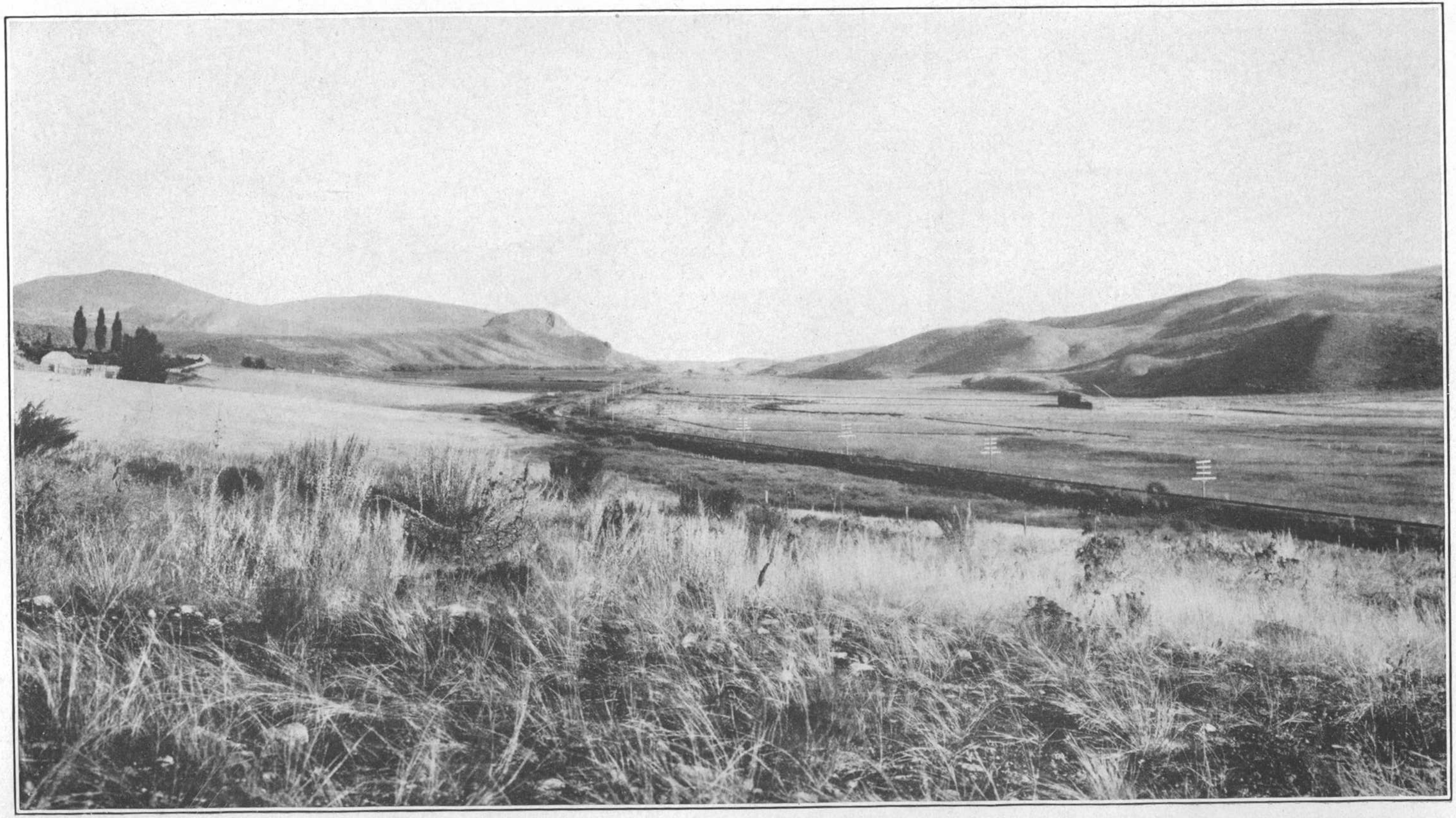


A. "THE GATES" OF BEAR RIVER, FROM THE EAST NEAR CACHE JUNCTION, UTAH.

Horizontal lines indicate wave-cut shore lines of ancient Lake Bonneville.



B. EAST BUTTE, IDAHO.



RED ROCK PASS AND THE OUTLET CHANNEL OF LAKE BONNEVILLE.

laid out by a colony of six families. White persons had, however, been here before. J. C. Frémont, in the report of his explorations in 1842, mentions meeting parties of emigrants in this locality, and Marcus Whitman traversed the valley in the fall of 1842 on his memorable journey from Oregon to Washington, D. C., with the object of saving Oregon Territory for the United States.

Logan, the principal town in Cache Valley, has a population of about 8,000 and is the location of the State Agricultural College, Brigham Young College, and one of the four great Mormon temples. The two towers of this temple, rising above the treetops at the foot of the mountains to the east, can be seen from the railroad. Two large sugar factories in this valley, at Logan and at Lewiston, contract for the yield of several thousand acres of sugar beets, the growing of which is one of the principal industries. Dairying is also an extensive industry and condensed-milk factories are located at Logan, Smithfield, Richmond, and Franklin.

On leaving Cache Junction the train crosses Bear River and turns to the north, giving a broad view of the south end of Cache Valley and its encircling mountains. Logan Peak, the highest point on the range near Logan, has an altitude of 9,713 feet. The strip of timber along the foot of the mountains from Logan north is not natural forest but is composed wholly of orchards, shade trees, and windbreaks around the farms.

Hammond.

Elevation 4,448 feet.
Ogden 53 miles.

Wave-cut terraces or beaches of old Lake Bonneville are well preserved on the side of Newton Hill, west of Hammond siding. The rock cliff here probably is the result of comparatively recent uplift along a north-south fault. Between Hammond and Trenton, at the point where the railroad turns from northeast to north, the white spots that look like closely set gravestones on the hillside west of the track are about 200 beehives. The bees feed on alfalfa and white clover, and the honey industry is growing. Many years ago the Mormons attempted to establish a silk industry in the valley but were not successful. Some of the mulberry trees they set out are still standing.

Trenton.

Elevation 4,460 feet.
Population 248.*
Ogden 57 miles.

The principal industry of Trenton is indicated by the grain elevators and large flour mills. Most of the ridge on the west is formed of soft sandy and limy rocks of Tertiary age. Some houses in the vicinity are built of these rocks, which are easily quarried and shaped. North of Trenton well-developed lake terraces may be seen on the ridge to the west, and in the late afternoon sunlight they are made particularly conspicuous by the shadows. To the east stretches a broad, level plain, the built-up floor of Cache Bay of the ancient Lake Bonneville.

Most of the villages in the valley are at the foot of the mountains on either side. The settlement of an arid country depends on the water supply, and as the best and most usable water was found at the mouths of mountain canyons, there the pioneers built their homes. The center of the broad valley is thinly settled, largely because Bear River and its tributaries have cut their channels so deep below the general level that it is hard to get water from them up on the land.

Ransom is only a railroad siding. Several miles to the northeast, in the broad valley of Bear River,[1] is the town of Preston, which has a population of about 3,000 and is the terminus of the Cache Valley branch of the Oregon Short Line. Hidden in the trees to the right of an isolated hill on the east side of Bear River is the village of Franklin. This hill, which is 6 miles east of the railroad, is a knob of limestone known as Mount Smart ("Franklin Butte" in Gilbert's report on Lake Bonneville; see p. 230) and was an island in Lake Bonneville. The story of that lake is carved in unmistakable signs on what was the windward side of this island. Cliffs cut by the waves that once beat against it and beaches covered with gravel are beautifully preserved on the southwest side, toward what was a broad expanse of open lake, while the east or shoreward side is comparatively smooth. Lime for the beet-sugar factories in this valley has been quarried in this hill.

Ransom.

Elevation 4,481 feet.
Ogden 61 miles.

At Cornish the train leaves Utah and enters the State of Idaho. The station stands on the State line. The irrigation canal seen at Cornish is 19 miles long, heads on Bear River above Battle Creek, 12 miles to the north, and supplies water for 20,000 acres of otherwise desert land. The irrigation systems in this valley were built and are owned by private companies.

Cornish, Utah.

Elevation 4,522 feet.
Population 143.*
Ogden 62 miles.

To those who remember Idaho in their school geographies as a small pink block, shaped like an easy chair facing east, it may be of interest that this State, which in 1890 added the forty-fifth star to the constellation on the flag, is nearly as large as Pennsylvania and Ohio combined and larger than the six New England States with Maryland included for good measure. It is divided into 33 counties, the smallest of which is half as large as the State of Rhode Island and the largest greater than the combined area of Massachusetts and Delaware.

Idaho.

[1] The mean discharge of Bear River as determined by measurements of its flow made at Preston, Idaho, during a period of 24 years, is 1,290 second-feet—that is, 1,290 cubic feet of water passing a given point each second. A maximum flow of 7,980 second-feet was recorded in 1894, and a minimum of 164 second-feet in 1905. There are two hydroelectric plants on Bear River above Preston, one under construction in Oneida Narrows, to have an installed capacity of 27,000 horsepower, and one at Grace, Idaho, with 17,000 horsepower.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
YELLOWSTONE PARK ROUTE
From Ogden, Utah, to the Yellowstone National Park

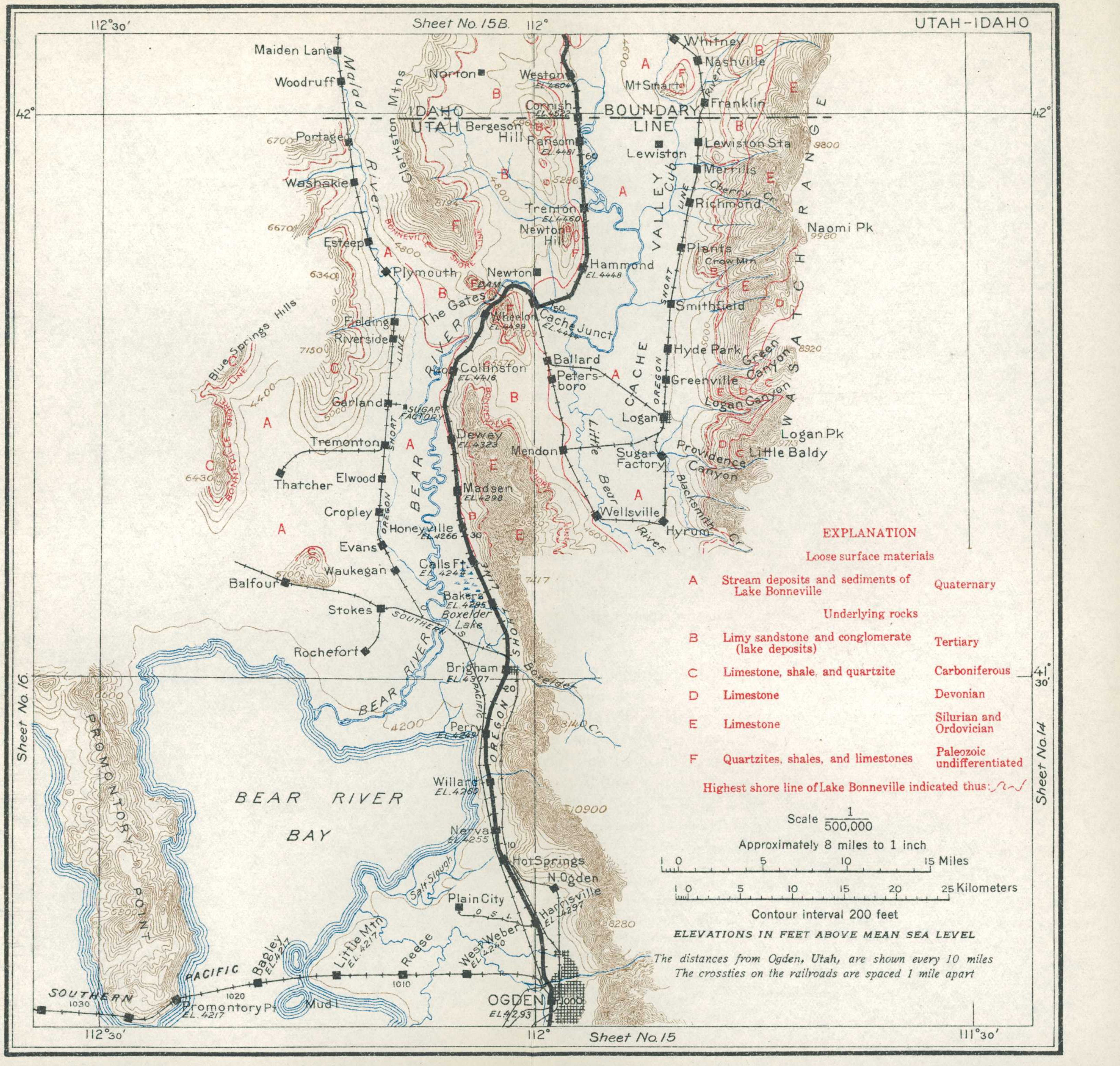
Base compiled from railroad alignments and profiles supplied by the Oregon Short Line Railroad Company and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915



Idaho covers an area of 83,888 square miles, divided principally between the Rocky Mountain region and the Columbia Plateau, only a small part, in the southeast corner of the State, lying in the Great Basin. In elevation above sea level the State ranges from 735 feet, at Lewiston, to 12,078 feet at the summit of Hyndman Peak. It is drained mainly to the Columbia through Snake River and its tributaries, and has an annual rainfall of about 17 inches, the range in a single year at different places being from 6 to 38 inches.

The industries of the State are chiefly agriculture, stock raising, and mining. Hay, wheat, oats, and potatoes are the principal crops. A large area is cultivated by irrigation. The mineral production includes gold, silver, copper, lead, and zinc. The output of lead in 1913 was valued at $13,986,366, that of silver at $6,033,473.

The population of Idaho in 1910 was 325,924.

Weston, Idaho.

Elevation 4,604 feet.
Population 398.
Ogden 65 miles.

A short distance from Weston the steel-tower electric line, which conveys power from the upper canyon of Bear River and which was last seen by the traveler at Bear River canyon, again crosses the railroad. Weston is an old Mormon village on the lake terrace west of the station. North of it the railroad ascends a slight grade, and the gullies cut in the lake deposit give the surface an uneven appearance, but on the upper level it is very apparent that the plain is only slightly dissected. In the distance to the northeast is a high-cut bank of Bear River, but the river is not in view because in this part of its course it has sunk its channel in the easily eroded lake deposits to a depth of 250 feet below the plain.

Dayton.

Elevation 4,745 feet.
Population 418.*
Ogden 71 miles.

The main highway from Utah to Montana follows the foot of the mountains on the west side of Cache Valley to its very head. Along this road are several old Mormon settlements, among which is Dayton (see sheet 15B, p. 124), located at the mouth of Dayton Canyon and the junction of a very rough road leading over the mountains to Malade. The big cliff at the mouth of Dayton Canyon is composed of very ancient sedimentary rocks (Cambrian?) dipping westward at a low angle. About half a mile up the canyon these rocks have been overridden by much younger (Carboniferous?) limestone, showing that the mountains west of this end of Cache Valley were formed by the piling up of upturned broken slabs of the earth's crust. The foothills back of Dayton are made of sandy and limy rocks which were originally deposited as sand and mud in a fresh-water Tertiary lake. Such rocks are found in many places around the edge of Cache Valley.

The train now approaches on the east a north-south ridge several hundred feet high, known as Battle Creek Butte. It is isolated in the midst of the valley and takes its name from Battle Creek, the scene of an Indian fight near its eastern base. Much of the ridge is made up of very old shales (hardened mud rocks), but the south end and some of the top are composed of diorite, a kind of granite which, in a molten condition, was forced up into these shales from below. This molten rock may not have reached the surface, for the surface at the time of the intrusion was considerably above the present one. Whether this ridge is an uplifted fault block or a remnant left by the forces of erosion has not been determined, but it certainly was an island when Lake Bonneville stood at its highest level. The north end of the ridge consists of soft Tertiary sandstone.

Opposite the middle of Battle Creek Butte is Garner, a station for the village of Clifton, which lies at the edge of the flat 1 mile west.

Garner.

Elevation 4,751 feet.
Ogden 75 miles.

Clifton is an old Mormon hamlet of about 100 people. Late in the afternoon the mountains on the west appear a hazy blue, details are obscured, and it may not be possible to distinguish the low rounded foothills made by Tertiary conglomerate and sandstone or to see the prominent lake-cut benches which continue along the edge of the valley as far north as Oxford.

A large reservoir among the Tertiary ridges just east of Garner is filled from a ditch that brings water from Mink Creek, several miles to the northeast. An inverted siphon carries water from this reservoir across the creek at Garner, and a wooden pipe line that goes under the railroad at the first road north of Garner station takes the water to Clifton, where it is turned into irrigation ditches. About 31,000 acres is irrigated from this one system.

A short distance north of Garner a clear view is again obtained of the Bear River Range, several miles to the east (right), and of the low Tertiary hills in front of it.

Oxford.

Elevation 4,748 feet.
Population 591.*
Ogden 81 miles.

The railroad passes a big marsh, one of the few areas in this part of the valley which is not yet much utilized, and continuing along the practically level lake floor comes to the station for a Mormon village, Oxford, which stands among the trees 2 miles to the west. The Provo shore line may be seen near the village. If Cache Valley should be filled again to the highest level of Lake Bonneville, Oxford village would be 400 feet under water, and the temple at Logan would stand in water 500 feet deep.

A low ridge just north of Oxford station extends eastward from the mountains and makes the valley bottom much narrower.

Swan Lake.

Elevation 4,772 feet.
Ogden 84 miles.

Directly ahead, about 7 miles distant, there are two prominent rocky points, which mark Red Rock Pass, the old outlet of Lake Bonneville. West of the track is Swan Lake, a small body of water on which it is common to see many ducks either resting quietly or, frightened by the train, skittering away through the weeds. The railroad grade, which has been gradually rising to Swan Lake station, now begins to descend. By the overflow of Lake Bonneville the drainage divide was moved from Red Rock Pass, where it stood before Bonneville time, back to this point, nearly 7 miles farther south. Sand and gravel dumped by small creeks coming out from the hills have dammed this part of the valley, making a marsh which extends most of the way from Swan Lake to the pass. The hills on the east are composed of Tertiary sediments, mostly shale, and show the Bonneville shore line about 340 feet above the marsh. At Red Rock Pass red limestone cliffs appear on both sides (Pl. XXXI, p. 113). From the road crossing just south of the pass may be seen on the right a small valley coming down from the northeast. This is the head of Marsh Creek, which in pre-Bonneville time probably drained southward into Bear River, but which, by the shift of the divide just mentioned, now turns at a sharp angle and goes through the pass to join the Snake River drainage system. Through this valley went the magnificent river made by the overflow of Lake Bonneville.

Zenda.
Elevation 4,743 feet.
Ogden 90 miles.

As most of the water of Marsh Creek is used in irrigation, the natural channel through the pass and for a short distance north of it may be dry in summer. The knobs of limestone, 200 to 300 feet high, which overlook the channel from opposite sides leave a maximum width of 600 feet for the river that drained Lake Bonneville just before it was drawn down to the Provo stage. (See Pl. XXXI.) When Lake Bonneville first started to overflow, the lake level stood higher than the tops of these limestone rocks, which had been buried beneath mountain waste. Gravel deposited by the stream that drained the lake at its highest stage is found on top of the red butte along the base of which the train passes. The Hunt ranch, mentioned by Gilbert in his description of this old outlet of Lake Bonneville published in 1890, was at the foot of this rocky citadel. The limestone crags bordering Red Rock Pass are conspicuous features of the landscape and were well known to the early travelers in this region and to the freighters who hauled supplies for the western Montana mining camps over the road that follows the course now taken by the railroad. The traveler going north from the pass may notice that although the steep-sided valley is a quarter of a mile or more wide, its stream is only a rivulet meandering through the meadow. (See Pl. XXXI.) The ill-matched stream and valley afford evidence that a great river once flowed where now there is only a brook. (See pp. 97–98.) Here, then, at or just north of the red cliffs, Lake Bonneville overflowed its rim and began the discharge which continued until evaporation exceeded inflow.

The valley bottom becomes wider toward the north, and the train leaves it and comes out upon a broad bench, from which an extensive view may be had of the valley of Marsh Creek.[1] On this bench is Downey, a small settlement in the midst of an extensive agricultural district. The first homes were built here about 1894, but it was not until 1910, when water was brought by a large irrigation canal from Portneuf River below Lava Hot Springs and it became possible to irrigate the land, that the settlement had any marked growth. It was named for one of the engineers or officers of the Oregon Short Line. The grain elevator and the broad fields of grain that stretch away in all directions tell of the principal industry of the people. About 12,000 acres is irrigated by the Downey Improvement Co.'s ditch and cultivated. When the ditch was completed in 1910 land sold for $35.50 an acre, $35 for the water right and 50 cents for the land. In 1914 it was worth about $45 an acre with water right but without improvements.

Downey.

Elevation 4,858 feet.
Ogden 95 miles.

Oxford Peak (elevation 9,386 feet), which overlooks Red Rock Pass, appears from Downey as a mountain mass with two tops of about equal height. The front of the mountain range east of Downey is made up of Carboniferous limestone dipping to the east; the mountains on the west are composed of Ordovician rocks, also dipping east. In all directions there is a strong suggestion that the comparatively level valley floor between the two mountain ranges was

[1] Marsh Valley, like Cache Valley, is inclosed between mountain ranges, and has a north and south trend. Its length is about 35 miles, and its greatest width is 8 or 10 miles. Twenty miles from Red Rock Pass the Portneuf River breaks through the eastern mountain chain and enters the valley, turning northward and running parallel with Marsh Creek to the end of the valley. There it receives the creek and then turns abruptly westward and escapes from the valley through a deep but open canyon. The upper canyon of the Portneuf has at some time admitted lava as well as water. A succession of basaltic coulees have poured through it into Marsh Valley and have followed the slope of the valley to the lower canyon. The Portneuf River follows the eastern margin of the lava beds, and Marsh Creek the western, each occupying a narrow valley sunk from 30 to 100 feet below the level of the lava table. A comparison of these valleys illustrates the disparity between Marsh Creek and its channel. Portneuf River is several times larger than Marsh Creek, but the immediate valley by which it is contained is smaller. Indeed, there is every evidence that the valley of Marsh Creek, having been formed by the ancient Bonneville River, is now in process of filling. It abounds in meadows and marshes and at one point contains a lakelet.

It appears, however, that the Bonneville River was not contained during its entire existence in the channel now occupied by Marsh Creek. The whole upper surface of the lava tongue, where it has a width of more than a mile, is fluted and polished and pitted with potholes after the manner of a river bed, and there seems no escape from the conclusion that it was swept by a broad and rapid current.

produced by outwash from the mountains. In other words, the débris brought down from the surrounding mountains by the numerous streams has spread out as a great apron, filling the valley to a considerable depth, and every year, especially at times when the streams are high, a little more sand and gravel are added to the deposit. The valley of old Bonneville River, now occupied by Marsh Creek, is cut in this fill. At Downey the flat floor is composed, at least near the surface, of well-rounded sand and partly cemented gravel. It is said that a well 600 feet deep west of Downey was drilled entirely in hill wash.

Virginia.

Elevation 4,790 feet.
Ogden 100 miles.

Arimo.

Elevation 4,736 feet.
Ogden 105 miles.

Virginia is the station for a considerable number of farmers living on irrigated lands in the vicinity. The fine large school buildings here and at Arimo, a few miles farther north, are typical of the school facilities provided for country pupils in this part of Idaho. After leaving Virginia the train runs down below the level of the upper bench and at Marsh Valley siding passes gravel pits from which a great quantity of material has been taken for fills and ballast along the railroad. The gravel shows the character of the valley filling. Arimo is one of the numerous little settlements on the main highway between Ogden and Pocatello, which parallels the track for many miles.

The valley of Marsh Creek has been flooded with lava in one of the later stages of geologic history, probably in Pleistocene glacial time. Lava of this kind, a basalt, is widespread in southern Idaho. It is seen first in Marsh Creek valley about 1½ miles north of Arimo, between mileposts 106 and 107. The edge of the lava first appears as a low vertical wall of black rock on the east side of the creek, just north of some ranch buildings. Marsh Creek flows along the west side of the lava and the railroad runs along the east edge for a short distance, gradually going up on the upper surface, which it traverses to McCammon. The surface appears smooth, but so much of it is bare rock partly hidden by sagebush that the land is not cultivated. Near McCammon, where there is more soil on the lava, crops are being raised. Just before reaching McCammon the traveler can see on the east the defile which Portneuf River has cut through the mountains. In the forties and fifties pioneers from the Mississippi Valley bound for Oregon diverged from the Astor route and entered the Snake River valley through this defile by ox team, where travelers now pass along in Pullmans and Packards.

At McCammon, the junction of the Granger and Ogden branches of the Oregon Short Line, the mountains on both sides of the valley are composed of Ordovician shale, limestone, and quartzite, dipping to the east. A cross section of the valley at this point (fig. 14) shows a fold in the hard rocks which explains how a single formation may occur in the same position in two parallel mountain ranges. It also shows the relation of the mountain wash to the bedrock and contains in diagram the record of an interesting series of events. After the mountains were uplifted and had been somewhat worn down by erosion, there seems to have been a long period when the earth's crust in this region remained practically stationary and the refuse from the wearing down of the mountains on both sides gradually filled the valley to a considerable depth. Subsequently,

McCammon.

Elevation 4,763 feet.
Population 321.
Ogden 111 miles.
Granger 191 miles.

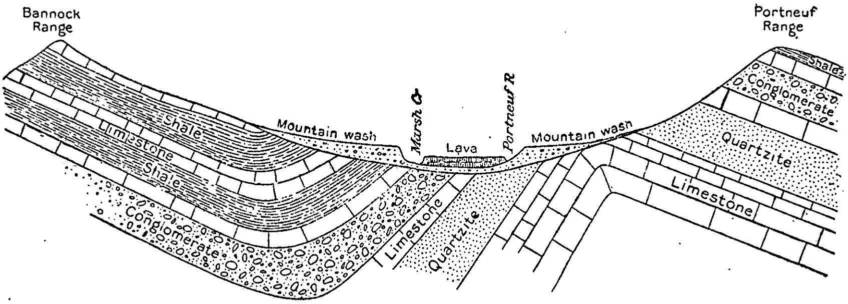


FIGURE 14.—Cross section of Marsh Creek valley at McCammon, Idaho.

an elevation of this region gave the streams greater fall, which increased their cutting power, so that they gradually washed out deep gullies in the fill. Then came a period of volcanic activity during which great quantities of lava welled up through cracks in the earth's crust and flowed out from volcanoes. The bottom of the valley occupied by Marsh Creek and Portneuf River, from a point near Arimo to Pocatello, was filled with black lava, most of which probably came up from a crack along the valley bottom. After the lava cooled Portneuf River, coming out from its canyon on the east, may have flowed for a time directly across the top of the lava to the west side of the valley, as suggested by an abandoned channel to be seen along the railroad just before entering McCammon, and there joined Marsh Creek. Subsequently it cut a new course along the east edge of the lava tongue to its present position and left Marsh Creek in possession of the opposite ledge. Long after the lava had cooled Lake Bonneville formed and its outlet stream through Red Rock Pass poured down Marsh Creek valley, flowed over the top of the lava, leaving deposits of sand and gravel in its wake, and carved deep channels on both sides of the narrow lava tongue.

A place of more than local interest is Lava Hot Springs, in Portneuf Canyon 12 miles east of McCammon, where in 1914 the State of Idaho built a natatorium inclosing a concrete swimming pool 33 by 66 feet for public use. A number of hot springs issue from the bank of the river, and near them is a popular camping place. In the canyon at and above the hot springs there is considerable calcareous tufa, a soft cellular limestone deposited by the evaporation of water carrying lime in solution.

The gently sloping benches or terraces from McCammon to the foot of the mountains on the east and west are composed of outwash material which, though deposited by mountain torrents, has nevertheless accumulated so gradually that it makes a good soil. Large quantities of grain are raised on it by dry farming. The great white ledge seen on the mountain side 5 miles east of the village is a band of gray sandy limestone about 100 feet thick. The Harkness ranch, just north of the village, was one of the first in this region and was a common stopping point for freighters before the railroad was built. Mr. Harkness maintained a toll bridge over Portneuf River at this point.[1] Water power at McCammon runs the local gristmill and electric-light plant.

Immediately on leaving McCammon the train runs down off the top of the lava into a little canyon, and for a number of miles follows the river and the edge of the lava. Toward the north the lava wall increases from 10 to 50 feet in height. In most places its upper edge is well exposed, but the lower part is concealed by large and small blocks broken from the ledge above by frost action and other natural forces. Fine exposures of black columnar basalt[2] are almost con-

[1] Measurements of the flow of Portneuf River show a mean discharge of 265 second-feet at Topaz, a station in the canyon east of McCammon, during 1913–14 and of 334 second-feet at Pocatello during 1897–1899 and 1912–1914. The records at Pocatello show from a minimum flow of 14 to a maximum flow of 1,880 second-feet. No large power plants are feasible on this stream.

[2] Columnar structure, or the division of a rock into prisms more or less straight and parallel to one another, is a common feature of basalts. Well-known examples of this structure are the Giants Causeway and Fingals Cave, in Ireland; the lavas in the Auvergne, in central France; the Palisades of the Hudson; the Watchung Mountains, west of Orange, N. J.; and the lavas in the Snake River canyon of Idaho and the valley of the Columbia in Oregon. As in the drying of a mud puddle cracks break the surface into figures having five or six sides, so in the cooling of molten basalt the prismatic shrinkage cracks start at right angles to the cooling surface. If the rock were perfectly homogeneous and the cooling uniform, the columns would all be hexagonal and of uniform thickness. The slower the mass cools and shrinks the larger will be the columns, and as the upper and lower surfaces of a mass of lava are likely to cool at different rates, it is common to find the lower portion separated into larger columns than the upper portion. As the columns are developed at a right angle to the cooling surface it follows that a sag or depression in the surface of a basalt sheet is underlain by radiate columnar structure.

tinuous on the west side of the track. Areas a few yards in extent showing radiate columnar structure may be seen at several points close to the railroad between McCammon and Pocatello.

Onyx.

Elevation 4,615 feet.
Ogden 117 miles.
Granger 197 miles.

Onyx is a siding just below a concrete bridge over Portneuf River. Near milepost 200 [1] the river tumbles over falls made by travertine, a soft cellular limestone deposited from calcareous spring waters. The small knobs of limestone in the valley bottom between the 198 and 200 mile posts were once buried in the lava which spread over the whole valley floor but have been brought to light again through the wearing away of the lava by the river.

Near the 201-mile post the railroad and river turn to the middle of the larger valley, where there are basalt walls on both sides. An abandoned channel of Portneuf River continues along the east edge of the lava mass, so that the lava east of Inkom is an isolated block lying between the abandoned channel and the new channel of Portneuf River.

Inkom.

Elevation 4,520 feet.
Population 549.
Ogden 122 miles.
Granger 202 miles.

At Inkom, a small settlement just below the point where Marsh Creek enters Portneuf River, the river turns from north to west and cuts through the range in a deep, narrow valley. The basalt formerly occupying the present position of Inkom has been gradually removed by the stream which comes in from the northeast. Portneuf River has worn the basaltic lava away from the south side of the valley from Inkom to Pocatello, leaving a black columnar wall on the north side of the track. In some places it is very apparent that there are two thin sheets of lava, one resting upon the other, indicating two distinct volcanic outbursts. About 4 miles west of Inkom the lava stops short, and there is none in the narrow pass through the mountains.

The valley of Portneuf River from McCammon to Pocatello is cut in ancient Paleozoic rocks, including limestones, shales, and quartzites, tilted at various angles but for the most part to the east. The Bannock Range west of Inkom, through which the train passes so quickly, is composed of Ordovician strata which are more or less folded, an anticline or upward bend being indistinctly recognizable on the south wall of the pass. There is no picturesque canyon here—only a short, sharp gap. A great fault or break in the rocks along the west side of the range crosses the river at the west end of this gap, but no trace of it can be seen from the train.

[1] In the Portneuf Valley between McCammon and Pocatello the railroad mileposts indicate the distance west of Granger, Wyo.

As soon as the train leaves the gap a basalt wall is seen again on the north. Probably the lava was originally continuous through the gap, having flowed down the valley from McCammon as a great molten tongue, but if so it has been completely removed from the gap by the river. Plainly there are two lava sheets here. The columnar structure is well developed, as shown in the vertical wall at the edge of the basalt. At a few places where there were original sags in the surface of the mass radiate structure can be recognized. The basalt ends in the Portneuf Valley with a gentle slope about 3 miles east of Pocatello. Near Pocatello the mountains swing away to the west and north, making room for the city.

Portneuf (spur).
Ogden 128 miles.
Granger 208 miles.

A low, steep-faced reddish ridge north of the track just east of the city appears to be a block of Ordovician quartzite uplifted by faulting.

Pocatello,[1] another "gateway to the mountains," is the junction of the divisions of the Oregon Short Line running north to Butte, Mont., and west to Huntington, Oreg. It was named for an Indian chief and began as a tent city in 1882, when the railroad was completed to this point. The early history of this locality is a wild one. In the days when the overland stage made its way through Portneuf Valley trouble with Indians and with highwaymen was common. The city is built on a town site of 2,000 acres sold by the Indians to the United States. It is divided by the railroad into two distinct parts, connected by a viaduct which crosses the numerous tracks at the station. It is growing rapidly and already has many noteworthy institutions, such as a Federal building, a Carnegie library, a hospital, a large railroad Y. M. C. A., and fine schools, including the Academy of Idaho, which bridges the gap between the common schools and the State university. The electric light and power used in the city is generated at American Falls, 25 miles west, on Snake River. The growth of the city is due largely to the railroad shops, which give employment to hundreds of men.

Pocatello.
Elevation 4,460 feet.
Population 9,110.
Ogden 134 miles.
Granger 214 miles.

Just west of the city highly tilted Cambrian quartzite is overlain by rhyolite, a light-colored siliceous volcanic rock, which flooded the surface before the basalt came. As the train leaves the station and passes the roundhouses and extensive railroad shops the traveler sees to the west the great Snake River plain. Far out in this plain a solitary mountain appears in dim outline. This is Big Butte, the cone of an extinct volcano, and the westernmost of three buttes which for generations have been landmarks in this part of the country.

Farther than the eye can see the Snake River plain stretches away to the west. The valley of the ancient Snake River was flooded

[1] The railroad mileposts from Pocatello to Idaho Falls give the distance from Ogden.

with great outpourings of black lava, which spread out sheet on sheet, buried the old land surface, and partly filled the valley with molten rock, which solidified and has remained to this day undisturbed except for the gorges that the streams have cut in it. In some places old mountains project through the petrified lava flood as islands project above the surface of the sea, and old ridges stick out into it as capes and promontories.

The description of the Snake River plain below given[1] is taken from a report written in 1901 by I. C. Russell.

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[1] Southern Idaho is a region composed of geologically old rocks, which formed an ancient land surface having a rugged relief. In the depressions of this surface, during later geologic time, extensive lake and stream deposits and vast lava flows were spread out. The older rocks, sharply separated from the younger by a long time interval, during which extensive movements in the earth's crust and deep erosion took place, are mainly granite, rhyolite, quartzite, and limestone. The younger of these is probably the limestone which is thought to be of Carboniferous age. These rocks were variously folded, faulted, and upheaved into prominent mountains, and deeply dissected by a large river, with many tributaries, which was long lived. The valley of the main stream, the ancient representative of Snake River, became broad and had many important tributary valleys opening from it and extending far into the bordering mountains. The sharp-crested mountain spurs between the lateral valleys are in some instances prolonged far into the main depression.

After the topography had passed maturity—that is, after the streams had excavated deep valleys, leaving sharp-crested or serrated divides between them—the main stream was obstructed, possibly by lava flows, but more probably by an upward movement of the rocks athwart its course, in the region now included in western Idaho and eastern Oregon, and a lake was formed which occupied a large part of the country now included in the Snake River plains. This water body, named by Lindgren Lake Payette, received the sediment brought in by tributary streams and the dust blown out by volcanoes and became deeply filled. These sediments, which have a known depth of over 1,000 feet, are now well exposed, particularly in southwestern Idaho. In places they contain impressions of leaves of trees which grew on the borders of the old lake, the shells of fresh-water mollusks, the bones of land mammals, and other remains. The fossils record a Tertiary (Miocene) age.

Before Lake Payette came to an end the vast lava flows which now form such a conspicuous feature of the Snake River basin began to be outpoured. In fact, the lava and the sediments of Lake Payette and of a later lake in the same basin were contemporaneous, the lava and lake sediments being interbedded. Some of the lava flows entered the lake, and the occurrence of thick beds of volcanic fragments (lapilli) and of scoriaceous, glassy lava, with a torn and slaglike structure, at the base of thick sheets of usually compact basalt records the energy of the steam explosions that followed. Highly liquid lava continued to be poured out at various intervals from a large number of volcanic vents and spread out in the previously formed basin, making, in truth, lakes of molten rocks. Besides these two processes of upbuilding—that is, sedimentation in lakes and the outpouring of lava which spread widely—there was a third, the washing of débris from the uplands and its deposition in alluvial cover and widely extended sheets of sand, gravel, and silt in the valleys. In addition, there are widespread eolian [wind] deposits. The volcanic eruption continued after the lakes were either filled or drained, so that by far the larger portion of the Snake River plains is

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
YELLOWSTONE PARK ROUTE
From Ogden, Utah, to the Yellowstone National Park

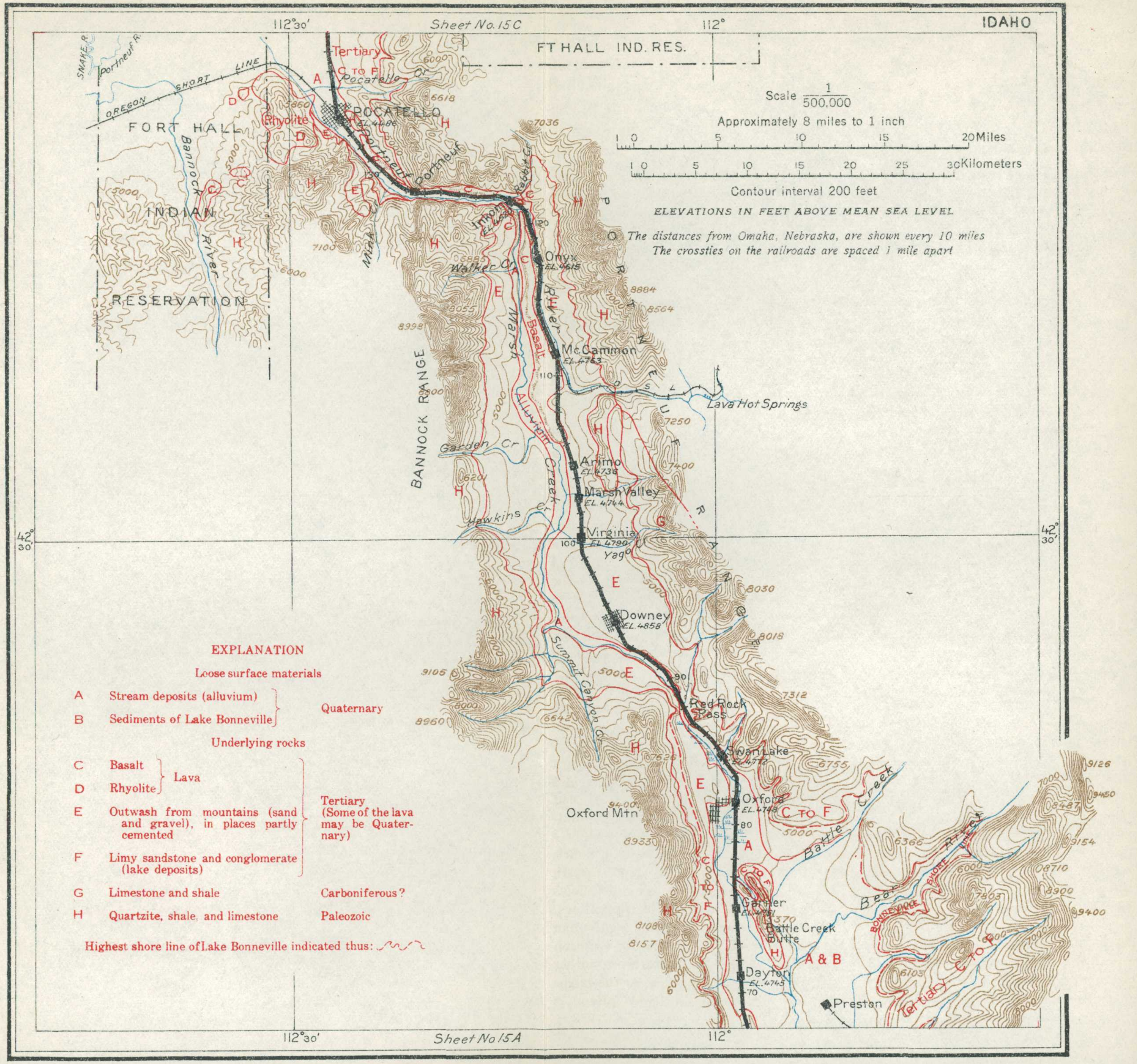
Base compiled from railroad alignments and profiles supplied by the Oregon Short Line Railroad Company and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915



Tyhee.

Elevation 4,458 feet.
Ogden 140 miles.

At Tyhee (see sheet 15c, p. 138), 1½ miles south of the Fort Hall Indian Reservation, the railroad turns more to the north and a view is obtained on the left of the middle and east buttes of the three already mentioned. The sagebrush flat now being crossed is owned by the Indians. Very little land has been cultivated in this part of the reservation, although much of the land is under ditches of the irrigation system installed by the Government. Near Tyhee may be seen the large upper canal which takes water from Blackfoot River about 15

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directly underlain by sheets of basalt. The last of the extensive volcanic discharges happened in very recent times, and the process of stream deposition still continues.

The estimated area covered by the Snake River lava is in the neighborhood of 20,000 square miles. So far as is now definitely known, there is but one lava field in North America of greater extent, namely, the Columbia River lava, the estimated area of which is about 200,000 square miles. In Snake River canyon, below Shoshone Falls, nearly 700 feet of lava in horizontal sheets are exposed, but whether this is the maximum thickness or not can not be told. As a rule, the various sheets of lava are relatively thin, averaging perhaps 50 to 80 feet and widely extended. That many independent outflows of lava have occurred is easily seen, but in the walls of Snake River canyon, where the best sections are exposed, it is difficult to determine the number unless lacustral deposits, beds of lapilli, etc., occur between them.

Although the soil of the Snake River plains has well-marked variations, it may be said that in general, and, in fact, almost everywhere, it is fertile and needs but the requisite moisture to enable it to produce a strong growth of either native or cultivated plants. In general, however, the soil of the plains is a fine yellowish-white siltlike material, largely a dust deposit, which mantles the surface not only on level tracts, but covers hills and broad depressions alike. This material is similar to the celebrated loess of China, except that it usually occurs as a comparatively thin layer, and resembles also the deposit bearing the same name in the Mississippi Valley. Like each of these formations, it is of exceptional fertility if properly irrigated.

The ever-present and characteristic plant of the Snake River plains is the sagebrush (*Artemisia tridentata*), which grows abundantly and, we might say, luxuriantly in the dry soil from the bottom of the Snake River canyon up to an elevation of some 2,000 or 3,000 or more feet on the mountains bordering the plains. It covers the broad arid valleys almost completely and is seldom lacking over any extensive area except where fires have recently occurred or cultivated fields supplant it. On the plains in summer fire sometimes sweeps through the sagebrush in much the same manner that it does over the prairies and "burns" are produced. The "sage" in the localities most favorable to its growth attains a height of about 10 feet, but usually is not over 3 feet high, the clump of bushes being commonly 6 to 8 feet apart. One can ride or walk over the sagebrush plains with but little difficulty. The light grayish-green leaves of this ubiquitous plant give color, or perhaps more properly, lack of color, to the plains and enhance their monotony. Although the Snake River plains are frequently termed a desert, the name is true only in the sense that they are practically without water. Comparatively little of the surface is destitute of plant life. In fact, the flora is found to be abundant and varied if one examines it closely. There are many lovely plants that blossom early in the spring, filling the air with fragrance, and in the summer and fall the yellow of sunflowers and of the still more plentiful "rabbit brush" (*Bigelovia graveolens*), miles to the north. The canal is carried under the track near Tyhee by means of an inverted siphon.

East and northeast of Tyhee the old flood plain of Snake River terminates against a bluff about 40 feet high, from the top of which the land rises gently in long slopes to the hills made of upturned Paleozoic rocks, more or less covered with lava. The gently sloping bench lands are themselves composed of marls, sandstone, conglomerate, volcanic ash, and lavas. These deposits are geologically very young, probably Pliocene. They cloak the older formations over many square miles.

Three gray stone buildings with red roofs east of the track belong to a boarding school for Indian boys and girls, where the 180 pupils are given instruction in practical matters relating to farm life as well as the ordinary academic courses.

Fort Hall.

Elevation 4,458 feet.
Population 1,672.*
Ogden 146 miles.

Fort Hall is the headquarters of the superintendent of the Fort Hall Indian Reservation and the engineers on the reclamation project. The Indian women seen here are dressed in blankets and moccasins, and the men in semicivilized costume. Some of the Indian maidens, however, wear gowns of the latest styles. Fort Hall, formerly called Ross Fork, from the stream on which it is built, takes its present name from a fort which was built in July, 1834, about 15 miles to the northeast, at the junction of the Missouri-Oregon and Utah-Canada trails, by Capt. N. J. Wyeth and named for one of his partners. It was to the original fort that Dr. and Mrs. Marcus Whitman and Rev. and Mrs. H. H. Spaulding came in 1836 on their way from Boston to missionary labors among the Indians in Oregon. Theirs were the first wagons and Mrs. Whitman and Mrs. Spaulding

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a relative of the goldenrod, here and there give broad dashes of brilliant color. Beneath the sagebrush in a state of nature nutritious bunch grass grows abundantly and still furnishes pasturage where sheep have not ravished the land. Where the plains are broadest—that is, north of the Oregon Short Line Railroad and especially in the vicinity of the three steptoes, Big, Middle, and East buttes—much of the land is without sagebrush and in the condition of a rolling prairie, which supplies excellent winter pasturage.

On the plains, more especially in the broader portions in the vicinity of the three prominent buttes that break their monotony, big game is still to be found. Antelope roam over them throughout the year, while deer and elk find there a safe winter range. The mountain sheep is also present in winter, and the mountain goat is reported to have been met with. The great horn cores of the mountain sheep are occasionally to be seen bleaching among the clumps of sagebushes. Occasionally also the horns and bones of the bison are found, showing that southern Idaho was within the former range of that species. Besides the animals just mentioned, the plains are visited by bears, wolves, lynxes, foxes, and skunks, and the coyote is only too abundant. Ducks, geese, and other birds visit the ponds and streams, particularly along Snake River and on the west side of the plain to the Lost River country. Grouse of several species are common and smaller birds are by no means rare.

the first white women to cross the Rocky Mountains. The party forded Snake River near the site of Blackfoot and went bravely west over the waterless plain. The old fort was abandoned many years ago and practically all vestige of it is lost.

In the Fort Hall Reservation sagebrush seems to cover every acre and the traveler may question if the Indians cultivate any land. Most of the Indians, however, live near the creeks and their homes can not be seen from the train. In 1914 they had 7,240 acres under cultivation. The principal crops are alfalfa, oats, wheat, potatoes, barley, garden truck, and sugar beets. According to the report of the Commissioner of Indian Affairs for 1914 the total Indian population of the reservation was 1,797, including 462 children of school age. Of these Indians, 1,506 are full bloods belonging to the Bannock and Shoshoni tribes. There had been allotted to the Indians 38,280 acres of irrigated land and 330,971 acres of grazing land. The old and decrepit Indians, 250 in number, get rations. More than two-thirds of the Indians live in tepees and tents. Nearly a third of them winter on the Snake River bottoms, where there is timber for shelter, fire wood, and plenty of pasturage and where snow rarely lies more than a few days.

The road up Ross Fork from Fort Hall station leads across the mountains to the dam of the great Blackfoot reservoir, about 30 miles east, built to store water for the Fort Hall irrigation system. Phosphate deposits occur about 20 miles east of Fort Hall station along this road. The deposits in this reservation contain approximately 738,000,000 long tons and are estimated to underlie 58½ square miles at depths of less than 5,000 feet; they doubtless underlie a much larger area at greater depths. The main phosphate bed is 6 or 7 feet thick and is rich in tricalcic phosphate, the mineral constituent in bones. The phosphate beds are relatively soft and are exposed in only a few places, although clearly recognizable fragments of phosphate rock are scattered more or less abundantly along the zone of outcrop. A description of the western phosphate field, by G. R. Mansfield, is given below.[1]

[1] A hard problem for the farmer is to discover the needs of his depleted or unfavorably proportioned soil. Its greatest need may be phosphoric acid, one of the three substances that are most necessary in maintaining fertility, the other two being nitrogen and potash. Phosphoric acid for use in fertilizers has been supplied for many years in part by the phosphates of Florida and Tennessee and from islands in the Pacific Ocean. These deposits can not always supply the demand, and therefore the recent discovery that the Rocky Mountains contain the largest known area of phosphate rock in the world is of vital interest to future generations, if not to the present one.

Albert Richter claims to be the original discoverer of the western phosphate deposits, because he recognized rock phosphate in Cache County, Utah, in 1889 and located claims on it. These phosphate deposits are said to have been independently discovered in 1897 by R. A. Pidcock in Rich County, Utah, in old diggings in black rock that he mistook for

North of Fort Hall station, 1 to 3 miles east of the track, there is a group of low rounded hills composed largely of basalt lava but covered for the most part with dark sand that was blown out from a volcano, the basalt appearing here and there as ledges and bowlders of black rock. From Fort Hall station an excellent view may be obtained of the highest mountains in the reservation, North and South Putnam, situated 15 to 18 miles to the southeast and reaching 8,837 and 8,989 feet, respectively, above sea level.

North and west of Fort Hall station the surface of the flat is overspread with dark sand, largely of volcanic origin. It is similar to volcanic ash except that it is coarser. This sand is piled in low dunes west of Fort Hall, and some of the dunes have been utilized as burial places by the Indians. These Indian cemeteries are marked by high poles, set rather close together, which may be seen for considerable distances. A cemetery about 2 miles west of the track and 1 mile north of Fort Hall can be seen from the train in clear weather. On close inspection the cemeteries are found to be decorated with effects of the departed Indians, including clothing, cooking utensils, and implements.

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gold prospects. A large sample analyzed in 1899, however, proved to be high-grade phosphate rock. In 1908, on recommendation of the Geological Survey, Secretary of the Interior Garfield withdrew from entry 4,500,000 acres of public land in Idaho, Utah, and Wyoming believed to be valuable for phosphate, and this phosphate withdrawal was continued by President Taft under the act of June 25, 1910. In 1909 and succeeding years these phosphate deposits were systematically examined by the United States Geological Survey, and in 1910 phosphate rock was discovered in Montana, near Melrose, by Geologist H. S. Gale. On January 1, 1915, the total area of phosphate lands in Montana, Utah, Wyoming, and Idaho withdrawn from entry was 2,713,155 acres. This phosphate reserve is larger than any similar area in the United States; it is, indeed, the largest area of phosphate rock yet recognized in the world.

A characteristic of the phosphate rock of this region is its oolitic texture, the rounded grains, resembling fish eggs, ranging in size from the tiniest specks to bodies half an inch or more in diameter. In its weathered condition these grains are more or less distinct and the rock has a grayish color. When freshly mined, however, the rock is dark brown or black. In some places where the rock has been subjected to great compression during the deformation of the inclosing strata it has apparently lost the oolitic texture and shows a slight increase in density.

The phosphate deposits in the West occur in definite beds that extend over wide areas and that are related to the associated rocks in the same way as coal beds. The associated beds are predominantly shaly, but include also sandstones and limestones, the whole ranging in thickness from a few feet to 175 feet. Above these phosphate shales there is commonly massive chert or cherty limestone, and below them in the Utah, Wyoming, and Idaho fields a light-colored siliceous limestone. These three sets of beds in Utah and western Wyoming are grouped together as the Park City formation, of Carboniferous age. In Idaho the phosphate shales and overlying chert are called the Phosphoria formation. The number of phosphate beds distributed through the phosphate shales varies from place to place. There is, however, usually near the base, a bed 5 or 6 feet thick in the Idaho field and the adjacent portions of Wyoming and Utah.

Volcanic hills, composed largely of a rhyolite lava, appear to the east at a distance of 4 or 5 miles from Gibson siding. On one of the nearer hills of this group there is a very symmetrical little cone built of material similar to that which makes so large a proportion of the dark volcanic sand found abundantly in this vicinity. It seems probable that this little cone is the crater from which the sand was blown out and that its eruption marks perhaps the latest chapter in the volcanic history of the district.

Gibson.

Elevation 4,463 feet.
Ogden 151 miles.

For many miles north from Fort Hall the three buttes in the Snake River plain are visible in clear weather. The westernmost, or Big Butte, is an old volcano rising 2,350 feet above the plain, or 7,659 feet above sea level. East Butte, also a volcano, is 700 feet high, and Middle Butte, an upraised block of basaltic lavas, is 400 feet high. Big and East buttes are ancient rhyolitic volcanoes which existed previous to the outpouring of the fluid basalt that flowed about them, their upper parts rising as islands in this sea of molten rock. They are about 25 and 35 miles from Blackfoot, and Big Butte is 15 miles from Middle Butte and 20 miles from East Butte. The Lost River and Lemhi ranges may be seen behind the buttes.

North of Gibson there may be a few tepees along the road. At the south end of the bridge over Blackfoot River there is a well-appointed ranch, the home of a prosperous Indian who owns an automobile and has several hundred head of horses and cattle in the hills.

This bed is also of uniformly high quality, averaging 32 per cent or more of phosphoric acid, equivalent to 70 per cent or more of bone phosphate. The total quantity of high-grade rock in this main bed, estimated for the areas examined by the Geological Survey in five years (not including Montana fields), is approximately 5,000,000,000 long tons. This estimate includes only rock that is believed to lie at minable depths—that is, less than 5,000 feet from the surface—but does not include a vastly greater quantity of lower grade rock.

The raw phosphate rock is not readily soluble, so that its action in fertilizing land is very slow, but the so-called superphosphate, made by treating the pulverized rock with sulphuric acid, which the smelters of the West can furnish in large quantity, contains phosphate in more easily soluble and available form. At present, on account of the cost of transportation to the eastern markets, the demand for western phosphate is confined to the Pacific Coast States, and even here it is in competition with phosphate rock imported from Ocean Island. Of the total phosphate rock produced in the United States in 1914, the Western States furnished less than one-half of 1 per cent. With the growing recognition of the importance of intensive agriculture and the consequent need of fertilizers in the great agricultural districts that have passed the period of maximum fertility, the demand for phosphate rock is certain to increase. Although at present the deposits in the Eastern States are more accessible to markets, these deposits are already approaching partial exhaustion, so that this rich and extensive western field, already important as a grazing district, is destined to become the scene of another thriving industry.

Blackfoot River,[1] which the railroad crosses 1 mile south of the village of Blackfoot, is the north boundary of the Fort Hall Indian Reservation.

Blackfoot.

Elevation 4,502 feet.
Population 2,202.
Ogden 158 miles.

Blackfoot city and river are named from a tribe of North American Indians. The name is explained as an allusion to an observation by pioneer whites that their leggins were generally blackened by walking over the freshly burned prairie. The Indians commonly seen about the station and on the streets, however, belong to the Lemhi, Bannock, or Shoshone tribes. Blackfoot is the business center of a large, well-settled, and prosperous irrigated agricultural district, and is sometimes called the "grove city," because all the streets in the residence section are well lined with mature shade trees. It is noteworthy that the first trees ever planted in upper Snake River valley were set out around the Blackfoot courthouse in 1886, and a ditch was constructed for irrigating them. Three grain elevators and a flour mill suggest that a large part of the produce of the surrounding district is grain. The railroad station, one of the finest on the line, is built of pink rhyolite, a lava rock that is abundant in the hills to the east. Blackfoot is the junction point for branch lines to Mackay and Aberdeen. Gasoline motor trains are run on these lines and also to Pocatello. The city water supply is pumped from wells drilled to depths of 120 to 150 feet, which reach basalt (black lava) at 65 feet. These wells show the depth of sand and gravel deposited at this place by Snake and Blackfoot rivers in wandering about over the surface before settling in their present courses.

The electricity used in Blackfoot is brought from a power plant on Snake River at American Falls, 40 miles to the southwest.[2] Gold placers on Snake River about 15 miles below Blackfoot have been worked intermittently in former years, but are now idle. In hard times a few men wash out a little gold by panning, but here, as elsewhere on Snake River, the gold is so flaky and fine that it is difficult to recover. Several attempts at large operations with dredges have been failures. A beet-sugar factory at Blackfoot, built in 1905 at a cost of $500,000, contracts for the beets from about

[1] The mean discharge of Blackfoot River in 1906–1909, measured at Presto, a few miles upstream from the railroad, was 415 cubic feet a second. It has a recorded range from a maximum of 2,370 to a minimum of 64 cubic feet a second during that period. No hydroelectric power plants are in operation or in process of construction on this stream. Although the fall of the river from the Blackfoot dam down to the mouth of the canyon is comparatively great, the storage of water for irrigation makes it impracticable to develop any very large amount of continuous power. Besides the 48,000 acres to be irrigated on the Fort Hall Reservation, 6,000 to 10,000 acres are irrigated by independent or private ditches taking water from the river.

[2] The mean discharge of Snake River at Blackfoot during 1911–1914 was 7,930 cubic feet a second.

7,000 acres and pays $5 a ton for them. The average yield is about 12 tons to the acre, but some tracts under skillful treatment produce 20 to 22 tons.

The flat extending from Snake River, 3 miles west of the railroad, to the foot of the hills on the east is all under irrigation ditches, practically every acre being cultivated. The agricultural interests of this valley are diversified; no one crop predominates. On either side of the track are fields of alfalfa, barley, oats, potatoes, sugar beets, timothy, and wheat. Apple orchards are common. Many of the highways are lined by trees, and almost every group of farm buildings is shaded and sheltered by Lombardy poplars. This tall poplar, a native of Europe, is a favorite because the trees grow rapidly and, if planted in rows close together, make excellent windbreaks. They are propagated by means of cuttings. While viewing this prosperous and beautiful rural country the traveler should bear in mind that only a few years ago, not further back than 1885, the entire Snake River plain was one great sagebrush desert, wholly barren of trees and populated mainly by jack rabbits, coyotes, and rattlesnakes.

Wapello.
Elevation 4,542 feet.
Ogden 164 miles.

Wapello in 1914 was a new settlement consisting of a store, a school, and a railroad siding. The trees about a mile to the west are on the bank of Snake River, the main stream of southern Idaho. The name of the river is said to be the translation of the name of a tribe of Indians, the Shoshones, who live along its banks. The river rises among the high peaks of the Rocky Mountains in Yellowstone National Park, flows southward, broadening into Jackson Lake, and then northward, and near Rigby, Idaho, is joined by Henrys Fork, locally known as the North Fork, which rises in Henrys Lake, near the Idaho-Montana State line. The portion of Snake River above Henrys Fork is locally known as the South Fork. These two streams receive numerous tributaries, much of whose water the year round is melted snow. Below the confluence Snake River flows in a general southwesterly course for 150 miles, to a point a short distance below the American Falls, where it turns nearly westward.

Firth.
Elevation 4,564 feet.
Ogden 169 miles.

The small settlement of Firth, which was started about 1911, is on the Snake River flat or first bottom. A three-span steel highway bridge crosses the river near by. Half a mile north of Firth the river itself first comes into sight from the train. The bluff rising to the second bottom is just east of the track. Five miles east of Firth a second bluff rises about 50 feet to a third flat or bottom. This flat is composed of material brought down from the mountains by Blackfoot River and deposited on the plain at the mouth of its canyon.

Blackfoot River has had a hard fight for existence. When the earth's crust cracked and broke and quartzites and limestones were faulted up across the river's course, it kept its place by grinding down its bed. The upturned hard rocks made a mountain range through which the river cut a narrow valley. This valley was afterward flooded with rhyolitic lava and the river had to grind its bed down again. After it had regained its grade through the rhyolite that blocked its course a stream of molten basaltic lava flowed down the channel, and for a long time all water that came this way was turned to steam. When the hot lava became cold rock Blackfoot River began a third time the task of sawing its bed down to grade. It has now sunk a deep, narrow canyon in the black basalt so deep that the road up the river is on a bench 100 to 300 feet above the stream.

The mountains east of Firth and Monroe, rising 7,000 feet above the sea, or 2,500 feet above the plain, are mostly made of limestone of Carboniferous age or older. They contain also younger rocks, but all the beds are so tilted and broken up that their relations are difficult to determine. Some of the mountains are included in the areas of phosphate land withdrawn, for high-grade phosphate rock has been found here by members of the United States Geological Survey.

The belt of irrigated land on the west side of Snake River at Firth is very narrow, owing to the fact that the "lavas" are close to the river. By this term is meant the area in which black lava, crumpled into low ridges, makes a rough surface with very little soil. Many of the ridges are cracked open along their axes as a result of internal movement after the surface of the lava had cooled. These cracked folds are called pressure ridges. The soil on the "lavas" is too poor and thin to be cultivated, and is used only for pasturage. Farther downstream the "lavas" recede from the river bank, and irrigation projects[1] have made great tracts of desert available for settlement.

[1] Water is diverted from Snake River at the Minidoka dam, 80 miles below Blackfoot, and at the Milner dam, 35 miles farther west. Jackson Lake, in Wyoming, just south of Yellowstone Park, has been made into a great reservoir in which 380,000 acre-feet of water, or enough to cover 380,000 acres to a depth of 1 foot, is now stored by the United States Reclamation Service for use on the Minidoka project. During 1914 work was in progress of raising the dam at the outlet of the lake to such an extent as to make it possible to store 780,000 acre-feet. The expense of this new work is being borne by the North and South Side Twin Falls projects, and the additional water obtained will be used on these projects.

The Minidoka project includes 117,090 acres and during 1913 81,518 acres was actually watered. The principal crops raised here are alfalfa, grain, wheat, oats, barley, potatoes, sugar beets, miscellaneous hay crops, and fruit—chiefly apples. Stock raising and dairying are thriving industries.

At the Milner dam water is diverted for irrigating lands included in the North and South Side Twin Falls projects. The exact area to be irrigated has not been definitely determined but will be about 400,000 acres. During 1913 about 150,000 acres lying within the South Side tract was watered and in cultivation. The land is used for alfalfa, wheat, oats, pasture, apples, potatoes, and peas. Sheep and hog raising are profitable industries. The crops raised on the North Side tract are similar.

Monroe.

Elevation 4,605 feet.
Ogden 172 miles.

Two miles north of Monroe siding and 1½ miles east of the track there is a low sandy hill, on the top of which is the reservoir in which the water supply of Shelley, pumped from a deep well, is stored. This hill is basalt partly mantled with drifted sand. Northeast of it there is a series of moving sand dunes extending for about 8 miles in the direction of the prevailing winds.

Shelley.

Elevation 4,619 feet.
Population 537.
Ogden 175 miles.

Shelley is the trading point for several small settlements away from the railroad and is the center of an irrigation district which has been brought to a high grade of cultivation.[1] A hydroelectric plant on Snake River, 2 miles north of Shelley, develops about 8,000 horsepower for use in this part of the valley.

West of Shelley the three buttes previously described are plainly visible far out on the Snake River lava plain. East Butte (Pl. XXX, *B*, p. 112) appears to have two sharp peaks between which there is a saddle-shaped depression. Big Butte has a less pronounced sag top, and Middle Butte shows a gentle south slope and steep north slope, which indicate that it is not a volcano. To the northeast, beyond the first low range of lava hills, is the crest of the Caribou Range. In very clear weather one can see more than 70 miles away a snowy peak coming into view over the crest of this range. This is Grand Teton, 13,747 feet high, the culminating peak of the range lying west of Jackson Hole and the largest of the three peaks which have been known as the Tetons or the Pilot Knobs since the members of the Astor expedition first saw them in 1811. (See p. 17.)

Cotton.

Elevation 4,661 feet.
Ogden 179 miles.

At Cotton, a railroad siding 3 miles south of Idaho Falls, named for the owner of an adjoining ranch, an electric-power house may be seen on the bank of Snake River. Just north of Bach, another siding 1½ miles south of Idaho Falls, is a grove in Tautphaus Park. This is the local fair ground, where the annual War Bonnet round-up is held. Every September for five days Idaho Falls is thronged with visitors. They come to see cowboys and Indians with their race horses, bucking horses, and wild steers gathered here to amuse the crowd and to contest for prizes in feats of skill in riding and rope throwing. The War Bonnet round-up is to Idaho what Frontier Day at Cheyenne is to Wyoming and the round-up at Pendleton is to Oregon.

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[1] The variety of products of this type of land is shown by the freight shipments made from Shelley from July 1, 1913, to June 30, 1914. According to the statement of P. J. Bennett, a notary public in Shelley, the shipments, in carloads, were: Wheat, 49; oats, 34; potatoes, 937; beets, 722; live stock, 104; mill stuff, 37; hay, 25; apples, 6; miscellaneous, 31; total, 1,945 carloads, or more than 74,000,000 pounds.

Idaho Falls.

Elevation 4,708 feet.
Population 4,827.
Ogden 184 miles.

The city of Idaho Falls has a significant name and its site has had an interesting history. Snake River[1] here falls over the edge of a lava flow, and the incessant wear of the running water has cut the falls back into the lava sheet fully half a mile and they are now at the head of a narrow canyon, the walls of which are at one point barely 50 feet apart. Here a toll bridge was built in 1866, and the toll money collected from the freighters over the Utah-Montana trail started a store and the store started a town. The town was called Eagle Rock, because for many years an eagle had a nest on the large rock in the stream just above the bridge. The name was changed to Idaho Falls a few years ago. Snake River forms the west boundary of the city, and the falls, the eagle rock, and the site of the original bridge are only three blocks west of the railroad.

Steel was laid on the main line north from Idaho Falls in 1879, and the railroad was completed to Silverbow, 6 miles from Butte, Mont., in 1881. The branch line to Yellowstone was completed in 1906. In 1914 a loop around the valley was being built from Idaho Falls northeastward to cross Snake River (South Fork) below Heise Hot Springs and thence go north to St. Anthony.

Idaho Falls owes its prosperity to the large quantities of farm products raised in its vicinity and is the most important shipping point between Ogden and Butte. Practically all the land in this part of the valley is in a high state of cultivation under irrigating ditches. The average yield of grain to the acre in the upper Snake River valley, on irrigated and dry land taken together, is estimated to be as follows: Wheat, 40 bushels; oats, 70 to 75 bushels; potatoes, 200 bushels; and beets, 14 tons. These averages are far below what the successful rancher gets, for oats on irrigated land make from 50 to 120 bushels an acre and weigh from 40 to 44 pounds to the bushel. Two hundred bushels of potatoes is a light yield, 200 sacks or 400 bushels a good yield, and it is reported that as high as 700 bushels an acre have been raised in one 20-acre tract. In 1913 the district between Blackfoot and St. Anthony shipped 5,000 cars of potatoes, Idaho Falls alone being the shipping point for 2,500 cars. Potato bugs are as yet unknown in this region. Wheat on irrigated land yields from 40 to 60 bushels, weighing from 60 to 63 pounds to the bushel. It is reported that one tract of 720 acres averaged 38 bushels an acre in 1913, and as much as 70 to 75 bushels an acre has been produced in 10-acre tracts. It is said that almost no commercial fertilizer is shipped to this country. Crop rotation is practiced. When oat fields fail to yield 85 bushels an acre, some ranchers sow them with alfalfa or clover for a few years. Seed peas and beans for planting kitchen gardens from Maine to California are grown in the upper Snake River

[1] The mean discharge of Snake River at Idaho Falls from 1890 to 1892, inclusive, was 10,300 cubic feet a second.

valley, and a seed-cleaning mill stands near the Idaho Falls station. Raw land with water right sold in 1914 for $40 to $60 an acre, and improved land brought $65 to $160 an acre, depending on the improvements, the lay of the land, and the location.

Red Duroc Jersey hogs are favorite money makers in this region, and sheep and cattle are ranged in the mountains in summer and pastured at the valley ranches in winter. The honeybee is respected and encouraged to greater industry. One man in this vicinity has 600 colonies of bees and keeps 4 tons of honey for their winter feed. Another bee keeper in the valley has 3,000 colonies. A factory at Idaho Falls extracts, stores, and ships hundreds of tons of alfalfa and sweet-clover honey every year.

A round stone tower (used as a tool house), which stands on the lawn at the north end of the Idaho Falls station shows the fitness of the local lavas, rhyolite and basalt, for use as building stone.

Soon after leaving the city[1] the train passes the first beet-sugar factory built in Idaho. It was erected in 1903 at a cost of a million dollars and has added much to the growth of Idaho Falls. Lincoln, a settlement of 300 people around the sugar factory, is reached by a branch line.

St. Leon.

Ogden 189 miles.

St. Leon is a siding at the crossing of Willow Creek. Far to the east, if the air is clear, two of the three Teton peaks are visible, and on the west, 12 miles from Idaho Falls, there is a low, broad, slightly sag-topped cinder cone, which holds a bowl-shaped depression about a quarter of a mile in diameter. Near this cone in 1914 there was a single tract of about 2,000 acres of dry-farm wheat.

Ucon.

Elevation 4,799 feet.
Ogden 192 miles.

The sagebrush plain just north of Ucon suggests what the whole valley once was, and the fertile fields already passed show what can be done by irrigation. Very little of the soil of the Snake River plain is derived from the basalt on which it lies. There is an abrupt change from the soil to the lava, and the exposed surface of the lava shows practically no trace of disintegration. The soil near the rivers, on their present or former flood plains, is largely river deposit, and that near the mountains is mountain waste, but the fine soil that covers the plains at a distance from the mountains is mainly wind-blown dust, which has accumulated gradually in the centuries since the basalt was poured out The sources of the dust are the naked cliffs in the mountains, talus slopes, stream deposits on the margin of the plains, and volcanic ashes. The Market Lake Craters (see p. 137), truncated volcanic cones 10 miles northwest of the track, and other volcanoes of that type threw out large quantities of volcanic dust. A vigorous growth of sagebrush attests the good quality of the soil.

[1] Mileposts north of Idaho Falls give the distance from this junction.

Near Ucon, as elsewhere in the valley, all trees except those along Snake River have been planted by the settlers. The main highway from Idaho Falls to Yellowstone Park parallels the railroad for several miles, but farther north it follows section lines, making the distance between towns by the highway somewhat greater than the railroad mileage.

North of Ucon the summit of the third and lowest of the three Teton peaks comes into view; farther north, at Ashton, they come into full view. The Teton Mountains were named from an Indian tribe. In "Astoria," Washington Irving's entertaining description of John Jacob Astor's expedition which crossed this country in 1811 on its way to establish a trading post at the mouth of the Columbia, there is the following reference to these mountains:

> September 15 one of the guides pointed to three mountain peaks glistening with snow, which rose, he said, above a fork of Columbia River. These remarkable peaks are known to some travelers as the Tetons; as they had been guiding points for many days to Mr. Hunt, he gave them the name of the Pilot Knobs.

The Astor party came into Idaho near Victor, the present terminus of a branch of the Oregon Short Line at the west foot of the Tetons, and followed down the valley of Teton River, reaching Henrys (North) Fork of Snake River near the present site of St. Anthony, where there was then a "fort" established by Mr. Henry, of the Missouri Fur Co. At the fort they built canoes and started down Snake River. The next day they reached some falls about 30 feet high, took another day to portage around them, and then pursued their journey southward from the present site of Idaho Falls. They soon found the river unnavigable, had to abandon their canoes and strike across country, and endured terrible privations the following winter, the account of which is told in thrilling narrative by Irving.

A branch railroad running northwest from Ucon passes through Menan, 2 miles south of the Market Lake Craters.

Rigby.
Elevation 4,851 feet.
Population 555.
Ogden 198 miles.

Rigby is the largest town in the east end of Jefferson County and is the trading and shipping point for an agricultural district having a population of several thousand. It was organized in 1886 by the Mormon apostle John W. Taylor, from Utah, and William F. Rigby, of the local church authorities. A post office was established in 1888, and the railroad came in 1899. Within 15 or 20 miles above Rigby, on Snake River, are the headgates of a dozen or more canals in one stretch of the river—a canal every three-quarters of a mile. These canals, when full, carry every minute enough water to flood 8½ acres to a depth of more than 1 foot. This great system of canals was built not by the Government or by promoters, but by the ranchers whose land they irrigate. The first canals were built between

1879 and 1884, when settlement began in this section. Potatoes are the leading crop near Rigby and a common yield is 300 bushels an acre. Under especially favorable conditions of soil treatment 700 bushels are said to have been taken from 1 acre. Wheat is reported to average about 45 bushels an acre, oats 65 bushels an acre, and beets 20 tons an acre.

Heise Hot Springs, 11 miles east of Rigby, is a resort on the north bank of Snake River (South Fork), at the foot of the wall formed by rhyolite tilted and overlain by horizontal younger lava flows. A log hotel that will accommodate about 150 guests and a bathhouse with two concrete pools have been built at hot springs which issue from the bank of the river. The springs have temperatures of 126° to 140° Fahrenheit. The water smells of sulphur and is strongly mineralized. Bathing in it is said to relieve rheumatism. Fishing is popular at this resort in summer and elk hunting in winter.

For a number of miles north of Rigby the railroad crosses a delta-like deposit built by Snake River. The stream brings great quantities of sediment down from the mountains, and here, on the Snake River plain, where the grade of the stream is decreased and its velocity is slackened, much of its load has been dropped. As a result, a low, broad fan has been built up, across which the river now flows in a number of channels. Henrys Fork joins Snake River at the base of the two craters seen a few miles to the west.

Between Rigby and Lorenzo the railroad crosses the "dry bed" of Snake River. This was formerly the main watercourse, but in 1894 the current shifted to the channel it now occupies, north of Lorenzo. At times there is water in the old channel, as part of its upper course is used as an irrigating canal.

The beet-loading platform at Lorenzo indicates one of the principal crops in this vicinity. Just after passing the station the train crosses the main channel of Snake River, which at this point is 500 feet wide.[1]

Lorenzo.

Elevation 4,866 feet.
Population 379.*
Ogden 202 miles.

The Market Lake Craters, 4 miles west of Lorenzo, are two low buttes, broad of base, with gently sloping sides and broad tops, rising 500 to 600 feet above the surrounding plain. Each butte has an oval base measuring about 1 by 2 miles, and each has a well-defined crater in its summit about half a mile in diameter and 150 to 200 feet deep. The beds of ejected material slope away in all directions at sharp angles around the rims

[1] The discharge of Snake River at Heise Hot Springs, about 10 miles above this bridge, in 1910–1913, averaged 8,920 cubic feet a second. The maximum and minimum recorded discharges are 36,000 and 2,310 cubic feet a second. The river passes through several canyons where dam sites could be found. The fall between Jackson Lake and Henrys Fork is about 2,000 feet. A large amount of potential power therefore exists along this stretch of Snake River.

of the craters and flatten toward the base, where they become nearly horizontal. Within the crater rim the beds slope toward the center. Sand and gravel contained in the strata of which the craters are built indicate that these volcanoes were upheaved somewhat explosively through an old river or lake deposit. There is nothing to show that either cone poured out a lava stream. Material brought into the craters by rain wash and wind has given fairly level floors to the broad bowl-shaped depressions. The two cones are supposed to be of about the same age and are moderately recent. The name was derived from their proximity to Market Lake, a former shallow body of water so called because ducks congregated on it in such numbers that hunters went there regularly for a supply of meat.

A black volcanic tuff, an open-structured rock made of partly cemented fragments and dust produced by volcanic explosions, is used for building in the vicinity of Rigby and Rexburg. This rock is quarried on the bank of Snake River at the base of the Market Lake Craters. Houses are built also of the pink rhyolitic lava which occurs abundantly in the hills at the east edge of the Snake River plain.

After crossing Snake River the train goes through a grove of native cottonwoods along the channels of the river. This is the only natural grove on the railroad between Ogden and the Targhee National Forest, north of Ashton.

Thornton.
Elevation 4,859 feet.
Ogden 205 miles.

A mile or two east of Thornton a bluff rises abruptly 100 feet or more to a bench. The foot of this bluff is the boundary between the rhyolite that forms the low hills to the east and the basalt that makes the floor of the Snake River plain. The relative ages of the two rocks are indicated by the fact that the rhyolite is deeply weathered and in places its beds are disturbed from their original nearly horizontal attitude, while the basalt is unweathered and its horizontal beds abut against or overlap the older rhyolite.

Several miles to the west there is a low-lying light-colored band of sand dunes with a group of hills at its north end.

Winder.
Elevation 4,855 feet.
Ogden 207 miles.

From Winder, a siding and beet-loading platform, a clear view may be had of the Market Lake Craters. Concrete tile for culverts is made here from sand and gravel dug beside the track. Near Rexburg the train crosses a large irrigating ditch, the water for which is taken from Teton River. Ricks Academy, a Mormon school, stands near the edge of the town. The numerous Mormon schools and churches in this region attest the fact that eastern Idaho was settled with the overflow population from Utah. In the late seventies and early eighties the fertile spots of northeastern Utah were already occupied and the stream of emigrants moved northward into Idaho.

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

YELLOWSTONE PARK ROUTE

From Ogden, Utah, to the Yellowstone National Park

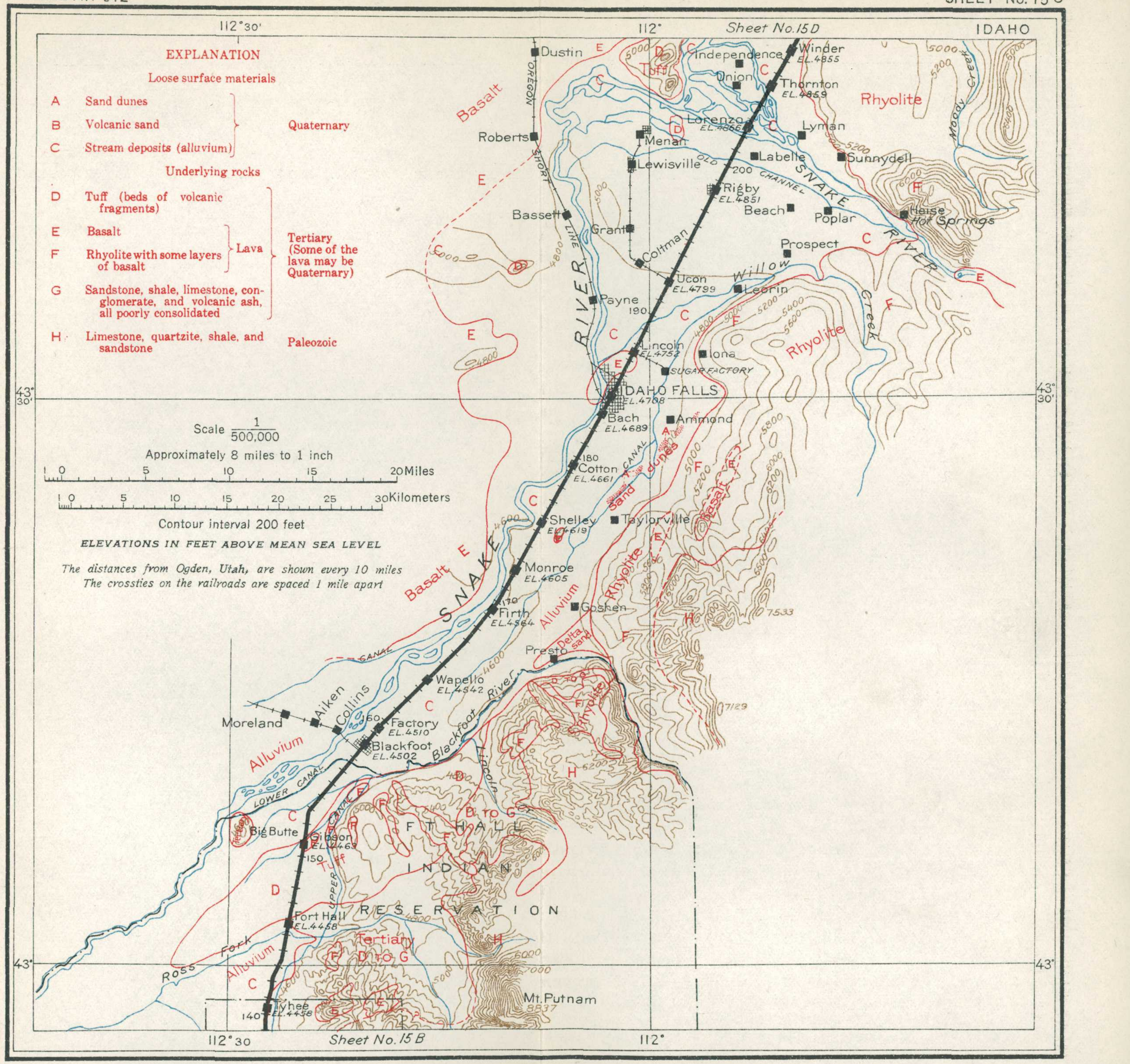
Base compiled from railroad alignments and profiles supplied by the Oregon Short Line Railroad Company and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist   R. B. Marshall, Chief Geographer

1915



Rexburg (see sheet 15D, p. 148) was founded in 1883 by Thomas Ricks, and the present name is a corruption of Ricksburg. Up to 1896 Rexburg was composed mostly of one-story dirt-roofed houses, but it is now a prosperous and well-appointed village, the county seat of Madison County, and the center of an irrigated agricultural district where crops never fail. Seed peas constitute one of the important crops. The produce forwarded from Rexburg in the 15 months between January 1, 1913, and April 1, 1914, was: Grain, 679 cars; flour, 256 cars; sugar beets, 226 cars; live stock, 190 cars; miscellaneous, 92 cars; total, 1,443 cars. Rexburg station is built of the local rhyolite or pink lava. Soon after leaving Rexburg the train crosses Teton River,[1] which drains Teton Basin and the west flank of the Teton Mountains.

Rexburg.

Elevation 4,866 feet.
Population 1,893.
Ogden 210 miles.

Sugar City is a settlement around a beet-sugar factory which was built in 1904 at a cost of $750,000. This factory contracts for the beets from about 7,000 acres and pays $5 a ton for them. A branch of the railroad runs west from Sugar City to Plano, tapping the lower end of the Egin bench, a celebrated and prosperous farming district on the west side of Henrys Fork.

Sugar City.

Elevation 4,890 feet.
Population 391.
Ogden 214 miles.

Four miles northeast of Sugar City is Teton City, a village of a few hundred people on the bank of Teton River, in the midst of grain and pea ranches. This settlement also was founded by Mormons, in 1883. The gently sloping hills from Teton City east to Canyon Creek are made up of rhyolite interbedded with a few thin layers of hard black basalt. The alternate layers of two different kinds of lava in these hills show that in the time of volcanic activity in this part of the country thick flows of rhyolite were succeeded by lesser flows of black lava. That the flows were separated by lapses of considerable time is shown by the presence of layers of soil between them. In a deep well hole sunk in the lava several miles east of Teton City the drill passed through a number of layers of soil between beds of basalt and rhyolite. One bed of soil was encountered at a depth of 400 feet.

A few miles north of Sugar City is a railroad siding known as Wilford. St. Anthony, the county seat of Fremont County, is hidden in the trees ahead. The building with a white dome seen on the left on entering the town is the county courthouse, and the large gray building just beyond the station is a Mormon temple.

[1] At the mouth of its canyon, a few miles east, Teton River has a mean discharge of about 900 second-feet. The maximum and minimum discharges recorded are 7,620 and 88 second-feet. There is a small hydroelectric power plant on this stream.

St. Anthony.

Elevation 4,969 feet.
Population 1,238.
Ogden 221 miles.

The location of St. Anthony, like that of Idaho Falls, was determined by the fact that the river has here cut a narrow canyon through basalt, with walls so close together that a bridge was easily built. Previous to 1893 this place included only "jack rabbits, lava rock, and Old Man Moon." C. H. Moon, the original settler, came here in 1887, built the first bridge and store, and called the place St. Anthony because of its fancied resemblance to St. Anthonys Falls, Minn. The river in the canyon has a fall of about 30 feet, and the walls at the highway bridge are barely 50 feet apart. Immediately below the bridge the river spreads out to an extreme width of 800 feet.

In the spring of 1893, when St. Anthony was made the county seat of Fremont County, the settlement consisted of three log cabins and one two-story log store building. The population increased rapidly from that date and now numbers about 2,000 persons. St. Anthony has two large schoolhouses, one of which cost $60,000, a $70,000 courthouse, an opera house, a large flouring mill, grain elevators, three banks, and a city water system supplied by pumping with electric power generated by Snake River.

One of the principal industries in the immediate vicinity of St. Anthony is the raising of seed peas. In 1913 there were 26,000 acres of seed peas in Fremont County. They are grown here extensively because the soil and climate are favorable, and under irrigation they yield heavily. There are nine seed warehouses in St. Anthony. The shipments from St. Anthony for the year 1913 were 396 cars of peas, 470 cars of oats, 259 cars of wheat, 10 cars of barley, 50 cars of potatoes, 106 cars of merchandise, 121 cars of stock, 52 cars miscellaneous; total, 1,464 cars. Thousands of head of stock are wintered in this vicinity each year after summering in the mountains.

As the train leaves the station a glimpse is had of Henrys Fork of Snake River. Twelve miles west of St. Anthony a group of hills known as the Sandhill Mountains rise about 1,000 feet above the plain. From a distance they appear to be two lines of hills with nearly parallel tops, but on entering the gap between these lines of hills one finds a cultivated valley surrounded on three sides by a ridge, the crest of which has rudely the outline of a mule shoe. The lava that caps this ridge slopes away on all sides from the central valley. This group of hills apparently is the broken-down remnant of an old crater. A great mass of yellow sand, drifted in from the southwest, is lodged in the north side of the crater.

Sand dunes 8 to 10 miles west of St. Anthony are plainly visible from the train. They consist of fine sand, which is drifting northeastward, and they cover several square miles. Most of the moving dunes are not more than 50 feet high, and between some of them the barren basalt bedrock is exposed. A well in the midst of these dunes is the source of drinking water for ranchers in the sand hills above.

A short distance north of St. Anthony there is a siding known as Twin Grove. To the west black basalt can be seen along Henrys Fork, and there is a broad view beyond the Sandhill Mountains, showing the uneven surface of the lavas in the distance.

Chester.

Elevation 5,073 feet.
Ogden 227 miles.

Before reaching Chester the train passes through a small cut in basalt and the plain on the east is seen to be less smooth, owing to the thinness of the soil on the irregular surface of the underlying black lava. The low and gently sloping hills beyond are underlain by rhyolite. Far to the north is the flat-topped ridge which forms the front of the great elevated volcanic province around Yellowstone Park and which terminates the Snake River plain. Chester is the site of a grain elevator and a few houses. Where the railroad crosses Fall River [1] there are exposures of basalt in the banks and bed of the stream.

After crossing Fall River the railroad leaves the flat floor of the Snake River plain and heads directly for Ashton over a slightly rolling surface of basalt which is exposed in the railroad cuts. The porous, cellular, or vesicular character of this black rock can be seen from the train. The cavities were developed by expansion of gases (probably for the most part steam) contained in the molten rock and are a common characteristic of the Snake River lava.

Ashton.

Elevation 5,256 feet.
Population 502.
Ogden 235 miles.

Practically all the cultivated land hereabouts is in grain, and four grain elevators at Ashton are seen directly ahead. Ashton, which was started in 1906 when the railroad reached this point, was named for the original owner of the town site. The water supply is pumped from a deep well, and electricity is brought from a hydroelectric plant on Snake River. Ashton is an outfitting point for the fishing and hunting grounds to the north and east and for camping parties bound for Yellowstone Park.

The view of the Teton peaks from Ashton (fig. 15) is superb and doubtless has been the inducement for many a tourist and sportsman to leave the main line for the Teton Range and the Jackson Hole country in pursuit of elk, sheep, trout, and unsurpassed mountain scenery. Owen Wister's "Virginian" was glad to get out of these mountains because, as he explained, "They 're most too big."

[1] The following measurements of Fall River were made about 12 miles above the railroad bridge in 1904–1909: Maximum discharge, 4,160 cubic feet a second; minimum, 168; mean, 800. No information is available concerning power sites. Water from the river is used for irrigation, but to what extent is not known.

The average American, who has only a vague conception of the natural beauties of the Rocky Mountains and imagines that real alpine forms are found only in Switzerland, must be surprised when he first sees the lofty peaks of the Tetons. Even a man who has climbed the Matterhorn would hesitate before daring to try Grand Teton. According to local report, this peak has been ascended only twice, in 1872 and 1894. As the snow-clad mountains along the Alaskan Archipelago, rising to cloud-reaching heights, stand with their feet bathed in the ocean, so from a viewpoint near Ashton the Tetons, towering to the sky, rise from the billowy surface of a sea of golden grain. The people who live within the shadow of these mighty peaks soon look to them only as barometers of to-morrow's weather; they no longer see the grandeur that thrills the traveler, heartens the hunter, and inspires the artist.

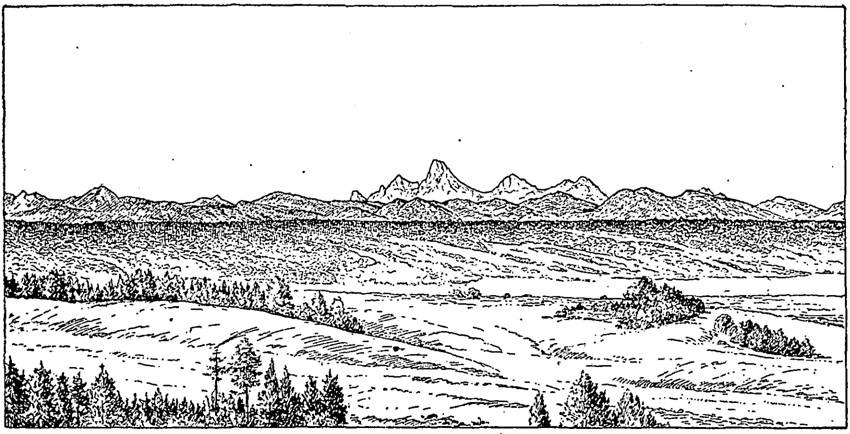


FIGURE 15.—The Three Tetons, looking east.

Ashton is the junction point of the Victor branch of the Oregon Short Line, which was built to Teton Basin in 1912. On this branch $1\frac{1}{2}$ miles from Ashton is Marysville, a small rural settlement that can be recognized from a distance by its grain elevator. From Marysville to Jenkins all the railroad cuts appear to be in glacial material, and probably a glacier heading in the Teton Mountains once extended nearly to Ashton. The canyons of Fall River and Squirrel and Bitch creeks, which the branch line crosses on high trestles, are cut in rhyolite. It was along Bitch Creek that the "Virginian" idled and fished on the day after Steve and Ed, the horse thieves, paid the penalty. Drummond, Driggs, Tetonia, and Victor are the main settlements on the branch. Victor, the terminus, is a small village 46 miles from Ashton, from which the mail stage road climbs over the Teton Range to Jackson Hole. There is a trail over the range from Driggs also. On the west side of the Teton Basin, near Victor, is the

Horseshoe Creek coal district, which contains several beds of excellent bituminous coal of Cretaceous age.[1]

North of Ashton fields of grain slope gently to the river. Here the Snake River plain ends and the train enters a region of wooded hills. The upland against which the great plain terminates is the edge of the Yellowstone Park plateau, an elevated area of volcanic origin. In geologically recent time (Eocene and Neocene epochs) volcanoes on the east, north, and west of the park poured out enormous volumes of molten rock. Flows of rhyolitic lava filled the depressed basin between the encircling mountains and moved down the outer slopes to a considerable distance. It is the outer edge of these lava flows that the train crosses on entering the shallow rock-ribbed canyon of Henrys Fork. Here outcrops of rhyolite are seen close to the track for the first time on this line. From the entrance of this canyon to the end of the railroad the route is across lavas which are older than the basalt underlying the Snake River plain. Rhyolite is the predominant rock in Warm River canyon and on the Continental Divide, but basalt, which is interbedded with the rhyolite, and is much more resistant to weathering and erosion, underlies the mesas and caps the canyon cliffs.

In the canyon of Henrys Fork rounded outcrops of rhyolite stick their heads above the river and form the lower part of the vertical walls. Basalt makes the rim of the canyon, and its columnar jointing and cellular character may be seen from the train. The trees are Douglas fir, outliers of the Targhee National Forest, within whose boundaries the route continues to Reas Pass.

Warm River.

Elevation 5,284 feet.
Population 146.*
Ogden 242 miles.

Warm River station is at the junction of Warm River and Henrys Fork. The few settlers whose homes are along the valley bottoms cultivate the benches above the canyon rim. Warm River is so called because it has a warmer temperature than that of other waters in the region. This immediate vicinity fits the description of the country where Owen Wister's "Virginian" caught and hung the horse thieves. That job was done west of the Tetons and a day's ride from Bitch Creek.

Here the railroad leaves Henrys Fork and follows the canyon of Warm River through the wildest scenery on the entire route from

[1] The coal beds are irregular in thickness and extent, are displaced by numerous faults, and dip at steep angles. The Government geologist who examined the field concluded that the coal beds are thick enough to be mined profitably if they were horizontal; but the steep dip and the breaks in the continuity of the beds render mining expensive, difficult, and uncertain. The district can supply a local domestic trade for a long time, but can not be reckoned as a factor in the great coal industry of the Rocky Mountain region.

Ogden to Yellowstone. The first bridge above the station crosses Robinson Creek.[1]

Just beyond this bridge the train crosses Warm River and begins to ascend along its west bank. The grade of the track is greater than that of the stream, so the train is soon well above the dashing, tumbling, noisy brook. From this place to Mesa the angler will mentally choose his flies and long for a chance at the trout that must be hidden in those pools and rapids. Little will he care that the roadbed is a niche cut in rhyolite and that there is a small fault marked by little springs in opalescent-colored lava just below milepost 62. Immediately at the milepost the rhyolite is turned on edge, crushed, and clay streaked, but the beds at the top of the cut are horizontal, showing that there was considerable disturbance and faulting before the later lava flow. The dashing mountain stream, tumbling and jumping over bowlders, makes a more vivid appeal to the traveler than the evidences of that stream's ancient history, which is recorded in the thick beds of finely sorted sand and the thin beds of gravel exposed above and below the tracks at milepost 63. This material was deposited in ponded water after the river had cut its channel nearly to the present depth. To the question, What and where was the dam that made a pond 100 feet deep in this canyon? the geologist has not yet found an answer.

Near milepost 63 a 561-foot tunnel is to be driven to avoid the danger from the scaling off of rocks in the points around which the track now winds. A short distance beyond the trestle, at milepost 66, the train leaves the canyon and comes out on a flat surface underlain by basalt.

Mesa.
Elevation 5,920 feet.
Ogden 251 miles.

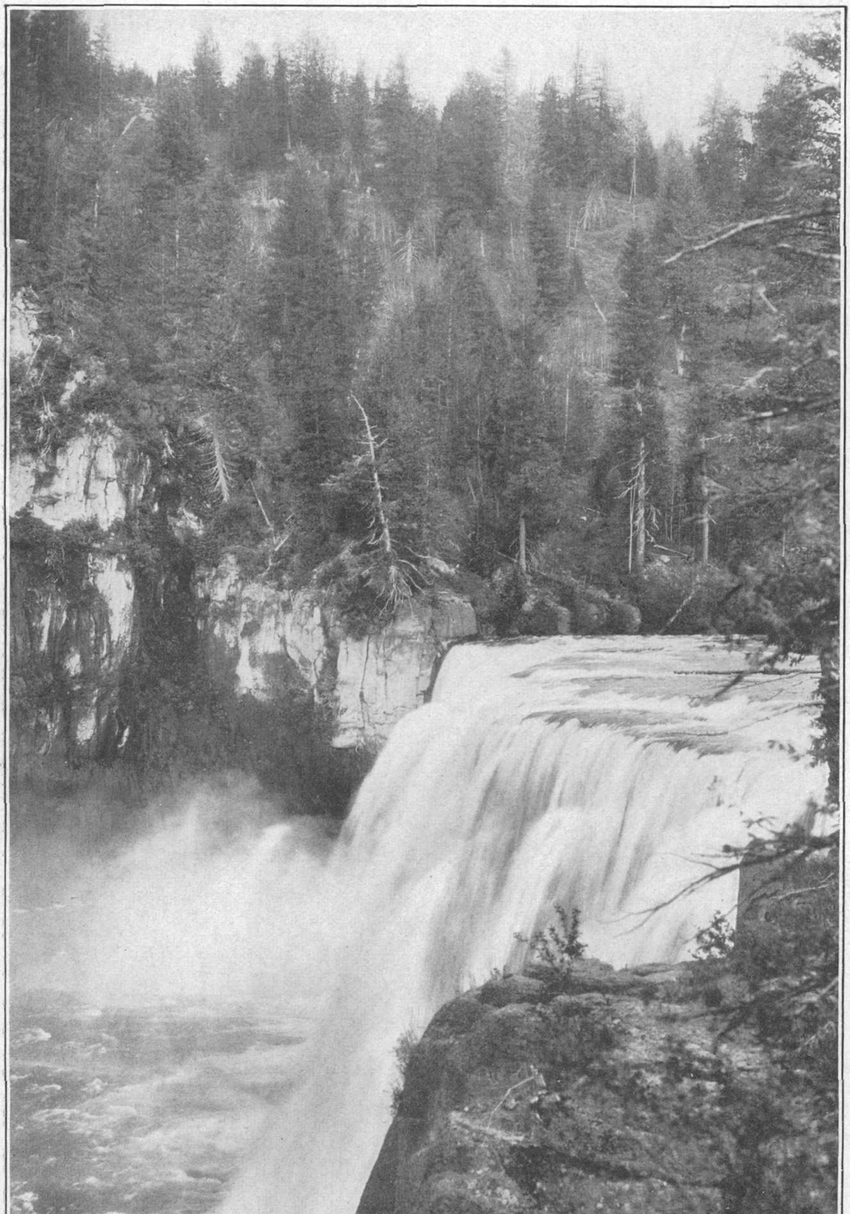
Mesa is a siding and Y in a natural park in the forest. The principal timber seen here is Douglas fir. From Mesa the serrate crest of the Teton Range is again in view, and a mile or two away on the right is the front of a great sheet of lava, now covered with grass and trees, rising 500 feet above the flat.

About 4 miles southwest of Mesa Henrys Fork plunges over a precipice 96 feet high with a sheer drop, and a mile below there is

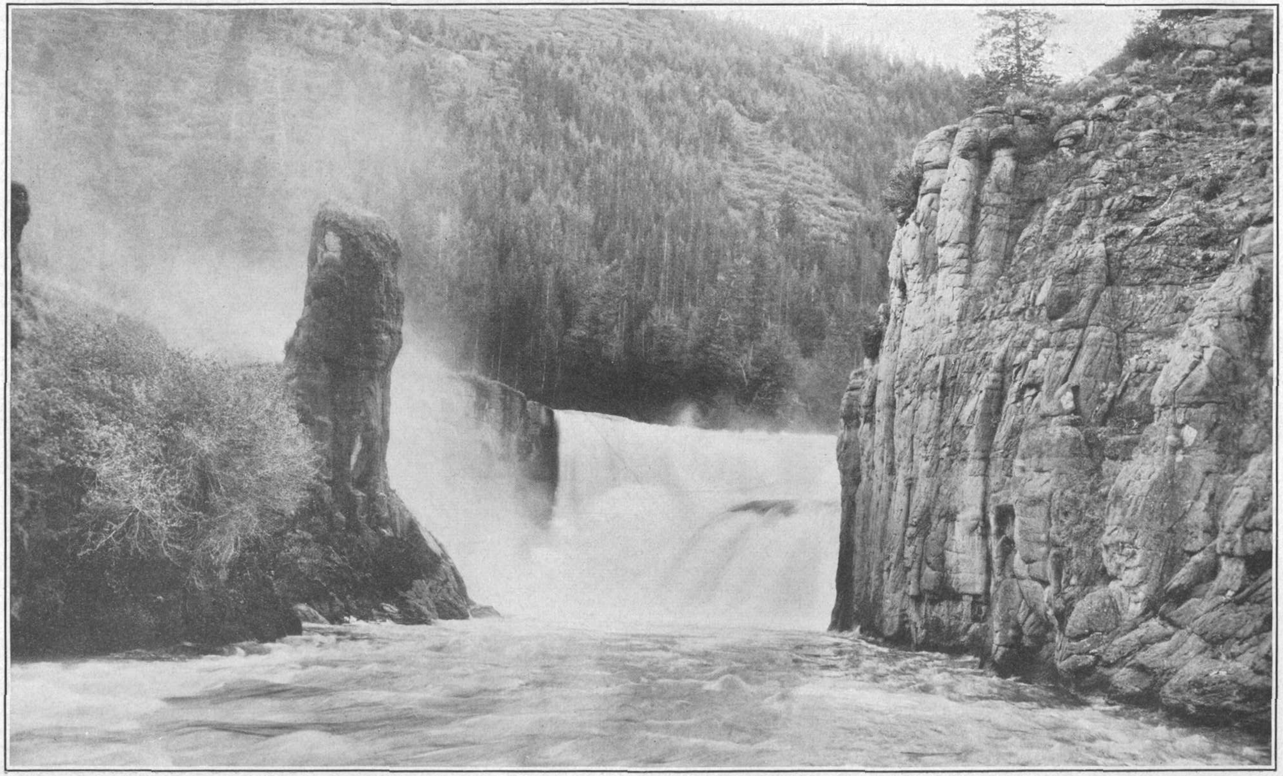
[1] The discharge of all three streams has been gaged near this station with the following results, expressed in second-feet (cubic feet a second):

	Maximum.	Minimum.	Mean.
Henrys Fork, 1910-1913	3,300	705	1,260
Warm River, 1912-13	900	192	295
Robinson Creek, 1912-13	1,140	53	180

There are no existing power developments on Warm River and Robinson Creek, and the water of these streams is not used to any great extent for irrigation.



UPPER FALLS, HENRYS FORK OF SNAKE RIVER.



LOWER FALLS, HENRYS FORK OF SNAKE RIVER.

another fall of about 70 feet. (See Pls. XXXII and XXXIII.) The river between these two falls flows rapidly in a canyon about 250 feet deep. The land in the vicinity is now owned by a Montana electric company, which contemplates building a dam 2 miles above the upper fall and carrying the water to a power house below the lower fall, thereby getting a drop of about 450 feet with a force sufficient to develop 40,000 horsepower.

About a mile north of Mesa, east of the track, there is a beaver pond, recognizable by dead trees standing in a marsh. From Mesa to Fishatch the railroad runs in a lane hewn through the forest and there is little to be seen. All the rock exposed is dark porous basalt. The low ridges through which railroad cuts have been made to depths of 6 to 10 feet—for example, that just north of milepost 70—show either arched structure or a roof-like form cracked along the top. These are called pressure ridges and seem to have been produced by an internal movement in the lava after the surface had hardened and become more or less rigid.

Fishatch.

Elevation 6,119 feet.
Ogden 257 miles.

A State fish hatchery built in 1908 is located at the station called Fishatch, on the bank of Warm River. The main building is a log structure 40 by 80 feet, equipped with 56 hatching troughs. These troughs are supplied with water from Warm River, which passes under the railroad at this point in a concrete culvert. The hatchery breeds trout exclusively, including rainbow, eastern brook, and native trout. The hatchery has a capacity of 3,000,000 fry annually. Beef liver, ground very fine, is the principal food of trout fry. Within the State reservation of 1,280 acres there are large springs of fresh water with a temperature of 42°, which supply the spawning pond and several concrete rearing ponds. Black and brown bear and moose are hunted successfully in this vicinity.

For half a mile north of Fishatch the view from the rear of the train shows the distant snowy Teton peaks framed in a lane through the evergreen forest. On the west, at milepost 75, an old beaver dam, now grown up with willows, is seen in the ponded Warm River close to the track. Fishing for native and eastern brook trout is said to be good here..

Island Park.

Elevation 6,290 feet.
Ogden 265 miles.

At milepost 78 the train enters the lower end of the Island Park country. Here are pits from which sand is taken by steam shovel for railroad ballast. Island Park is an open sagebrush tract several square miles in area, surrounded by a solid wall of lodgepole pine with a border of aspen. This broad flat is underlain by sand and fine gravel, composed largely of disintegrated volcanic rocks with a considerable percentage of black volcanic glass or obsidian. This mixed material is either alluvium deposited by Henrys Fork on its wide valley floor or a lake deposit. It may have been laid down in a lake caused by the ponding of the river by a glacier in the canyon below Mesa. An ice tongue or glacial dam in this canyon would have held the water back in a broad lake in which would have accumulated a deposit of sand and gravel such as is seen in the ballast pits. A low rise indicated by a slightly greater height of the tree tops about 3 miles west of Island Park is said to be an old volcanic crater. Mrs. E. H. Harriman has a large cattle ranch on the river 6 miles west.

At milepost 84 the railroad crosses Buffalo River, and a third of a mile north of the bridge there is a small cut in rhyolite, the first exposure of bedrock along the track north of Island Park. This stretch of straight track heads nearly into the gap below Henrys Lake. On the left of the gap is Sauttelle Peak, flat-topped and rising 10,123 feet above sea level, or 3,800 feet above the river. Three miles west of it is Bald Peak. The mountains east of the gap are called the Henrys Lake Mountains.

Trude.

Elevation 6,327 feet.
Ogden 270 miles.

Trude is a siding for loading lumber and the station for Macks Place and the fishing clubs on the river. Snow lies so deep here in midwinter that the residents get about on snowshoes or skis and by dog teams. North of Trude rhyolite is seen in the rock cuts. Smoothed rock surfaces and large rounded bowlders perched on near-by knolls indicate that this country once was covered by a glacier.

Big Springs.

Elevation 6,409 feet.
Ogden 275 miles.

At milepost 90 Henrys Fork of Snake River is seen on the west. The stream crossed at this point is formed by the discharge of Big Springs, which are half a mile east of the railroad and are reached by a wagon road that goes through a straight-cut lane in the forest to Big Spring Inn and a fishing club house. Most of the water issues at two places about 300 yards apart, and at each are several springs. The discharge of the two groups joins midway between them and at a bridge just below the junction is 120 feet wide and 3 to 4 feet deep.

A mile and a half north of Big Springs is a high wooded slope trending southeastward, the front of a great flat-topped mass of lava which came from Yellowstone Park. As the train climbs the mountain soon after leaving Big Springs, rhyolite is seen in the railroad cuts and bowlders of black glistening obsidian or volcanic glass strew the surface. These bowlders have come from ledges in the mountain side above the track. Beyond milepost 93 there is a wide view over a timbered plateau and the alluvial flat of Henrys Fork. At the upper end of this flat is Henrys Lake, which is not visible from the train. One of the railroad cuts near by yielded the material for building the station at Yellowstone.

At Reas Pass the train stops to test the air brakes before descending the grade to Yellowstone Park. Here the route crosses the Continental Divide, going from the Pacific slope to the valley of a small stream that flows into Madison River, thence to the Missouri, the Mississippi, and the Gulf of Mexico. Where the train enters a rock cut just beyond the railroad Y on which the helper engine turns before going back, a signboard marks the State line between Idaho and Montana. This board says that the boundary is 9 miles from Yellowstone and 6,914 feet above the sea. The rock in the cut at the divide is light-colored rhyolitic lava, but the ledges 100 feet above the track on the east are obsidian or volcanic glass. This black glass, which crumbles rather rapidly under the sudden and great changes of temperature common at this altitude, is the source of a large part of the sand that covers the broad flats below.

Reas Pass, Idaho.
Elevation 6,938 feet.
Ogden 281 miles.

That glaciers once existed on the mountains around Reas Pass is shown by the ice-sculptured surface, by old glacial moraines, and by large bowlders which have evidently been transported by ice. Such bowlders may be seen as the train descends the north side of the mountain. The timber at Reas Pass is mostly a dense growth of young lodgepole pine, through which it is difficult to travel except by the opened roads and trails, because of the intricate network of fallen poles killed by fire.

The train runs slowly down the steep grade north of the pass as it follows a small, rapid brook which to a fisherman's eye looks like good trout water. Light-colored rhyolite is exposed in the railroad cuts. Down a little valley the train goes, and the view reaches no farther than the wooded flat-topped mountains near by. In fact, there is practically nothing to see but trees from this point to Yellowstone station. At milepost 105 the foot of the grade is reached, and from this point to Yellowstone the road bed is on the flat pine-covered surface of a wide alluvial deposit, made by Madison River when it flowed over this part of its flood plain.

The sand carried by the river and spread on its flood plain is derived from the crumbling of volcanic rocks and owes its dark color to a considerable percentage of black volcanic glass. The forest here is practically all young lodgepole pine, sometimes called jack pine.

As the traveler alights at Yellowstone, the terminus of the railroad, his eye will turn from the attractive station, built of pink rhyolite, to the four-horse stage coaches waiting for passengers. He may not notice that the engine is within a few rods of a line of blazed trees at the end of the station grounds, but those blazed trees are significant. They mark the boundary of Yellowstone National Park.

Yellowstone, Mont.
Elevation 6,669 feet.
Ogden 291 miles.

OGDEN, UTAH, TO SAN FRANCISCO, CAL.

The railroad leaves Ogden (see sheet 15, p. 102) in a northwesterly direction and follows for a mile or more the old line of the Central Pacific Railway, which made a considerable detour around the north end of Great Salt Lake. At milepost 781 [1] the present line diverges from the original route and, swinging gradually westward, turns directly away from the great mountain wall of the Wasatch Range. It is 15 miles from Ogden to the eastern shore of Great Salt Lake, and for 32 miles beyond this point the way lies directly across the lake to its western shore.

As the train goes toward the lake the view from the rear, or observation platform, is one of the finest panoramas of mountain scenery to be had from the railroad, especially if the light and weather are favorable. Just back of Ogden appears an almost sheer mountain wall of dark and rugged ridges standing above the flat valley in the foreground. Such an abrupt face on one side is more or less typical of the Great Basin mountains and is believed to be significant of the manner in which they have been formed. There is little doubt that these mountains have originated by fracture of the earth's crust and uplift along one side or settling along the other side of the crack. In geologic terms, the mountains are upheaved fault blocks. Since the faulting the forces of erosion have more or less rounded and scored the original cliff or scarp made by the break. The deep notch across the range in the middle background is the canyon of Ogden River, which flows into Weber River a few miles below Ogden.

The railroad extends across the level lands that border the east side of Great Salt Lake. For several miles most of this land is cultivated and is richly productive after it has been "broken"—that is, after it has been plowed and partly leached of its alkali salts by irrigation. The common crops are hay, grain, sugar beets, and vegetables. Tomatoes raised here are canned in considerable quantity. In certain favorable situations along the foot of the mountains peaches, apples, and other fruits are grown.

Near milepost 778 a line of steel towers of an electric-power transmission line crosses the railroad from north to south. This conveys current from large hydroelectric plants on Bear River, near Collinston, 20 miles north of the lake, straight across the meadow flats to Salt Lake City and beyond to the Bingham mines and to the smelter at Garfield.

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[1] Mileage along the route is marked by milepost boards on telegraph poles and numbers on semaphore signals, culverts, and bridges. The figures given represent distance from San Francisco and show the westbound traveler how far he still must go.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
YELLOWSTONE PARK ROUTE
From Ogden, Utah, to the Yellowstone National Park

Base compiled from railroad alignments and profiles supplied by the Oregon Short Line Railroad Company and from additional information collected with the assistance of this company

UNITED STATES GEOLOGICAL SURVEY

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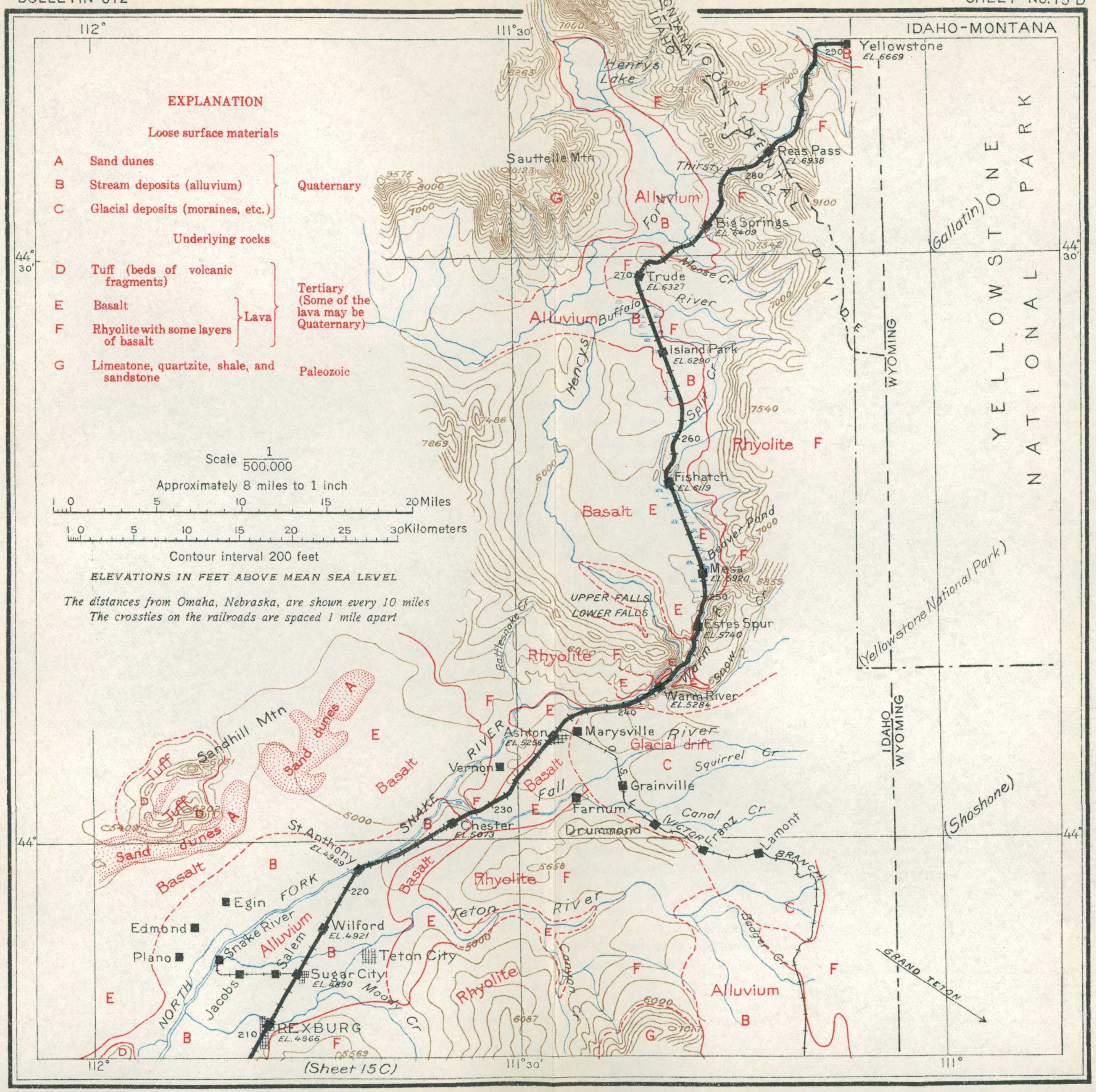
1915



West Weber (see sheet 15, p. 102) is a farming community in the midst of a broad, gently sloping plain, where water for irrigation may be distributed by ditches almost anywhere. Artesian wells bored along this side of the lake, to a depth of 300 or 400 feet, yield natural flows of pure, fresh water that has come down from the mountains in porous layers of rock that lie underneath some relatively impervious layer. Along the east side of the lake this fresh water may even be tapped in wells put down through the salt water of the lake itself. Beyond West Weber the ground becomes more and more salty on the surface, and the cultivated lands diminish in area, the salty meadows or marshes being used for pasture. A few miles farther west the ground, during the dry season, is white with crusted salt.

West Weber, Utah.
Elevation 4,240 feet.
Population 823.*
Omaha 1,006 miles.

Little Mountain, the name of a railroad siding at milepost 769, refers to the low, rounded terraced hill north of the track. The terraces here, as on the islands in Great Salt Lake and around Promontory Point, mark old shore lines of Lake Bonneville, described on pages 97–99. To the south, near the shore of the lake, are the remains of evaporation vats, formerly used in the manufacture of salt by crystallization from the water of the lake. The industry of this place was ended by a general rise in the lake level during recent years (see fig. 11, p. 95), but large quantities of salt are still manufactured near Saltair, at the south end of the lake.

The building of the Lucin cut-off, completed in 1903, was an epoch-making event in railroad construction. By this great fill and trestle straight across Great Salt Lake the main-line route from Ogden to San Francisco was shortened about 44 miles and the steep and troublesome grades around the north end of the lake, including one climb of 680 feet to the old Promontory summit, were eliminated. The new line is level for 36 miles and the grade is almost inappreciable for 36 miles more, being nowhere over 21 feet to the mile, or less than 0.5 per cent.

The cut-off was constructed at first as a gravel fill across the shallow marginal portions of the lake and as trestle work through the deeper part. Much of the trestle work has since been replaced by fill. The gravel used at first came from pits near the railroad, the largest of which was near the west side of Promontory Point. Rock was originally used only on the surface of the embankment, but later, in places where reconstruction was necessary, rock was employed exclusively. The rock has been obtained from Promontory Point and from the immense quarries near Lakeside. The dark-gray, almost black limestone from the Lakeside quarries now covers the surface of the fill all the way across the lake.

An unexpected difficulty was encountered after the construction was well under way. It was found that the material which was dumped into the lake and which evidently sank deep into the mud did not at once reach a firm and permanent foundation. Long after the roadway had apparently been completed and trains had been run by way of the new route, successive "sinks" occurred, especially along certain portions of the route. The weight of the filling material, with the added weight and vibration of passing trains, seemed to break through some sustaining layer in the lake bottom and then a whole section, track and all, would settle into the lake, and traffic would have to be diverted to the old route until the "sink" could be repaired. This happened so frequently that it might fairly have discouraged the railroad company, but perseverance finally conquered. With the sinking of the track, ridges of mud appeared on both sides, squeezed up from the lake bottom by the subsiding fill. Just beyond Bagley, which is only a section house and side track on the cut-off, remnants of these mud ridges can still be seen, although, naturally, where they rise above the water they are being leveled by the waves. The elevation of the track across the cut-off is 4,217 feet above sea level according to railroad figures; the lake is usually 10 to 15 feet lower.

A channel of open water 600 feet wide under a trestle at milepost 762 is now the only connection between Bear River bay and the main lake. As Bear River, the largest tributary of Great Salt Lake, enters at the north side of this bay, and as more water is evaporated from the main lake than from the bay, there is usually a flow of water from the bay into the lake through this passage. The water of Bear River bay has for this reason become so much fresher that lately it has frequently frozen over to considerable thickness during the winter.

The view toward Ogden and the Wasatch Mountains expands as the train proceeds. The high summit above Ogden is Observation Peak, 10,103 feet above sea level; Ben Lomond, the summit on the long, high ridge farther north, is still higher (10,900 feet). The upper shore lines of the former Lake Bonneville show distinctly as a series of clearly defined terraces on Promontory Point and also around Fremont Island. On Fremont Island only a single little point like a cap, undercut by wave action on all sides, rises above the highest water level of the old lake.

Milepost 759 is just at the west edge of the first section of the fill, the section that crosses Bear River bay. This eastern part of the cut-off is 8 miles long. The track skirts the south shore of Promontory Point for 4½ miles and then runs out on the second section of the fill, which is over 20 miles long.

Promontory Point.

Elevation 4,217 feet.
Omaha 1,023 miles.

The station at Promontory Point (see sheet 15, p. 102) is maintained chiefly for purposes of railroad operation. Rock and gravel for building the embankment across the lake were obtained at several places along the south end of the point. The rock exposed in railroad cuts and quarries here is a black slate, which weathers rusty and brown.

Just west of Promontory Point station, on the north side of the track, is a pond cut off from the lake by the railroad embankment. At times of high water in the lake this reservoir fills by percolation through the embankment, and during the summer this water is concentrated to a brine by evaporation. The deep pink color of the brine is a phenomenon that appears in salt ponds generally when a certain concentration is reached. In the salt ponds of San Francisco Bay this color is due to a certain bacillus which lives in saturated brines and also in the heaps of salt as it is piled for drainage and shipment. Prohibitive to life as such an environment might be considered, strong natural brines are, in fact, inhabited by a number of minute organisms—animals as well as plants. The pink color disappears in winter or when fresh water is introduced into the pond. The railroad company has done some experimental work on preserving piles and ties by soaking them in this pond.

Beyond the pond the track follows the lake shore along the south end of Promontory Point for a mile or two, passing a minor station and group of railroad section houses called Saline.

Looking a little east of south from Promontory Point, one can see on the south shore of Great Salt Lake the town of Garfield, the concentrating mills of the Utah Copper Co., and the copper smelter of the Garfield Smelting Co. A long column of smoke may usually be seen trailing away over the mountains from the smelter stack. These plants were constructed a few years ago to treat copper ores from Bingham Canyon, a short distance to the south, in the Oquirrh Range, and the town of Garfield was established to furnish accommodations for the men employed at the mills and smelter. The two mills of the Utah Copper Co. are among the largest concentrating plants in the world and together are capable of treating over 20,000 tons of ore daily. The ore treated contains an average of about 1.5 per cent of copper in the form of sulphides.

At the semaphore marked 754.5 miles the railroad runs out on the fill across the west arm of the lake. Large excavations near by are in the "gravel" that was at first used in constructing the fill. This "gravel" is of a very unusual character. If examined closely, preferably with a magnifying glass, it is found to consist of smoothly rounded, opaque grains, not like ordinary sand grains. These are known as oolites, the word oolite meaning literally fish-egg stone or roe stone. Each oolite is built up, onion-like, of one layer over another. These layers consist of carbonate of lime chemically deposited from solution in the lake water. There is almost no lime in the water of Great Salt Lake as a whole, as the brine seems to be too strong in other more soluble salts to retain the less soluble carbonate. Waters sweeping into the lake around its margin and the tributary river waters, however, contain a considerable amount of lime, and this on mixing with the lake water is deposited on the bottom in the form of these oolitic grains. The grains may be compared to little pearls, which in fact they resemble both in composition and structure. It has been shown that minute plants (algæ or bacteria) have had much to do with the manner in which this lime is precipitated; but that is another story, too long to tell here.

A mile and a half farther west the road runs across deeper water, the track here being on a trestle, which continues for about 12 miles. The surface or deck of the trestle is ballasted with rock, so that it is not very different in appearance from the solid fill.

From the railroad the islands in Great Salt Lake come successively into view. Fremont Island has already been referred to. Antelope Island, a submerged mountain of considerable size, is south of Fremont. Stansbury Island (with twin peaks on the summit) may be seen in the distance at the south end of the lake. Far to the south also are Carrington Island and Hat or Bird Island. North of the railroad are Gunnison and Dolphin islands and Strong Knob, which was formerly an island but has lately been connected with the mainland by a narrow spit. A double track with station and railroad section houses has been built on the trestle out in the middle of the lake, where the water is reported to be 42 feet deep. The station is called Midlake. Between this station and Lakeside is Rambo.

Midlake.

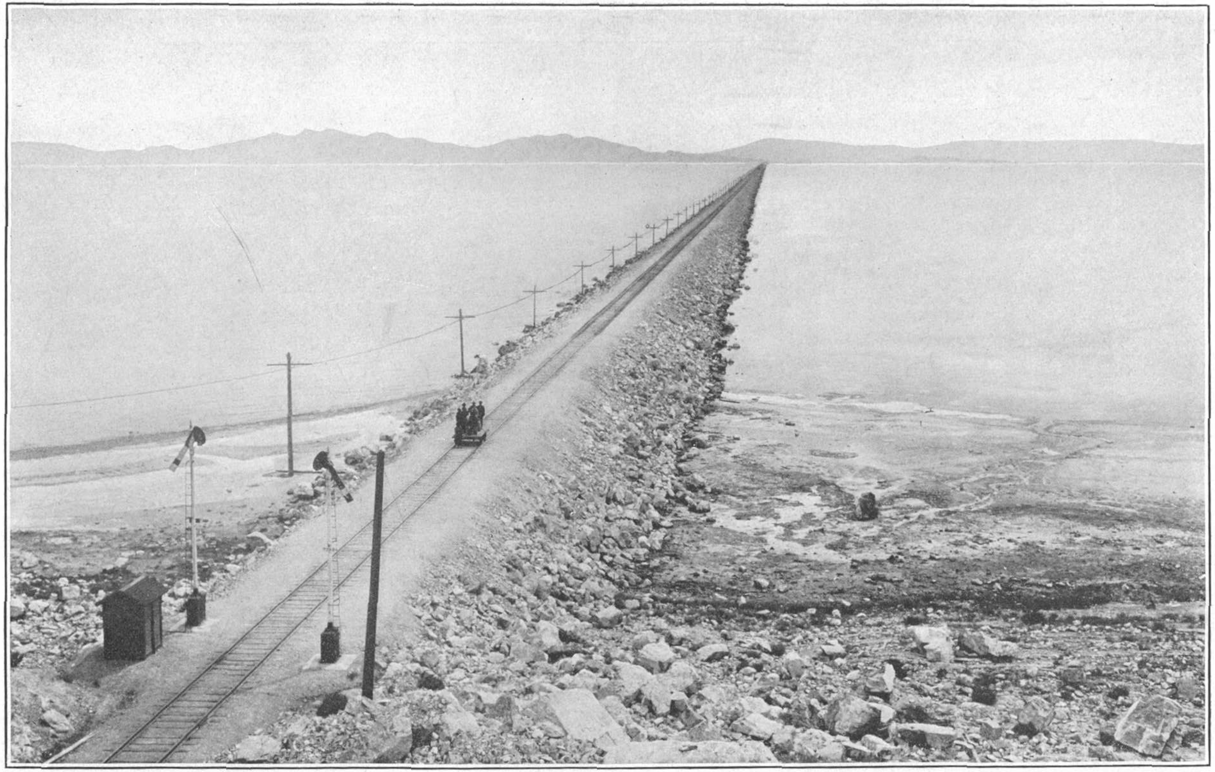
Elevation 4,217 feet.
Omaha 1,037 miles.

Near milepost 735 the railroad reaches the west shore and passes through a cut in limestone rock, beyond which is a great cliff of blue limestone in thick beds that dip toward the southeast. These rocks are of Paleozoic age, the dark-blue to black limestones near Lakeside belonging to the Carboniferous period. (See table on p. 2.) The range lying along the west shore of Great Salt Lake is known as the Lakeside Mountains.

Lakeside (see sheet 16, p. 156), a railroad maintenance, construction, and quarry camp, lies at the west end of the great fill across the lake (Pl. XXXIV), only a short distance from the shore. Here white dune sand which has been blown back from the beach is piled up along the tracks. It is oolitic sand like that already referred to, and should a stop happen to be made here the traveler may find interest in examining a handful of the grains. To the south great

Lakeside.

Elevation 4,216 feet.
Omaha 1,047 miles.



VIEW EASTWARD ALONG THE LUCIN CUT-OFF ACROSS THE WEST ARM OF GREAT SALT LAKE.

Photograph furnished by Southern Pacific Co.

PALISADE CANYON, NEV.

Humboldt River has here cut a narrow channel through the Tertiary lavas. Photograph furnished by Southern Pacific Co.

quarry faces expose the thick beds of dark-blue Paleozoic limestone. To the north Strong Knob, which at the present lake level is almost an island, presents a bluff front of conspicuous white and black rock.

Salt marsh lands on both sides of the track are sometimes flooded, sometimes covered with a crust of glistening white salt,[1] stretching away to the south as far as the eye can see. A mirage can nearly always be seen on these plains, the distant mountains to the south appearing to be surrounded by water, the ghost of the greater Lake Bonneville. (See pp. 97–99.) This area is a part of the Great Salt Lake Desert and is so low and so flat that only a small rise in the general level of the lake would reflood the whole area.

A water tank and section house at milepost 730 are at the end of a 52-mile pipe line. Drilling for fresh water on the west side of Great Salt Lake has not been successful. All the sandy stretches, both north and south of the track, are composed of oolitic grains, here mixed with some mud and heavily incrusted with salt, therefore not so uniform or so clean as those in the dunes at Lakeside.

Brown fly larvæ and their cast-off shells pile up along the railroad embankment when the water is high, often creating an offensive odor. Sometimes they collect in such masses over the rails that they make the tracks slippery, actually interfering with the passage of trains.

Olney.
Elevation 4,211 feet.
Omaha 1,057 miles.

Olney, a siding and signboard only, is situated in the midst of a bare salt-incrusted desert. Beyond it the railroad rises slightly over low gravel ridges, some of which show distinct beach terraces and gravel bars, marks of former higher lake levels. A few isolated outcrops of dark limestone project through the valley deposits. The railroad descends slightly to the level of the Great Salt Lake Desert

[1] The white incrustation seen for a long distance west of Great Salt Lake consists of chemical compounds or salts that are more or less soluble in water, all of which are popularly included in the term "alkali." In its strict sense that term refers only to a certain group of chemical compounds that have the power of neutralizing acids and have a corrosive action on animal and vegetable tissue. The most powerful of these are the lyes, the hydrates of sodium and potassium. The salts which incrust the desert surface are not ordinarily of this character at all. For the most part they consist chiefly, in places almost exclusively, of common salt (sodium chloride). In many places, however, they include also other readily soluble salts—Glauber's salt (sodium sulphate), washing soda (sodium carbonate), baking soda (sodium bicarbonate), and less commonly borax. More rarely in this part of the country the soluble calcium or magnesium salts are found. However, where the soluble (sodium and potassium) carbonates occur the salts in fact partake of the character of true alkali. The carbonates of sodium and potassium, being formed by the combination of a strong base (sodium or potassium) and a weak acid (carbonic), break up (hydrolyze) to a certain extent in solutions, and thus there is actually liberated a small amount of free caustic alkali. The water-soluble carbonate of soda, known on account of its darkening effect in soils as "black alkali," is very destructive of vegetation. The less harmful "white alkali" consists of a mixture of the neutral soluble salts, in large part common salt, and its presence, as the name implies, is indicated by a white incrustation.

again, and the route is bounded on both sides by barren areas of white clay, or playas,[1] and low dunelike or lumpy areas of clay soil.

At milepost 718 is the beginning of a straight piece of track (tangent), 38 miles long, which extends to the junction with the old route around the north end of the lake near Lucin.

Loy.
Elevation 4,221 feet.
Omaha 1,066 miles.

At Loy, a siding and section house only, the route is still bordered by bare mud playas on each side. A dark rocky range, the Newfoundland Mountains, juts out of the flat desert ahead to the south. These mountains were formerly islands, as is shown by the traces of old shore lines high about their rock slopes. The desert here is only a little—perhaps 5 feet—above the level of the tracks on the cut-off over Great Salt Lake, and a slight rise in that lake would again cover this extensive flat.

Newfoundland.
Elevation 4,221 feet.
Omaha 1,076 miles.

Another railroad siding and group of section houses situated in the midst of the bare mud desert bears the name Newfoundland. Two very distinct benches, marking higher shore lines of old Lake Bonneville, may be seen on the front of the Newfoundland Mountains (the Rocky Hills of some of the older maps) to the south, and the upper bench was evidently cut by waves into the solid rock.

Lemay.
Omaha 1,080 miles.

At Lemay, a pump station with section houses, a long pipe line which comes from a spring in the mountains 27 miles to the north, reaches the railroad. This line furnishes an excellent supply of clear, fresh water along the route across the Great Salt Lake Desert. About 1903 a well was bored at Lemay to a depth of 2,340 feet. For about 1,000 feet the well penetrated desert mud like that at the surface, with intercalated layers of clear crystalline gypsum. Below this material the hole was bored in limestone and brown sandstone. This record is interesting in showing the depth of the former lake or desert deposits in this part of the valley.

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[1] A playa is a shallow, flat-floored depression, characteristic of valleys having no regular drainage to the sea, in which storm waters collect and evaporate. It may be a shallow lake or a salt-incrusted mud flat.

In his description of Lake Lahontan, Russell writes:

"The scenery on the larger playas is peculiar and is usually desolate in the extreme but is not without its charm. In crossing these wastes the traveler may ride for miles over a perfectly level floor, with an unbroken sky line before him and not an object in sight to cast a shadow on the ocean-like expanse. Mirages, which may be seen every day on these heated deserts, give strange fanciful forms to the mountains, and sometimes transfigure them beyond recognition. A pack train crossing the desert a few miles distant may appear like some strange caravan of grotesque beasts fording a shallow lake, the shores of which advance as one rides away. The monotony of midday on the desert is thus broken by elusive forms that are ever changing and suggest a thousand fancies which divert the attention from the fatigues of the journey. The cool evenings and mornings in these arid regions, when the purple shadows of distant mountains are thrown across the plain, have a charm that is unknown beneath more humid skies, and the profound stillness of the night in these solitudes is always impressive."

Beyond Lemay the route continues through the barren playas. Beppo is a railroad siding and section house only. The view of the mountain ranges to the west, across the State line in Nevada, is characteristic of the scenery which will be displayed for several hundred miles. Ahead, somewhat to the south, is Pilot Peak (elevation 10,900 feet), at the south end of the Ombe or Pilot Range. This was a well-known landmark in the early days. One of the principal overland emigrant routes led around the south end of Great Salt Lake, then across the barren desert to the low pass south of this peak. The Western Pacific Railway follows nearly this same course. The route of transcontinental automobile travel now known as the Lincoln Highway follows that railway around the south end of Great Salt Lake and then swings southwest around the Great Salt Lake Desert.

Jackson (elevation 4,241 feet), Teck (4,289 feet), and Pigeon are mere railroad sidings and section houses. The route continues through the flat, low-lying desert lands, from this point on more or less covered with scattered patches of brush. Owl Butte, an isolated peak north of the railroad, is composed of lava (rhyolite), and its slopes show jutting ledges, which are probably the edges of lava flows. The top is in the form of a cap. Apparently it was a little island when Lake Bonneville stood at the higher levels and was sculptured into this form by the waves. At Pigeon a spur track leads off to a gravel pit, from which material is excavated by the railroad for ballasting along the track. The gravels are ancient beach deposits, remnants of the deposits laid down around the shores of the old lake at its higher levels. Generally these gravel beaches extend out from some rocky headland, the source of the rock fragments which, worn, rounded, and sorted by the action of waves and currents, were distributed as gravel and sand along the adjacent shores. The bedding of these deposits is irregular, showing that they were laid down by shifting currents. The source of the original material at Pigeon was evidently the lava on Owl Butte.

Lucin, Utah.
Elevation 4,474 feet.
Population 200.*
Omaha 1,103 miles.

The Lucin railroad station is somewhat beyond the old settlement, where there is a store and a post office. Here the route leaves the Great Salt Lake Desert and enters a grazing country. Both sheep and cattle find sustenance in the sparse grass that grows among the sage, and it is said that over half a million sheep pass Lucin twice annually, going south to their winter range and north for the summer. Lucin is the point of departure for a stage line to Grouse Creek, a settlement 30 miles to the north. Beyond Lucin the railroad begins to climb more noticeably, and the stream beds indicate clearly that the surface or storm waters flow toward Great Salt Lake.

The actual junction of the present line with the original route of the Central Pacific around the north end of Great Salt Lake is at Umbria Junction (see sheet 17, p. 162), half a mile beyond Lucin station. Once a week a train is sent over the old route.

Between Umbria Junction and Tecoma light-colored clay and gravels in regularly bedded deposits are exposed along the railroad. These are either deposits in the waters of Lake Bonneville or later stream deposits of wash brought down by erosion from lake-bed clays and beach materials higher up. These beds show a slight tilt toward the east, indicating that they were probably left here by running water.

The Utah-Nevada State line, marked by a monument and a fancifully decorative design in set stones at the north side of the track, is passed opposite the first ranch building seen west of Great Salt Lake. To the south the State line passes over the escarpment capped by lava (basalt), the columnar jointing (see footnote on p. 121) of which may be distinguished even at this distance.

Nevada.

Nevada is a Spanish word meaning "snowy" or "white as snow," and the name of the State was derived from the Sierra Nevada. The State ranks sixth in size in the Union. Its length from north to south is 484 miles, its width 321 miles, and its area 109,821 square miles, of which about 60 per cent has been covered by public-land surveys and approximately 21 per cent has been appropriated. National forests in Nevada cover an area of 8,683 square miles, and Anaho Island, in Pyramid Lake, has been made a bird reservation. The population of Nevada, according to the latest census, was 81,875, or about one person for each 1.4 square miles.

Nevada is one of the most important metal-mining States of the West and has yielded large quantities of gold, silver, and lead. Of late also it has become a large producer of copper.

The history of Nevada is chiefly the history of her mines. Since the discovery of the Comstock lode and other famous ore bodies, periods of activity and prosperity have alternated with periods of depression. Each discovery of high-grade ore in noteworthy quantity has been followed by rapid settlement in that locality and the establishment of one or more towns. Exhaustion of the richer or more accessible ores or the bursting of overinflated speculative bubbles has been followed by at least local stagnation and depopulation. In 1890–1893 a sharp decline in the price of silver initiated or accompanied a period of depression in Nevada's mining and general industrial prosperity. Silver is so important a resource of the State that to a large extent even now her prosperity depends upon the market for that metal. Of late years, however, an increased production of gold, copper, and recently of platinum has accompanied a gradual and, it is hoped, substantial industrial progress. Permanent towns have grown up and agriculture and related pursuits are becoming firmly established.

The mining districts in the State number about 200 and are widely distributed over its area. Almost every one of the larger mountain ranges contains some ore. In the following pages emphasis will be

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

OVERLAND ROUTE

From Omaha, Nebraska, to San Francisco, California

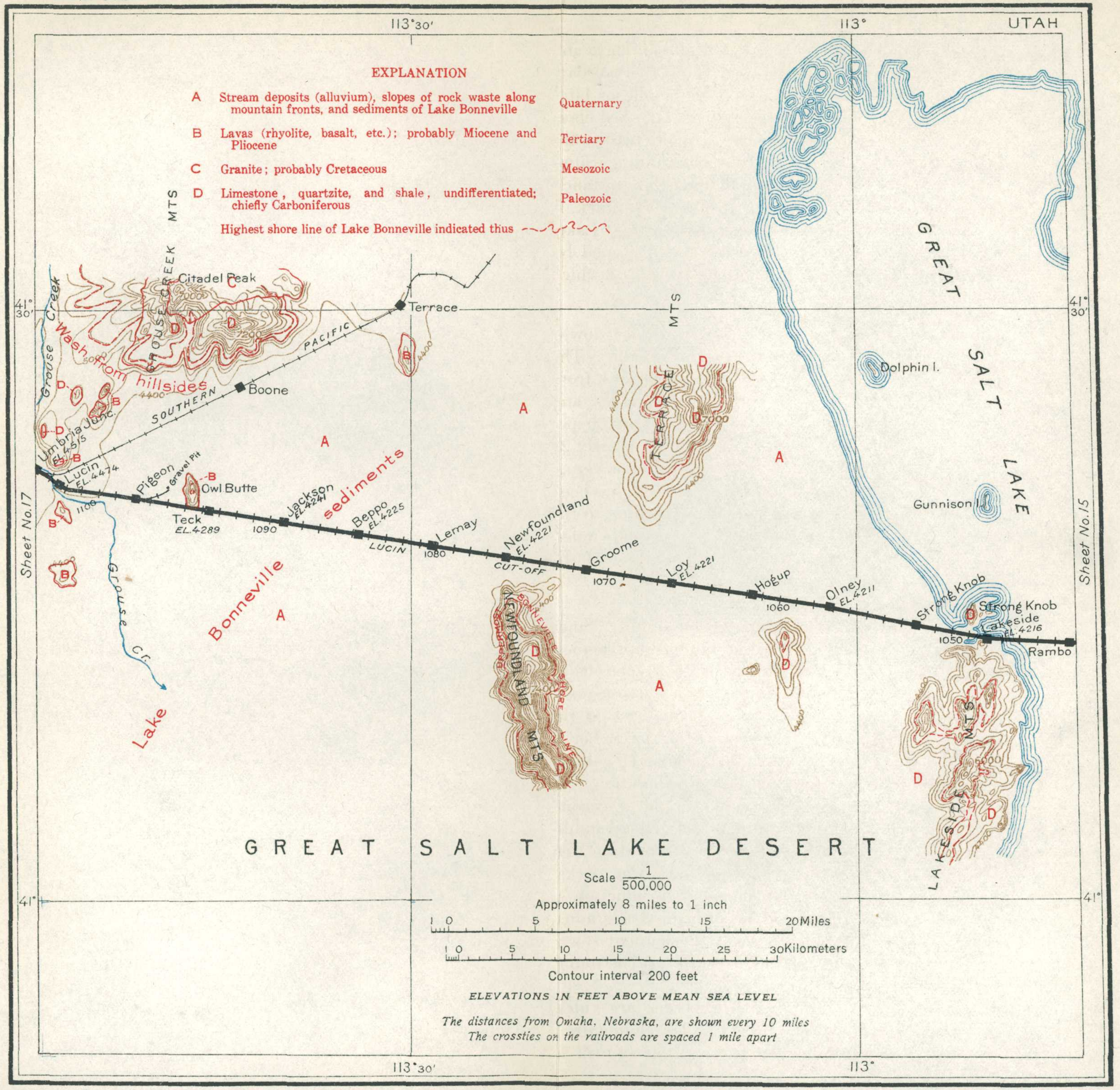
Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915



laid on the record and the development of mining districts adjacent or tributary to the railroad. More complete accounts of most of the districts may be found in the publications of the United States Geological Survey.

The geology of Nevada is that typical of the Great Basin, in which the two prevalent topographic elements are the basin ranges and the intervening valley plains. In the mountains probably the most conspicuous rocks are the Tertiary lavas, although a full series of sedimentary beds is also present, as well as great masses of intrusive igneous rocks of various types. The rocks may be briefly mentioned in the order of age. (See table on p. 2.) The pre-Cambrian basal or foundation rocks, on which the younger sedimentary rocks and lavas rest, are visible in a few places. East of a line passing somewhat east of Winnemucca through Austin to a point a little west of Tonopah Paleozoic strata are the predominating sedimentary rocks in the mountain ranges, which include few or no Mesozoic beds. The enormous thickness of the Paleozoic section at Eureka (almost 30,000 feet) suggests that the shore line of the Paleozoic sea was somewhere near this place. This is further indicated by the fact that west of the line mentioned the Paleozoic rocks disappear and are succeeded by a thick series of Triassic and Jurassic sediments. During the Paleozoic era western Nevada was apparently a land from which sediments were washed into a sea on the east. In Mesozoic time the situation seems to have been reversed. The Jurassic and Triassic sediments were apparently derived from a land area of uplifted Paleozoic strata in the eastern part of the State. The Triassic limestone, slate, and sandstone and the associated lavas of the Humboldt Range have an estimated thickness of 10,000 feet. Somewhat similar Jurassic rocks add several thousand feet more to the record of deposition in this region during Mesozoic time. No Cretaceous sediments have been found in Nevada, and it is therefore supposed that the Great Basin during that period was a land area.

Large and small bodies of granular intrusive igneous rocks, chiefly such as may be called granite (including quartz monzonite, granodiorite, and similar rocks), extend from the great masses in the Sierra Nevada to the eastern part of the State or beyond. All these bodies may be more or less related; they appear to be younger than most of the Jurassic sediments but older than the Tertiary rocks and are probably of Cretaceous age. The Tertiary lavas (rhyolite, andesite, and basalt) are widely distributed and cover large areas, some ranges being entirely made up of them. Vast areas in the valleys are covered with the gravelly deposits of streams, with material laid down in lakes, or with the ash or pumice ejected with the lava during volcanic eruptions.

The movements by which the mountains and valleys have been formed probably occurred in different periods, but it is evident that most of them broke and shifted the sheets of Tertiary lava, and were therefore subsequent to these lava flows in date. The present ranges in the Great Basin are therefore young compared with mountains in general. They are supposed to have been uplifted by movements that lasted at least through a part of Tertiary time and perhaps have extended to the present day. The earth breaks or faults along which the mountain blocks were upheaved are still recognizable at many places in the topographic form of the mountains.

As a supply or trading point Lucin is now largely superseded by Tecoma, a considerable settlement a few miles farther west. Of the mines in the Lucin district,[1] south of Tecoma, only the Copper Mountain mine has lately shipped much ore. This mine is connected with the railroad by a 6-mile spur track and an aerial (wire cable) tramway. Stock raising is now the principal industry in this region, but north of the railroad there are some large land holdings which are to be subdivided and utilized under a private irrigation project.

Tecoma, Nev.
Elevation 4,807 feet.
Omaha 1,114 miles.

After ascending the drainage channel above Lucin, the railroad passes out into a broader and more open valley through which the track heads straightaway toward Montello. In this valley the railroad reaches the elevation of the uppermost water level of the former Lake Bonneville, but traces of the old lake shores are not readily discerned.

Montello is a railroad town and the first freight terminal west of Ogden. The characteristic Nevada or Great Basin scenery is well displayed here, steep mountain ranges with rugged declivities contrasting sharply with the broad, gentle slopes of rock waste and gravel from which they project. The railroad winds in and out among such ranges all the way across Nevada, generally finding low passes through them or going around the end of the ranges.

Montello.
Elevation 4,878 feet.
Population 355.*
Omaha 1,120 miles.

Leaving Montello the road begins the steeper climb by which it passes over the divide and out of the Bonneville Basin. The highest

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[1] The Lucin mining district is in the Ombe or Pilot Range, a few miles south of Tecoma. Ore was discovered in the district about 1869, and there was a considerable output of silver and lead until about 1876, after which the district was nearly deserted. The increasing demand for copper in recent years has encouraged the development of the copper deposits in the Lucin district, and the value of the copper produced there from 1906 to 1912, inclusive, was approximately $1,700,000.

The sedimentary rocks of the district are chiefly of Carboniferous age. They have been invaded by igneous rocks of various kinds, the larger bodies of which consist of a coarsely porphyritic rock of granitic character (quartz monzonite porphyry). The black rocks seen from the railroad at the north end of the range are basaltic lavas.

The ore bodies, which embrace copper deposits and lead-silver deposits, have resulted from the replacement of limestone adjacent to faults and fissures. The copper ores are oxidized, no sulphides having yet been reached. The lead-silver ores are also oxidized. Wulfenite, the yellow molybdate of lead, is abundant, and the district is probably best known to mineralogists for the beautiful crystalline specimens of this mineral that it has yielded.

water level of old Lake Bonneville lay somewhere near Montello, at an elevation of about 5,000 feet, probably just above the town, but no distinct traces of the old water line can be seen from the train. Looking back or down across the valley (southward), the traveler may see Pilot Peak, the highest point at the south end of the Pilot Range. Banvard (elevation, 4,976 feet), Noble (5,117 feet), Ullin (5,256 feet), Tioga (5,597 feet), and Omar (5,640 feet), passed in the order named, are mere sidetracks or minor stations.

The surface material of the valley is mostly a light-colored clay mingled with pebbles and fragments of rock. The fragments include many of light-gray limestone, evidently representing rock that is exposed in the adjacent mountains. The valley is covered with a fairly uniform growth of brush, and the sparse grass which in less arid regions would hardly be noticed affords good grazing for stock. The mountains appear smooth and rounded as seen from a distance and are in part covered with a scanty growth of cedars.

Just beyond Tioga, a sidetrack and signboard near milepost 653, the railroad reaches the head of the open valley. Bedrock projects in many places, and ridges of rock extend down from the mountain front to the north toward the railroad. These are limestones and quartzites of Carboniferous age. Similar rocks show as rugged edges on the more distant mountains to the south. In the reports of the Fortieth Parallel Survey the pass through which the railroad climbs was named Toano Pass, and the mountains to the south were called the Gosiute Range and those to the north the Toano Mountains. A large part of the high country for a long distance beyond Toano Pass is made up of Carboniferous sediments. Phosphate rock is reported to have been found in these rocks in the same relative position as in the great phosphate fields of southern Idaho and vicinity, but in Nevada the beds, so far as known, are too thin to be of commercial value.

From the upper end of Toano Pass, near milepost 649, may be seen in the valleys on both sides beds that are conspicuously exposed as chalky-white cliffs or as bare white patches on the rolling plains or on low ridges. These beds are composed mainly of friable gray, white, and drab sandstone and marly limestone, at many places containing a great deal of volcanic material, chiefly the tuff or ash that accompanied lava (rhyolitic) eruptions. These rocks belong to the Humboldt formation [1] and cover large areas in this part of Nevada.

[1] The Humboldt formation was described by Clarence King in 1878 as the deposit of a great lake which he thought had occupied most of the territory from the Wasatch Mountains in Utah to the Sierra Nevada, in Pliocene time. He named this hypothetical body of water Shoshone Lake, and these sediments, which he supposed had been laid down in its water, he called the "Humboldt series." During recent years little attention has been given to the further study of this formation, but geologists of the present day are much inclined to doubt the existence of the extensive lake thus conjectured, as well as the necessity for assuming that these beds as a whole were lake deposits.

Cobre.

Elevation 5,922 feet.
Omaha 1,138 miles.

At Cobre (pronounced co′bray, Spanish for copper) is the junction with the Nevada Northern Railroad, which since 1906 has given access to the Ely or Robinson copper districts,[1] 140 miles to the south, and a number of other less well-known districts, including Cherry Creek and Egan Canyon.[2]

West of Cobre the railroad crosses a number of scarcely perceptible divides. The old town of Toano, opposite milepost 643, is now represented only by a few fallen and deserted stone buildings. These were built from blocks cut from the sandstone of the Humboldt for-

[1] The first mining locations in the vicinity of Ely were made in 1867, three years after the organization of the Eureka mining district, in the same year in which bonanza silver ores were discovered in the White Pine district, 60 miles to the west. Early operations disclosed a few deposits of lead-bearing ores carrying precious metals to the value of $10 to $40 a ton. Occasionally small bonanzas were found, and shallow deposits of rich copper ore were mined.

The present copper industry of the district is the outgrowth of explorations that began about 1901. The aggregate quantity of low-grade sulphide ore developed is perhaps 80 million tons, in which the mean copper content is a little over 1½ per cent. In 1906 extensive reduction works were built at McGill, on the east side of Steptoe Valley, about 25 miles from the mines.

The sedimentary rocks of the district, comprising limestones, quartzites, and shales, range in age from Ordovician to Pennsylvanian. They have been disturbed by folding and especially by faulting and have been invaded by masses of igneous rocks (monzonite porphyry).

The ore, like the greater part of that at Bingham, Utah, consists of monzonite porphyry, greatly altered (metamorphosed) as a result of the igneous intrusions, carrying disseminated grains of pyrite and chalcopyrite, and varying amounts of chalcocite. Masses of porphyry which, through metamorphism, had been almost uniformly charged with grains of pyrite and chalcopyrite became subject to erosion and oxidation. As the rock was gradually worn down, surface waters attacking the metallic sulphides and charged with copper derived from them soaked downward into the rock and deposited the dissolved copper by chemical reaction with the pyrite and chalcopyrite in the rock. In this way a part of the rock was gradually converted into ore by addition of the copper sulphide. Superficial examination of ore samples shows a white to gray rock specked through and through with a black mineral, which is the rich copper sulphide chalcocite. On close inspection it is found that this mineral occurs mainly as films or coatings on grains of the pale-yellow iron mineral pyrite or the deeper yellow copper-iron sulphide chalcopyrite. The oxidized capping or overburden has an average thickness of about 100 feet. The underlying ore blankets are from 15 to 500 feet thick. Up to the present time comparatively little underground mining has been done, though caving methods were employed in the Veteran mine. The Ruth ore body, estimated to contain 8 to 10 million tons of ore carrying over 40 pounds of copper to the ton, may be mined in a similar way. Where the overburden is shallow the ore is mined by steam shovels, and between 1908 and January, 1914, nearly 12 million tons of ore averaging about 38 pounds of copper to the ton had been produced in this way, and in addition some 20 million tons of overburden had been removed.

[2] On the west side of Steptoe Valley, 93 miles south of Cobre, are the Cherry Creek and Egan Canyon mines, in a low pass

mation (Pliocene) near by. Valley Pass (elevation 6,072 feet) is the highest of the low divides just mentioned. It is marked by a railroad station and a water tank. The mountains across the rolling valley to the north, grassy on top but more or less thickly covered with scrubby cedar trees on their lower slopes, are composed of Paleozoic sandstone, shale, and limestone.

Beyond Valley Pass the drainage channels lead off to the northwest toward Thousand Springs Valley. The broad brush-covered plains adjacent to the railroad have little distinctive character geologically or otherwise. They are presumably underlain by the volcanic ash beds (tuffs) and other beds of the Humboldt formation, which are trenched by shallow gullies. Cuts along the railroad show stream-deposited gravels.

Within the 30 miles west of milepost 637 the train passes Icarus (elevation 6,108 feet), Pequop (6,143 feet), Fenelon (6,153 feet), Holborn (6,103 feet), Anthony (6,124 feet), Moor (6,166 feet), Cedar (5,969 feet), and Kaw (5,831 feet) —merely sidetracks, section houses, or water tanks maintained chiefly for the use of the railroad. For a long distance the coarse white tuffaceous sandstones of the Humboldt formation are the principal rocks seen near the railroad. Just beyond Pequop, however, between mileposts 630 and 629, are conglomeratic strata interlayered with evenly bedded clays or clay shales of a distinct light-greenish color, which are believed to be of older Tertiary age (Eocene, Green River formation). Faults displacing the clays and conglomerate are visible in the railroad cuts but possibly would not ordinarily be noticed from the train.

Between Anthony and Moor an extensive view may be had to the south and southeast over the north end of Independence Valley, the larger part of which lies beyond the range of vision. This valley constitutes another of the distinct drainage units of which the Great Basin is composed. The railroad continues to ascend gradually, skirting the slopes at the north edge of the valley. For several miles near the summit of this part of the route the road passes through groves of cedars, such as are frequently observed from a distance on the flanks of desert mountain ranges.

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that was used by the Pony Express and Overland Stage in pioneer days. Gold was discovered here in 1861, and between 1872 and 1882 the district supported a population of about 3,000. The total production amounted to several millon dollars, but at present comparatively little work is in progress. Gold ores and silver-lead ores occur here in sedimentary rocks, principally in quartzite.

In the Gosiute mining district, which lies 20 miles south of Cherry Creek, in the Egan Range, silver-lead ores have recently been mined from veins occurring in limestone. The Spruce Mountain, Hunter, Schellbourne, Duck Creek, and Ward mining districts, in which work has been more or less active during recent years, are also tributary to the Nevada Northern Railroad.

At Moor the divide between the drainage of Independence Valley and that of Humboldt River is reached, and the traveler enters the area tributary to the ancient Lake Lahontan, an extensive body of water that formerly spread out through most of the lower valleys in northwestern Nevada. (See p. 172.)

Moor.

Elevation 6,166 feet.
Omaha 1,166 miles.

From the summit of Moor the train makes a long westward descent, at first down a heavy grade between Moor and Wells. Minor stations along the way are Cedar and Kaw. A broad valley extends off toward the north, the railroad skirting its southern side. Tulasco Peak, the prominent pointed summit in the range across this valley, is formed of limestone and quartzite of Carboniferous age, with lava (rhyolite) at its base and beds of Pliocene tuff in the valley.

Wells, formerly a more important settlement and trading center than it is now, was named from a group of springs called Humboldt Wells, an objective point along the branch of the old overland emigrant trail, which here comes from the south into the route followed by the Southern Pacific. From Great Salt Lake to Wells the trail followed in general the route which has been taken by the Western Pacific Railway. From Wells to a point a little beyond Winnemucca both the Southern Pacific and the Western Pacific run in nearly parallel lines down the valley of Humboldt River, beyond which they diverge to separate passes across the Sierra Nevada.

Wells.

Elevation 5,631 feet.
Population 598.*
Omaha 1,175 miles.

The springs at Wells are reported to be from 30 to 150 in number and range in size from a few inches to 3 or 4 rods across. They are inconspicuous little pools scattered about in a grassy meadow just north of the railroad, a short distance west of the town. The flow is variable; it reaches a maximum about October, but during a large part of the year there is no overflow at all. This variability with the season indicates that the springs may originate in the underflow drainage in the valley, rather than from some deeper-seated source, which probably would not be so subject to seasonal influences. These wells have been called the head of Humboldt River, but that stream has longer branches, which enter the valley below Wells.

Wells is still the center of an extensive cattle and sheep industry, which has now largely replaced the mining of earlier days. A large private irrigation project is being carried out in the valley beyond the high mountains to the north. Near Wells, Humboldt River, Willow Creek, Trout Creek, and Meadow Creek supply water for the irrigation of 1,900 acres, or about 3 square miles of land, which is devoted principally to growing winter feed for stock, although, according to reports, barley, oats, potatoes, and cabbage are also raised. Clover Valley, at the foot of the Ruby or East Humboldt Range, south of Wells, is a good agricultural and stock-raising valley

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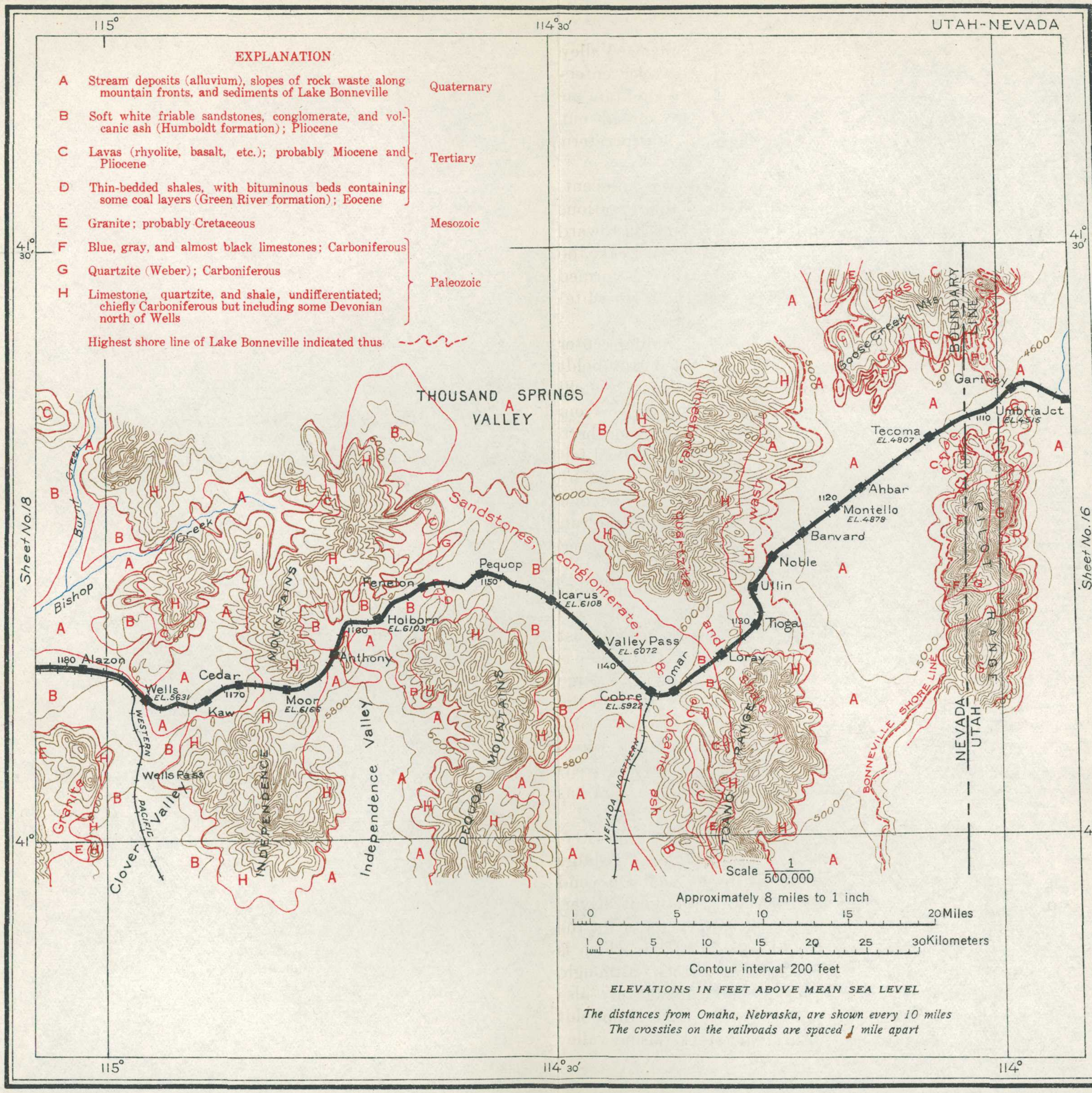

that was formerly dependent for its transportation facilities on Wells but is now served by the Western Pacific Railway.

Humboldt River, which was so named by Frémont, and which is one of the largest river systems in Nevada, heads entirely within the desert ranges of the central Great Basin. It rises on the eastern border of Nevada and flows westward for about 200 miles. Near some of the higher mountains it receives considerable water, but it dwindles downstream and finally disappears. It enters the basin formerly flooded by the waters of Lake Lahontan near the present town of Golconda and from that point continues its course through Lake Lahontan beds for nearly 100 miles to Humboldt Lake. In the dry season the river water gets no farther than Humboldt Lake, but during the winter this lake commonly overflows, the waters passing on to the Carson Sink, where they are evaporated. Throughout its course it is almost if not quite destitute of native trees along its channel. In its upper course Humboldt River receives a number of tributaries, the largest of these being Reese River, which enters it from the south. During the summer and fall several of these streams, including Reese River, commonly dry up before they reach the main channel.

Just below Wells the train runs along the margin of a strip of meadowland and then passes into a narrower portion of the valley hemmed in by low bluffs on each side. These bluffs and the cuts along the railroad show bedded deposits of white and greenish clays or sand, which are classed with the Tertiary Humboldt formation. Beyond the narrows lies a broader valley.

As the valley opens out the traveler may see to the south a panorama of the Ruby or East Humboldt Range, the highest and most rugged mountain mass in Nevada. The name Ruby Mountains, or Ruby Range, is locally accepted in preference to East Humboldt and seems to have priority. Old settlers describe the finding of "rubies" and "ruby sand" in the gravels of some of the streams coming from these mountains. Specimens of these "rubies" are in fact red garnet, a rather common mineral developed in rock under the influence of the heat accompanying igneous intrusion.

At first only the north end of the range, around which the railroad passes, is seen, but farther west the western flank and the lofty summits come into view. A number of these peaks attain a height of 11,000 or 12,000 feet, and snow lingers along the crest of the range late into the spring and comes early in the fall. Owing to their height these rugged slopes receive a larger rainfall than the surrounding country and supply water to the adjacent valleys, which contain some of the most productive agricultural regions in the State. On the east slope of the Ruby Range the waters quickly disappear in the beds of the narrow canyons but break out again lower down in cold springs that feed Ruby and Franklin lakes. On the west side the descent is more gentle and the waters gather in the South Fork of the Humboldt. The crest of the Ruby Range is included in the Humboldt National Forest.

The Ruby Range is a typical Great Basin mountain ridge. It rises abruptly on all sides from flat valley plains or low, even slopes of rock detritus or "wash." The northern part of the range is granite, formerly considered Archean but now known to be of post-Jurassic, probably Cretaceous age. (See table on p. 2.) Flowing streams from the Ruby Range reach the railroad in places, and hay meadows and grainfields have been established wherever the water supply is sufficient to permit irrigation. Wild grasses are cut for hay along the flood plain in the main Humboldt Valley, and numerous haystacks are usually visible from the railroad. Beyond Nardi (see sheet 18, p. 168) a few ranches appear along the Humboldt, which is joined near Deeth by Marys River, from the north. It is said that 7,000 acres are irrigated in this vicinity, but on account of the scanty water supply only native grasses are grown, which are sometimes cut for hay and sometimes used for grazing in fall and winter.

The main settled areas in this general region are Starr and Ruby valleys, south of the railroad, at the foot of the Ruby Range. Starr Valley contains some 3,700 acres of irrigated lands, for which Herders, Starr, Ackler, Deering, and Boulder creeks furnish an ample water supply until about the middle of July each year. Nearly one-fourth of this valley is "self irrigating" through seepage from higher irrigated lands. These "self-irrigating" lands are usually left in native grass, which is cut for hay or used for pasture.

Deeth.

Elevation 5,341 feet.
Population 200.*
Omaha 1,193 miles.

From Deeth, which is a trading center for Starr and Ruby valleys, a stage line runs north 52 miles to Charleston (Cornwall Basin), whence ore and concentrates (gold and copper) are shipped through this station. Jarbidge, a gold and silver mining camp in the extreme northern part of the State, formerly had its outlet through Deeth but now receives mail and supplies from Twin Falls, Idaho, by way of the Oregon Short Line.

West of Deeth the view of the Ruby Range broadens as the railroad bends southward along the west front of these mountains and at the same time gradually leaves them. The range from this viewpoint shows a high and rugged crest with approximate north-south trend, notched near the north end by a low pass. The highest summits lie north of the pass, among them Mount Bonpland, about 11,300 feet in elevation, and Clover Peak, just south of it, probably higher.

Natchez and Rasid are unimportant stations between Deeth and Halleck. The Humboldt appears as a meandering stream close at hand south of the railroad, bordered by narrow meadows of wild grass, behind which are low terraces or ridges. These terraces have evidently been formed by the river at an earlier period of its history and generally have a surface covering of gravel.

Halleck.

Elevation 5,232 feet.
Population 117.*
Omaha 1,206 miles.

Halleck is a shipping point for cattle and sheep. The station received its name from old Camp Halleck, a fort and military reservation of pioneer days, close under the mountain front, about 12 miles away, just south of the pass near the north end of the range. Stage lines run from Halleck to several places on the north and south.

Elburz.

Elevation 5,204 feet.
Omaha 1,209 miles.

Elburz, a water tank, sidetrack, and section house, is just above the mouth of North Fork, the principal tributary of the Humboldt from the north. The land watered by the North Fork and its tributaries is divided into an upper and a lower valley by a range of mountains through which the stream flows midway in its course. About 4,500 acres of land is irrigated in the upper valley of the North Fork and 1,200 to 1,500 acres in the lower valley. Hay is the only crop raised.

Just below the North Fork the Humboldt Valley narrows to Osino Canyon. For a distance of about 50 miles, extending nearly to Beowawe, the strip of irrigable land along the river is rather narrow—in fact, in some places there is none. The meadow land is used for hay or pasture.

In Osino Canyon the railroad passes through three tunnels and crosses the river several times. The walls of the canyon consist of lava rock, which, although light colored when freshly broken, is weather-stained to dark or rusty tints.

West of Osino Canyon the valley is broader, and near Elko cultivated fields and ranches come into view. The valley here extends from the foothills of the Elko Range on the southeast to the low benchlike spurs of the River Range on the northwest. These spurs slope off gently toward the middle of the valley and are composed almost entirely of volcanic ash, generally of white color, containing fragments of lava. These beds belong to the Humboldt formation (Pliocene). Underneath them are steeply tilted strata which contain beds of impure coal and are supposed to be of Eocene age.

Elko.

Elevation 5,061 feet.
Population 1,677.*
Omaha 1,226 miles.

The origin of the name of Elko, the seat of Elko County, is not certain, for according to some it is an Indian word and according to others it was given on account of the abundance of elk in this vicinity. A camp site near some hot springs $1\frac{1}{2}$ miles west of the town made this place a station on the old emigrant route, but the present town originated with the building of the railroad in 1868. The older part of the town, through which the two railroads now pass, is built on the river flood plain, but a more recent extension of the residence portion may be seen on a terrace north of the river.

The main industries of this locality are stock raising and ranching. A stage line runs from Elko to Tuscarora,[1] a mining camp 50 miles to the north.

Indians are usually seen about Elko, Lovelock, Reno, and at other stations along the route. Several Indian reservations lie wholly or partly in Nevada, and Indian schools are maintained at Carson and near Fallon. The Indian population of Nevada, about 5,000, consists of Piutes, Shoshones, and the remnants of other tribes.

For many years there has been much interest in the possibility of finding oil in some of the Tertiary shales a few miles south and east of Elko. Several wells have been drilled in this vicinity, but oil has not been found in commercial quantity. Some oil appears to be disseminated through these shales, but it is questionable whether they contain any oil pools. Similar shales in this country and abroad have been made to yield oil by distillation, and this industry might under favorable conditions be profitable here. Oil-bearing shales of Tertiary age occur in other parts of the country, as in the Book Cliffs of Colorado and Utah.

Sandstone from the Tertiary beds near Elko has been used as a building stone, and there is a granite quarry some 30 miles to the north.

A mile and a half west of Elko, south of the railroad and across the river channel, is a group of buildings, including a hotel and bath houses, that mark the position of the hot springs above mentioned. The main group of springs is well up on the lower slope, at the upper edge of a terrace near the foot of the steep mountain front. Others issue lower down, near the river channel. These springs are probably related to the zone of late faulting by which this mountain block has been uplifted. Waters derived from great depth may owe their heat to the higher temperatures generally found with increase in depth, to the fact that they have passed through or near some mass of intruded igneous rock, or to direct volcanic action. Faults along which there has been comparatively recent movement produce openings that allow such waters to reach the surface. Hot springs are found in many parts of the Great Basin.

[1] Placer gold was found at Tuscarora in 1867 and rich silver veins were discovered several years later. In the seventies and eighties a number of silver mines were opened, and for several years a large production was maintained. Most of the ore was milled at Tuscarora, and only very high grade ore was shipped to smelters. The production of the district, chiefly in silver, is estimated to have been between $25,000,000 and $40,000,000, most of which was obtained between 1872 and 1886. In recent years most of the mines have been closed.

Other camps of this general region are Bullion and Lone Mountain. Bullion, where the mining of silver and copper ores began 40 years or more ago, became inactive when the price of silver fell, but in 1911 mining was resumed, and during the early part of 1914 ore was hauled by motor trucks to Palisade. Lone Mountain, 28 miles north of Elko, shipped in 1913–14 some ore yielding copper and silver.

West of Elko distinct river terraces show on the south side of the river. The Southern Pacific follows the upper edge of the meadow north of the river; the Western Pacific keeps closer to the stream.

Avenel (elevation 5,021 feet), Moleen (4,982 feet), Tonka (4,958 feet), and Vivian (4,918 feet) are sidings or unimportant stations. After passing Moleen (between mileposts 545 and 544) the train runs southwestward down the narrowing valley, passing close to cliffs of massive blue limestone. The railroad here is approximately parallel with the trend or strike of the beds. At the entrance to Moleen Canyon the track turns sharply to the northwest and within the next mile or two passes a most interesting exposure of Carboniferous limestones and quartzites. The limestone is about 2,000 feet thick, although not all the beds are exposed in continuous section. The quartzite underlying the limestone is in beds which stand nearly vertical. The river here makes a sharp bend to the north, rounds a ridge of the quartzite, and returns on an almost parallel course on the other side. The railroad passes through this ridge in a tunnel. Beneath the quartzite on the south side of the river lie slaty and heavy blue limestones, inclined 45° or 50° E., which extend along the south side of the valley as far west as Carlin. One of the shaly beds near the top of these lower limestone beds contains a little impure coal.

Beyond Tonka there is a tunnel and the Southern Pacific and Western Pacific tracks wind down the narrow canyon together. The valley again broadens as Carlin is approached.

Carlin.
Elevation 4,898 feet.
Population 423.*
Omaha 1,248 miles.

Just before reaching Carlin station the train passes an icing plant where the ice boxes of refrigerator cars are replenished in summer. Some of the ice thus used is cut near by, in vats in which river water is allowed to freeze in winter, and some is shipped from the Sierra Nevada. Carlin is a railroad division point with shops and engine houses. There are some ranches in the vicinity, and several mining camps along the east slope of the Cortez Range north of Humboldt River and west of Carlin. None of the mines, however, is extensively developed or has produced more than a few tons of ore.

The valley below Carlin is narrow and is bordered on the south by rounded, indistinctly terraced hills, passing into a low rolling country to the north. Beyond Tyrol (a sidetrack, elevation 4,876 feet) the valley becomes still narrower, and rusty-brown ledges of lava appear on both sides. This is the upper end of Palisade Canyon (Pl. XXXV, p. 153), which within a short distance contracts until there is little room for more than the river and the railroads, hemmed in by the lava cliffs. Parts of the canyon wall show that the lava consists of a number of flows, indicating eruption at several distinct times.

From the small town of Palisade the narrow-gage Eureka & Palisade Railroad runs to Eureka,[1] one of the most famous of the old mining camps of Nevada, 80 miles to the south. The narrow-gage line goes up Pine Creek, the mouth of which is passed just beyond the tunnel at Palisade. Pine Creek valley trends due north, and irrigated lands lie along it for 30 to 35 miles.

Palisade.

Elevation 4,844 feet.
Population 242.*
Omaha 1,257 miles.

Below Palisade the route continues down the canyon, which is wider and bounded by less steep walls than east of this town. The lavas, which all look much alike in general aspect, are chiefly basalt

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[1] The first claims in the Eureka camp were located in 1864, but it was not until 1869 that the Eureka mine was developed on Ruby Hill. From that time until the early eighties this was the most active mining camp in Nevada and had a population of about 6,000. Between 1869 and 1883 the district yielded $60,000,000 in bullion, about one-third gold and two-thirds silver, and about 225,000 short tons of lead. After 1878 the production declined. The lead ores constituted the main source of gold and silver until 1910, since when the greater part of the precious metals has been derived from milling ore containing little or no lead.

The Eureka district comprises a rough, almost completely isolated mountain mass, and it is doubtful if within the Great Basin province there can be found any region of equally restricted area surpassing it in its exposures of Paleozoic formations, especially those of the lower and middle Paleozoic systems. The sedimentary formations represent all ages from Lower Cambrian to Pennsylvanian (see table on p. 2) and have a total thickness of 30,000 feet.

In post-Jurassic time the strata in this district, as elsewhere in Nevada, were crumpled into a series of folds, some of them with very steep sides. The folding was followed by intense faulting. The more profound faults had a general northerly trend, and there were branches or connecting faults of northwesterly trend. Next came a long period of erosion. Tertiary time was marked by great volcanic activity, lavas (andesite, rhyolite, and basalt) breaking up to the surface along certain of the larger faults.

The Ruby Hill ore deposits were found in a roughly V-shaped mass of shattered limestone between the main Ruby Hill fault and a branch fault which for the most part followed the contact of the limestone with quartzite. The shapes of some of the ore bodies suggest that they were formed by replacement along fractures, but as a whole they are very irregular. The minerals originally deposited in the limestone were pyrite, arsenopyrite, galena, and zinc blende, with minor amounts of molybdenite and other minerals, but the bulk of the ore mined was oxidized nearly down to ground-water level, which ranged from 600 to 1,100 feet below the surface. One of the principal kinds of ore, known as "red carbonate," was composed of a hydrous iron oxide mixed with sulphate and carbonate of lead and inclosing residual lumps of galena. Most of it carried gold and silver to the amount of $25 to $50 of each to the ton. In some of the ore, however, the gold was worth much more than the silver.

Several of the ore bodies in Prospect Mountain contained a large amount of quartz and a relatively larger proportion of gold to silver, with less lead. Some contained bismuth and tellurium.

According to J. S. Curtis, who studied the deposits in 1881 and 1882, the ores were deposited by hot volcanic waters which ascended along the fissures after the rhyolite eruptions. Curtis assumed that these waters had leached the metals from some deep-seated rock.

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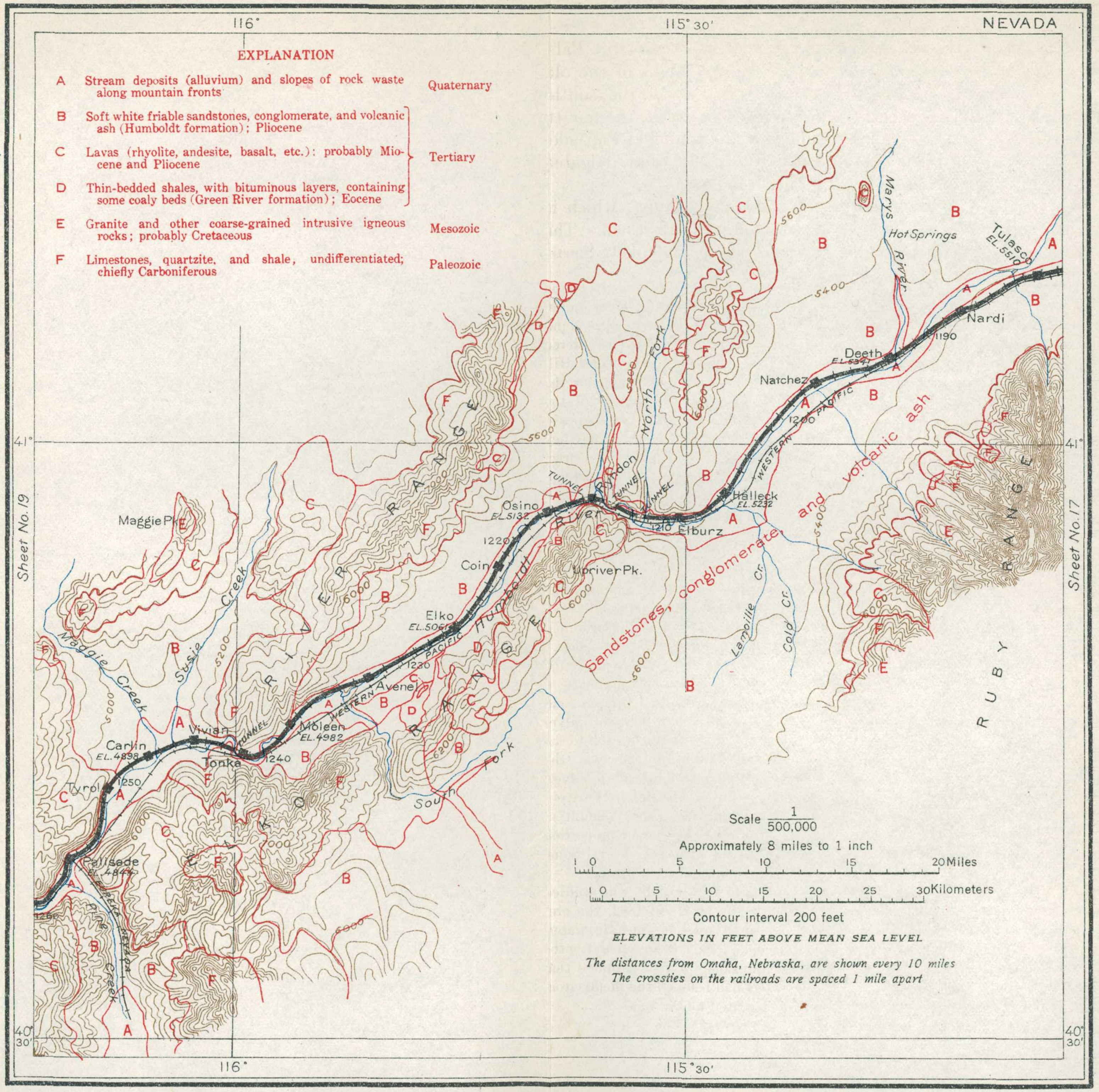

and andesite. Not far beyond Palisade the Southern Pacific and Western Pacific tracks cross, but both lines still follow Humboldt River closely.

Gerald is a station just east of Barth.

Barth (see sheet 19, p. 170) is a sidetrack and shipping station near the lower end of Palisade Canyon. (See Pl. XXXV, p. 153.) Just across the river there is an extensive deposit of iron ore, which has been developed for use as flux in the smelters in Utah. From 100 to 300 tons of iron ore has been shipped daily from this place for a number of years, the total shipments being more than 250,000 tons.[1] Besides the iron mine there are in the vicinity at least two other mines, the Onondaga and the Zenoli, about a mile south of Barth, which have produced $200,000 in silver from veins in andesite. The ores in addition to silver carry lead and copper.

Barth.

Omaha 1,262 miles.

About 2½ miles west of Barth the canyon opens into a broad valley with terraced floor. Harney and Cluro are stations in a somewhat unpromising looking stretch of country, with hard, white, clayey soil, deeply cut by gullies.

The old settlement at Beowawe (be-o-wah'we), which may be seen from the railroad, stands south of the station in a group of trees that is surrounded by cultivated land. The name is said to be an Indian word meaning gate and was given to this place because of the peculiar shape of the hills near by, which present the effect of an open gateway up the valley to the canyon beyond. The settlement at the railroad is comparatively modern. It contains the power plant of the Buckhorn Mines Co., from which a transmission line goes to the company's mine and mill, about 35 miles to the southeast. The mine was opened about 1908 and is reported to be working a large body of low-grade gold-silver ore in Tertiary lava. Concentrates from the Buckhorn (Mill Canyon) district are shipped by way of Palisade, but some ore from the Tenabo and Cortez districts, south of Beowawe, is shipped from this station. It is reported that 6,780 acres are under irrigation near Beowawe. The land is used for growing alfalfa and native hay and for pasture.

Beowawe.

Elevation 4,695 feet.
Population 155.*
Omaha 1,274 miles.

Leaving behind Beowawe, the railroad swings to the north. Across Whirlwind Valley to the south may be seen a white line, or terrace, against the distant mountain side. This is a hot-spring deposit and,

[1] This deposit of iron ore is mentioned in one of the reports of the Fortieth Parallel Survey. The ore is massive hematite, carrying from 60 to almost 70 per cent of iron. It is of high quality, its content of phosphorus, though above the Bessemer limit, being much less than that of the Alabama iron ores. The ore body, a mass about 200 feet in diameter and about 80 feet deep or thick, has been described as a replacement deposit in andesite.

like so many others in Nevada, is situated just below the steeper part of a mountain front. Here, as elsewhere, the spring has probably risen along the line of the fault or displacement which blocked out the mountains from the valley.

Ladoga, Farrel (elevation 4,626 feet), Mosel (4,583 feet), Argenta (4,553 feet), and Rosney are minor stations between Beowawe and Battle Mountain. The railroad passes around the north end of a broad lava plateau, and similar uplands are to be seen far across the valley to the north. As the train skirts the northern foothills of the plateau, the dark lava (basalt) may be seen close at hand. Beyond Argenta the train runs out into one of the most extensive valley areas along the Humboldt, the route traversing a broad expanse of plains far south of the main river channel.

Battle Mountain.
Elevation 4,512 feet.
Population 878.*
Omaha 1,307 miles.

The town of Battle Mountain was named after the mountain to the southwest, where in the early sixties a band of gold seekers attacked by Indians fortified themselves just south of the prominent eastern ridge. Antler Peak is the highest point on Battle Mountain visible from the train. The town is a distributing and shipping center for a number of well-known mining districts, the principal among which are the Austin[1] and Reese River districts. It is the northern terminal of the narrow-gage Nevada Central Railroad, which runs south 93 miles to the old town of Austin, the seat of Lander County. Probably more than $50,000,000 worth of silver has been taken from

[1] Austin has a population of about 1,000 and supplies an extensive grain and stock ranching territory along Reese River and in the Smoky Valley. It is the starting point for a number of stage lines into central Nevada.

The discovery of ore near Austin is said to date from May 2, 1862, when William Talcott, one of the riders of the Pony Express, on his regular trip to Virginia City picked up a piece of the rock along his route and had it assayed. On his return he located the Pony claim. Eight days later the Reese mining district was organized, and the fame of Lander and Union hills soon brought thousands of prospectors to the camp.

The ore about Austin is in narrow veins in granite (a porphyritic monzonite). The veins consist of quartz and rhodochrosite through which the metallic minerals (tetrahedrite, pyrargyrite, proustite, stephanite, polybasite, galena, sphalerite, pyrite, and chalcopyrite) are distributed. The first five minerals named are rich ores of silver containing also antimony or arsenic and copper with sulphur; galena, sphalerite, and chalcopyrite are ores of lead, zinc, and copper, respectively. The veins run northwest and dip 15° to 45° NE. They are closely spaced, and several may occur in the breadth of a claim (600 feet). They have been displaced in a remarkable manner by parallel north-south faults that dip to the west. All these faults are normal—that is, the ground west of the fault has sunk with respect to that on the east side. The granite on both sides of the veins has been decomposed and bleached by the solutions that deposited the ores. Mining in these small faulted veins has been costly, but miles of underground tunneling attest the value of the ore, which has been found in rather regularly distributed shoots.

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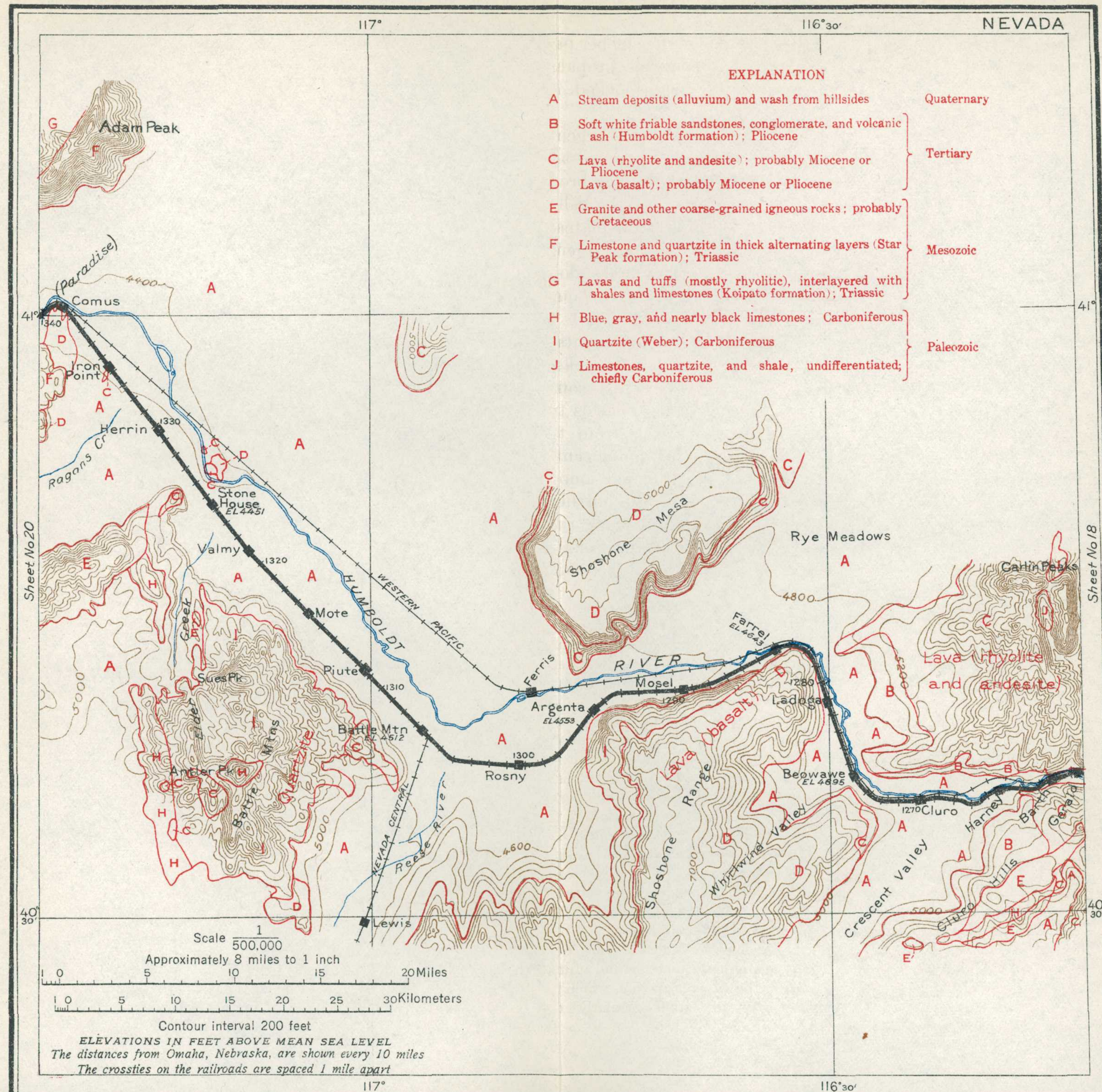
David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.



this district alone. Among the producing mining camps adjacent to Battle Mountain are those of the Mayesville, Kimberly, and Hilltop districts, 20 miles southeast. Deposits of lead, copper, silver, and gold occur in the mountains to the southwest and recently placer gold has been obtained on the south side of the mountain. Five or six million dollars' worth of ore has been taken from the various mining camps about Battle Mountain.[1]

From Argenta, 10 miles east of Battle Mountain, to the canyon above Golconda, the river and railroads pass through an extensive valley about 45 miles long and from 10 to 20 miles wide. Although most of the land along the river has been taken up, several thousand acres that lie at some distance from the river and that lack a water supply is still under Government ownership.

Piute (elevation 4,509 feet), Valmy (4,507 feet), Stonehouse (4,451 feet), Herrin (4,408 feet), Iron Point (4,390 feet), Comus, and Preble (see sheet 20, p. 178) are minor stations passed in turn. Stock and hay raising are the chief industries in this vicinity. Stonehouse was a station on the Overland Stage route. The name refers to an old stone building near a spring at the foot of the Battle Mountain Range. Conflicts with the Piute Indians occurred hereabouts, and there are many graves in the vicinity. Beyond Stonehouse the railroad approaches the foothills of lava and cuts through some of the lower spurs. These sheets of lava with some interbedded softer rocks have been broken by faults, and the resulting blocks have been tilted up into ridges having abrupt, broken fronts and gradual back slopes. Several such ridges are passed in succession.

At Preble Humboldt River enters another canyon, which extends through the Hot Springs Range. Just east of Preble, above the upper end of the canyon, may be seen bluffs of black shale with some fractured and iron-stained limestone. West of Preble the limestone, which is exposed in railroad cuts, is in thick dark-bluish beds with veinlets of white calcite, separated by some thick layers of shale. These strata dip toward the east, and their general trend is southwest, so that the railroad crosses them. The rocks belong, at least for the most part, to the Star Peak formation, of Triassic age. Rocks of this formation make up a large part of the Humboldt and other ranges, to be passed later, though there will be no other opportunity to see them so close at hand.

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[1] The ores of the Battle Mountain district occur in veins in sedimentary rocks, as replacements of calcareous parts of dark shales, or in contact-metamorphic deposits. The main vein deposits are of two types—pyritic gold quartz veins and galena-silver-calcite veins. Copper has been obtained from veins of both types.

Golconda.

Elevation 4,389 feet.
Population 430.*
Omaha 1,349 miles.

Golconda, another old stage station, is a warm-spring resort and a supply point for numerous mining camps. In 1897 a smelter and a concentration mill were built at Golconda to treat the copper ores from the Adelaide mine[1] about 12 miles to the south. The ore proved difficult to treat, and the mill, in which several processes were tried, is no longer used. It stands north of the track. The Pequart mine, an early producer, is about 6 miles south of Golconda, and there is a gold mine in the lone conical hill about 2 miles south of the station. Ranches stretch along the river below Golconda. The crops raised are alfalfa, native hay, and potatoes.

The elevation of Golconda is almost exactly that of the highest level attained by Lake Lahontan,[2] already referred to as having spread over a large part of northwestern Nevada. The history of this great lake is analogous to that of Lake Bonneville, in Utah, already described (pp. 97–99 and fig. 10, p. 82).

The Overland Route passes across the basin of Lake Lahontan at what is nearly its widest part. For 177 miles from a point in the Humboldt River valley near Golconda to a point in Truckee Canyon about 15 miles beyond Wadsworth or Fernley, the train passes over the bed of this extinct lake, and many of the features of the landscape

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[1] The Gold Run district, in which the most important mine is the Adelaide, is on the east slope of the northern part of the Sonoma Range—the Havallah Range of the Fortieth Parallel Survey reports. The district was organized in 1866.

The ore is a replacement of limestone and contains copper, zinc, and a little lead (pyrrhotite, chalcopyrite, sphalerite, and galena with garnet, pyroxene, etc.). The general country rock is dark calcareous slate (Star Peak) of Triassic age.

[2] The large lake which flooded a number of the valleys of northwestern Nevada at a very recent geologic date but has now passed away was named Lake Lahontan in honor of Baron La Hontan, one of the early explorers of the headwaters of the Mississippi. The lake covered approximately 8,400 square miles at its greatest expansion, and in its deepest part, the present site of Pyramid Lake, it was at least 880 feet deep—that is, its surface stood approximately 500 feet above the present water surface of Pyramid Lake. The ancient lake had no outlet except the one that led straight up, its waters being dissipated entirely by evaporation.

Fluctuations of the water level in these ancient lakes undoubtedly record climatic changes. It has been generally concluded that the periods of lake expansion were related to the stages of ice extension in the glacial epoch, or more specifically that their waters rose to their highest levels during the period when the glaciers were retreating from their farthest advance.

With the decrease of water supply the lake level has fallen, and in many parts of the basin the water has almost or entirely disappeared. Traces of former levels remain, however, in the form of elevated beaches. As the lake fell, ridges emerged and separated it into smaller units. Some of these minor basins are now essentially dry, although the lowest parts are periodically flooded to shallow depths during rains. When these areas dry up they show almost level floors with smooth mud surfaces, which check or crack in the dry air. These are the so-called mud lakes or playas, which are in some basins very extensive. The basins that are still fed by perennial streams contain lakes.

and some of the rocks seen in the valleys along the route are evidences of its former presence. The mountain ranges stood as islands or peninsulas in this body of water, and when the eye is trained to recognize them the old shore lines can be traced from point to point along the slopes.

Between Golconda and Humboldt Lake Humboldt River flows in a trench that it has excavated in Lake Lahontan sediments since the last drying up of the ancient lake. For a number of miles below Golconda the river is practically a surface stream flowing between low banks of marly clay belonging to the upper part of the lake deposits. At Mill City its channel begins to deepen, and at Rye Patch the river is a little over 200 feet below the general level of the desert. The general appearance of the trench cut by the river in the lake sediments is shown in Plate XXXVII (p. 177). The threefold division of the strata exposed in the steep banks (upper lake clays,[1] medial gravels, and lower lake clays) is easily distinguished where the beds are not obscured by débris. Below Rye Patch the banks decrease in height, and south of Oreana they are in few places over 40 or 50 feet high. The total thickness of the section thus exposed is not much over 200 feet. Borings in the desert valleys, however, have developed the fact that sediments of similar character occupy the rock troughs between the mountain ranges, in many places to very great depths, probably thousands of feet. No way has been devised of determining how much of this filling was deposited in the Quaternary lake and how much may be older, possibly of Tertiary age.

Beyond Golconda the brown, rusty-colored ranges on both sides of the railroad, having characteristic sharp and ragged peaks and ledgy slopes, afford good exposures of the early Mesozoic shales and limestones, very generally associated with lavas.

Eglon and Tule (elevation 4,325 feet) are unimportant stations west of Golconda. Beyond Eglon the railroad bends close around the foothills on the south and is here far enough above the valley to afford an extended view to the north, over Paradise Valley, which is drained by Little Humboldt River. Little use appears to have been made of the lower part of this valley except for grazing and for cutting wild

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[1] According to I. C. Russell, mammalian bones were obtained at a number of localities in the sides of the Humboldt and Walker River canyons and, with the exception of a single vertebra found in the medial gravels, were derived from the upper lake beds. So far as determined they include an elephant or mastodon, a horse, an ox, and a camel. The fossils are usually scattered through the sediments, more than one or two bones of the same individual being seldom found at a single locality, though the elephant or mastodon bones obtained in the Humboldt Canyon near Rye Patch constitute nearly an entire skeleton. Many of the bones had been removed as curiosities, however, before the collections that were submitted to study were obtained. Recently similar remains have been found in the beach or bar deposits of the former lake near the north end of Pyramid Lake.

grasses for hay. Beyond Paradise Valley the Southern Pacific turns and for a long distance pursues a general course to the southwest. On the right, ahead, Winnemucca Peak projects like an island from the desert plains. A whitish band along its base is the edge of an extensive area of sand dunes.[1]

Winnemucca.

Elevation 4,334 feet.
Population 1,786.*
Omaha 1,365 miles.

The town of Winnemucca, named for a chief of the Piute tribe, is the seat of Humboldt County and serves an extensive ranching and mining country. It was originally a small trading station, established in 1850, on the emigrant route to California and was then known as French Ford. Before the Oregon Short Line was built Winnemucca was the gateway to the whole of southern Idaho. The Southern Pacific and Western Pacific railroads pass through the town about a mile apart, and Humboldt River flows between them. The agricultural and stock-raising districts tributary to Winnemucca include Paradise Valley, to the northeast, and the Quinn River valley, to the north. Of less importance are the narrow bottoms along the Humboldt above and below the town, on which the chief crop is wild hay.

The National mining district,[2] in the Santa Rosa Range, about 70 miles north of Winnemucca, is reached from that town by stage. The National mine is noted for the occurrence of a remarkably rich shoot of ore, which has yielded about $4,000,000.

After leaving Winnemucca the train runs straight down the valley of Humboldt River for several miles, in a course parallel to the river

[1] A large area a few miles north of Winnemucca is covered with sand dunes formed since the disappearance of Lake Lahontan. This belt of drifting sand extends westward from the lower part of Little Humboldt Valley to the desert between Black Butte and the Dona Schee Hills and is about 40 miles long from east to west and 8 or 10 miles wide. The dunes are fully 75 feet thick, and their steeper slopes are on the east side, thus indicating that the whole vast field of sand is slowly traveling eastward. This progress has necessitated a number of changes in the roads in the southern part of Little Humboldt Valley during recent years. In some places in this region the telegraph poles have been buried so deeply that they have had to be spliced in order to keep the wires above the crests of the dunes. The sand is of a light creamy-yellow color and forms beautifully curved ridges and waves that are covered with a fretwork of wind ripples, and many of these ridges are marked in the most curious manner by the footprints of animals, which form strange hieroglyphics that are sometimes difficult to translate.

[2] The gold-silver deposits at National were discovered in 1907. The most prominent and widespread rock in the district is basalt, which occurs in a thick series of flows and is probably of Miocene age. The principal ore deposits, however, are associated with older Tertiary lavas, especially with rhyolite and an andesitic rock (latite). The veins were deposited by hot waters soon after the eruption of the rhyolite. They carry quartz, stibnite (sulphide of antimony), free gold alloyed with silver, and other less abundant or less characteristic minerals. Some veins occur also in older rocks.

but high on the terraces along its south side. Grass Valley, an extensive depression between the Sonoma Range on the east and the East Range on the west, opens on the Humboldt Valley from the south just west of Winnemucca. From the rear platform the town is seen to stand on a broad, flat, brush-covered alluvial slope, leading down from the mountains on the east to the river channel at the very foot of Winnemucca Mountain. The river bottom lands are but narrow strips, where wild grass is cut for hay.

Beyond Rose Creek (elevation 4,324 feet) the two railroad lines diverge, the Western Pacific taking a route which lies north of the Southern Pacific route and passing out of the valley of Humboldt River.

Mill City.
Elevation 4,233 feet.
Population 153.*
Omaha 1,393 miles.

From Mill City, which was for a long time an important supply and shipping station, roads lead to Bloody Canyon, Star City, Unionville, Chafey (formerly Dun Glen), and other camps that were of note in early days.[1] Most of these camps are south of the railroad.

The valley of Humboldt River in its course through the old Lake Lahontan sediments takes on a more desolate aspect as the river becomes more deeply intrenched in these barren clays. Apparently no utilization of the narrow river bottoms is attempted here, and the channel, swinging off to the northwest, is soon lost to view from the railroad.

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[1] The discovery of a rich body of silver ore close to the surface in the Sheba mine, on the east side of the West Humboldt Range, due south of Mill City, led to the rapid growth of Star City from 1861 to 1865. The town had two hotels, express and telegraph offices, daily mails, and a population estimated at about 1,000. This was before the building of the railroad, and all supplies were hauled by wagon from Marysville or Sacramento, Cal. In 1871 the town was reported as nearly abandoned. At Unionville there are extensive mine workings dating back to about the same time. Mills were built here at an early date, and from 1860 to 1880 Unionville, although perhaps rivaled or surpassed for a short time by Star City, was on the whole the most important town in the region, as it was the local supply point for many smaller communities in neighboring mining districts. There was considerable activity during the same period near Dun Glen (now known as Chafey).

The Kennedy district, 50 miles south of Winnemucca and about 45 miles by road from Mill City, lies on the east side of the Stillwater Range, and first attracted attention in 1890. Kennedy soon became a flourishing town, mills were built, and considerable work was done in several mines. After the oxidized pay shoots were exhausted the amalgamation mills proved unfit for coping with the complex gold-silver-lead ores, and since 1904 the district has sunk into obscurity. The total output has been estimated at $120,000.

The mines in the West Humboldt Range have yielded far more silver than gold. Most of them were opened and were worked extensively before the completion of the railroad. The great improvement in mining facilities brought about by railroad communication was not sufficient to offset the diminution in tenor of the ore bodies below their enriched portions and the decline in the price of silver.

Imlay, a town of recent establishment, is a railroad division point. With its growth Mill City has declined. Due south of Imlay is the north end of the West Humboldt Range, the northern and higher part of which is also known as the Star Peak Range. Here is an excellent example of the characteristically abrupt termination of the basin ranges. The smooth, gradual slope of the alluvial plain sweeps up to the very foot of the mountain front, and foothills proper are lacking.

Imlay.

Elevation 4,197 feet.
Population 326.*
Omaha 1,398 miles.

South of Imlay a fairly abundant supply of good water is found in springs near the base of the mountains and piped down to the railroad. The natural flow from such springs never reaches far beyond the base of the mountain, as the water rapidly sinks in the loose soil or rocky detritus of the piedmont plains. From Imlay to Humboldt the railroad curves around the north end of the Star Peak Range and then, turning almost due south, keeps the west side of this rugged mountain mass in full view. (See Pl. XXXVI, *A*.)

At Humboldt station is Humboldt House, an old hotel building that was formerly a meal station on the railroad. A good supply of pure water is brought down in pipes from the mountains southwest of Humboldt, making the place an oasis, with trees and green fields. The Ruby quicksilver mine is in Eldorado Canyon, about 8 miles southeast of Humboldt.

Humboldt.

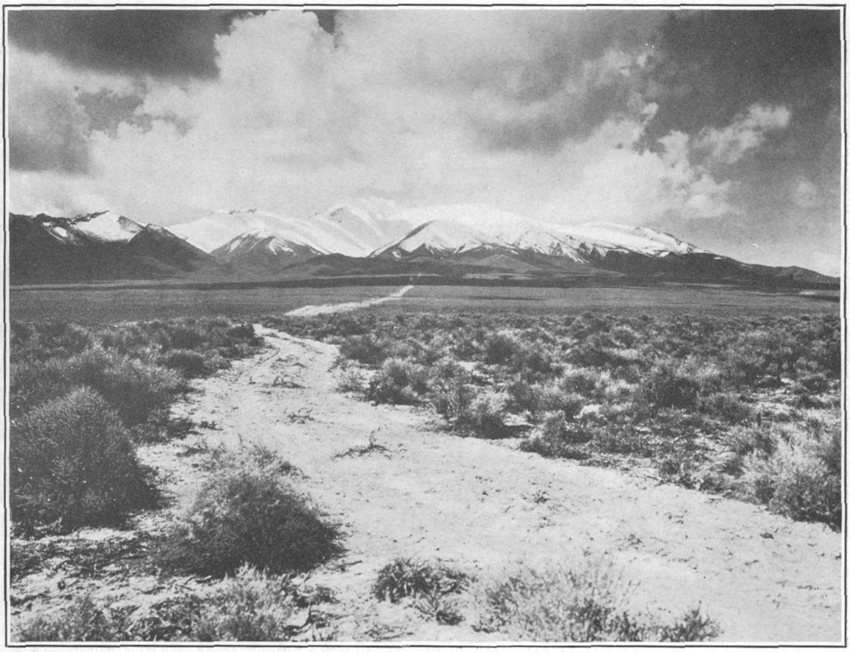
Elevation 4,238 feet.
Omaha 1,405 miles.

The Star Peak Range[1] is rather regular in outline and is about 75 miles long. On the south it is separated by a low pass (Cole

[1] The Star Peak Range is made up of great masses of Triassic rocks belonging to two formations, the Star Peak and the Koipato. The Star Peak formation, the younger of the two, occupies mainly the northern half of the Star Peak Range and has an estimated thickness of 10,000 feet. It is made up of quartzite, limestone, and slates, among which have been found fossil remains of both Middle and Upper Triassic vertebrate and invertebrate animals. These rocks are overlain conformably by limestone and dark slates containing Jurassic fossils. The underlying Koipato rocks, so called from the Indian name of the west Humboldt Range, form a considerable part of the southern half of the Star Peak Range. The Koipato formation was originally described as consisting chiefly of beds of quartzite (silicified sandstone) overlain by interstratified beds of limestone, quartzite, and "felsitic porphyroids," and as having an estimated thickness of 6,000 feet. According to later determinations, however, the Koipato consists chiefly of lava flows (rhyolite) with subordinate nonvolcanic sediments, including limestones. Much of the rock originally taken to be quartzite is actually rhyolite.

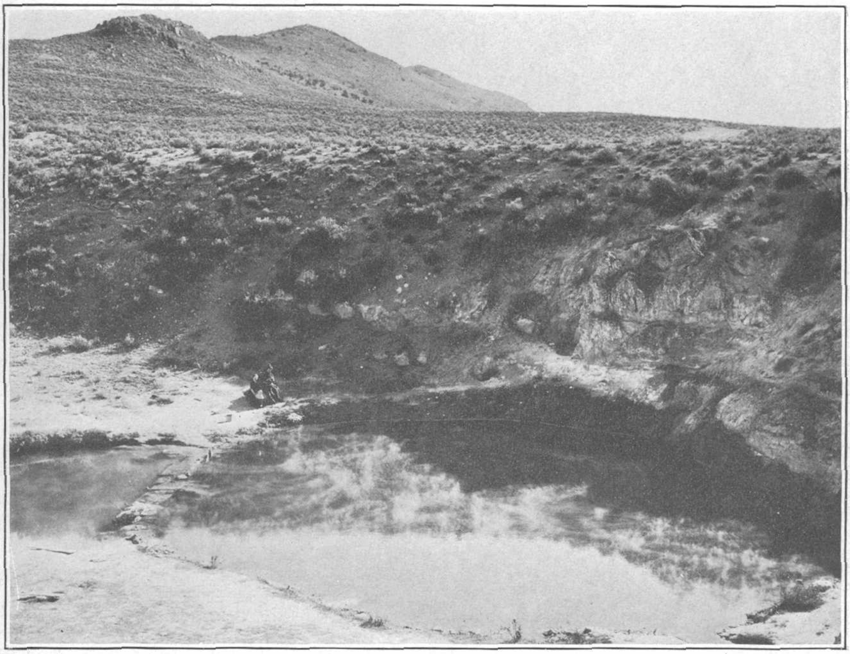
The Triassic slates and limestones of the West Humboldt Range are noted for the abundant and well-preserved fossils found in them. These comprise skeletons of ichthyosaurs ("fish lizards," extinct marine animals of large size), spines and teeth of extinct types of sharks, and numbers of the coiled shells known as ammonites.

On the lower slopes of the Star Peak Range are considerable bodies of Tertiary rhyolite and basalt, with which occur related beds of tuffs or other water-laid sediments of about the same age.



A. SNOW ON THE NORTH END OF THE HUMBOLDT MOUNTAINS.

View from a point near Imlay, Nev. Photograph furnished by Southern Pacific Co.



B. HOT SPRING NEAR ELKO, NEV.

Photograph furnished by Southern Pacific Co.

CHANNEL OF HUMBOLDT RIVER NEAR RYE PATCH, NEV., EXCAVATED IN THE DEPOSITS OF FORMER LAKE LAHONTAN.

Photograph furnished by Southern Pacific Co.

Canyon) from the much lower southern division of the West Humboldt Range, sometimes called the Humboldt Lake Mountains. The Star Peak Range culminates in Star Peak, about 10,000 feet above sea level. At its south end is Buffalo Peak, about 8,400 feet in elevation. All along the rugged slopes facing the railroad and also on the opposite side of the range are prospects and mines. One mine, the Star Peak, which is being worked, is almost at the summit of the peak whose name it bears. The Rosebud district, about 28 miles northwest of Humboldt, or 35 miles north of Mill City, was the site of a boom that followed the discovery of ore there in 1906. A town was rapidly built, to be as quickly abandoned.

Some mounds about half a mile south of Humboldt, on the right (west) side of the Southern Pacific track, are composed principally of calcareous tufa. Each mound has an opening at the top lined with crystallized gypsum and sulphur. These deposits were undoubtedly made by hot springs that are now extinct. Small pits and an old retort just west of Humboldt mark the site of some old works on these sulphur deposits, but the supply was evidently too small to be of economic importance.

Beyond Humboldt the railroad continues down the east side of the valley over a broad, gently sloping plain of stony detritus and sand, washed down from the mountains. Valery is a sidetrack and loading platform for the Star Peak mine. The mining camp may be seen by looking sharply at the right-hand end of a long, dark rocky ridge near the crest of the range. A deep cut along the railroad at milepost 373 exposes a sand and gravel bar, a beach deposit of Lake Lahontan. The old beach lines may readily be traced along the hillsides, particularly late in the afternoon of a clear day. From the rear platform there is now a fine view of the higher part of the West Humboldt Range, which shows a lofty continuous crest with exceedingly steep rocky slopes that contrast sharply with the smoothly graded alluvial fans that spread out from the canyon mouths and coalesce into a gently sloping plain reaching down to the river.

Rye Patch.

Elevation 4,256 feet.
Omaha 1,416 miles.

The old hotel building which serves as the station called Rye Patch is a relic of the boom days of the old Rye Patch mine. The name Rye Patch refers to the wild rye grass that formerly grew abundantly about the place. The Rye Patch mine, about 5 miles east of the station, produced much silver ore in the early seventies, but has lain idle for over 20 years. Lately a cyanide plant has been installed, and the old dump is being reworked. The ore occurred in limestone, probably of Triassic age.

After passing Rye Patch the train runs nearly due south, the track lying well up on the broad, gently sloping alluvial plain between

Humboldt River on the west and the West Humboldt Range on the east. (See Pl. XXXVII.) Beyond Rye Patch is Zola.

Nenzel.

Elevation 4,185 feet.
Omaha 1,424 miles.

Nenzel, which until recently was called Nixon (see sheet 21, p. 184), is near the site of the old town of Oreana, noted as being the place where silver-lead smelting was first successfully carried on in Nevada. Oreana has been referred to as the birthplace of silver-lead smelting west of the Rocky Mountains, but some lead was produced earlier at Argenta, Mont. The Nevada ore that was first smelted at Oreana in 1867 came from the Montezuma mine, in the Trinity Mountains, west of the railroad.

Nenzel is now a supply station for the new camp of Rochester. A branch railroad, the Nevada Short Line, extends from Nenzel for 5 miles to the mountain foot, but the mines and settlement are high up on the Star Peak Range. As late as August, 1912, Joseph Nenzel relocated some old claims in this district and discovered the ore which has made it a producing district. A small shipment of ore made in August was followed by the discovery of larger bodies later in the year. In less than a month the hitherto desolate canyon had a population of more than 2,000 people and contained many substantial two-story buildings. The total production to September, 1914, is reported to be over $1,200,000.[1] In the early days Rochester Canyon and the adjacent ravines yielded considerable placer gold that must have been derived from the disintegration of the gold-bearing veins on the mountain slopes above.

The West Humboldt Range is divided southeast of Nenzel by a low pass, Cole Canyon, which crosses the range obliquely. This pass separates the Star Peak division of the range from the lower Humboldt Lake division. The pass probably marks the place where a fault, which runs along the west base of the Star Peak Range and has caused the elevation of that block, swings across the range to the south. If so, the Star Peak and Humboldt Lake ranges are distinct in structure as well as in form. Traces of recent fault movement can be found also along the alluvial slopes at the west base of the Humboldt Lake Range.

Below Nenzel the train again approaches the river, and the deep trench cut by the river into Lake Lahontan clays is well exhibited to the traveler. Some of the artificial cuts along the railroad are also in these lake-deposited clays, which are capped by gravelly beach

[1] The ores of the Rochester district are found in rocks which were classed by the early geologic surveys as Triassic (Koipato) sedimentary rocks, but which have now been identified as mainly lavas (rhyolite and some other varieties). The silver-lead ores containing antimony were deposited along zones of parallel cracks in rhyolite. The valuable metals occur with quartz, in the form of argentite, cerargyrite, proustite, and pyrargyrite (all silver minerals), and native gold.

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

OVERLAND ROUTE

From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

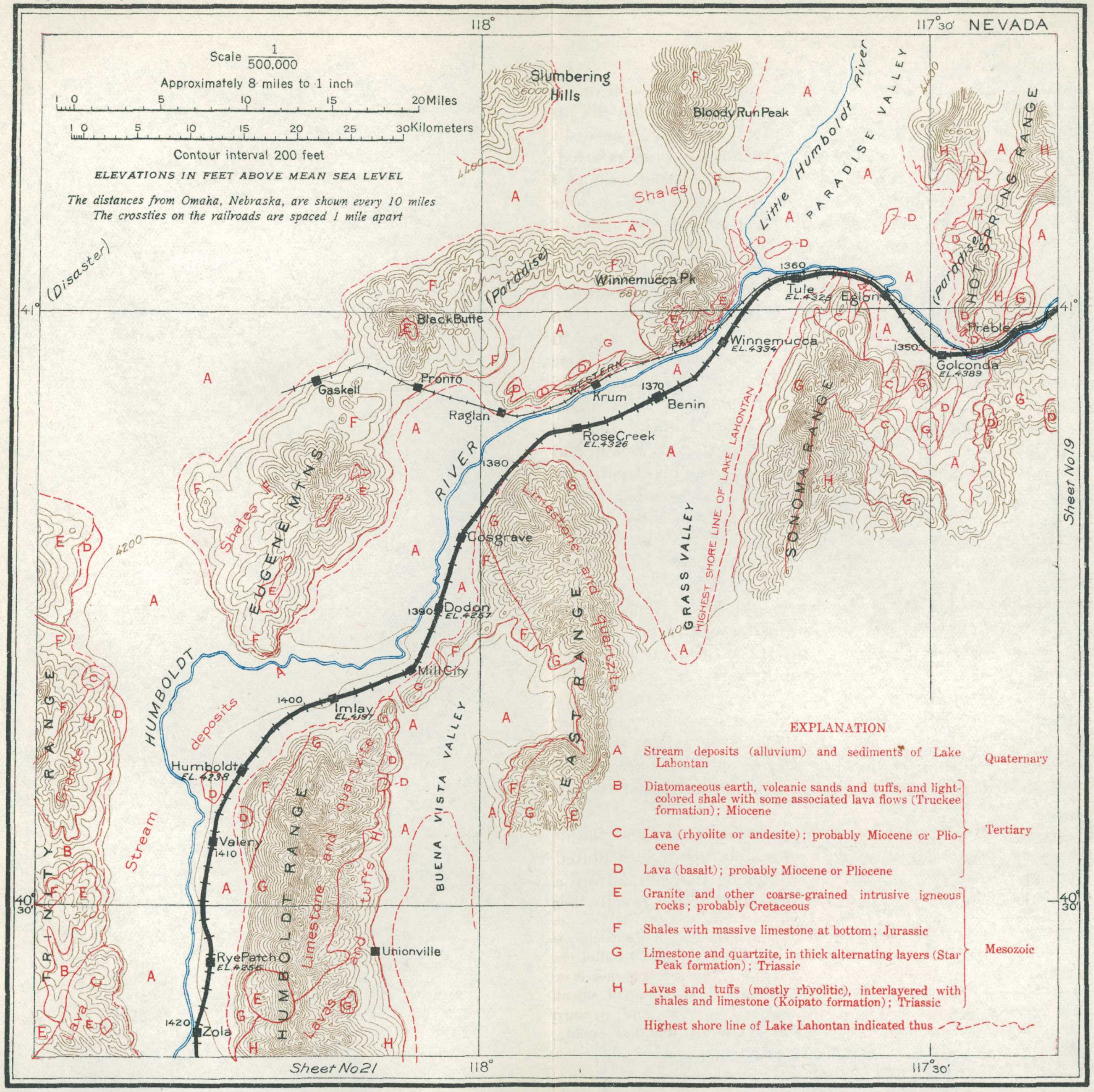
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.



deposits. The gravel in places slides down over the clays and conceals them.

Beyond Woolsey, a siding and section house, the upper beaches of Lake Lahontan are very distinct, especially in evening light. The railroad now begins to descend to the broadening bottom lands of Lovelock Valley, with its trees, fields, and ranch buildings.

Kodak is a sidetrack from which gypsum was formerly shipped to a plaster mill at Reno, and fragments of the gypsum rock are strewn along the railroad. They are of granular texture, like loaf sugar, and some portions show distinct lamination or banding. The deposit is an immense mass that forms a bare bluff of light-colored material in the low slopes of the Humboldt Lake Range opposite Kodak. It is evidently an interbedded layer in the Triassic sedimentary series, probably a chemical deposit formed in Triassic time in a comparatively small basin. Deposits of gypsum were laid down over very extensive areas during Triassic and Permian time in other parts of the country, indicating widespread conditions of aridity in those periods.

Kodak.

Elevation 4,014 feet.
Omaha 1,433 miles.

Lovelock and the adjacent Lovelock Valley, the lower 16 or 18 miles of the valley occupied by Humboldt River above Humboldt Lake, constitute one of the most prosperous agricultural settlements of Nevada. Lovelock is also the railroad and supply point for a number of mining districts. At present its principal industries are connected with the raising of sheep and cattle and especially the winter feeding of stock. The river is 15 to 25 feet below the general level of the cultivated flood plain, so that it is necessary to bring the water for irrigation in ditches from points upstream. In 1900 about 14,000 acres were irrigated, and a little over half of this area was in alfalfa. Wheat, barley, and potatoes are also grown, and the town has a flour mill.

Lovelock.

Elevation 3,979 feet.
Population 1,421.*
Omaha 1,438 miles.

Of the mining camps which are generally reached by way of Lovelock, Seven Troughs,[1] a gold camp, is at present the most important. North of Lovelock, in the Trinity Mountains, is the Montezuma mine, which supplied antimonial lead-silver ore to the Oreana smelter in the sixties. There are a number of antimony deposits in the

[1] The Seven Troughs district, including four little towns, Seven Troughs, Vernon, Mazuma, and Farrell, is about 30 miles northwest of Lovelock and lies on the east slope of a minor range now generally known as the Seven Troughs Mountains. It is one of the more recent camps, not much prospecting having been done here before 1905 or 1907. The ores are in Tertiary volcanic rocks and occur in veins of soft, crushed material which does not crop out at the surface. The veins carry native gold containing a considerable proportion of silver, in sugary quartz. Some very rich ore has been found in this district, and some of the mines have yielded considerable returns.

mountains hereabout, one of them in the West Humboldt Range a few miles east of Lovelock. Nickel and cobalt deposits, not now worked, occur in the Stillwater Range about 30 miles southeast of Lovelock. A little niter has been found in this neighborhood, chiefly in the Humboldt Lake Range.[1]

From Lovelock the railroad continues down to the west side of the Humboldt Valley, at first through broad fields of hay and grain. At Perth (a sidetrack) there is a very large pit from which gravel has been taken for grading along the railroad. The gravel here, as at other places in this part of Nevada, is one of the old beach deposits of Lake Lahontan. Shore terraces, which are in many places very distinct, may be seen here on both sides of the valley.

Beyond the cultivated region the low irregular valley surface consists of a mixture of clay and sand in dunelike form, the lumpy surface being due more or less to the growth of brush and to consequent local protection from the wind. The yellowish-green brush that covers the country is greasewood (Sarcobatus), which seems to prefer ground that is otherwise unproductive.

Granite Point (elevation 3,973 feet), a railroad siding and group of section houses, is named from a rocky bluff that projects into the west side of the valley below Lovelock. It is horizontally scored by the upper Lake Lahontan terraces. Below this point the valley is more barren, the hard white clay in the low-lying ground supporting only isolated clumps of greasewood.

Humboldt Lake, a water body of irregular outline and variable area which receives the surplus drainage of Humboldt River, comes into view at or a little southwest of milepost 334. It is on the left (east) of the railroad, at the bottom of a broad, smoothly graded wash slope. The level and size of the lake vary greatly with the seasons. At times of high water it overflows into Carson Sink. At other times, however, evaporation exceeds the supply and the lake decreases in size. The water is not densely saline, as it is partly

[1] Saltpeter, or niter, which is a necessary constituent in the manufacture of most gunpowders and is also very largely used for fertilizers and for other purposes, has been found in small quantities in many places in the United States, although practically the entire supply of these salts now used in this country is obtained from Chile. Niter was discovered in the foothills bordering the Lovelock Valley at about the time of the first coming of the railroad through this part of the country, and the possibility of developing a local supply of these important salts has ever since been a source of intermittent interest. Incrustations of salt containing in some places a considerable proportion of sodium nitrate are found on some of the fractured cliffs and ledges of volcanic rock just above the edge of the valley land south and southeast of Lovelock. Continued exploration and experimentation in these districts have, however, failed to discover any mass of niter-bearing material of sufficient volume and richness to justify or encourage an enterprise for its commercial development.

freshened by occasional overflow into the final "evaporation pan" of the Carson Desert.

Beyond Toulon (a sidetrack) the railroad gradually approaches the lake. There is no cultivation of the ground about here, nor any settlement other than that represented by the railroad section houses. At high water a narrow ridge parallel to the railroad appears as a long tongue of land that extends out into the lake parallel to the shore. A telephone line runs down the valley, and very commonly the poles here stand well out in the water. These poles were set when this part of the valley was dry, but the wire was later put on them from boats.

The Humboldt Lake Range, at the east side of the valley, dwindles to a long, narrow ridge extending off to the southwest. Over this summit, beyond its southwesternmost point, lies the Carson Desert, one of the most extensive of the Nevada desert valleys, and its saline lake, Carson Sink.

Toy.
Elevation 3,930 feet.
Omaha 1,453 miles.

Toy (formerly Brown's station), a group of railroad section houses, stands just above the edge of Humboldt Lake at high water. A little beyond this place the railroad crosses the line between Humboldt and Churchill counties. In the hills northwest of Miriam (a siding) a deposit of scheelite [1] was recently found.

The basin of Humboldt Lake is partly closed at its lower or southwest end by a remarkable gravel embankment which looks like a great artificial dam. Just beyond milepost 323 the railroad passes through one end of this embankment in a deep cut that exposes well the character and attitude of the beds of which it is built. The embankment is clearly one of the beaches or bars of former Lake Lahontan. Such bars are formed by waves and currents in lakes or along the seashore at the present time. This embankment, now high above any recent water level, with even crest and smoothly curving front in its sweep across the valley, is a striking topographic feature.

The embankment is cut across in one place near its south end by the overflow from Humboldt Lake. The breach has been partly repaired by an artificial dam which largely increases the area of the lake and, it is stated, furnishes power for mining and milling. Humboldt Lake overflows only a part of the time, but at very high water a considerable stream passes from it to Carson Sink. The breach through which it overflows can be seen from the train by looking back after the embankment has been passed. The embankment is

[1] Scheelite (tungstate of calcium) is a very heavy mineral, which is ordinarily found in veins in crystalline rocks. It is an ore of tungsten, a metal that is used to form an alloy with steel, made for uses requiring great hardness. Tungsten is also employed in making filaments for electric lights.

more or less concave toward the valleys on both the upper and lower sides, but the backward view from the lower side best shows its form.

The railroad crosses and recrosses the overflow channel, traversing broad stretches of bare white mud and irregular areas of lumpy ground built up from white sand and clay. About 2 miles beyond Ocala (a section house at milepost 320) salt vats and a small salt-making plant lie close to the railroad, in the middle of one of the white clay flats or playas. (See p. 154.)

Huxley.

Elevation 3,908 feet.
Omaha 1,465 miles.

The station called Huxley (formerly White Plains) is approximately at the junction of the present railroad with the original line of the Central Pacific, which ran from this point due southwest, climbing over a divide of several hundred feet and passing a station called Mirage. The present line swings southward along the border of the Carson Desert.

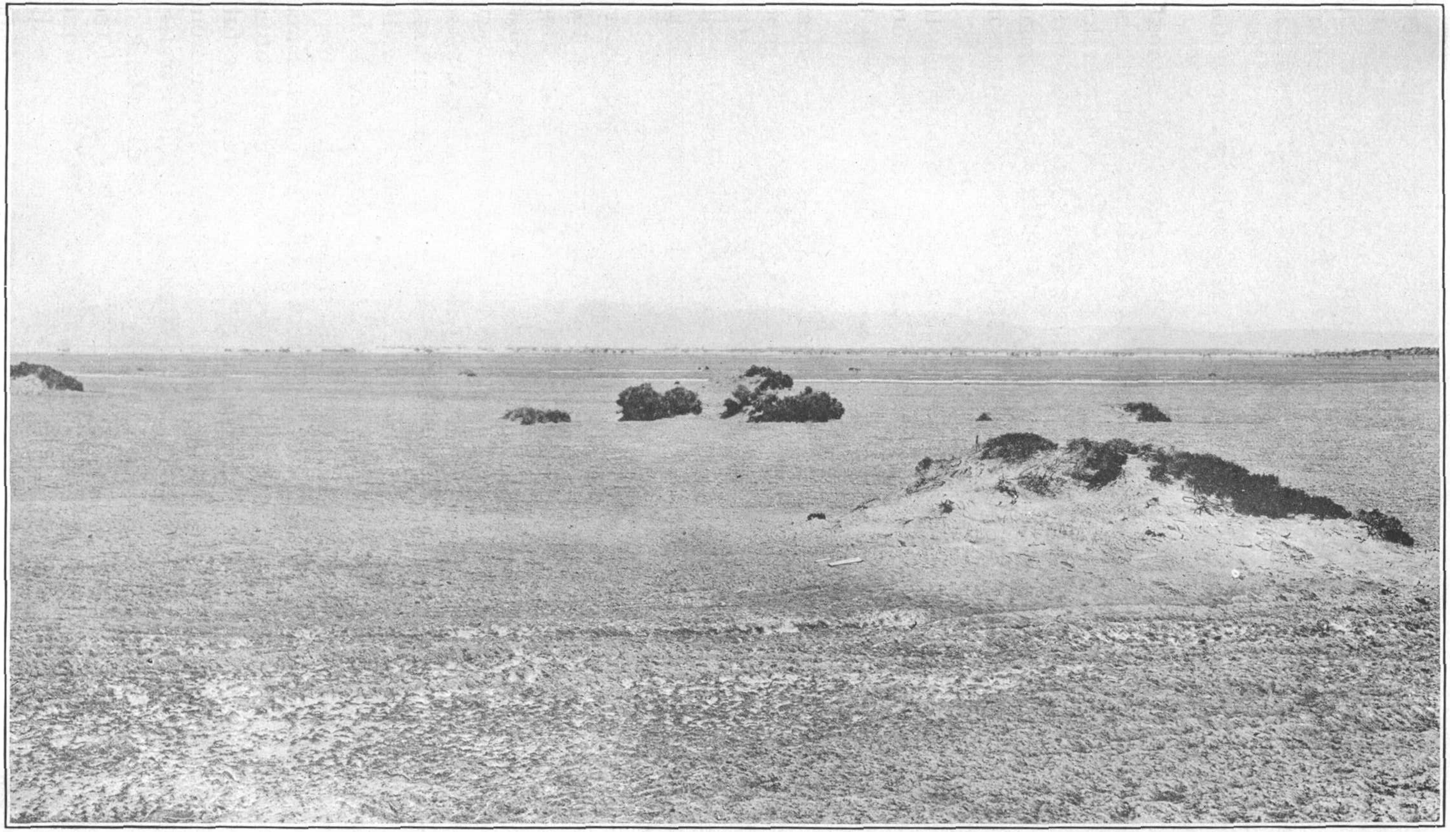
The Jessup mining district, a gold camp, lies in the mountains 10 miles northwest of Huxley. Some shipments of gold-bearing ore were made during 1908 and later, but the district has not been a large producer.

One of the first deep wells drilled in the West was put down near this place by the Central Pacific Railway in 1881, in a search for good water. The boring reached a depth of 2,750 feet, but the water obtained was of very unsatisfactory quality. At 1,700 feet the drill encountered a bed of "petrified clams," and the record states that at 1,900 feet well-preserved "redwood timber" was found.

Huxley is the shipping point for the small salt plant passed a short distance back. An old kiln east of the track has been used in the past for making lime from a mass of compacted shells constituting one of the shore deposits of the former Lake Lahontan. This deposit seems to indicate that the lake waters could not have been very heavily charged with salts at the time when the inhabitants of these shells lived, although it must be admitted that the shells might have been washed into the lake by Humboldt River. Many of the shells are intact and perfectly preserved. The shell deposit is said to be continuous for several miles along this part of the valley.

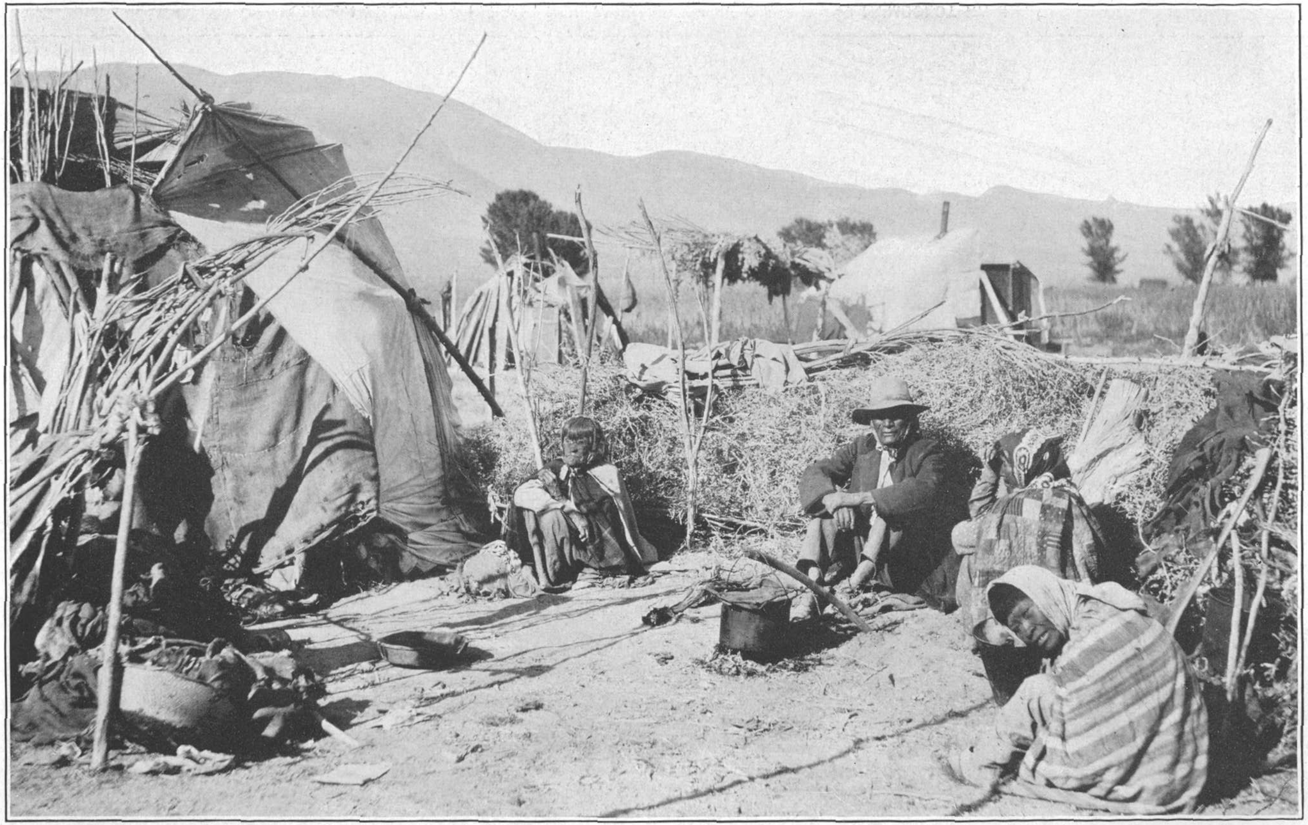
Near Huxley the river spreads out, forming extensive marsh lands (the Mopung marshes), and during flood seasons this region is often a favorite resort of waterfowl. The small lakes are said to be full of carp and other fish at such times, doubtless carried down from Humboldt Lake. Pelicans, ducks, geese, snipe, and other waterfowl are found in the vicinity of the Nevada lakes and marshes.

At milepost 315 is the beginning of another long tangent of the railroad which heads almost directly south. Along this stretch the valley opens out toward the Carson Desert, across which the Stillwater Range may be seen in the distance. From Huxley to a point



CARSON DESERT AT PARRAN, NEV., THE "SINK" OF CARSON AND HUMBOLDT RIVERS.

Photograph furnished by Southern Pacific Co.



PIUTE INDIANS AT HOME.

Photograph furnished by Southern Pacific Co.

a little beyond Hazen the train passes through some of the most typically desert country to be seen along the whole route. The overflow channel from Humboldt Lake is crossed for the last time, as it turns off to the east toward the lowest part of Carson Sink. The railroad passes along the margin of the sink, which has here a lumpy dunelike surface consisting of sand and clay soil, the mounds surmounted by isolated patches of greasewood.

Parran.

Elevation 3,888 feet.
Omaha 1,470 miles.

Parran is the lowest point on the Nevada portion of the Southern Pacific route. The salt-incrusted surface about the station is typical of the margins of the large playas that are common in these deserts. Water generally stands on the surface of the sink, and in the distance on its south side may be seen a thin line of dark trees trailing out into the desert. These trees are cottonwoods, which border the lower channel of Carson River, the principal source of the water that flows into the sink. At Parran is an old salt plant which has not been operated for several years, but which formerly produced a few hundred tons of salt annually for local use at near-by settlements. There is a water tank and pump station at Parran, but all the water used at this place is brought in tank cars, being run into an underground cistern from which it is pumped into the tank.

Beyond Parran lies a desolate stretch of barren dunes of clay and sand with scattered clumps of greasewood. The desert is bordered on the northwest by bare hills, whose slopes, in many places even to the summits, are covered with white, wind-drifted sand. The scenery along this part of the route offers but little variety and suggests extreme desolation. (See Pl. XXXVIII.) High sand dunes, more or less covered with greasewood, and small bare mud plains (playas) continue beyond Hazen. Just east of Hazen is another gravel pit which, like several already mentioned, is in one of the beach-bar deposits of former Lake Lahontan.

Hazen.

Elevation 4,012 feet.
Omaha 1,494 miles.

An extensive area in Nevada may be considered tributary to the main line of the Southern Pacific by way of Hazen. Within this area are the Tonopah, Goldfield, Yerington, Luning, Silver Peak, Rawhide, Wonder, Fairview, and other well-known mining districts.

Fallon, 15 miles away on the low, broad alluvial fan of Carson River, is the center of the Truckee-Carson irrigation project.[1] It

[1] On the western border of the Great Basin, in the bed of ancient Lake Lahontan, in Nevada, the Government is bringing to completion a project to irrigate more than 200,000 acres of land. This is one of the driest parts of the United States, and was called "Fortymile Desert" by the gold hunters who crossed it on the way to California. Its average annual rainfall is only 4 inches. To the man from the humid region the valley at first looks very desolate, but to one acquainted with these deserts the Lahontan country presents many attractions. As the train from Hazen nears Fallon the possibilities of the region

is reached by a branch railroad from Hazen which passes the old settlement of Ragtown.[1]

Another branch line runs south from Hazen to Goldfield, which is connected by rail with Las Vegas, Nev., on the Los Angeles, San Pedro & Salt Lake Railroad, and with Ludlow, Cal., on the Santa Fe system. This line gives access to Yerington [2] by a branch from Wabuska, to Rawhide by a branch from the head of Walker Lake, to Silver Peak by a branch from Tonopah Junction, to Tonopah, and to numerous other mining districts. Connection may be made also at Fort Churchill for Virginia City (the Comstock lode; see Pl. XLIII, p. 189), Carson, and Reno.

The deposits at Tonopah [3] were discovered in 1900, when the mining industry generally in Nevada had sunk to a very low level.

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become more apparent. It has all the potential resources of the country that surrounds Boise, Idaho, and Greeley, Colo., and the energetic citizens who are settling here will in a few years make this district as fertile and famous as those.

The soil is sandy loam, clay loam, and volcanic ash. The valley will produce every variety of crop grown in the North Temperate Zone. Alfalfa, wheat, barley, and oats grow luxuriantly, and sugar beets are a profitable crop. Apples, pears, apricots, and cherries, as well as garden vegetables, do well and find a ready market in the mining towns near by. Potatoes, celery, and cantaloupes raised here are of superior quality and are shipped for consumption on dining cars and in first-class hotels. A considerable number of farms now await settlers, and additional areas will be thrown open from time to time to meet the requirements of homeseekers.

The Truckee-Carson project was the first of the large irrigation projects undertaken by the Government. The water is derived from Carson and Truckee rivers, that from the Truckee being brought across the divide at Fernley by means of a large canal.

[1] Before the railroad was built overland emigrant travel followed various routes, one of which passed north of Great Salt Lake and came down Humboldt River. At that time, of course, Hazen had no existence, but one of the principal stations along the old route was Ragtown, a few miles southeast of Hazen. It was merely a trading station and derived its name from its ragged and miserable appearance, for about the station stood a group of huts of Piute Indians, constructed of brush, pieces of old wagon covers, ragged remnants of tents, old quilts, and Indian mats, a more or less familiar sight in parts of Nevada even to-day. (See Pl. XXXIX.)

Near Ragtown, not far from the present railroad between Hazen and Fallon, in the midst of the sand dunes of the Carson Desert, there are two remarkable lakes, formerly known as the Ragtown ponds, now called Big Soda and Little Soda lakes. They are believed to be old volcanic craters, whose tops are now almost on a level with the desert. They contain a strong solution of sodium carbonate, or washing soda, together with other salts, from which soda was for a time extracted.

[2] Yerington is a copper district. The principal ore bodies are of irregular shape and occur in Triassic limestone near intrusive masses of granite (granodiorite). They belong to the type of contact-metamorphic deposits. The minerals characteristically associated in the deposits are pyrite, chalcopyrite, garnet, and pyroxene. There are also some veins in the district.

[3] The Tonopah deposits are quartz veins carrying a number of silver sulphide minerals, particularly argentite, stephanite, and polybasite (the last two containing antimony as well as sulphur), with some gold. The country rocks are trachyte, rhyolite, and andesite. The veins have been faulted and displaced in a remarkable manner, so that skill is required to mine them.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
OVERLAND ROUTE
From Omaha, Nebraska, to San Francisco, California

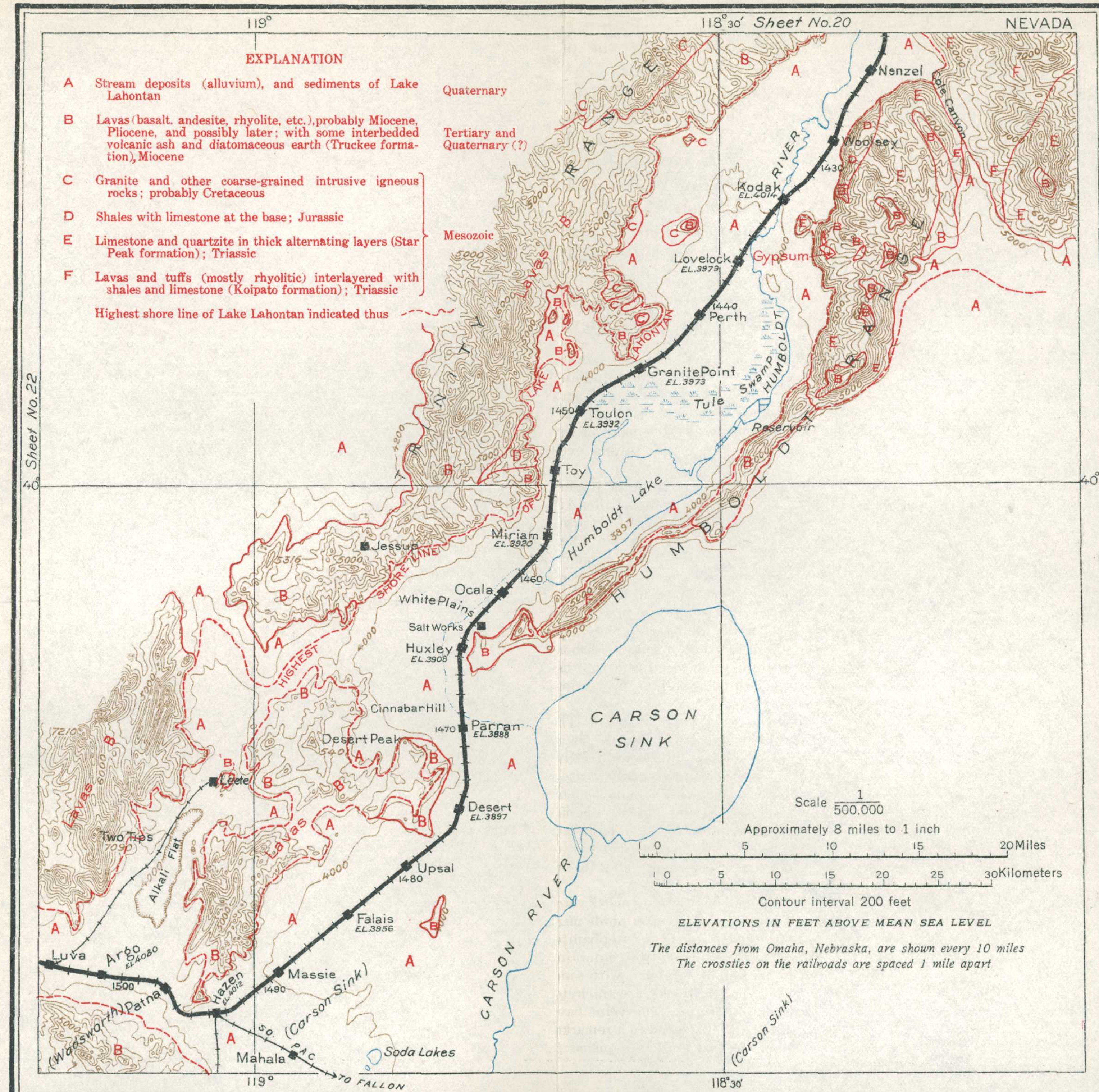
Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

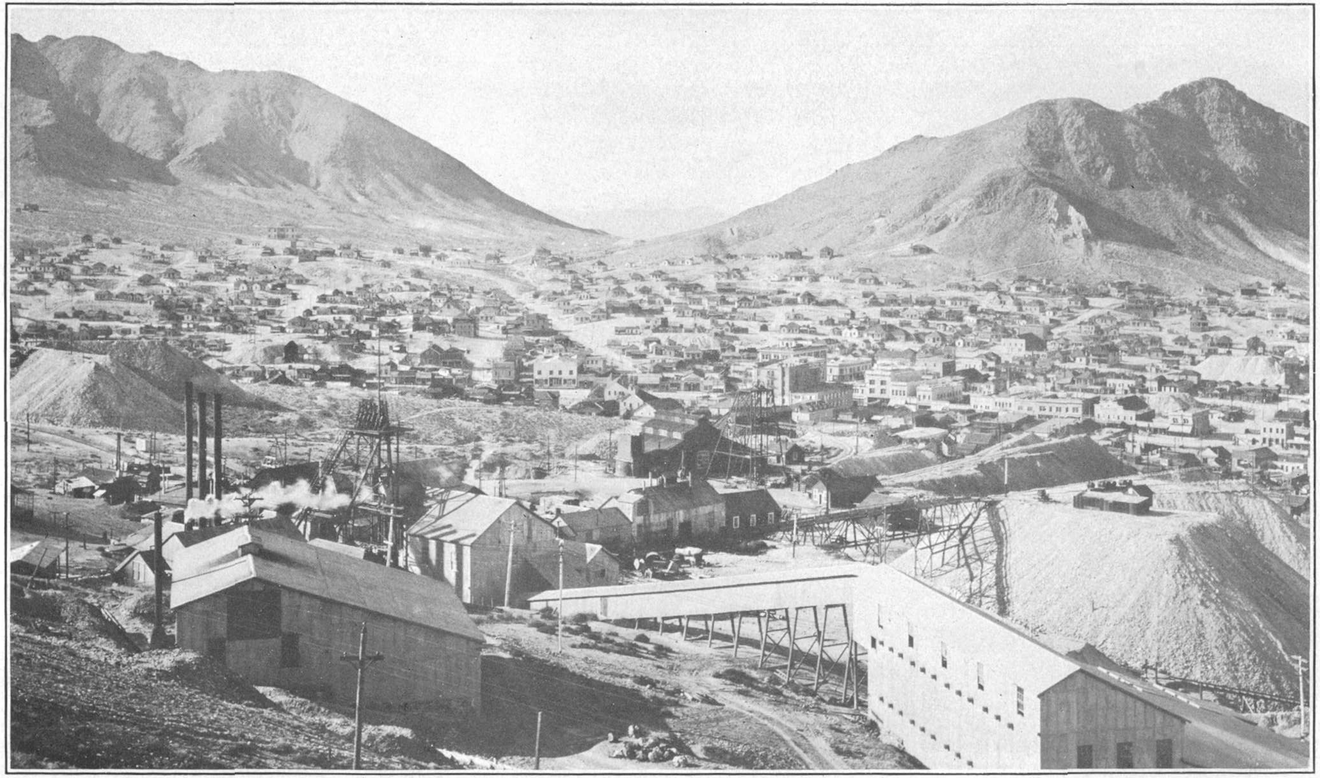
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR
David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

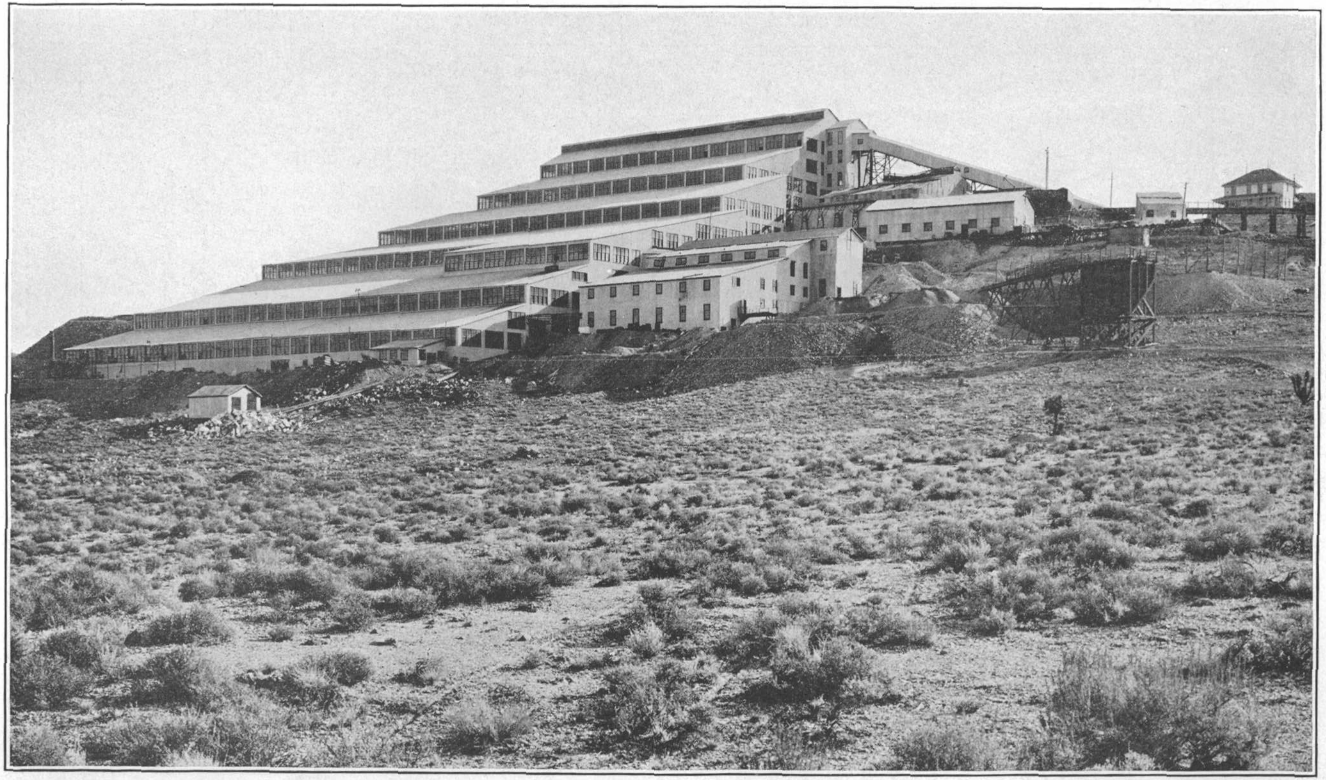
Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.





TONOPAH, NEV., A TYPICAL MINING COMMUNITY.

Photograph furnished by Southern Pacific Co.



CONSOLIDATED MILL, GOLDFIELD, NEV.

A modern mill where gold ore is crushed and its valuable metallic portion separated. Photograph furnished by Southern Pacific Co.

The discovery greatly stimulated prospecting and led to the revival of mining throughout the State. The district has produced silver and gold to the total value of more than $60,000,000 from veins in Tertiary volcanic rocks. (See Pl. XL.)

The discovery of gold at Goldfield[1] in 1902 was a direct outcome of the development at Tonopah. The deposits here also occur in Tertiary volcanic rocks, but in form and character they are entirely different from the Tonopah veins. The total production from Goldfield to the end of 1913 was over $65,000,000 in gold and silver. Of late years considerable copper has been recovered from the concentrates of the Goldfield mills. (See Pl. XLI.)

Argo and Luva, west of Hazen, are merely sidetracks, except that Luva stands at the junction of the main line with a now little-used branch that connects with a part of the original line of the Central Pacific, until lately operated as far east as Leete, where there are old salt works. Formerly the main line of the railroad followed a more direct route through this valley to White Plains (Huxley). The present route by Carson Sink, though longer, avoids a steep and troublesome hill, where helper engines were employed.

Fernley.
Elevation 4,157 feet.
Omaha 1,506 miles.

Fernley (see sheet 22, p. 202) is one of the more recently developed agricultural settlements resulting from the Truckee-Carson reclamation project. The ditch from Truckee River runs along a hillside a considerable distance south of the railroad, and from it water is supplied for irrigating some very promising bench lands. Good water for domestic use is found in wells 100 or 200 feet deep. From Fernley a recently finished line of the Southern Pacific, known as the Fernley-Lassen branch, extends north and northwest into California. Here also the traveler crosses the divide between two modern subdivisions of the former Lahontan basin, going from a basin tributary to Carson Sink into the valley of Truckee River, whence all natural drainage passes northward toward Pyramid and Winnemucca lakes. As a part of the Truckee-Carson project, a part of the Truckee River water has been artificially diverted over the Fernley divide into the Carson and Humboldt basins.

Truckee River, named from the Indian guide of Gen. Frémont, flows through the old town of Wadsworth just beyond Fernley and 100 or more feet below the present railroad grade. The original route of the Central Pacific passed down into this valley, and Wadsworth

[1] The Goldfield deposits, which are rather irregular in form, occur along zones of fissuring in dacite, andesite, and latite, all closely related lavas. A large part of the ore consists of silicified portions of these rocks. The gold is partly free, partly combined with tellurium. A peculiar feature of these deposits is their content of alunite, a hydrous sulphate of potassium, sodium, and aluminum.

was one of the important stations on it. Now, however, the railroad swings to the south to maintain an even grade on the westward climb along upper Truckee River.

Truckee River rises in Lake Tahoe and is of greater purity and subject to less fluctuation than any other stream that enters the Lahontan basin. At Wadsworth the Truckee makes a bend to the north and then flows through a narrow and canyon-like channel for 18 or 20 miles to Pyramid and Winnemucca lakes, where its waters are evaporated. Wadsworth was formerly a trading post and also served as an Indian agency and fort. Pyramid Lake is still included in an Indian reservation, the present Indian agency being situated at the south end of the lake near the mouth of Truckee River. The Indians are mostly of the Piute tribe. There are many references to Wadsworth in the history of the early events in this part of the country.

West of Wadsworth a backward view down to the narrow bottom lands along the river presents a pleasing contrast to the rocky barrenness of the hills on either side, at least during the summer, when a stream of clear water glitters amid green fields and trees. The train soon enters the Virginia Range and the canyon of the Truckee, which gradually narrows upstream. The rocks exposed in the canyon walls are mostly lavas, including volcanic flows and interbedded layers of volcanic tuff or ash, representing successive periods of volcanic activity. The lavas are of varied character, including light-gray rhyolite, darker andesite, and black basalt. At lower elevations along the bottom of the canyon are white, even-bedded clays, lying horizontal, which were left by the receding waters of Lake Lahontan. These clays rise to the maximum level reached by the former lake waters, about 4,400 feet above present sea level.

Between mileposts 273 and 272 the mining district of Olinghouse[1] may be seen, though it is at some distance across the canyon to the north or northwest. This district is now reached by way of Wadsworth.

Opposite milepost 265 are the reservoir and diversion dam (Pl. XLII, p. 188) by which Truckee River water is taken into the ditch of the Truckee-Carson reclamation project. Unassorted and unconsolidated deposits of bowlders, gravel, and sand exposed in some of the railroad cuts are recent river deposits. The somber coloring of these barren rocky slopes is very characteristic of the Nevada desert ranges, particularly of the volcanic regions. Rock cuts along the railroad expose also some materials of brilliant hues, principally weathered

[1] The White Horse or Olinghouse district lies on the east side of the Virginia Range and covers about 6 square miles. The prevailing country rock is andesitic lava. The district has yielded fine ore specimens and has shipped some good ore, but on the whole it has not been very productive.

volcanic tuffs belonging to the succession of lavas of which the Virginia Range is mainly composed.

Gilpin (a sidetrack) is in the midst of almost continuous rock cuts and cliffs, mostly in basalt and basaltic tuffs. The channel here is so narrow that little or no cultivation is possible along the stream. At low elevations near the river channel the horizontal white lake beds are clearly exposed across the valley.

Derby was formerly the junction of the original route, which passed by way of Wadsworth, with the present line, but the old track down the south side of the river has now been taken up and the grade is used as a public road. West of Derby the canyon narrows and its walls become higher, consisting of continuous bluffs that show the lava flow rocks and interbedded layers of ash, including deposits of white tuff and diatomaceous earth, which appear as conspicuous white earthy bands at a number of places, both high and low, on the slopes. The successive flows of dark lava show here in the steep bluffs across the river, on the south side of the canyon.

Derby.

Elevation 4,165 feet.
Omaha 1,513 miles.

The line between Storey and Washoe counties follows the channel of Truckee River, and county-line posts are seen at one end or the other of the bridges.

Clark is a minor station in the canyon and is the point of departure for the Ramsay mining district,[1] in the Virginia Range, to the south. West of Clark the Lake Lahontan clays are exhibited in cuts along the railroad. These extend to a siding named Ditho (elevation 4,304 feet), where the last remnants of such deposits are found, the track level at this point being almost exactly coincident with the uppermost level reached by the waters of the old lake. This is therefore the western limit of the former Lake Lahontan, whose basin the railroad has been continuously crossing from a point at exactly the same level in the Humboldt Valley near Golconda.

Clark.

Elevation 4,257 feet.
Omaha 1,520 miles.

For several miles beyond Ditho remnants of a very recent though prehistoric lava flow may be seen in the river valley. The flow is a layer, apparently 10 to 20 feet thick, of dense black basalt, which lies chiefly along the very bottom of the valley. It is exposed in cross section at several places by the cutting of the river and along the old railroad grades, which lie slightly above the present route. This lava has flowed down since the valley attained practically its present form.

[1] Ramsay, a town of about 100 inhabitants, is 17 miles south-southeast of Clark station, with which it is connected by a good road traversed by a daily stage. The country rock is Tertiary lava (andesite and a little rhyolite). Several mines have shipped some gold ore, but the production has not been large.

West of Hafed, a sidetrack opposite a ranch on the valley bottom, some good examples of columnar jointing in the basalt lava are exposed just above the railroad track. (See footnote, p. 121.) Volcanic tuff, both coarse and fine, apparently underlies the basalt and forms bluffs. To the west the river channel narrows again and is bordered on both sides by steep rocky ridges and spurs.

Hafed.

Elevation 4,376 feet.
Omaha 1,529 miles.

Vista, an old station and group of section houses, is at the upper end of the canyon in the Virginia Range, and immediately beyond it the Truckee Meadows spread out broad and flat. The extreme lower part of the meadows near the entrance to the canyon is marshy, from a cause explained in the footnote on page 189. The many prospects of the Wedekind mining district may be seen in the low foothills at the margin of the valley to the north. The district has never produced much ore.

Vista.

Elevation 4,395 feet.
Omaha 1,532 miles.

The city of Sparks was named after John Sparks, governor of Nevada from 1903 to 1906. Although the second city in Nevada in population, it is primarily a railroad division point and contains the Southern Pacific Co.'s shops and roundhouses. A stop of 15 or 20 minutes is usually made at the railroad offices and shops, where a huge mountain-climbing locomotive is substituted for the ordinary one. After another stop at the passenger station, three-fourths of a mile farther on, the train proceeds westward 2½ miles across the open valley to Reno.[1]

Sparks.

Elevation 4,225 feet.
Population 2,500.
Omaha 1,536 miles.

[1] To the westbound traveler the view to the rear across the Truckee Meadows toward the narrow gorge by which Truckee River passes through the Virginia Range is suggestive of many events in the geologic history of this general region. The Virginia Range illustrates the block-fault structure that characterizes the ranges of the Great Basin. Its front stands like a great wall along the lower edge of the meadows, almost no foothills intervening between mountain and plain. The steeper part of the mountain front is trenched by gulches or canyons and is connected with the level plain at its foot by short slopes of talus and small alluvial fans. These works of erosion and deposition, however, do not obscure the fact that the range is essentially an uplifted block of the earth's crust, and the valley below, now buried by river flood-plain deposits, is a relatively downthrown block. (See fig. 16.)

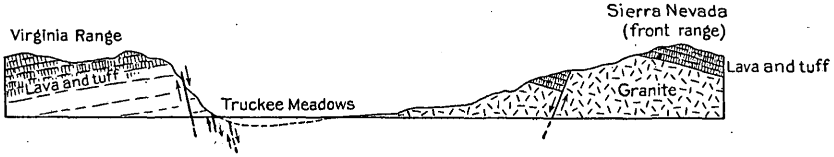
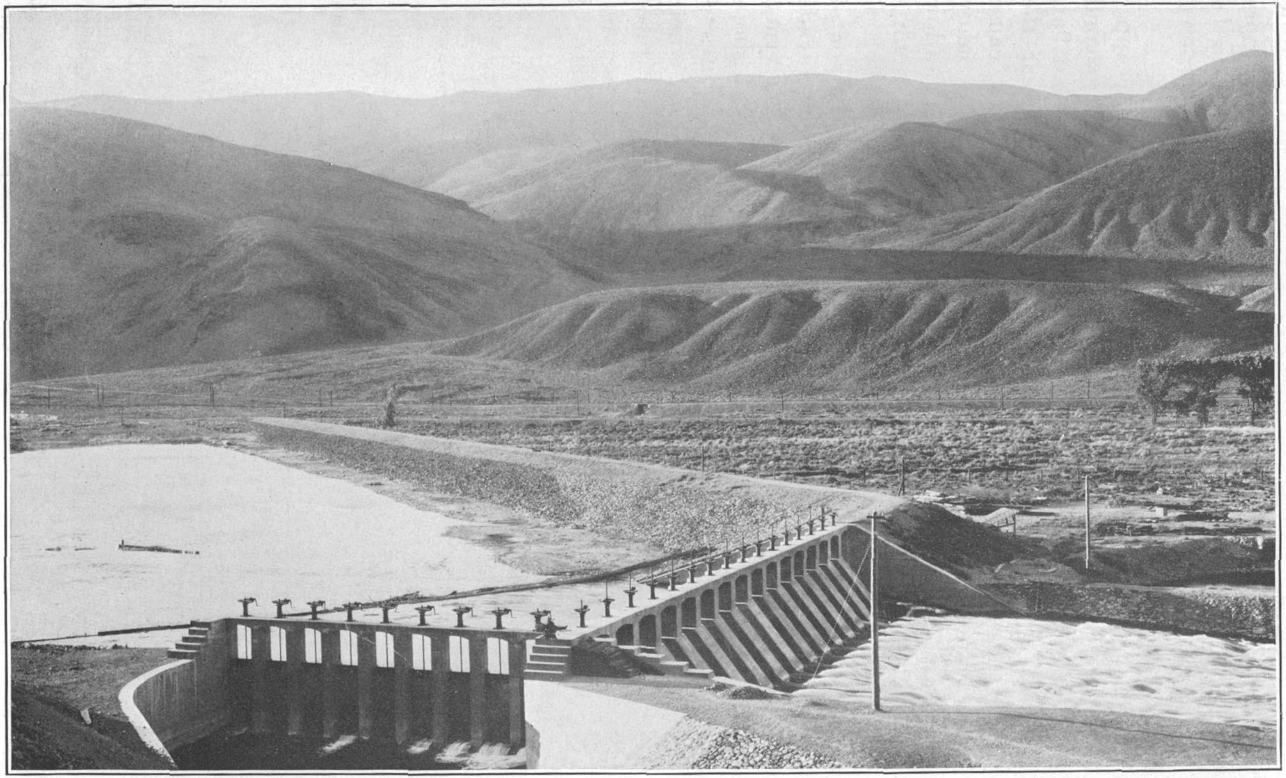


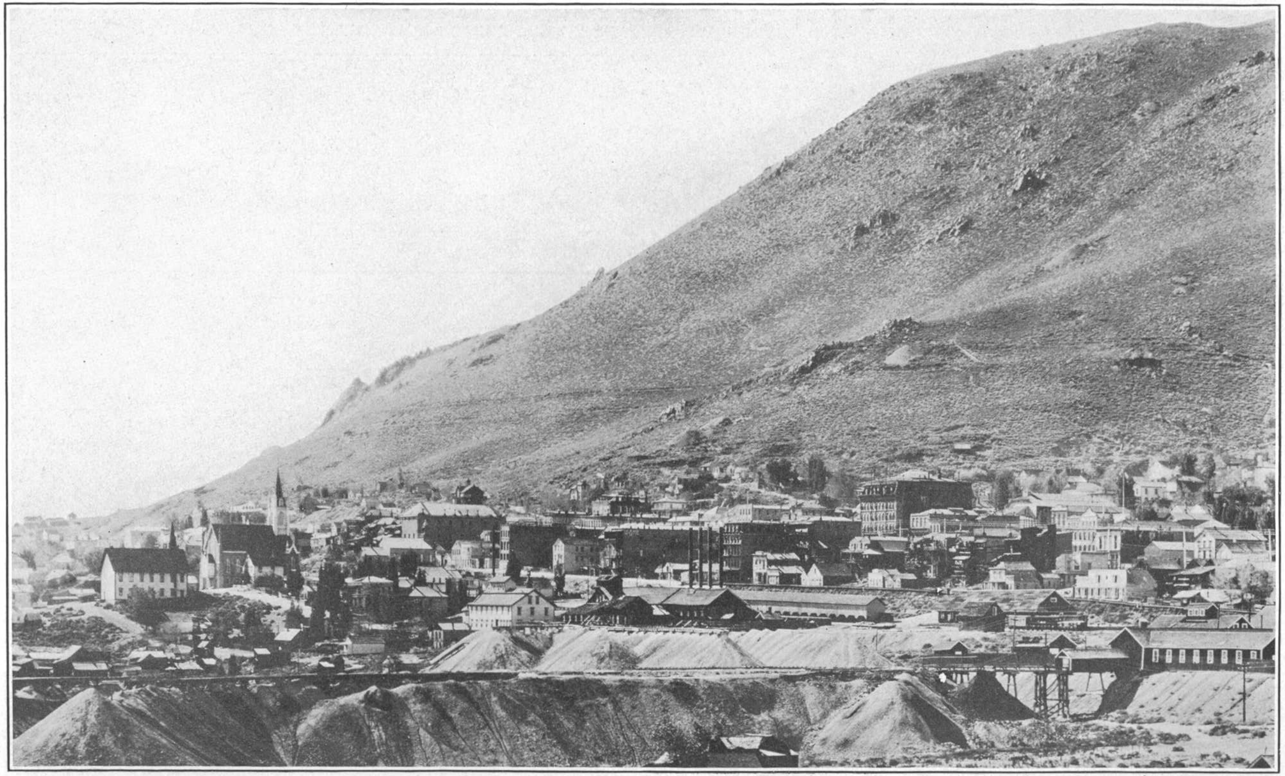
FIGURE 16.—Diagrammatic cross section showing the geologic structure of the Virginia Range in its relation to Truckee Meadows.

The mountains around the Truckee Meadows are broken by a narrow gorge through which Truckee River escapes. This gorge, now deep and narrow and worn into solid rock through the most of



UNITED STATES RECLAMATION SERVICE DAM ON TRUCKEE RIVER IN THE VIRGINIA RANGE, BELOW RENO, NEV.

Terraces of Lake Lahontan beds in foreground, a broad, low alluvial fan at the mouth of the gulch, and somber-looking hills covered with broken fragments of Tertiary lavas. Photograph furnished by Southern Pacific Co.



VIRGINIA CITY, NEV., ON THE FAMOUS COMSTOCK LODE.

This lode is worked through deep shafts, one of which is under the building having four smokestacks, in the center of the picture. Photograph furnished by Southern Pacific Co.

Reno.

Elevation 4,497 feet.
Population 10,867.
Omaha 1,539 miles.

The largest city in Nevada is Reno, the seat of Washoe County, which has long been the principal commercial and industrial center of western Nevada. From this point the Virginia & Truckee Railroad runs south to Carson (31 miles), the State capital, and to Virginia City (52 miles), the locality of the famous Comstock lode,

its course, has undoubtedly been cut by the river. It seems that such a channel may have been developed in one of two ways. Either Truckee River, dammed by the rise of a mountain ridge across its path, formed a lake and, after an outlet had been established by overflow at some low point on the margin, gradually wore this down into a canyon, or else the river, having established its channel across low-lying plains that existed before the mountains were uplifted, simply maintained its course by cutting down its channel as fast as the mountain barrier rose. That the latter hypothesis is the true one appears from the following considerations. If the site of the Truckee Meadows had ever been dammed to a considerable depth by uplift of the Virginia Range, the lake waters would have soon found an outlet through a low pass to the north, reaching Pyramid Lake by a more direct course than they now take. There is, however, no sign of such a channel nor of traces of shore lines about the valley to indicate that the lake ever rose to this height.

The uplift of the ranges in the Great Basin and of the Sierra Nevada, which is now near at hand, is a comparatively recent event as reckoned on the geologic time scale. (The term uplift is used only in a relative sense; it does not necessarily imply actual uplift. Some apparent uplifts may be due to a sinking of adjacent valley areas.) These mountain-building movements began late in the Tertiary period and have continued even down to the present day. Little by little blocks of the surface crust readjust themselves, and here and there earthquakes or the opening of fissures at the surface signify the gradual slipping of one fragment of the earth's crust against another. Probably the movements that uplifted the higher mountain ranges took place in the past in much the same gradual manner as to-day. The east front of the Sierra is now an earthquake zone, in which are felt occasional shocks and tremors due to movements in the earth's crust, and these appear to come periodically. They may be frequent for a period covering several months, which may be followed by a period of relative quiescence.

The Truckee Meadows may have been intermittently a shallow lake and a meadow. At present the river is flowing over volcanic bedrock at the entrance to the canyon, on the east, while the valley above is occupied by alluvium and possibly some lake beds. The ground water, following the general course of the stream, rises as it encounters the natural rock dam at the entrance to the canyon, making the lands above the canyon entrance marshy.

The mountains around the Truckee Meadows are composed of sedimentary rocks that are probably Mesozoic or possibly in part Paleozoic, igneous, and metamorphic rocks, and lavas and associated sedimentary deposits of Tertiary or later age. The pre-Tertiary rocks were exposed for a long period to weathering and erosion before the Tertiary sediments were laid down upon them. In Tertiary time an extensive series of volcanic flows was poured out, accompanied by showers of volcanic ash and the accumulation of fresh-water lake or marsh deposits. These materials, with the deposits spread by running streams, form the later group of geologic formations here represented. The geologic column in the vicinity of Reno is very incomplete—that is, long periods of geologic time are unrepresented here in the record preserved by rock formations. Although some deposits may have been laid down during these periods and later entirely worn away, it may be with the discovery of which Nevada's mining history began.[1] To the north the Nevada-California-Oregon Railway reaches Alturas (184 miles), in the northeast corner of California, and has lately been extended to Lakeview (238 miles), across the line in Oregon. Reno is the seat of the Nevada State University, which includes the Mackay School of Mines. Its manufactures include flour, foundry and machine-shop products, packed meats, and beer. Farming and stock raising are important industries in this vicinity, particularly in the

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inferred in general that the land surface in this vicinty was elevated and that by erosion its rocks were contributing to sedimentation in other parts of the region.

The lavas are principally andesites of varied mineralogic composition, but the series includes also much rhyolite and some basalt. All the lavas are interbedded with layers of volcanic ash, tuff, or tuff-breccia, the last consisting of angular lava fragments thrown out from the volcanic vents. Most of the lavas are Tertiary, but some are more recent.

The foregoing summary of volcanic activity applies especially to the eastern Sierra foothill belt, but it is broadly applicable to the whole western part of the Great Basin province. Moreover, the lavas here described are undoubtedly related directly to the extensive flows that spread out over the Sierra, although the later sedimentary record west of the Sierra divide is entirely distinct from that in the Great Basin.

[1] Virginia City (Pl. XLIII) is in the Virginia Range near its crest, only 12 to 15 miles south of the canyon through which the railroad crosses these mountains. Ten years after the first gold excitement in California prospectors began to search the stream channels of Nevada. They found "pay dirt" along Carson River and traced these gravels far upstream. In January, 1859, prospectors followed these gold gravels to their source high on the slopes of Mount Davidson, and as washings from the loose surface croppings yielded rich returns, they dug down to bedrock. Then it was that the lode was discovered. A rush of prospectors followed, and Virginia City rapidly grew into one of the principal towns of the far West. In 1870 a narrow-gage branch railroad, 52 miles in length, was completed from Reno. This has been referred to as the most prosperous railroad in the country in its day, as it was said for a time to have regularly operated 40 trains a day over its 52 miles of crooked track. As the workings were deepened the ingress of hot water and the high underground temperature made mining difficult. The mines were in part drained by the Sutro tunnel, a notable engineering feat for that time. Work in the deeper levels is rendered possible only by the constant forcing of large volumes of air through the entries and a liberal use of ice water, both for drinking and for bathing, by the men, who work in very short shifts.

The Comstock lode is a great fissure vein, 4 miles long, along a line of faulting in the Tertiary eruptive rocks (chiefly andesite) of the Virginia Range. It crops out on the east side of Mount Davidson. The mountain range but not the summit may be seen in clear weather from Reno by looking up the open valley to the southeast. The ore, which is of high grade, carries silver and gold in quartz. In the old days it occurred typically in great bodies called "bonanzas." The district was noted for the large scale on which everything connected with the mining, including the speculation, was carried on. The size of the old dumps and the kind of machinery employed show even those who are used to mining that great things were done here. About $400,000,000 in gold and silver, in the ratio, by value, of 2 of gold to 3 of silver, has been taken out of the Comstock. Considerable ore is still being mined, but the great bonanzas have been worked out, and Virginia City is a melancholy wreck of what was once a lively town of some 20,000 people.

Truckee Meadows and in the broad expanse of open valleys lying to the south, in the upper Carson Valley.

Reno lies near the extreme western edge of Nevada and of the Great Basin, at the foot of the Sierra Nevada. Here Truckee River emerges from the foothills of the high mountains and flows out into the open Truckee Meadows. Now, as in the early pioneer days, Reno is a landmark in the journey across the continent. Here ends the long stretch of desert, and here the high timbered slopes of the Sierra Nevada, with their streams of fresh running water, appear near at hand. On the site of the present city a road house was erected in 1859 for the accommodation of travelers and freight teams on their way to and from California. By 1863 this place had become known as Lakes Crossing, and five years later it was chosen as a site for a station by the Central Pacific Railway. The name Reno was given to it at that time in honor of Gen. Jesse Lee Reno, a Federal officer of the Civil War. It became an important point of distribution for this part of Nevada, particularly for the adjacent towns and camps, which included the already famous Comstock.

Carson, the capital of Nevada, lies about 30 miles to the south and, like Reno, stands in a broad, fertile valley at the eastern base of the Carson Range, a front range of the main Sierra. This is the upper valley of Carson River, which, like the Truckee, flows eastward into the Great Basin.

About 10 miles south of Reno on the road to Carson is a group of hot springs known as Steamboat Springs. These and other hot-spring waters along the Sierra front have their origin in the heated depths of the earth, and come up along fault fissures generally parallel with the Sierra. The ground around Steamboat Springs has been built up by silica deposited by the hot waters, as a low ridge of white sinter, which is a conspicuous feature in the landscape. Many of the pools are actually at boiling temperature, and in cool weather clouds of steam rise from them.[1]

[1] Steamboat Springs, Nev., has figured prominently in discussions of the origin of ore deposits. The waters of these springs contain the precious metals in minute quantities, and the sinter deposited by them contains several minerals that are common constituents of ores, as well as small quantities of many of the rarer metallic constituents of ore deposits, including gold and silver. Such springs, therefore, suggest that many and perhaps most ore-bearing veins have been formed by hot waters rising from great depths, which have brought their metal contents up in solution and deposited them in open spaces or fissures in the rocks through which the waters passed, the deposition of some ores being influenced by chemical reaction with the surrounding rock. Many ore deposits are undoubtedly formed in other ways, for some are unquestionably of sedimentary origin and the metal content of some others has been carried down, redeposited, and concentrated by rain water that descended into the earth's crust; but the "hydrothermal" origin—that is, their deposition from ascending hot water—of many of the more valuable ore deposits is indicated by the close relation observed at many places

Leaving Reno the railroad runs west along the north side of Truckee River, here again confined in a canyon, which, however, is not so narrow or steep as the canyon in the Virginia Range. The river is bordered on both sides by a succession of terraces, the uppermost of which is several hundred feet above the river bottom. In the outskirts of Reno, on the north side of the track, there is a clay pit and brick plant, and beyond them are large pits that have been excavated in the river terraces for sand and gravel to be used in construction work. The site of Reno and much of the valley to the west is overspread by deposits of bowlder and gravel left by the river during the period of terrace building. The open lands at the foot of the high mountains permitted the streams to spread out and deposit the load of bowlders and finer sediments that they had washed through the steeper and narrower parts of their channels above.

Projecting in places from beneath the nearly horizontal terrace deposits are regularly bedded, tilted sedimentary rocks, the only unaltered sediments of the Reno region known to be older than Quaternary. They belong to a series of fresh-water deposits called the Truckee formation, generally considered of Miocene age. These beds, which consist of clay, gravel, sand, and a peculiar white earth, are finely exhibited in conspicuous white bluffs 2 to 4 miles west of Reno, and are worthy of particular notice, for the chalk-white earth of which they are so largely composed here occurs in unusual quantity. This chalk-white material consists largely of microscopic shells, or frustules, as they are called, of one-celled plants known as diatoms,[1] once included under the general name Infusoria. These remains have collected here in numbers so immense as to form deposits hundreds of feet thick and in places make up almost the entire mass of the rock. This mass of fossil diatoms, or diatomaceous

between mineral veins and eruptive rocks. Thermal waters are believed to be, in part at least, given off by slowly cooling and solidifying masses of igneous rock (magma) deep within the earth.

[1] Diatoms are of many different forms and inhabit both fresh and salt water. They consist of single isolated cells, or of strings of cells attached in linear succession or in zigzag chains. Those that compose the beds west of Reno are entirely of fresh-water origin. All diatoms secrete siliceous shells about their living parts, each shell consisting of two valves, which fit together like a pill box and its cover. Seen under the microscope they exhibit marvelous beauty and delicacy of structure. The myriads of such shells that accumulate after the death of these plants may form large deposits, although the individual shells are so minute as to be undiscernible by the unaided vision. Diatomaceous earth is used largely as a scouring or polishing powder, to which it is well adapted because of the hardness and sharpness of the individual grains and their uniform fineness. It also has uses dependent on its absorptive properties and has been so used in the manufacture of dynamite. As it is a poor conductor of heat and very light it is valuable as a packing for safes, steam pipes, and boilers, and for the manufacture of fireproofing materials. No use seems to have been yet made of the deposits near Reno.

earth, formerly called infusorial earth, is white and looks like chalk but differs from chalk in that it is composed of silica instead of lime carbonate. It has also been called tripolite, from Tripoli, where a similar deposit is found. It is so light that it will almost float on water.

Lawton.
Elevation 4,650 feet.
Omaha 1,545 miles.

Near Lawton's hot springs granite projects through the sediments, and the fresh rock is exposed in cuts along the railroad. The outcrop is characteristic of rock of this type, consisting of weather-rounded joint blocks that look like big bowlders but are really a part of the solid rock in place. Beyond the granite stream banks and railroad cuts reveal gravel, sand, and bowlder deposits, generally coarse and ill assorted but with nearly horizontal bedding. These are old river deposits, cut into by later deepening of the river channel.

At the bridges near milepost 234, by which the wagon road and railroad cross the river, and particularly at the wagon bridge over the railroad, is an interesting exposure of some of the tilted Tertiary strata. Here the beds consist of shale and sandstone and justify their usual designation as "lake beds" by their uniform thin bedding or lamination. They contain abundant and well-preserved impressions of leaves and grasses. These beds are believed to represent the Miocene epoch of Tertiary time. Beyond the bridge these sediments are again covered by terrace deposits.

Verdi, Nev.
Elevation 4,904 feet.
Population 543.*
Omaha 1,550 miles.

Verdi is a lumber town whose history dates back to the days of the Comstock, before the coming of the railroad, when many of the timbers that went up to the mines were brought from this part of the mountains and hauled by way of Reno. West of Verdi, stretching north and south as far as the eye can see, is the steep front of the Sierra Nevada, this part of which is known as the Carson Range. The front is determined primarily by faults. (See explanation of formation of Wasatch Range, in footnote on p. 100.) The Truckee emerges from the mountain front after traversing a narrow canyon, steeper and more rocky than any part of its lower course. Scattered timber here clothes the mountain flanks, extending down even to the railroad and river although, of course, all the older and larger trees were long ago cut away. The green pines with their long needles and the growth of underbrush afford a welcome change from the monotonous barrenness of the ranges and plains of the Great Basin. There is some cultivation in a small way along the narrow strip of river bottom lands.

On leaving Verdi the railroad turns southward up into the Truckee Canyon which soon becomes so narrow that there is not room for both railroad and wagon road, the latter diverging northward and crossing the range 10 miles or more farther north. The wagon road joins the railroad again at Truckee. The rocks in the canyon walls are Tertiary lavas, mainly andesites, and for some distance the supposedly Cretaceous granite, or a related rock, appears beneath these lavas along the river gorge. It is not always possible at a distance to distinguish between these two classes of rocks.

A few miles beyond Verdi the train passes a post marking the California-Nevada State line, and about half a mile beyond it is a signboard and railroad siding marked Calvada, a name derived from those of the two States. This place is in a southward stretch of the canyon, so that the State line is crossed at a slight angle only a short distance west of the longitude of Verdi.

Calvada, Cal.
Elevation 5,041 feet.
Omaha 1,553 miles.

California, known as the Golden State, is next to the largest State in the Union. It is 780 miles in length and about 250 miles in average width, and has a total area of 156,092 square miles, being nearly equal in size to New England, New York, and Pennsylvania combined. The population of California in 1910 was 2,377,549, or about one-tenth that of the Eastern States named. The area covered by public-land surveys is 123,910 square miles, or nearly 80 per cent of the State, and 21 per cent of the State was unappropriated and unreserved July 1, 1914.

California.

Along the State's 1,000 miles of bold coast line there are comparatively few indentations. The bays of San Diego and San Francisco are excellent harbors, but they are exceptional.

The climate of California varies greatly from place to place. Along the coast in northern California it is moist and equable. Around San Francisco Bay a moderate rainfall is confined almost wholly to the winter, and the range in temperature is comparatively small. In parts of southern California typical desert conditions prevail. The great interior valley is characterized by moderate to scant winter rainfall and hot, dry summers. Snow rarely falls except on the high mountains, where—as, for example, in the Sierra Nevada—so much of it may accumulate as to interfere with railway traffic.

Forests cover 22 per cent of the State's area and have been estimated to contain 200,000 million feet of timber. They are notable for the large size of their trees, especially for the huge dimensions attained by two species of redwood—*Sequoia washingtoniana* (or *gigantea*), the well-known "big tree" of the Sierra Nevada, and *Sequoia sempervirens*, the "big tree" of the Coast Ranges. Some of these giant trees fortunately have been preserved by the Government or through private generosity against the attacks of the lumberman.

The 21 national forests in California have a total net area of 40,600 square miles, or about one-fourth of the State's area. The national parks in the State are Yosemite (1,124 square miles), Sequoia

(252 square miles), and General Grant (4 square miles). The national monuments in the State are the Cabrillo, Cinder Cone, Devil Postpile, Lassen Peak, Muir Woods, and Pinnacles, and there are bird reserves at Klamath Lake, East Park, Farallon, and Clear Lake.

Agriculture is a large industry in California, and with the introduction of more intensive cultivation its importance is increasing rapidly. In the variety and value of its fruit crops California has no rival in the United States, if indeed in the world. Its products range from pineapples and other semitropical fruits in the south to pears, peaches, and plums in the north, but it is to oranges and other citrus fruits and to wine grapes that California owes its agricultural supremacy. During the season from November 1, 1913, to October 31, 1914, California produced 48,548 carloads of citrus fruit, 42,473,000 gallons of wine, and 12,450 tons of walnuts and almonds.

Of its mineral products, petroleum ranks first in total value and gold next. In 1913 California's output of petroleum was valued at $59,581,948, nearly 16 per cent of the world's yield, and its output of gold at $20,241,300. In the production of both petroleum and gold California leads all other States in the Union.

California was formerly a part of Mexico but in 1848 was ceded to the United States and on September 7, 1850, was admitted to the Union as a State. Its history is full of stirring and romantic episodes and should not be neglected by the visitor desirous of understanding the spirit of the land.

One of the power houses where electricity is generated from the Sierra streams, an industry that has now reached great magnitude on both sides of the range, is seen in Truckee River near milepost 225. The ledges of volcanic rock exposed in the canyon in many bluffs and cuts along the railroad present varied forms of lava, breccia (cemented fragments of volcanic material), and tuff or ash. The exposures are of many hues, light gray, rusty, purplish, and greenish.

Floriston.
Elevation 5,350 feet.
Omaha 1,559 miles.

At Floriston is a pulp mill, situated near the source of the wood from which the paper pulp is made. The wood is brought down from Hobart Mills by way of Truckee and nearly 100 cords of wood—four or five carloads—are used here daily. Floriston is in the narrowest and steepest part of the canyon. (See Pl. XLIV, *A*.) Reservoirs have been built in the river above the town to store water for developing power and for making ice in winter. No natural ice is obtained at lower elevations in California, and as the winters in the Nevada desert country are not very severe thick ice is rarely formed there. Consequently an extensive business has grown up in the production of ice on reservoirs built along the Sierra streams near the railroad. From this town onward many ice plants and storage houses will be observed, as ice cutting is the principal industry of many of the small places along the route. Iceland, a small station just beyond Floriston, has a name suggested by this industry.

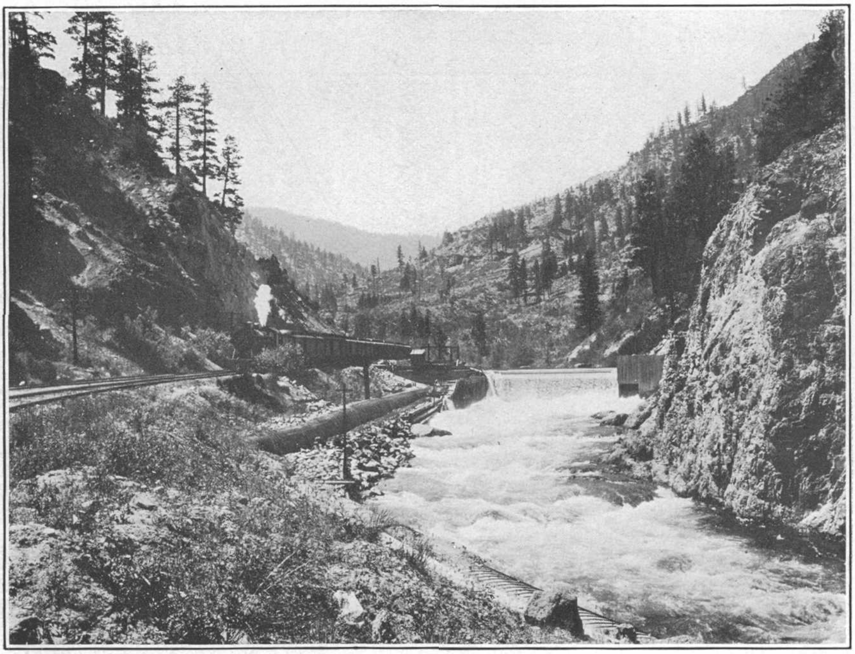
Boca.

Elevation 5,534 feet.
Omaha 1,565 miles.

Boca is an ice station and seems to consist principally of a picturesque little hotel and a store. It is the starting point of the Boca & Loyalton Railroad, primarily a lumber road, running north to Loyalton (26 miles) and thence to Portola (45 miles), where it connects with the Western Pacific Railway. The canyon opens somewhat at Boca, and to the rear may be seen the high continuous crest of the Carson Range, just passed. West of the Carson Range and between it and the main summit of the Sierra there is a broad and relatively depressed area, the southern part of which is occupied by Lake Tahoe and the northern part by Sierra Valley. A belt of relatively low though mountainous country connects the basin of Lake Tahoe with Sierra Valley. This depressed belt, like the mountain scarps, is of structural origin. The area corresponds to a block bounded by faults, that has sunk or has been less uplifted than the adjacent ranges.

During the uplift of the Carson Range the upper portion of Truckee River was occasionally dammed to form a lake, but in the main the river kept its course by cutting down its channel across the hard rock as the mountains rose. West of Boca terraces built at former higher levels of the stream channel are represented by benchlike remnants along the sides of the valley, but the unmistakable evidence of the damming of Truckee River is found in certain distinctly and evenly bedded or laminated deposits of clay, sand, and gravel, which are interpreted as laid down under standing water. A glance at the geologic map will show that these deposits spread over an extensive area west of the Carson Range. It is supposed that after the close of the andesite eruptions there followed a long period of erosion, during which Truckee Canyon was cut to very nearly its present depth. Then came a basalt eruption, covering large parts of the valley and damming the river afresh. The resulting Pleistocene lake probably persisted during a large part of the glacial period, gradually diminishing in size as Truckee River cut down its outlet. Its beach gravels are found all around this upper Truckee basin.

Low terraces overflowed by basalt may be seen along the river, at one place (milepost 214) showing a good illustration of columnar joint structure, which is a characteristic shrinkage phenomenon frequently exhibited by such lava flows.

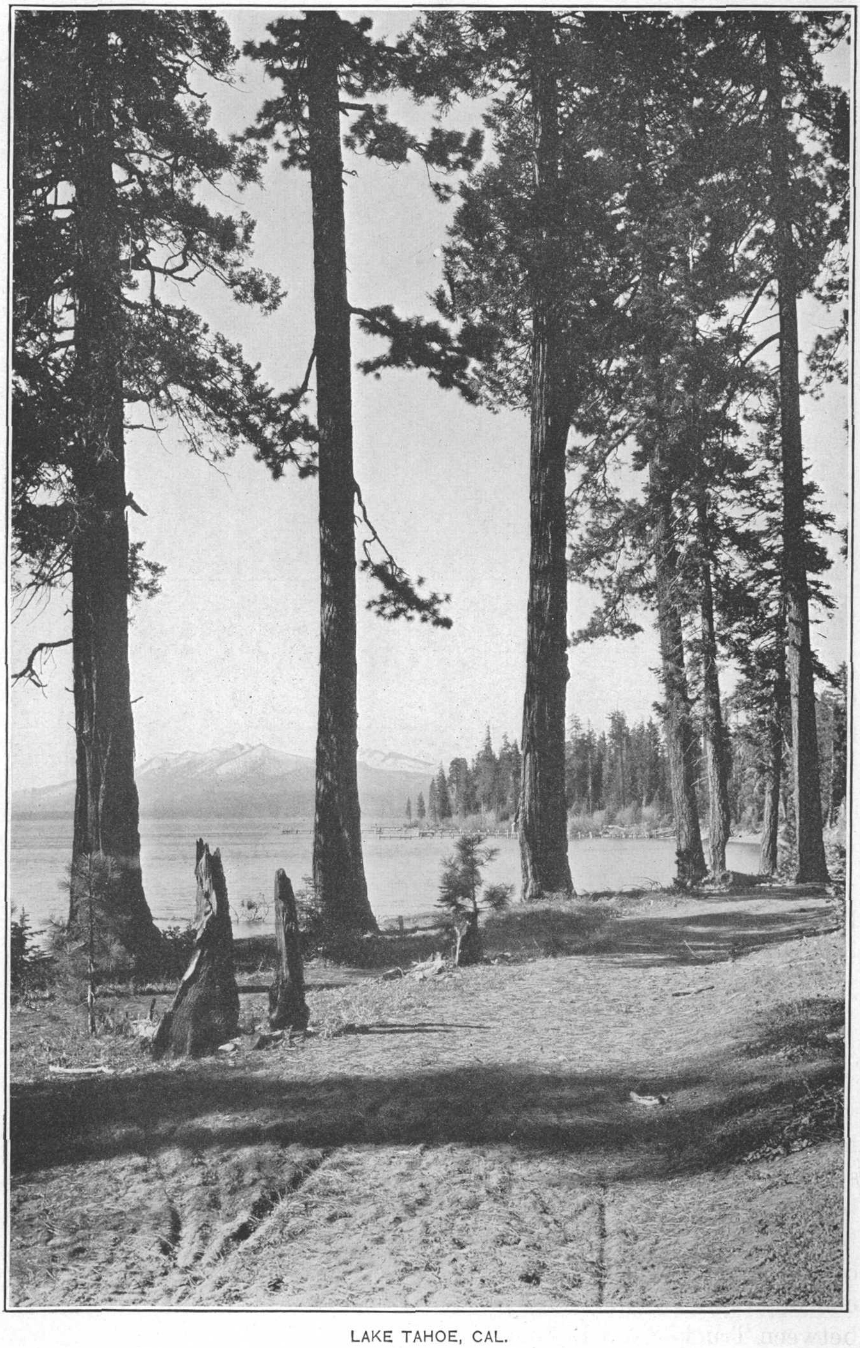


A. TRUCKEE RIVER CANYON NEAR FLORISTON, CAL.

View of the narrower part of the canyon through the Carson (or front) Range of the Sierra. Shows volcanic breccia in the ledges in the foreground and sparsely timbered lower slopes. Photograph furnished by the Southern Pacific Co.

B. TRUCKEE, CAL., LOOKING EAST TOWARD THE CARSON RANGE.

View taken from the lower end of the glacial moraines found in Truckee Valley, the upper part of the town being built on the terrace-like surface. Photograph furnished by Southern Pacific Co.



LAKE TAHOE, CAL.

Shore and road near Tahoe Tavern. Rubicon Peak in the distance. Photograph furnished by Southern Pacific Co.

Truckee River from Lake Tahoe down to Boca or beyond is a favorite resort of fishermen in summer. Camps and a number of small hotels afford stopping places that are easily reached from the California side of the mountains. The route from Polaris (milepost 211) to a point near Emigrant Gap and Towle, on the west side of the Sierra, lies in the Tahoe National Forest.

Union Mill.

Elevation 5,623 feet.
Omaha 1,568 miles.

Exposures of the thinly and regularly bedded lake deposits continue and may be seen in a cut just west of Boca. Here is a layer of white diatomaceous earth, which includes fragments of leaves and stems and is believed to have been laid down in quiet water.

Near the town of Truckee the valley broadens considerably and the river terraces become very distinct. To the north a branch lumber railroad climbs the edge of one of the terraces, exposing in deep cuts loose white bedded gravels and other stream deposits corresponding in age to the Pleistocene lake beds observed lower down the range.

From Truckee, the last town passed on the climb to the summit, a narrow-gage railroad runs up the main river valley to Lake Tahoe (15 miles) and a short lumber road goes north to Hobart Mills, but the latter does not carry passengers. There is much of interest from almost every point of view to be seen in crossing the Sierra Nevada, and many features of geology, physiography, forestry, and history which can here be only briefly noted. Beyond Truckee the evidences of glacial action become apparent. The Sierra down to an elevation of 5,000 feet was long buried under ice. The grinding of this moving ice mass widened the bottoms of the canyons, smoothed off and steepened their sides, and removed enormous amounts of loose rock and soil. To a large extent, however, the ice protected from water erosion the area that it covered. Moraines composed of rough and angular but not water-rounded bowlders of all sizes, mixed with finer detritus and sand, were deposited by the ice tongues that projected down the valley, particularly at their ends and along their sides. The lower valleys which the ice did not reach differ in form from those that were glaciated. Below the glaciated region the valleys are narrow and V-shaped in cross section, but the glaciated valleys are broader and U-shaped and many of them are characterized by nearly level stretches occupied by meadows (filled-in lakes), separated by rocky portions of steeper grade. At Truckee lake beds and stream terraces of the lower river course, the records of work by water, join moraines, the records of work by ice. The upper part of the town is built on the lowest identifiable portions of these glacial deposits. (See Pl. XLIV, *B*.) The canyon of Truckee River between Truckee and Lake Tahoe has evidently never been glaciated,

Truckee.

Elevation 5,820 feet.
Omaha 1,574 miles.

though the glaciers extended down the tributary valleys from the west, just reaching the river at one or two points.

Lake Tahoe.

Elevation 6,225 feet.
Truckee 15 miles.

To the traveler in the heat of summer there is probably no more refreshing and on the whole delightful side trip on the journey across the continent than that to Lake Tahoe. The trip to the lake is usually taken by the branch railroad from Truckee, but it may also be readily made by automobile. The railroad terminus is at the northwest side of the lake, where its waters overflow to form the head of Truckee River. From this point a circuit of the lake may be made by a small steamer, the trip occupying most of a day. The steamer stops at many summer camps, hotels, and permanent settlements. During the winter most of the resorts are closed, as the snowfall is heavy at this elevation.

Lake Tahoe is not a natural wonder, as that term is applied to the Yellowstone or the Grand Canyon, but the lover of nature can probably get no truer satisfaction than can be had from a quiet and restful sojourn along its beautiful shores. (See Pl. XLV.) There is much in the history of its origin and that of the ranges surrounding it that is full of interest.

The lake is 21½ miles long from north to south and about 12 miles in its greatest width. Its surface, which stands 6,225 feet above sea level, covers 190 square miles. The water is of unusual depth, Crater Lake, in Oregon, being said to be the only deeper mountain lake in America. A sounding of 1,635 feet was obtained a short distance south of Hot Springs, in what is perhaps the deepest part, but the contour of the bottom is not accurately known. According to a generally accepted statement this lake never freezes over in winter, probably on account of its great depth. The mountains around the lake rise abruptly and culminate in Mount Rose, in the Carson Range, at 10,800 feet. It has already been noted that the Sierra Nevada is here a double range of almost parallel north-south ridges and that the lake lies in a part of the depression between the two. The mountains of the Carson Range, east of the lake, though they do not seem unusually high or rugged as viewed from the lake, present an exceedingly bold escarpment when viewed from the Nevada side. The mountains to the west form the main watershed between the streams flowing to the Pacific and those flowing to the Great Basin. Near Tahoe the peaks on this divide do not attain so great a height as those of the Carson Range, but farther south the main Sierra becomes higher and culminates in Mount Whitney (14,502 feet).

One of the chief beauties of Lake Tahoe lies in the clearness and purity of its water and its wonderful coloring, varying from the deep blue of the main lake on a clear day to the crystal green of Emerald Bay. The lake abounds in fish, which include several species of trout. Shoals of the smaller fish may be seen from boats or along the shore and may be watched even at considerable depth through the clear water as they dart over the bowlder-strewn bottom.

There is a dam and headgate at the outlet into Truckee River by which the lake level is raised a few feet during the spring, the surplus water being released during the dry season, when it is most needed for maintaining a full flow at the power plant below and for irrigation in Nevada.

The statement sometimes made that "Tahoe is an old volcanic crater" is not true. The region about the lake shows evidences of volcanic activity of various kinds, and the lake waters themselves have probably been dammed at times by outpourings of lava. A lava flow appears to have temporarily filled the outlet channel below Tahoe City. The lake, however, lies in a structural depression—a dropped block of the earth's crust.

During the Neocene epoch and the earlier part of the Pleistocene epoch the waters of Lake Tahoe stood much higher than now, probably on account of lava dams which have since been cut through. Distinct beaches that mark former higher levels are found up to about 100 feet above the present lake, but it is believed that the waters formerly rose to still greater heights. At Tahoe City the most distinct of these old beaches is a terrace 35 to 40 feet above the level of the lake, and it is this terrace that makes the level ground on which Tahoe Tavern is built. Similar terrace levels may be distinguished from point to point almost all the way around the lake. (See Pl. XLVI.)

West of Truckee the main line of the railroad follows Truckee River for a little over a mile to the mouth of Donner Creek and then runs up along the south side of the broad glaciated valley of that stream. Here morainal deposits and forms characteristic of glaciation are conspicuous. Huge bowlders of granite, brought here on the moving ice during the glacial epoch, strew the surface on all sides.

At milepost 206, by looking across Donner Creek, the traveler may see a large white cross at the forward edge of a low terrace on the opposite side of the valley. This is a monument to the Donner party, whose tragic story is told at length in most of the histories of early California emigrations. About half a mile above this cross, in the woods near the lower end of Donner Lake, is a cube of granite inscribed as follows:

> This stone marks the site of the Donner party cabins, where a monument will be erected under the auspices of the N. S. G. W. [Native Sons of the Golden West] to the pioneers who crossed the plains.

Donner Lake and the pass now used by the railroad are particularly dentified with one of the emigrations that preceded the great gold rush to California in 1849. Of these earlier emigrations to the Pacific coast there were two. The first was that to Oregon in 1843, during which some parties turned off and entered California, guided along Humboldt River by the renowned mountaineer, Joe Walker. The second was that to California in 1846 during hostilities between the United States and Mexico. Bancroft says:

> These adventurers were assured that California was a most delightful country—one every way desirable to settle in; that it was thinly peopled and except along the seaboard almost unoccupied; and that now the Nation was roused to arms, engaged in a hand to hand conflict with the weaker power, it would probably result in the acquisition of all that territory by the stronger. * * * The result proved as had been anticipated; scarcely had the emigrants of 1846 arrived in the valley of California when the whole magnificent domain fell a prize into the lap of the United States.

It was during the second of these migrations that the Donner tragedy[1] occurred.

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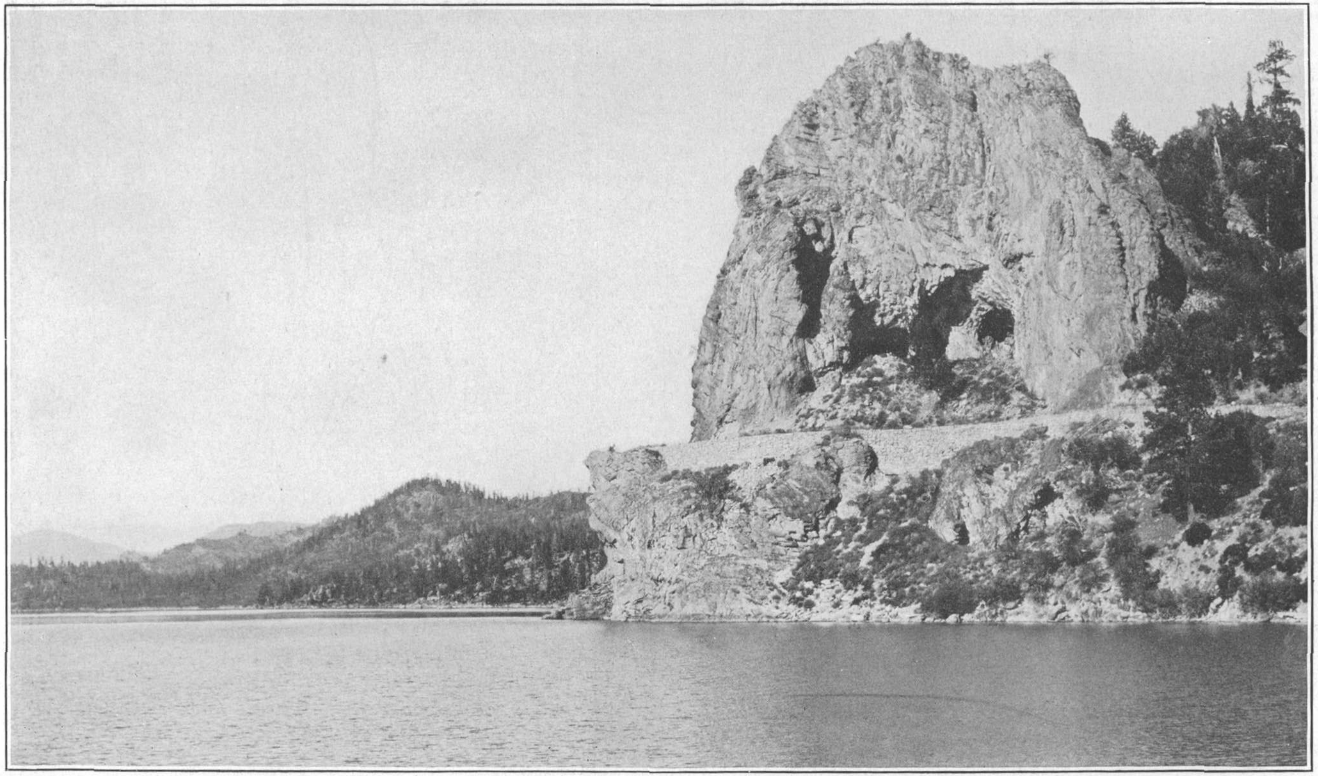
[1] In the spring of 1846 some 2,000 emigrants were gathered at Independence, Mo., waiting for the grass of the plains to attain sufficient growth for feed for their cattle before commencing the long journey to the Pacific coast. Some of these were bound for Oregon and the rest for California. Among the parties that were finally formed for the journey was one known as the Donner, or Reed and Donner party. It consisted of the brothers George and Jacob Donner and their families and others, making in all about 88 persons; 24 were men, 15 women, and 43 children. It was a well-equipped party, and George Donner, a man of some wealth, who was at its head, was carrying a stock of merchandise for sale in California. For a time all went well. Most of the emigrants of those days followed the Oregon Trail northward as far as Fort Hall, Idaho, and then, turning southwest, crossed to Humboldt River in Nevada and so went west to the Sierra. At Fort Bridger, Wyo., however, the party met a man whose advice was to cause their ruin. Lansford W. Hastings, who had led a party of emigrants across to Oregon in 1842 and had returned and published a guide to Oregon and California, now claimed to have discovered a shorter route which would save 200 miles over the old route by Fort Hall. After deliberating several days the emigrants divided. The greater part, going by Fort Hall, reached California in safety, but the Donner party, who had elected George Donner captain, decided to try the Hastings cut-off. Both parties left Fort Bridger on July 28.

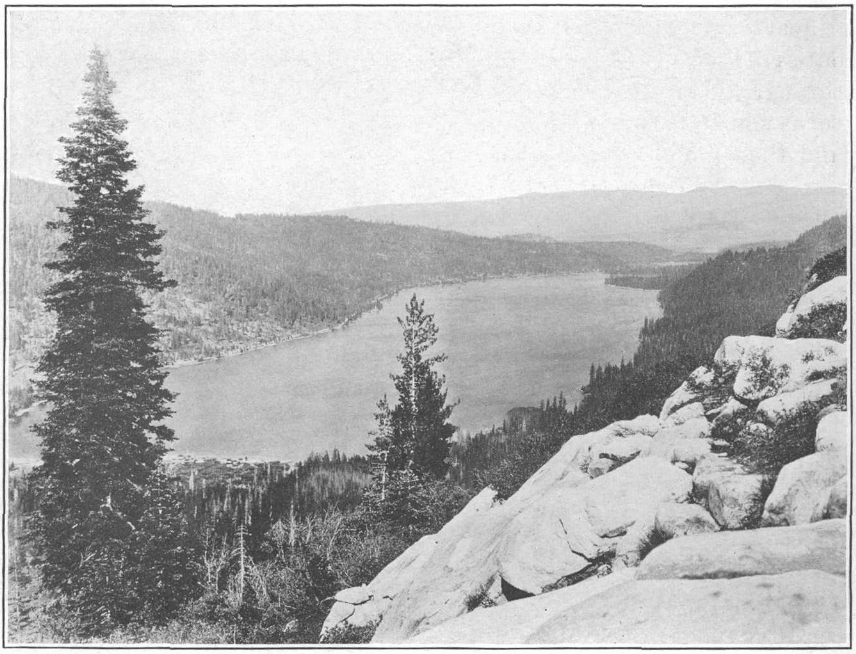
At the start the Donner party followed approximately the present route of the Union Pacific Railroad and had little difficulty until they reached Weber Canyon, where the roads seemed impassable for wagons. Making a detour to avoid this canyon, they did not reach Salt Lake until September 1. From September 9 to 14 the party were crossing Salt Lake desert, going around the south end of the lake by the route which is approximately that of the Western Pacific Railway today. Here disaster began to overtake them. Some of the oxen died of thirst, a part of the wagons and goods had to be abandoned, and some of the party were forced to walk. Rations were short and the first snows of the season commenced. The cattle were attacked and stolen by Indians and the situation gradually became desperate. Slowly they made their way westward across Nevada.

On October 19 the starving emigrants met a relief party with some provisions at the lower crossing of Truckee River (site of Wadsworth). After resting a few days the party proceeded up by Truckee Meadows (Reno) and finally, on October 31, reached the vicinity of Truckee. Here the winter snows overtook them. On December 16 some of the party attempted to escape by crossing the summit on snowshoes. A few succeeded in reaching Sacramento and told of the plight of their companions. When the rescue parties reached Donner Lake they found that 36 of the 81 who had camped at the lake had perished.



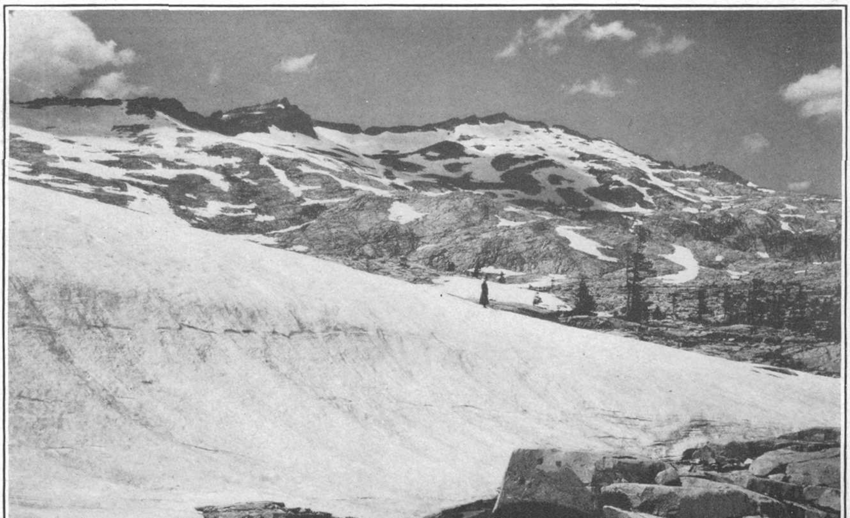
CAVE ROCK, LAKE TAHOE, CAL.

The bench in the foreground is a remnant of a former higher shore and is now utilized by the road that passes around this side of the lake to Glenbrook and thence over the range and down to Carson City. Photograph furnished by Southern Pacific Co.



A. DONNER LAKE.

Glaciated ledge of granite in the foreground. Photograph furnished by Southern Pacific Co.



B. DESOLATION VALLEY, NEAR LAKE TAHOE.

Characteristic view of the higher Sierra even in midsummer. The bare and more or less rounded surfaces of the rock ledges testify to the scouring action of the ice that has moved over them. Photograph furnished by Southern Pacific Co.

Just beyond the Donner cross and before the first snowsheds are entered, a bit of the lower end of Donner Lake may be seen by looking through the trees up the valley ahead. From this point the train turns southwestward, going up one side of the valley of Cold Creek, and then doubles back again, still climbing, on the other side. As the train rounds the loop in Cold Creek valley the rear platform affords a view of the Sierra crest, culminating in Tinker Knob (9,020 feet), only 2 or 3 miles distant. Along the north side of Cold Creek the snowsheds are almost continuous. They extend from this valley along about 40 miles of the railroad, the last shed being just beyond Blue Canyon, on the west slope. It is unfortunate that no satisfactory plan has yet been devised to protect the tracks from snow without marring the most beautiful part of the route over the mountains.

Rounding the point of the ridge at the left (north) and passing through a curved tunnel, the train comes out just above Donner Lake. The basin of this beautiful mountain lake is apparently of glacial origin, as the water occupies a hollow, evidently once filled by a glacier, with bare granite cliffs at its upper end and a heavy terminal moraine at its lower end. This moraine holds back the water of the present lake, but the basin is believed to have been originally dammed lower down by flows of basaltic lava which spread across the valley just west of Truckee and through which Donner River subsequently cut its way. Near the head of Donner Lake the train runs back into another southward loop and, crossing some heavy deposits of morainal débris, comes out above the upper end of Donner Lake. (See Pl. XLVII, *A*.) From this point it is but little more than a mile to the long tunnel through granite by which the crest is pierced.

Summit.
Omaha 1,589 miles.

Donner Pass, the highest point along the railroad, is just above the tunnel. The elevation of the tunnel is 7,012 feet; the pass above the tunnel is of course somewhat higher. Just beyond the tunnel is a flag stop known as Summit Hotel, and half a mile or so farther is the station in the snowsheds called Summit. Although it is difficult to see out of the snowsheds, glimpses to the south disclose the west side of the main Sierra crest, usually with at least a few snow patches throughout the summer. The 150-mile trip from Sacramento to this point, a climb of nearly 7,000 feet, and down the east side of the range into Nevada is mentioned in the Sacramento papers in the unimpassioned phrase "going over the hill." And yet they say that the westerner exaggerates.

The annual precipitation is very high over the west slope, ranging from a mean of 52 inches at Cisco, at about 6,000 feet, to 48 inches at

Summit, 1,000 feet higher.[1] At the higher elevations a large proportion of this precipitation is snow, as it rarely rains much during the summer. Near the summit the snow may accumulate to a depth of 20 feet on the level during a single winter. (See Pl. XLVII, *B*.)

On the west slope of the range, between the elevations of 6,000 and 7,500 feet, is the great Sierra forest zone, although the full grandeur of the forest is not displayed along this particular route. A note on the principal trees to be seen between the summit of the Sierra and San Francisco Bay has been kindly supplied by Prof. W. L. Jepson, of the University of California.[2]

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[1] The mean annual precipitation at several places along the route is shown by the following table compiled from records of the United States Weather Bureau extending over periods of 30 years or more:

Mean precipitation on Sierra slopes along line of Southern Pacific Railroad.

	Inches.
Reno, Nev	8.65
Boca, Cal	20.84
Truckee, Cal	27.12
Summit, Cal	48.07
Cisco, Cal	52.02
Blue Canyon, Cal	74.22
Towle, Cal	59.38
Colfax, Cal	48.94
Auburn, Cal	35.13
Sacramento, Cal	19.40

[2] At the summit of the Sierra are found:

Jeffrey pine (*Pinus jeffreyi*), a near relative of the yellow pine having a red, rusty, or wine-colored bark and a large cone suggestive by its outline of an old-fashioned beehive.

Whitebark pine (*Pinus albicaulis*), a timber-line tree, dwarfed and often prostrate, commonly associated with the Jeffrey pine.

Tamrac pine (*Pinus contorta* var. *murrayana*), found chiefly at the higher altitudes and especially abundant in swampy meadows, but grows also on the granite ridges and is frequently a timber-line tree. It is characterized by its short foliage consisting of two needles in a place and by its small burrlike cones. This tree is not the eastern tamarack.

Western juniper (*Juniperus occidentalis*), a very characteristic tree of granite ridges and cliffs.

On the middle western slope the four prevailing species, which can probably be recognized from the train, are:

Yellow pine (*Pinus ponderosa*), the dominant tree of the Sierra forest belt and on the average the largest tree, except the big tree (*Sequoia washingtoniana* or *gigantea*), which is not of general occurrence. The yellow pine is distinguished by its yellow bark, which is checked into large plates 1 to 3 feet long and 6 inches to 1 or 2 feet wide, slightly resembling the back of an alligator. The cones are ovoid and about 3 to 5 inches long.

Sugar pine (*Pinus lambertiana*), usually associated with the yellow pine, occurs in the main forest belt; distinguished by its finely checked bark, by its cones 12 to 16 inches long, and by the very noticeable feature that the branches in the very top run out into a few unequal horizontal arms.

Incense cedar (*Libocedrus decurrens*), the only cedar-like tree at middle altitudes; has a reddish fibrous bark and for that reason is sometimes mistaken for the Sequoia by the amateur.

White fir (*Abies concolor*), a common tree on the lower slopes below the main summit, mostly associated with the yellow pine. These trees will probably attract attention because of the beautiful symmetry of their crowns, gently tapering to a pointed top. Their branches expand horizontally and impart a stratified or layered appearance to the crown. On the higher slopes of the Sierran axis this species is replaced by the red fir, which is similar in appearance but has a reddish instead of a whitish bark.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
OVERLAND ROUTE
From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

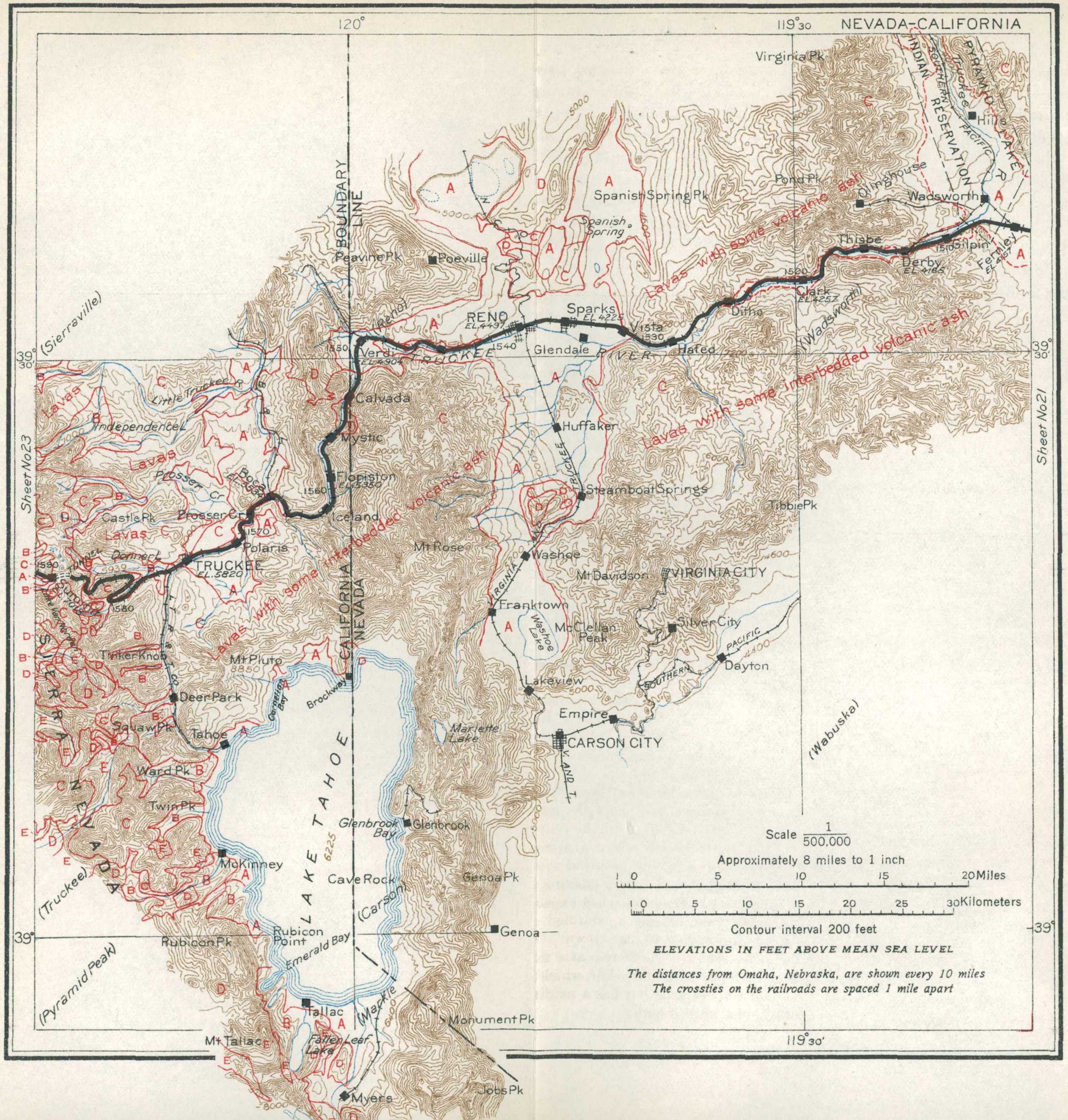
1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.

EXPLANATION

A	Stream deposits (alluvium), sediments of Lake Lahontan, and, in upper valley of Truckee River, other lake deposits	Quaternary
B	Glacial deposits, moraines; Pleistocene	
C	Lavas (rhyolite, andesite, basalt, etc.), probably Miocene, Pliocene, and later; with some interbedded volcanic ash and diatomaceous earth (Truckee formation), Miocene	Tertiary and Quaternary (?)
D	Granite and other coarse-grained intrusive igneous rocks (granodiorite, gabbro, etc.); late Jurassic or early Cretaceous	Mesozoic
E	Slate, schist, and quartzite (including Sailor Canyon formation, Triassic)	

Highest shore line of Lake Lahontan indicated thus



For about 2 miles from the summit the route follows an upland meadow, undoubtedly of glacial origin, the lower end of which is now submerged in a reservoir called Lake Van Norden, after a family of eastern capitalists who have taken a prominent part in the water-storage, water-supply, and hydroelectric power developments that have been so largely extended in the Sierra during the last few years. The mountain streams thus utilized supply light and power throughout much of California and Nevada.[1]

Soda Springs.

Elevation 6,748 feet.
Omaha 1,592 miles.

Below Soda Springs (see sheet 23, p. 214) the railroad follows the south side of the upper valley of South Fork of Yuba River, a typical glacially scoured valley, its broad and smoothly rounded bottom worn down to bare granite. Along the sides of the valley is scattered more or less morainal débris.

An especially noticeable feature of the western slope of the Sierra Nevada is the general evenness of its sky line. In any extensive view it is not difficult to overlook the deep canyons and imagine oneself looking over a great forested plain sloping gently westward. The ridges between the canyons are in fact remnants of a former surface of

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In the foothills there occur:

Digger pine (*Pinus sabiniana*), a light-gray dusty long-needle pine, having a foliage so thin that it scarcely casts a shadow. It has a large, heavy cone and is sometimes known as bull pine.

Blue oak (*Quercus douglasii*), almost always associated with Digger pine, recognizable by its white trunks and bluish foliage.

In the Sacramento Valley the scattered oaks and groves are composed of:

Interior live oak (*Quercus wislizenii*), a symmetrical evergreen tree, frequently with a hemispherical top, set low to the ground.

Valley oak (*Quercus lobata*), a deciduous tree which is taller than the live oak and has long, drooping, cordlike branchlets pendant from the great crown.

Near San Francisco Bay the interior live oak is replaced by the coast live oak (*Quercus agrifolia*), of similar appearance. A marked feature of Coast Range scenery is the considerable groves of the eucalyptus, an introduced tree, various species of which have been set out in this country within the last 30 or 35 years. They come mostly from Australia. Of the many species probably 120 are now represented in the State. They are rapid growers and produce exceedingly hard wood, which is difficult to cure for utilization as lumber but which is of very great strength when it can be properly seasoned.

[1] There are in California about 75 developed hydroelectric power plants, most of which, including the largest, are in the Sierra. Along the route of the Southern Pacific the principal developments are those of the Pacific Gas & Electric Co., which consist of a system of storage reservoirs, conduits, and power houses for the utilization of the flow of Yuba and Bear rivers. Most of the structures visible from the railroad, as at Lake Van Norden and in the vicinity of Colfax, have been built in connection with the recently completed Drum plant, which has an ultimate capacity of 40,000 kilowatts, or 53,600 horsepower. The further utilization of the power of Bear River will involve the construction of five additional power plants extending from Lake Spalding to Newcastle, the total power capacity of the completed system to be 160,000 horsepower.

low relief. By the elevation and westward tilting of this surface the Sierra Nevada was formed.

The rocks near the summit are principally granite (or granodiorite),[1] lavas (andesite, rhyolite, and basalt), tuffs, and breccias. The volcanic rocks generally cap the ridges, the canyons being cut through them into granite or into sedimentary rocks which have been invaded by the granite. In general, throughout the western slope of the Sierra Nevada, the lavas, the associated gold-bearing gravels, and the other Tertiary rocks lie nearly horizontal on the worn surface or eroded edges of a much older tilted set of rocks. These older rocks comprise altered sediments, such as slates and schists, altered lavas and tuffs, in part rendered slaty or schistose by pressure, and intruded igneous masses. The various sedimentary formations are not readily distinguishable from one another from the train. The most widespread and characteristic are the Calaveras formation, of Carboniferous age, and the Mariposa slate, of Jurassic age. Both consist chiefly of slaty rocks, although the Calaveras is less uniform than the Mariposa and contains some limestone. The dip of the older rocks varies, especially near intrusive masses, but in general it is 60° to 70° E.

Cisco.

Elevation 5,940 feet.
Omaha 1,602 miles.

Near Cisco the older sedimentary formations of the Sierra begin to take the place of the granite and volcanic rocks. North of the railroad, on the summit of a high ridge known as Signal Peak, the railroad company maintains a lookout station, from which a watch is kept for fires in the snowsheds, many miles of which are in view from this one point. The ridge on which the signal station is situated is composed of metamorphosed slates (Sailor Canyon formation) of Triassic age, like those that occur at Cisco. The brown talus from these slates is in decided contrast with the white granite outcrops previously passed.

Cisco is an old railroad-construction camp, now a small settlement for the railroad employees. Here also is a summer hotel and camp. In the valley of the South Fork of the Yuba below the railroad, on the right, is a favorite summer automobile road which crosses the Sierra and forms a section of the recently named Lincoln Highway.

There are openings in the snowsheds here and there at bridges and at places where one part of the shed is made to telescope into another, being mounted on wheels for that purpose. These tele-

[1] The granodiorite of the Sierra Nevada is an enormous mass of intrusive rock only partly bared by erosion. Such a mass that extends to unknown depth is called by geologists a batholith. The batholith of the Sierra Nevada is merely one member of a chain that comprises many such masses, which extend along the western coast of North America. These immense bodies of igneous rock were intruded in late Jurassic or Cretaceous time and may all be connected at great depth.

scoping sections are rolled back in summer, as a precaution against the spread of fires. Crystal Lake (elevation 5,758 feet), Yuba Pass (5,614 feet), and Smart (5,351 feet) are unimportant stations in the snowsheds. The block-signal system in use on this part of the road is interesting, and an account of it may be obtained by conversing with those who are socially inclined among the railroad crews.

Emigrant Gap.
Elevation 5,225 feet.
Omaha 1,610 miles.

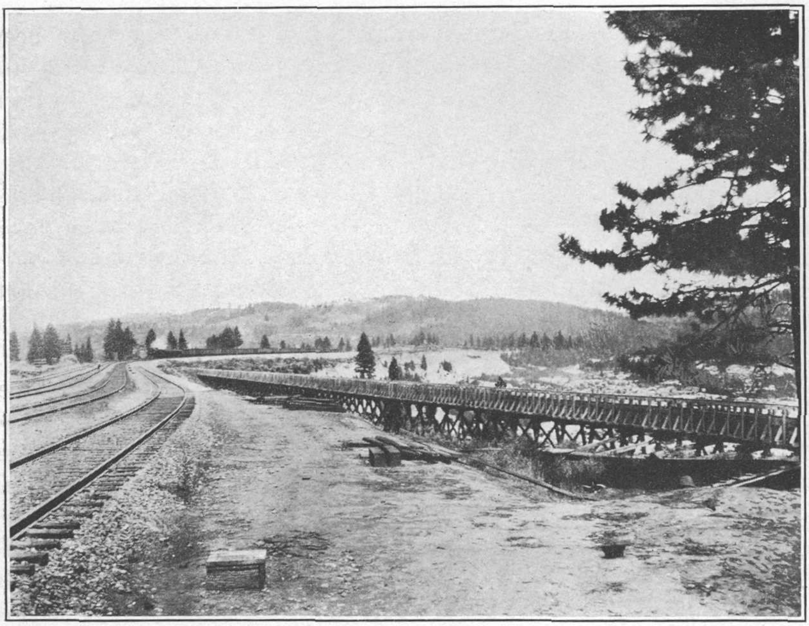
Just beyond Smart, near milepost 173, a glimpse forward on the right shows the South Fork of Yuba River in its now rapidly deepening valley far below. The river here turns sharply north and immediately disappears into a very narrow and deep rocky gorge. This is a striking example of what is known among physiographers as stream capture. The part of the river already passed is the former headward portion of Bear River, which now rises near this point and flows southwestward through a smooth, grassy gap, known as Emigrant Gap. Another stream on the north, the original South Fork of the Yuba, working backward at its head in the manner common to streams, cut its canyon faster and deeper than that of the ancient Bear River was cut and finally worked back into the Bear River valley and, tapping that stream, drained off its water through the narrow canyon to the north. (See fig. 17, on sheet 23, p. 214.) The present Bear River approaches within a quarter of a mile of the railroad just beyond Gold Run. The evidence of this interesting bit of ancient river history remains in view but momentarily, for the railroad plunges through a short tunnel and emerges on the opposite side of the ridge, in one of the upper tributary valleys of the American River system.

Emigrant Gap is the first station on the descent which suggests a surrounding agricultural or fruit-raising country. The railroad cuts expose slates and micaceous schists (Calaveras formation) which belong to the Carboniferous system. Here may be noted a change from the upper region where glaciers have scoured the rocks clean of all loose material to the lower region where a mantle of soil and disintegrated rock gives better opportunity for forest growth.

Blue Canyon.
Elevation 4,701 feet.
Omaha 1,615 miles.

The station of Blue Canyon is situated on the timbered hillside in a deep reentrant curve of the railroad, which is here high above the North Fork of American River, near the crest of one of the characteristic flat-topped, lava-capped ridges of the mid-Sierra slope. (See Pl. XLIX, *B*, p. 207.) The last of the snowsheds is near at hand. Beyond them, as the road winds in and out on the mountain side, distant views bring out with great distinctness the evenness of the sky line that is significant of the smoothness of the older (early Tertiary) topographic surface by whose uplift and westward tilting in late Tertiary time the Sierra Nevada came into being as a mountain range. The depth to which the modern river canyons have been cut below this surface is an index of the amount of erosion that has been accomplished since this uplift. The old plateau surface has been deeply dissected, but it is yet far from being destroyed. The stream channels are considered as still in the "youthful" stages of their development. When they attain "maturity," perhaps thousands of years from now, the ridges between them will have been worn down to low, rounded divides, and the streams themselves, instead of roaring through rocky canyons, will glide in leisurely meanders through broad green meadows. The canyons are thus evidence of the geologic recency of the elevation of the Sierra Nevada.

Beyond Blue Canyon the train skirts a thickly wooded steep slope, above the gradually deepening canyon of Blue Creek. This part of the railroad follows closely the bottom of the lava that caps the ridge, the canyon below being cut in the slaty rocks of the Calaveras formation. The main cap rock of the ridge is andesitic tuff-breccia. Under this in places is some lighter-colored rhyolite tuff. For a while there are few distant outlooks. The hillsides are, for the most part, thickly covered with small timber and underbrush, which is evidently second growth, the original forest having been destroyed long ago by lumbering or by forest fires. At Forebay (milepost 162), which is a sidetrack and water station, there is again a partial view across the canyon to the distant level sky line. West of this are several deep cuts along the railroad, showing the character of the deposits that were formerly spread out over the old plateau surface, composed largely of fragmental volcanic materials ranging from fine tuff to coarse blocks of lava. (See Pl. XLVIII, *B*.) Just beyond Midas (elevation 4,142 feet, milepost 161) appears a seemingly almost sheer drop into the deep gorge of the North Fork of American River, here 2,000 feet below the track. The evenness of the ridge tops to the south, due largely to the fact that they are capped with volcanic rocks, chiefly andesite tuff-breccia, is again clearly apparent. Beyond Gorge station (elevation 3,904 feet) the railroad again skirts the 2,000-foot gorge, just above a constriction in the canyon known as Giant Gap, also as Lovers Leap. The canyon is narrow here because it cuts across a belt of altered igneous rock (amphibolite) that is harder than the slates above it. The railroad here turns northward through a little gap in the ridge into a small upland valley. The rock in the gap itself is white rhyolite tuff, but above and below the gap the railroad crosses some serpentine (an altered magnesian igneous rock) which is a part of a north-south belt of this rock that extends along this part of the Sierra slope.

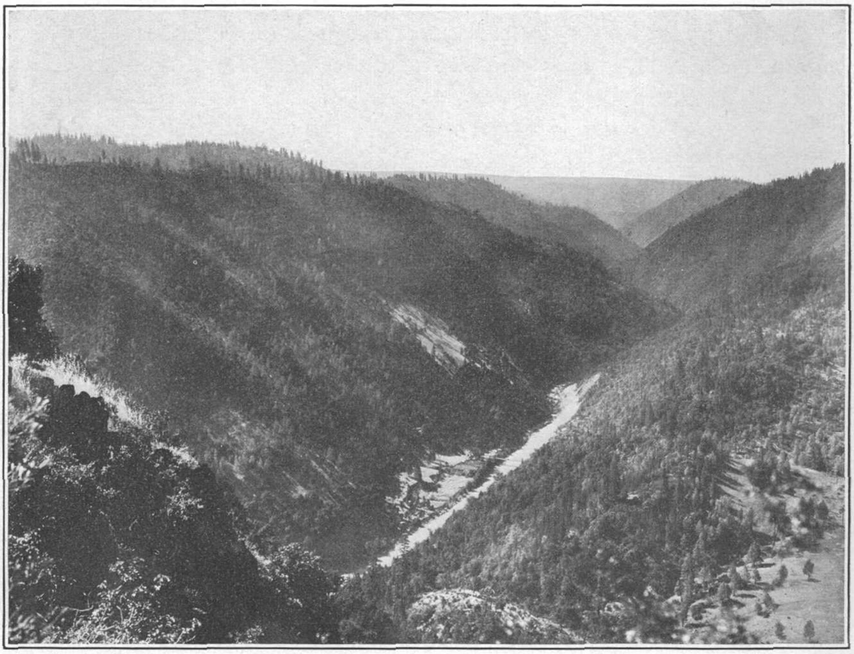


A. VIEW OF TERTIARY GOLD-GRAVEL DEPOSITS BETWEEN GOLD RUN AND DUTCH FLAT LOOKING BACK OVER THE GOLD GRAVELS FROM GOLD RUN.

Note the flume in which water is conducted, formerly used in the washings but now employed for irrigation.

B. VIEW IN A RAILROAD CUT BETWEEN FOREBAY AND MIDAS.

Shows the character of the deposits laid down over the old plateau surface, which, now uplifted and tilted to the west, forms the west side of the Sierra. The cut exposes rounded stream bowlders, coarse angular blocks of lava, and layers of finer volcanic ash and sediment.



A. VIEW DOWN CANYON OF NORTH FORK OF AMERICAN RIVER FROM CAPE HORN, CAL.

The even sky line in the distance represents the former surface by whose elevation and western tilting the Sierra Nevada was brought into existence. Photograph furnished by Southern Pacific Co.

B. BLUE CANYON, CAL.

This village is near the lower limits of the snowsheds. Trees are white firs. Photograph furnished by Southern Pacific Co.

Towle.

Elevation 3,692 feet.
Omaha 1,623 miles.

At Towle are some of the higher orchards of the Sierra, and here again, close at hand, is the Lincoln Highway. In the woods hereabouts are summer camps and small hotels. In the bed of the little stream just below the railroad station on the left have lately been found some magnesite (a carbonate of magnesium) and also some asbestos. So far as known the deposits are not of sufficient extent to be of value. They occur with the serpentine, the usual association for magnesite deposits. Dark ledges of amphibolite (the same belt that occurs at Giant Gap) and of serpentine show along the railroad.

Alta.

Elevation 3,602 feet.
Omaha 1,624 miles.

Just below Towle is a railroad cut in some of the white volcanic tuff (rhyolitic) already referred to as occurring below the andesite tuff-breccia. These volcanic deposits are mere remnants, and once extended across the areas now occupied by the canyons. The andesite tuff-breccia particularly covered enormous areas of the west slope of the Sierra before that slope was tilted by earth movements and cut into by the streams. At Alta are summer camps and a sanitarium. The surrounding country is rather thickly timbered, but there are clearings planted as orchards or cultivated in other ways.

Just beyond Alta is a sidetrack where round bowlders of white quartz, obtained from the old gold diggings a short distance away, are shipped. These bowlders are used in the furnaces of the railroad repair shops at Sacramento. They come from a placer mine which is called Nary-a-Red, referring to the absence of the usual red bowlders in these gravels. The pure white cobbles remain behind after the finer materials have been washed away by the hydraulic method of mining for gold.

Dutch Flat.

Elevation 3,399 feet.
Omaha 1,626 miles.

Beyond a bend on the north side of the ridge the town of Dutch Flat, almost surrounded by the great pits made by hydraulic washing for gold, comes into view a short distance away from and below the railroad. The railroad station of the same name is about a mile south of the town, at a former settlement of Chinese miners that was known as Chinatown. Here the view from the railroad embraces a region that was prominent in the early mining days of California for its yield of placer gold. The gold of Dutch Flat came chiefly from the upper or bench gravels, deposited by the rivers of Tertiary time[1] and now high above the present streams. Hydraulic

[1] The Tertiary streams that flowed down the western slope of the Sierra occupied wider valleys than the present ones and accumulated extensive deposits of gold-bearing gravels along their channels. These gravels were later covered by lavas and flows of stony mud (tuff-breccia) erupted from volcanoes near or east of the present summit. When the grade of the slope was increased by the tilting of the range in later Tertiary time the rivers cut new canyons, and many of the old chan-

mining, in which the gravel is attacked by powerful jets of water, is no longer in progress near Dutch Flat, partly because the rich parts of the deposits have been worked out but chiefly because laws enacted for the protection of the agriculturists along the lower courses of the rivers prohibit the washing of silt and sand and other mining débris into the streams. The general character of these old hydraulic workings can be well seen from the railroad.

The historically important discovery of gold in California was made in January, 1848, at John Sutter's mill on South Fork of American River near Coloma, a point only 10 or 15 miles southeast of the town of Auburn, through which the train will soon pass. From 1850 to 1853 the greatest yield was derived from the gravels, and the largest annual output for this period was more than $65,000,000, in 1852. There was some reaction in 1854, due to previous wild speculation, but a production of about $50,000,000 a year, chiefly from placer mines, was maintained up to 1861.

At first the gold was won chiefly from the gravels along the present streams. Those who first got possession of the rich bars on American, Yuba, Feather, and Stanislaus rivers and some of the smaller streams in the heart of the gold region made at times from $1,000 to $5,000 a day. In 1848 $500 to $700 a day was not unusual luck; but, on the other hand, the income of the great majority of miners was certainly far less than that of men who seriously devoted themselves to trade or even to common labor.

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nels with their lava caps now lie on the ridges. (See fig. 18.)

Of interest in connection with the Tertiary river gravels is the story of the Calaveras skull. For a time this skull attracted much attention not only from people in California, but from scientific men the world over. It was reported to have been found in 1866, near the town of Angels, Calaveras County, at a depth of 130 feet, in Tertiary gold-bearing gravels underlying Tertiary lava. The finding of a human skull embedded in such deposits was for a time believed to indicate that man had been in existence in North America very much longer than had been supposed. Strange to say, the skull is of a higher type than skulls which, although known to antedate historic times, are known also to be much younger than the Tertiary. Although Prof. J. D. Whitney, then State geologist, accepted the skull as a bit of genuine scientific evidence, it is generally believed by students of the antiquity of man that the Calaveras skull, while undoubtedly old, probably did not come from the auriferous gravels at all.

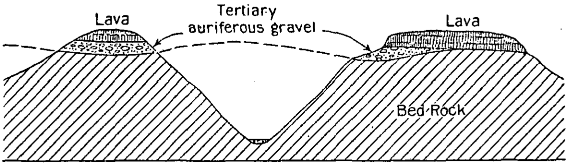

FIGURE 18.—Diagram showing the present relation of the Tertiary auriferous gravels to bedrock and lavas, also the position of the gravel remnants high on the ridge summits.

The gold pan, the "rocker," the "tom," the sluice, and the hydraulic "giant" or "monitor," named in the order of increasing efficiency, were the tools successively used by the miners. Into the "rocker" and the "tom" the miner shoveled gravel or "dirt," rocking the machine as he poured in water and catching the gold, often with the aid of quicksilver, on riffles set across the bottom of his box. Sometimes a stream was diverted into a flume to lay bare the gravel in its bed so that the miner could get at it. In sluicing, the gravel was shoveled into a similar but much longer box through which a stream of water was allowed to run. The hydraulic giant was employed to wash into long riffle-set sluices immense quantities of gravel, especially from the higher (Tertiary) deposits, much of which was too lean to work out by hand. Water was brought for many miles in ditches and flumes from the high Sierra and conducted under great head to a nozzle from which it was projected with tremendous force against the gravel. It was the vast quantity of refuse washed into the streams by these hydraulic operations that brought about the conflict between mining and agricultural interests, finally decided in favor of the farmers. Of late years the gold obtained from quartz veins in California has exceeded that won by placer mining.

Half a mile beyond Dutch Flat station the railroad track rests on Tertiary gold-bearing gravel, the right of way having been preserved from attack by the miners. (See Pl. XLVIII, *A*.) The lower part of the gravel under the railroad is said to be worth about $8 a cubic yard, and it is worthy of note that elsewhere gravels yielding only $1 or $2 a yard are now being worked with profit by tunneling or drifting. The bedrock on which the gravels at Dutch Flat rest is a dark-green, somewhat altered intrusive igneous rock (gabbro).

Gold Run.
Elevation 3,224 feet.
Omaha 1,628 miles.

Just beyond the hydraulic washings is Gold Run, which like Dutch Flat was formerly a flourishing placer town. Beyond Gold Run the railroad for about 6 miles crosses a north-south belt of slate or slaty schist of Carboniferous age (Calaveras formation). These rocks are cut by dikes of dark, altered igneous rock (amphibolite). Patches of Tertiary lavas, outlying remnants of the former plateau surface, cap the highest hills along the summit of the ridge near this part of the route. On the right is Bear River, already mentioned as having lost its original upper portion, above Emigrant Gap, through capture by the South Fork of the Yuba.

Magra (elevation 2,899 feet), Cape Horn (2,656 feet), and Wirt (2,442 feet) are unimportant stations. From a point near milepost 148 can be seen placer pits at Iowa Hill and Michigan Bluff, high on the ridges across the canyon of the North Fork of American River, far away to the southeast. These places, busy mining centers of the early days, are now quiet little back-country settlements.

Just beyond Cape Horn station the train turns south along the side of a wooded ridge and suddenly, at the south end of the ridge, rounds a point known as Cape Horn. Until this year (1915) the road skirted the point at the summit of a precipice 1,500 feet above the North Fork of American River, which afforded the superb canyon view shown in Plate XLIX, *A*. Now the old line "around Cape Horn" has been abandoned, and railroad traffic goes through double tunnels built to eliminate what had seemed like a dangerous curve around the point. Turning back along the other side of the spur, the railroad crosses a deep ravine up which runs the narrow-gage road from Colfax to Grass Valley and Nevada City. This ravine, which opens on the North Fork of American River, is cut in slate of Jurassic age (Mariposa slate). This formation and some of the altered slaty or schistose volcanic rocks associated with it (amphibolite schist, greenstone, etc.) contain some of the principal gold-bearing quartz veins of California, including the series of veins known as the Mother Lode.[1]

[1] The Mother Lode, so called because the early miners imagined it had some sort of ancestral relation to smaller lodes, extends from the vicinity of the Middle Fork of American River southward for fully 120 miles, past the towns of Placerville, Amador, Sutter Creek, Jackson, San Andreas, Angels, Jamestown, Jacksonville, Coulterville, and Mariposa. It is not, as the name implies, a single great vein, but a remarkable linear system of closely parallel and overlapping veins, some of which are many miles in length. The lode has the same general trend as the belts of slaty or schistose rock that are characteristic of the western mid-Sierra slope and follows in the main a very persistent belt of Mariposa slate, although it is not confined to that formation. In places the Mother Lode veins are in altered schistose igneous rocks (amphibolite schist or greenstone schist), in slaty rocks of the Calaveras formation, or even in serpentine.

The slaty rocks of the Mother Lode region generally dip 60° to 75° E., and most of the veins are a little less steeply inclined than the rocks in their vicinity. The veins consist chiefly of quartz carrying free gold, auriferous pyrite, and other minerals that are less constantly or less abundantly present. They were deposited in early Cretaceous time by hot waters probably given off, in part at least, by deep-lying, slowly cooling masses of granite (granodiorite).

A few of the principal mines along the Mother Lode are the Plymouth, Fremont, Bunker Hill, Original Amador, Keystone, Lincoln, Wildman-Mahoney, Eureka, Amador, Central Eureka, South Eureka, Oneida, Kennedy, Argonaut, Zeila, Gwin, Gold Cliff, Lightner, Utica, Melones, Rawhide, Dutch, App, Eagle-Shawmut, and Princeton. Not all of these are now active. The deepest mine and one of the most productive is the Kennedy, which has a vertical shaft 4,000 feet deep.

The ore of the Mother Lode is treated in stamp mills, and the gold is recovered partly by amalgamation and partly by concentration and cyanidation of the pyrite and other sulphides present. The gold quartz mines of California produce annually gold valued at from $10,000,000 to $12,000,000. The greater part of this comes from the mines along the Mother Lode.

Beyond the ravine is Colfax, first known as Illinoistown but later renamed for Vice President Colfax. The Central Pacific Railway, being built up from the Sacramento Valley, reached this place on September 1, 1865. The Nevada County Narrow Gage Railroad runs from Colfax to the important mining districts of Grass Valley and Nevada City, where there are many lode mines that have long been productive.[1]

Colfax.
Elevation 2,422 feet.
Population 621.
Omaha 1,639 miles.

After leaving Colfax the train passes through shallow cuts in yellow soil derived from the deep decay of the Jurassic slates. The road continues the descent along a ridge between canyons, although the traveler will hardly recognize this fact without reference to the map. The upper slopes near the railroad have been largely cleared of timber and are now covered with a dense underbrush, including manzanita,[2] scrub oak, and other shrubs and dwarf trees. The Jurassic rocks in some places carry a few distinctive fossils, but the numerous outcrops of slate as seen from the train do not look very different from the rocks of Carboniferous age (Calaveras) that occur east of Cape Horn.

About 2 miles below Colfax the tracks separate, the westbound route turning off to the north side of the ridge. From this point to Rocklin the two lines are in general some distance apart, although here and there they run together and at two places even cross each other. The older line, used by the westbound trains, affords the better views, as the newer, more uniformly graded track passes through deep cuts and many tunnels.

Lander (elevation 2,282 feet), New England Mills or Weimar (2,278 feet), and Applegate are all small settlements along the route.

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[1] The Nevada City-Grass Valley district is second only to the much larger Mother Lode district as a source of vein gold in California, and probably nowhere else in the State has there been so great a concentration of gold in a small area. The veins occur in many kinds of rock, including granodiorite, slates of the Calaveras formation, altered volcanic rocks (greenstones, amphibolite schist, etc.), and serpentine. They vary much in trend and dip, are generally rather narrow, and yield ore of higher grade than the Mother Lode veins. The veins are similar in general character to those of the Mother Lode, although they show some mineralogic differences. A famous mine of the district is the North Star, the most productive gold mine in California. From 1884 to the end of 1913 this mine has yielded gold to the value of over $15,000,000. Its main shaft, an incline, is 5,850 feet long and attains a vertical depth of 2,200 feet.

[2] The manzanita (*Arctostaphylos patula*) is a shrub having a smooth bark of rich chocolate color, small pale-green roundish leaves, and berries that resemble diminutive apples. It is this resemblance that gives the shrub its common name, Spanish for little apple, by which it is known everywhere on the Pacific coast. Bears are very fond of these berries. The manzanita covers many of the hills in California with a stiff, almost impenetrable growth. Its wood is hard, and the blaze from an old gnarled root cheers many a western fireplace.

From several points in this vicinity a very fine view to the rear may be had across the level-topped upland surface which slopes up to the now distant summits of the main range near the south end of Lake Tahoe.

The route crosses obliquely the outcrops of Jurassic (Mariposa) slate and after running for a few miles near the western edge of this belt of rocks enters, near New England Mills, a belt of the Calaveras formation. This change, however, is not readily recognized from a moving train, as both formations consist largely of similar slaty and schistose rocks.

Fruit growing is obviously the principal industry of the country about Applegate, and evidences of it increase as the journey continues.

Applegate.

Elevation 1,965 feet.
Omaha 1,647 miles.

The train, still following the crest of a broad ridge, passes through a country of rolling hills covered with orchards, fields of grain, and patches of timber. It is said that some of the settlements along this part of the route specialize in certain fruits. For instance, Applegate raises pears chiefly, New England Mills prunes, and so on. Snow falls occasionally here and may lie for a few hours, and there is some frost. Consequently this country is not suited to the growing of oranges and other semitropical fruits.

Clipper Gap, a little settlement on the narrow ridge followed by the railroad, is surrounded by orchards and cultivated ground. A few

Clipper Gap.

Elevation 1,757 feet.
Omaha 1,650 miles.

miles beyond it, between mileposts 128 and 127, the slates of the Calaveras formation are succeeded on the west by altered greenish igneous rocks (diabase, amphibolite, and amphibolite schist), in places slaty or schistose and decomposing in general to a reddish soil. These rocks are the record of volcanic activity in Jurassic time and perhaps also in Carboniferous time.

The westbound traveler passes along the east side of the thriving town of Auburn, the seat of Placer County, named by settlers from

Auburn.

Elevation 1,360 feet.
Population 2,376.
Omaha 1,657 miles.

the city in New York. The eastbound trains go west of the town. The older part of Auburn, dating from the early mining days, is built in the valley of the small stream called Auburn Ravine, but since those days the settlement has spread over the surrounding hills and fruit growing has largely taken the place of mining. The principal fruits raised here are peaches, plums, prunes, raisin and table grapes, and olives. Many of the ranchers have a few orange trees, but these are more numerous at Newcastle, the next station, 400 feet lower, where the soil and temperature are better adapted to citrus fruits. From the suburb of Aeolia Heights, just east of the railroad, may be obtained fine views of the deep canyon of American River, similar to those seen from the train near Cape Horn (Pl. XLIX, *A*);

and from the hills west of Auburn may be seen on a clear day the summit of Mount Diablo, on the other side of the Great Valley of California, more than 80 miles away.

About 2 miles west of Auburn, north of the railroad, is the Ophir mining district, where gold and silver veins occur in granite (granodiorite) and greenstone (amphibolite) schist. Beyond Auburn the route continues for about 2 miles farther across amphibolite schist, which, as exposed in railroad cuts, looks like dark-colored slate and is in places rusty. The railroad winds along the south side of Dutch Ravine, keeping approximately to the general slope of the former plateau surface. Here again are remnants of the Tertiary lava cover, and at one place the railroad passes through a deep, narrow cut in the andesitic tuffs and breccias. These beds rest on granite (granodiorite), which is the prevalent rock from this vicinity down to Sacramento Valley.

Newcastle.

Elevation 970 feet.
Population 755.*
Omaha 1,662 miles.

Just beyond a tunnel on the westbound track is the station of Newcastle, in the center of an orchard country. Pears, peaches, and prunes are grown here, and also some oranges and lemons. Fig trees and palms may be seen near the station. Beyond Newcastle a rolling timbered lowland comes into view to the south. Granite is exposed in the cuts along the road and as bowlder-like outcrops in the fields.

Penryn.

Elevation 635 feet.
Population 240.*
Omaha 1,666 miles.

Penryn, like all the other stations along this part of the route, ships great quantities of fruit. Granite[1] was formerly extensively quarried here for use in railroad construction and in public buildings. A small production is still maintained.

Loomis.

Elevation 391 feet.
Omaha 1,668 miles.

At Loomis is another large granite quarry. The stone is intermediate in color and texture between that quarried at Penryn and at Rocklin. It is coarser and darker than the Rocklin granite but is finer and carries less biotite than the Penryn stone. Loomis is, however, principally a fruit-shipping point, and the fruit-packing houses may be seen near the station. It is said that fruits, especially oranges, ripen early in this section, and that injurious frosts are unknown. The soil in this locality is decomposed granite, and beyond the station bowlder-like granite ledges crop out here and there on the soil-covered plain.

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[1] The Penryn stone is a dark biotite granite, rather uniform in color, but varying somewhat in texture in the different quarry openings. Dark blotches where the biotite crystals have segregated are avoided as far as possible in the selection of the stone. About a mile east of Penryn a gabbro, or "black granite," is quarried. This stone is used chiefly for monuments, as it takes a brilliant polish.

Rocklin.

Elevation 249 feet.
Population 1,026.
Omaha 1,671 miles.

Rocklin, also in the fruit belt, is the principal granite-producing locality in California, whence its name. In the vicinity of the town 20 or 25 quarries are in operation, and some of them may be seen from the railroad. The first quarry was opened in 1863, and the stone was used in construction work on the Central Pacific Railway. The stone for the State Capitol at Sacramento (Pl. L, p. 216) and for many buildings in San Francisco came from Rocklin.[1]

The traveler has now practically reached the Great Valley of California. The country spreads out to the north and south in low undulations and ahead are plains as far as the eye can see.

The great gold-dredging fields of California lie along the belt of country where the Sierra slope merges into the valley plain, but none of these fields is crossed by the Overland Route. One productive district is near Folsom, about 10 miles south of Rocklin, on American River. This district produced gold to the value of $2,498,603 in 1913. The Marysville dredging district, on Yuba River about 30 miles northwest of Rocklin, produced $2,420,455 in 1913, and the Oroville district, on Feather River about 25 miles north of Marysville, $1,918,050. The gold is obtained by powerful electrically driven dredges—huge floating scows, some of them 150 feet long, provided with great buckets, linked together in an endless chain, for scooping up the gravel and with complete machinery for screening and washing the gravel and recovering the gold. Once floated in a pond the dredges dig their way through fields, vineyards, and orchards, filling in behind them with washed gravel. The gold was brought down from the slopes of the Sierra and deposited in recent geologic time by the rivers near which the dredges are working. Of late years the hard bowlders left by the dredging have been crushed and utilized as broken rock for road building. Some effort has been made also to restore the dredged ground to arable condition. Where this has been successfully accomplished in the Sacramento region vineyards and olive groves occupy areas from which gold and road metal have been mined.

At the west base of the Sierra, but not continuously exposed all along it, are beds of brown Upper Cretaceous sandstone (Chico formation) and of lighter-colored Eocene sandstone and clay, containing thin coal beds (Ione formation).[2] All these beds are younger than

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[1] The rock is of light-gray color and of medium fine grain. Grayish quartz grains, white feldspars, black or dark-brown biotite, and silvery muscovite in small scales may be readily distinguished with the unaided eye. In composition the rock is a normal granite, but a short distance from Rocklin the country rock grades into a granodiorite.

[2] The Ione formation has been described as Miocene, but recent investigations indicate that it is Eocene.

GEOLOGIC AND TOPOGRAPHIC MAP
OF THE
OVERLAND ROUTE
From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.

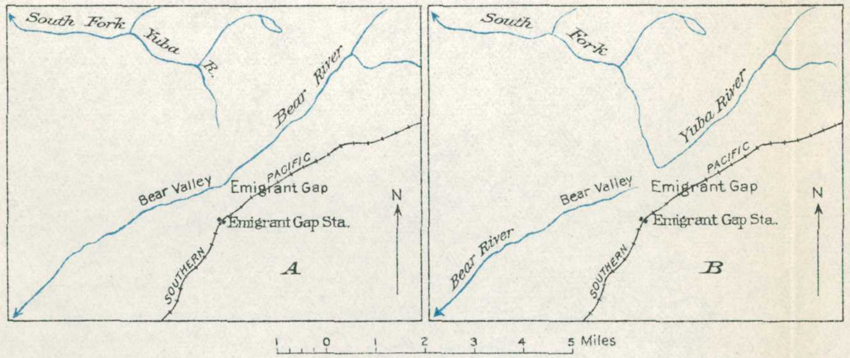
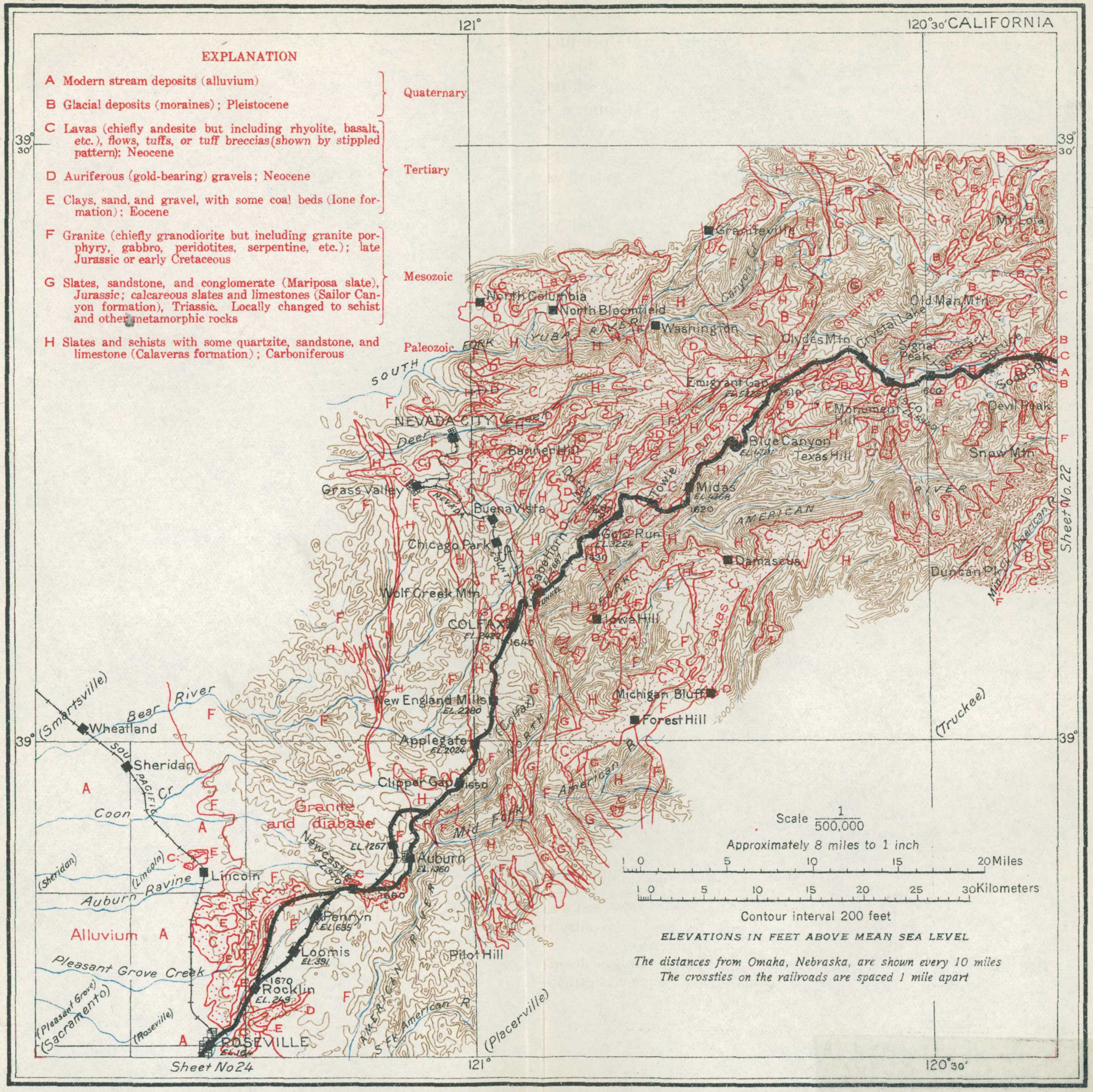


FIGURE 17.—SKETCH MAPS SHOWING CAPTURE OF UPPER PART OF BEAR RIVER BY SOUTH FORK OF YUBA RIVER. *A*, BEFORE CAPTURE; *B*, AFTER CAPTURE. RAILROAD SHOWN TO IDENTIFY LOCATION.



the rocks forming the mass of the Sierra and have not been squeezed or altered. They dip gently westward and are covered by gravels, silts, and muds washed into the Great Valley of California by streams. Remnants of the lavas that were poured down the Sierra slopes during Tertiary time cap some of the foothills along this part of the route. West of them all is open plain.

Roseville.

Elevation 164 feet.
Population 2,608.
Omaha 1,675 miles.

At Roseville the main line is joined from the north by the Southern Pacific Co.'s line to Marysville, Chico, and Tehama. At Tehama this line joins the main Shasta Route of the same company, which south of Tehama lies along the west side of Sacramento Valley. Beyond Roseville is a nearly level country, practically all of which is under cultivation, chiefly in grain but partly in orchards. The scattered oak trees in this part of the valley include two species, the live oak and the valley oak. (See footnote on p. 203.) Antelope (see sheet 24, p. 218) is a few miles beyond Roseville. Beyond Ben Ali, a siding about 12 miles from Roseville, there is a tile and brick yard north of the track.

As it approaches Sacramento the train runs on an embankment, a part of a rather extensive system of levees which hold the flood waters of Sacramento and American rivers in check. After crossing American River the train skirts the north side of the city to the station, which is close to Sacramento River.

Sacramento.

Elevation 30 feet.
Population 44,696.
Omaha 1,693 miles.

Sacramento, the capital of California, is on the east bank of Sacramento River 61 miles above its mouth, just below the mouth of American River. The city is on the low flood plain of Sacramento River, about 30 feet above mean sea level. It is a distributing point and wholesale center for the vast and fertile Sacramento Valley and has numerous manufactures, of which flour is the chief. As boats drawing 7 feet of water can come up to the city, freight can be transported by water to and from San Francisco Bay. Electricity for lighting, for street railways, and for power is furnished by hydroelectric plants at Folsom, on American River, 22 miles away, and at Colgate, in the Sierra, on Yuba River, 119 miles away.

The first settlement on the site of Sacramento was a fort built in 1839 by John Augustus Sutter, a Swiss military officer in the service of Mexico. In 1841 Sutter was granted 11 square leagues of land by the Mexican Government, but the real history of the town begins with the discovery of gold in 1848. In December, 1849, the population was 4,000, and a year later it had increased to 10,000. The city was made the State capital in 1854. Before 1862 destructive floods were frequent, but since that date the city has been protected by levees. The lower portions of the main streams in the Sacramento Valley, overloaded with silt and, especially since 1849, with the débris from the placer mines in the Sierra, have built their channels above the level of the adjacent valley lands. Thus it has become of great importance to the farmers to confine the flood waters within the river channels, and to this end the banks have been raised by levees. There are many channels, usually dry, which lead out into the valley, particularly from the Coast Range. The flood waters of these channels can not reach the main river at all and therefore spread out over the lowlands on either side, to be eventually dissipated for the most part by evaporation. This accounts for the numerous areas of low marshy lands that border the river.

Leaving Sacramento the train crosses Sacramento River on a steel bridge and runs across flats which lie almost at tide level but which, being protected from inundation by levees, are cultivated as market gardens and for hay or grain. Farther west the land becomes marshy and is covered with a thick growth of tule (pronounced too′ly), a bulrush (*Scirpus lacustris* or *californicus*) which looks like a coarse, high grass. These marshes extend for miles on both sides of the track. In places the ground is slightly above the general level and its surface is covered with short grass used for the grazing of cattle and sheep. Beyond this country the train reaches slightly higher and better-drained lands, on which Swingle, a minor station, is surrounded by hay meadows and corn fields.

Davis.
Elevation 42 feet.
Population 750.*
Omaha 1,706 miles.

At Davis the Shasta and Overland routes join. The country in this vicinity is a smooth plain, near tidewater level, but nevertheless high enough to provide drainage. With its rich fields of grain and orchards, it has a distinctly prosperous look. Beyond Davis the Coast Ranges[1] become more prominent, especially to the right, ahead of the train, where one of them appears as a low dark ridge broken by one or more gaps. Valley and live oaks are again a common feature through the fields.

Dixon.
Elevation 61 feet.
Omaha 1,714 miles.

Dixon is an agricultural town in Solano County. Beyond it the Coast Range now looms larger as the traveler proceeds westward. Elmira (elevation 79 feet), a junction whence a branch road goes to Vacaville, Winters, and Rumsey, is next passed. Beyond Elmira the road approaches low foothills of the Coast Range—first a bare ridge with gaps through one of which the railroad passes over a slight rise.

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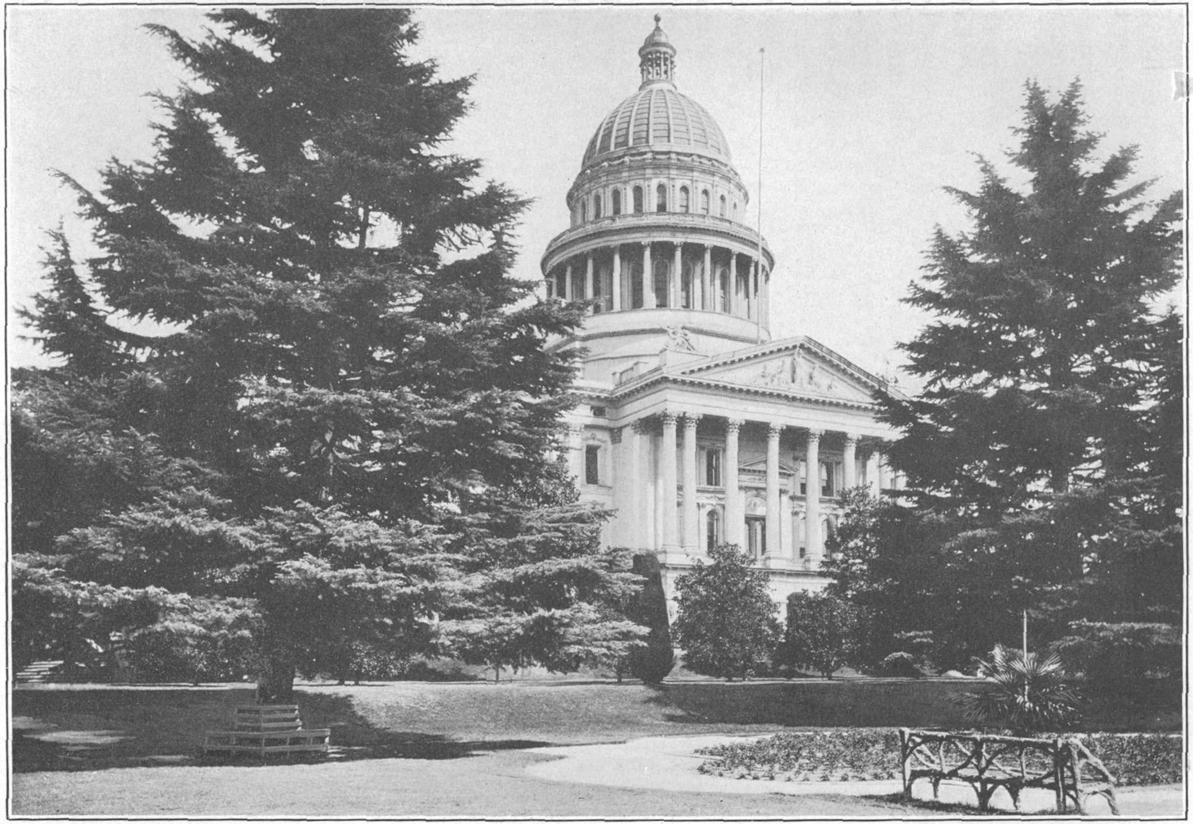
[1] Along the Pacific coast, from the vicinity of Santa Barbara on the south to Humboldt County on the north, rise the Coast Ranges, dividing the Great Valley of California from the ocean. These ranges are broken by the one great gap by which the combined Sacramento and San Joaquin rivers find outlet into the Bay of San Francisco. The Coast Ranges are geologically the most recent of the great structural features of the State. They are built up largely of folded and crushed Cretaceous, Jurassic, and Tertiary sedimentary rocks, which are in places broken through by andesitic and basaltic lavas and by older igneous rocks (diabase and other dark, heavy rocks, in part altered to serpentine).



STATE CAPITOL AT SACRAMENTO, CAL.

Photograph furnished by Southern Pacific Co.

The factory of the Pacific Portland Cement Co. and adjacent shale quarries can be seen to the north. The limestone used here to mix with the shale is brought from a point near Auburn.

The traveler coming across the Sacramento Valley in the day during midsummer is likely to find the trip warm, but on reaching this gap in the Coast Range he almost invariably notices a change. The cool breezes sweeping in from the west and carrying the smell of the salt marshes become fresher as the train proceeds, and it is a reasonable precaution to have wraps handy from this point on.

Beyond the first spur of the Coast Range the valley again broadens. Higher mountains, more or less darkened by scrubby timber on their upper slopes, border the valley to the north and far to the south. If the air is moderately clear, Mount Diablo [1] and the southern continuation of the Coast Range may be seen. A group of low, round, and grassy hills a few miles to the south are known as the Potrero Hills. (Potrero, pronounced po-tray′ro, is Spanish for horse pasture.)

Suisun.
Elevation 15 feet.
Population 641.
Omaha 1,733 miles.

Suisun (suey-soon′, locally soo-soon′, the name of an Indian tribe, said to mean great expanse) and the adjoining town of Fairfield (the seat of Solano County, population 834) are at the edge of another swampy district green with tule. From this point the railroad is graded across the Suisun Flats, which are so near tidewater level in Suisun Bay, to the south, that no cultivation is possible under present conditions, though the camps of several duck-shooting clubs are situated among the sloughs. The railroad has encountered much difficulty in maintaining its grade across this soft ground. Certain spots have been continually sinking ever since the road was first constructed, and it is seldom, even now, that in going over this part of the route the traveler does not see work

[1] From a point near Benicia, if the day is clear, an excellent view may be had of the double summit and graceful curves of Mount Diablo. Its general outline and isolated position have given the impression that this mountain is an old volcano. It represents, however, the higher portions of an overturned arch or anticline of sedimentary rocks thrust from the northeast toward the southwest. From its summit to the sea level at Carquinez (car-kee′nez) Strait is displayed a remarkably complete series of typical Coast Range formations, including Franciscan, Knoxville, Chico, Martinez, Tejon, Monterey, San Pablo, late Tertiary fresh-water beds, Pleistocene, and Recent. Although Mount Diablo is of moderate height (3,849 feet), its isolation and its situation on the edge of the Great Valley make it one of the finest viewpoints in the State. From its top, on a clear morning, the summits of the Sierra Nevada can be traced for over 200 miles. Lassen Peak is often visible and sometimes Mount Shasta. The Great Valley appears divided into squares like a checkerboard by the section-line roads and fences. The San Francisco Bay region is sometimes hidden by a rolling, snowy sea of fog. The mountain is easily reached from San Francisco, though at present the actual ascent must be made on foot or by driving. It is expected that the road, which goes practically to the summit, will be fitted for automobile travel.

trains and grading crews busily engaged in filling and raising some sunken portion of the track. Mud ridges have risen along the tracks on both sides, and their broken and lumpy surfaces indicate a slow flowing mass of mud squeezed out by the weight and vibration of passing trains. It is said that as much as 30,000 carloads of coarse gravel ballast have been dumped into one of these spots.

Beyond the marshes the railroad meets the rocky headlands that here close in upon Carquinez Strait. Some fine exposures of Cretaceous and Tertiary sandstones and shales may be seen in the cliffs and road cuts around Army Point.

Benicia.

Elevation 6 feet.
Population 2,360.
Omaha 1,749 miles.

Near Benicia, on the left, is a United States arsenal and signal station. Benicia (named by Gen. Vallejo after his wife) is a manufacturing town with deep-water frontage. It contains, besides the arsenal, tanneries and other commercial establishments. Southeast of Benicia, across the strait, is the town of Martinez, near which John Muir, California's great naturalist, lived for many years. The tall smokestack east of the town belongs to the smelter of the Mountain Copper Co., which mines its ore near Kennett, in Shasta County. At this smelter sulphur fumes are utilized in making sulphuric acid, which in turn is used in treating rock phosphate brought from the company's mine near Montpelier, Idaho, and here turned into fertilizer. Just beyond Benicia the train is run onto a ferryboat and is carried across Carquinez Strait to Port Costa, a distance of a mile.

The geologic section from Benicia and Port Costa to the vicinity of Berkeley and Oakland is particularly interesting, as in it are represented many of the characteristic sedimentary formations of the Coast Range. This stratigraphic section is quite different from that of corresponding age in the Sierra foothills.

Port Costa.

Elevation 11 feet.
Omaha 1,750 miles.

Port Costa (see sheet 25, p. 224), the western ferry terminus, is a shipping point, particularly for grain, which comes from the extensive grain-producing district in the valley[1] and is here loaded into ocean-going vessels. A long line of galvanized-iron grain warehouses may be seen on the water front.

On leaving Port Costa the train skirts the south shore of Carquinez Strait, where the steep bluffs offer many good exposures of folded sedimentary rocks. The first rocks seen are Upper Cretaceous

[1] Agriculture in California had its beginning in wheat raising, and wheat was long the State's greatest crop. Its production steadily increased until about 1884, to over 54,000,000 bushels annually. The levelness of the great grain fields of the valley led to the utilization of combined harvesters, steam gang plows, and other farm machinery of extraordinary size and efficiency. Recently, however, fruit growing has become a more important industry than grain farming. In the value of its fruit crop California leads all the other States.

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1915

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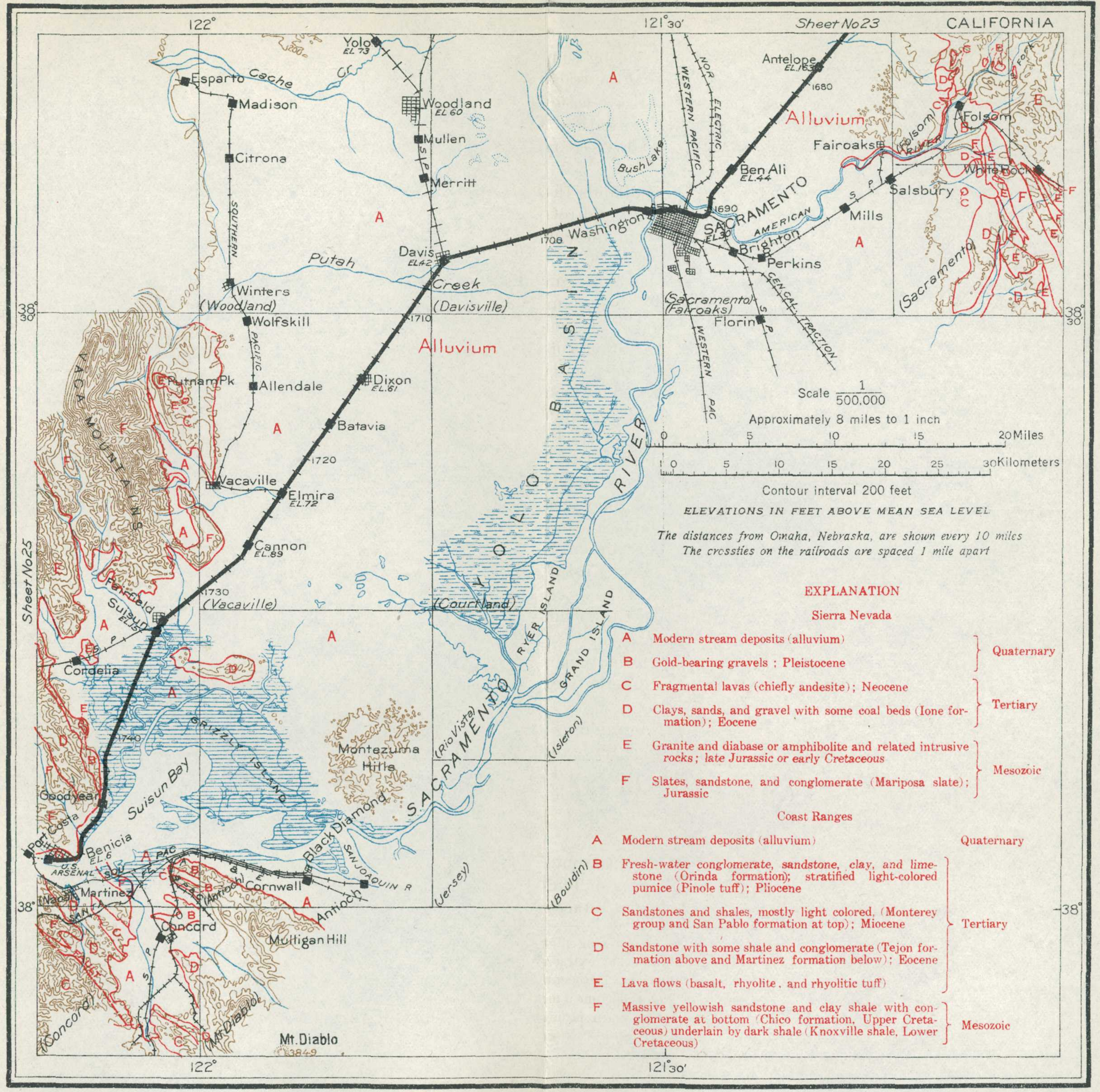


(Chico) sandstone and shale. The rocks have a moderately steep westward dip and trend almost directly across the course of the railroad, so that as the train proceeds successively younger formations are crossed. At Eckley, a short distance beyond Port Costa, brick is manufactured from the Cretaceous shale. At Crocket is a large sugar refinery. Mare Island, across Carquinez Strait, is the site of the United States navy yard, which, however, is not readily discerned from this point. The Cretaceous shales and sandstones continue to Vallejo Junction and a little beyond.

On the southeast side of San Pablo Bay, near the west end of Carquinez Strait, there are wave-cut terraces and elevated deposits of marine shells of species that are still living. These terraces and deposits do not show south of San Pablo Bay, and therefore seem to indicate the recent elevation of a block including only a portion of the shore around the bay. This block probably includes the Berkeley Hills and a considerable territory to the east, perhaps even extending to Suisun Bay.

Vallejo Junction.
Elevation 12 feet.
Omaha 1,754 miles.

From Vallejo Junction a ferry plies to Vallejo (val-yay'ho), which is on the mainland opposite the navy yard, and from which railroad lines extend into the rich Napa and Sonoma valleys. Santa Rosa, the home of the famous Luther Burbank, is in the Sonoma Valley. Vallejo was named from Gen. Mariano Guadalupe Vallejo, who played a prominent part in the early history of California. It was the capital of the State from 1851 to 1853. Beyond Vallejo Junction Carquinez Strait begins to open out into San Pablo Bay.[1]

[1] The section along the shore of San Pablo Bay between Vallejo Junction and Pinole (see figs. 19 and 20, on sheet 25, p. 224) includes six of the most widespread divisions of the sedimentary series in the Coast Range region of California. The formations or groups represented are the Chico (Upper Cretaceous), Martinez, (Eocene), Monterey (earlier Miocene), San Pablo (later Miocene), Pinole tuff (Pliocene), and Pleistocene. The only large divisions of the middle Coast Range sequence not represented are the Franciscan (Jurassic?), Tejon (Eocene), and Oligocene, all of which are found within a few miles to the east and south.

In the San Pablo Bay section all the formations below the Pleistocene are included in a syncline, on the northeast side of which the strata are nearly vertical, but on the southeast side the dip of the beds is lower. The Pleistocene beds rest horizontally across the truncated edges of the Miocene and Pliocene. The aggregate thickness of the sediments in the San Pablo Bay section is not less than 8,000 feet. With the exception of the Pliocene and a portion of the Pleistocene, all the formations are of marine origin. A portion of the Pinole tuff was certainly deposited in fresh water. The Pleistocene beds were deposited under varying marine, estuarine, and fluvial conditions.

Fossil remains are found in all the formations of the San Pablo Bay section, and at least six distinct faunas are represented. Very few specimens have been procured in the Chico near the line of the railroad, but abundant fossils are found in the same formation a few miles to the east. The Martinez fauna is represented in the cliff opposite the Selby smelter. The Monterey and the San Pablo contain abundant remains. The fresh-water

The dark Cretaceous shales near the railroad station at Vallejo Junction are soon succeeded by brown shales and massive sandstones belonging higher in the Cretaceous system. The contact between the Chico and the Martinez (Eocene) beds is in a fault zone cut by the railroad tunnel a short distance west of Vallejo Junction. Just beyond the tunnel the contact between the Martinez and the Monterey (Miocene) is clearly shown in a high cliff to the left, opposite the Selby Smelting Works, where the buff-colored Monterey sandstones and shales rest with marked unconformity upon the black Eocene shales. Near the contact the Eocene shale is filled with innumerable fossil shells of boring Miocene mollusks. The Monterey beds are extraordinarily well exposed in the cliffs to the left, and immediately beyond the contact, where they consist of fine buff shales with shaly sandstones and thin bands of yellow limestone.

After leaving these cliff exposures the train passes Tormey station, crosses a little swamp, and approaches a tunnel cut into vertical cliffs of massive gray sandstone; this is the type locality of the San Pablo formation (upper Miocene). The refining plant of the Union Oil Co., at the east end of this tunnel, is located on the upper part of the San Pablo beds. Vertical beds of massive tuff immediately west of the oil refinery represent the lower part of the Pinole tuff. Beyond these beds the train crosses another swamp and enters a cut in which white volcanic ash beds of the Pinole tuff dip at a relatively low angle to the northeast. This change in dip shows that these beds are on the southwest side of the San Pablo Bay syncline, the axis of which passes through the swamp area. Resting upon the tilted ash deposits in this part of the section are horizontal beds of Pleistocene shale.

Rodeo.

Elevation 12 feet.
Omaha 1,757 miles.

The name Rodeo (ro-day′o), meaning "round-up," indicates that the station so called was formerly a cattle-shipping point. Beyond Rodeo the train enters a series of cuts. Near the station are exposures of massive tuffs close to the base of the Pinole tuff. Beyond this point the San Pablo (Miocene) appears, with low dips to the northeast. In the sea cliffs on San Pablo Bay a few yards from the railroad are excellent exposures of the Miocene capped by Pleistocene shale. At Hercules, where there are large powder works, the railroad cut is in broken shale of the Monterey group, the same beds that were seen near the Selby smelter, on the northeast side of the syncline. Beyond Hercules the railroad passes over Monterey shale

fauna of the Pinole tuff is represented by molluscan species. Leaves and remains of vertebrates are also present. The Pleistocene shale contains abundant marine shells of a few species, with mammal bones representing the elephant, horse, camel, bison, ground sloth, antelope, lion, wolf, and other forms.

to the town of Pinole (pee-no′lay, a Spanish term used by the Indians for parched grain or seeds), where the Pinole tuff is in contact with the Monterey and is covered by a thick mantle of the Pleistocene shale. In the cuts southwest of Pinole the rocks exposed are all either steeply inclined Pliocene tuffs or horizontal Pleistocene beds.

Pinole.

Population 798.
Omaha 1,760 miles.

At Krieger, where the tracks of the Santa Fe route may be seen approaching the bay front from the south, is a so-called "tank farm." The oil-storage tanks, which belong to the Standard Oil Co., are beyond the Santa Fe line. Beyond Sobrante station is Giant, another powder factory, and beyond that are pottery works which obtain clay from Ione, in the Sierra Nevada. The bay shore near Oakland is largely given over to industrial uses, on account of its facilities for rail and water transportation.

Beyond Giant the foothills retreat from the bay shore and the railroad enters the broad lowland on which the cities of Berkeley and Oakland are built. Near San Pablo, in the vicinity of San Pablo and Wildcat creeks, there is a gravel-filled basin. Many wells sunk in this gravel may be seen near the tracks, and from them a municipal water company and both railroads obtain water. West and southwest of San Pablo station a line of hills shuts out a view of San Francisco Bay. These hills constitute the Potrero San Pablo, so called because, being separated from the mainland by marshes, they were a convenient place in which to pasture horses during the days of Mexican rule, when fences were practically unknown. The hills are made up wholly of sandstone belonging to the Franciscan group.[1] On the other side of them are wharves, warehouses, and large railway shops belonging to the Santa Fe system. From that side also the Santa Fe ferry plies to San Francisco.

San Pablo.

Elevation 30 feet.
Omaha 1,765 miles.

[1] The rocks of the Franciscan group comprise sandstones, conglomerates, shale, and local masses of varicolored thin-bedded flinty rocks. The flinty rocks consist largely of the siliceous skeletons of minute marine animals, low in the scale of life, known as Radiolaria, and on this account they are known to geologists as radiolarian cherts. All the rocks mentioned have been intruded here and there by dark igneous rocks (diabase, peridotite, etc.), which generally contain a good deal of magnesia and iron but little silica. The peridotites and related igneous rocks have in large part undergone a chemical and mineralogic change into the rock known as serpentine. Closely associated with the serpentine as a rule are masses of crystalline laminated rock that consist largely of the beautiful blue mineral glaucophane and for that reason are called glaucophane schist. Schist of this character is known in comparatively few parts of the world, but is very characteristic of the Franciscan group. It has been formed from other rocks through the chemical action known as contact metamorphism, set up by adjacent freshly intruded igneous rocks. The Franciscan group is one of the most widespread and interesting assemblages of rocks in the Coast Ranges.

Richmond.

Population 6,802.
Omaha 1,767 miles.

Richmond, on both the Southern Pacific and the Santa Fe lines, is becoming a busy shipping, railroad, and manufacturing point, on account of the congestion of the water front of Oakland and San Francisco. The hills on the east side of the track, known to old Californians as the Contra Costa Hills, but now often referred to as the Berkeley Hills, rise steeply from the plain. The most conspicuous summit from the west is Grizzly Peak (1,759 feet), but Bald Peak, just east of it, is 171 feet higher. The hills are generally treeless on their exposed western slopes, although their ravines and the eastern slopes are wooded.[1]

Beyond San Pablo and Richmond the rocks of the Franciscan group outcrop in low hills. At Stege the railroad is still close to the shore of the bay. Between this place and the hills is one of the suburbs of Berkeley known as Thousand Oaks. The traveler can get here an unobstructed view out over the bay and through the Golden Gate. Mount Tamalpais is on the right and San Francisco on the left. Just to the left of the Golden Gate the white buildings of the Exposition grounds can readily be distinguished if the day is at all clear. At Nobel station a little wooded hill of Franciscan rocks stands close to the railroad on the left. Beyond Nobel an excellent view may be had of the hilly portion of the city of Berkeley.

Berkeley.

Elevation 8 feet.
Population 40,434.
Omaha 1,772 miles.

West Berkeley station, also known as University Avenue, is in the older part of the city of Berkeley, and the center of the city is now almost 2½ miles back toward the hills. Berkeley was named after Bishop Berkeley, the English prelate of the eighteenth century who wrote the stanza beginning "Westward the course of empire takes its way," by those who chose it as a site for the University of California. One of them, looking out over the bay and the Golden Gate, quoted the familiar line, and another suggested "Why not name it Berkeley?" and Berkeley it became.

The University of California was founded in 1868. It is one of the largest State universities in America, including besides the regular collegiate and postgraduate departments at Berkeley the Lick Observatory, on Mount Hamilton; colleges of law, dentistry, pharmacy, art, etc., in San Francisco; the Scripps Institution for Biological

[1] The geologic structure of these hills is rather complicated. Along their southwest base, between Berkeley and Oakland, is a belt of the sandstones, cherts, and schists belonging to the Franciscan (Jurassic?) group and characteristically associated with masses of serpentine. Overlying the Franciscan rocks are sandstones, shales, and conglomerates of Cretaceous, Eocene, and Miocene age. These in turn are overlain by tuffs, fresh-water beds, and lavas of Pliocene and early Quaternary age. The general structure of the ridge east of Berkeley is synclinal, the beds on both sides dipping into the hills. The upper part of Grizzly Peak is formed chiefly of lava flows of Pliocene age.

Research, at La Jolla, near San Diego; and other laboratories for special studies elsewhere. It is a coeducational institution and had a total enrollment for 1914–15, not including that of the summer school, of 6,202. The members of the faculty and other officers of administration and instruction number 890. The university buildings at Berkeley are beautifully situated and have a broad outlook over San Francisco Bay. Their position can readily be identified from the train by the tall clock tower. Another prominent group of buildings occupying a similar site just south of the university grounds is that of the California School for the Deaf and the Blind.

Just before reaching Oakland (Sixteenth Street station) the train passes Shell Mound Park. The mound, which is about 250 feet long and 27 feet high, is on the shore of the bay close to the right-hand side of the track. It is composed of loose soil mixed with an immense number of shells of clams, oysters, abalones, and other shellfish gathered for food by the prehistoric inhabitants of the region and eaten on this spot. The discarded shells, gradually accumulating, built up the mound. Such relics of a prehistoric people are numerous about the bay, for over 400 shell mounds have been discovered within 30 miles of San Francisco. The mound just described is one of the largest, and from excavations in it a great number of crude stone, shell, and bone implements and ornaments have been obtained. The mounds evidently mark the sites of camps or villages that were inhabited during long periods, for the accumulation of such refuse could not have been very rapid. Archeologists who have studied the mound say that it must have been the site of an Indian village over a thousand years ago, and that it was probably inhabited almost continuously to about the time when the Spaniards first entered California.

Oakland.

Elevation 12 feet.
Population 150,174.
Omaha 1,774 miles.

The first stop in the city of Oakland is made at the Sixteenth Street station, about 1½ miles from the business center of the city. Oakland is the seat of Alameda County and lies on the eastern shore of San Francisco Bay directly opposite San Francisco. Its name is derived from the live oaks which originally covered the site. It is an important manufacturing center and has a fine harbor with 15 miles of water front. Visitors to Oakland should if possible take the electric cars to Piedmont, from which a fine view may be had of San Francisco, the bay, and the Golden Gate. This view is especially good at sunset. A walk or drive to Redwood Peak takes the visitor past the former home of Joaquin Miller, author of "Songs of the Sierras" and many other familiar poems, and affords equally fine views.

Leaving the station at Sixteenth Street, the train skirts the west side of the city and runs out on a pier or mole 1⅓ miles long. This is the end of the "overland" part of the route, for the rest of the journey must be made on the San Francisco ferries. The distance across the bay is 4 miles, and the trip is made in the ferryboats in about 20 minutes. In crossing the bay the traveler sees Goat (or Yerba Buena), Alcatraz, and Angel islands to the right, Marin Peninsula beyond them, and the Golden Gate opening to the west of Alcatraz.

Goat Island lies close to the ferry course across the bay. Like most of the other islands in the bay, it is owned by the Government. On the nearest point there is a lighthouse station, and below it the rocky cliff is painted white to the water's edge. Just to the right of this is the supply station for the lighthouses of the whole coast from Seattle to San Diego. Behind this station is the United States naval training station, of which the officers' quarters may be seen on the hillside and the men's quarters near the larger buildings below. At the extreme northeast point of the island is a torpedo station, where torpedoes are stored for use in the coast defense.

On Alcatraz, the small island west of Goat Island, is a United States military prison, and on Angel Island, north of Alcatraz, are barracks and other military buildings, a quarantine station, and an immigrant station.

Few people in viewing the Bay of San Francisco think of it in any other way than as a superb harbor or as a beautiful picture. Yet it has an interesting geologic story. The great depression in which it lies was once a valley formed by the subsidence of a block of the earth's crust—in other words, the valley originated by faulting. The uplifted blocks on each side of it have been so carved and worn by erosion that their blocklike form has long been lost. Erosion also has modified the original valley by supplying the streams with gravel and sand to be carried into it and there in part deposited. The mountains have been worn down and the valley has been partly filled. Possibly the valley at one time drained out to the south. However that may be, at a later stage in its history it drained to the west through a gorge now occupied by the Golden Gate. Subsidence of this part of the coast allowed the ocean water to flow through this gorge, transforming the river channel into a marine strait and the valley into a great bay. Goat Island and other islands in San Francisco Bay suggest partly submerged hills, and such in fact they are.

San Francisco.
Population 416,912.
Omaha 1,782 miles.

San Francisco, the chief seaport and the metropolis of the Pacific coast, is the tenth city in population in the United States and the largest and most important city west of Missouri River. The population in 1910 showed a gain of 20 per cent since 1900. The city is beautifully situated at the north end of a peninsula, with the ocean on one side and the Bay of San Francisco on the other. The bay is some 50 miles in length and has an area of more than 300 square miles.

GEOLOGIC AND TOPOGRAPHIC MAP

OF THE

OVERLAND ROUTE

From Omaha, Nebraska, to San Francisco, California

Base compiled from United States Geological Survey Atlas Sheets, from railroad alignments and profiles supplied by the Union Pacific Railroad Company and the Southern Pacific Company and from additional information collected with the assistance of these companies

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

David White, Chief Geologist R. B. Marshall, Chief Geographer

1915

Each quadrangle shown on the map with a name in parenthesis in the lower left corner is mapped in detail on the U. S. G. S. Topographic sheet of that name.

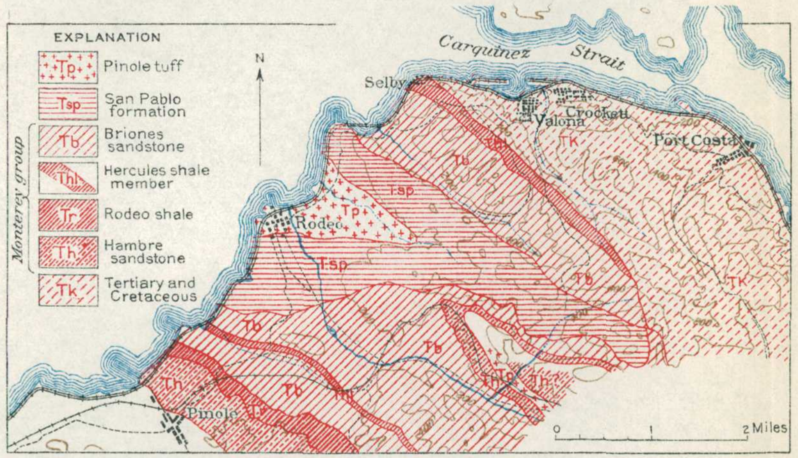


FIGURE 19.–MAP SHOWING GEOLOGIC FORMATIONS ALONG THE SOUTH SHORE OF SAN PABLO BAY.

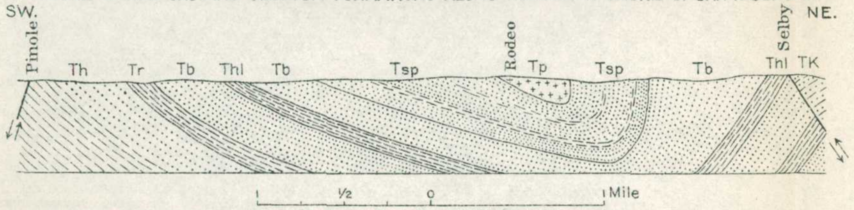
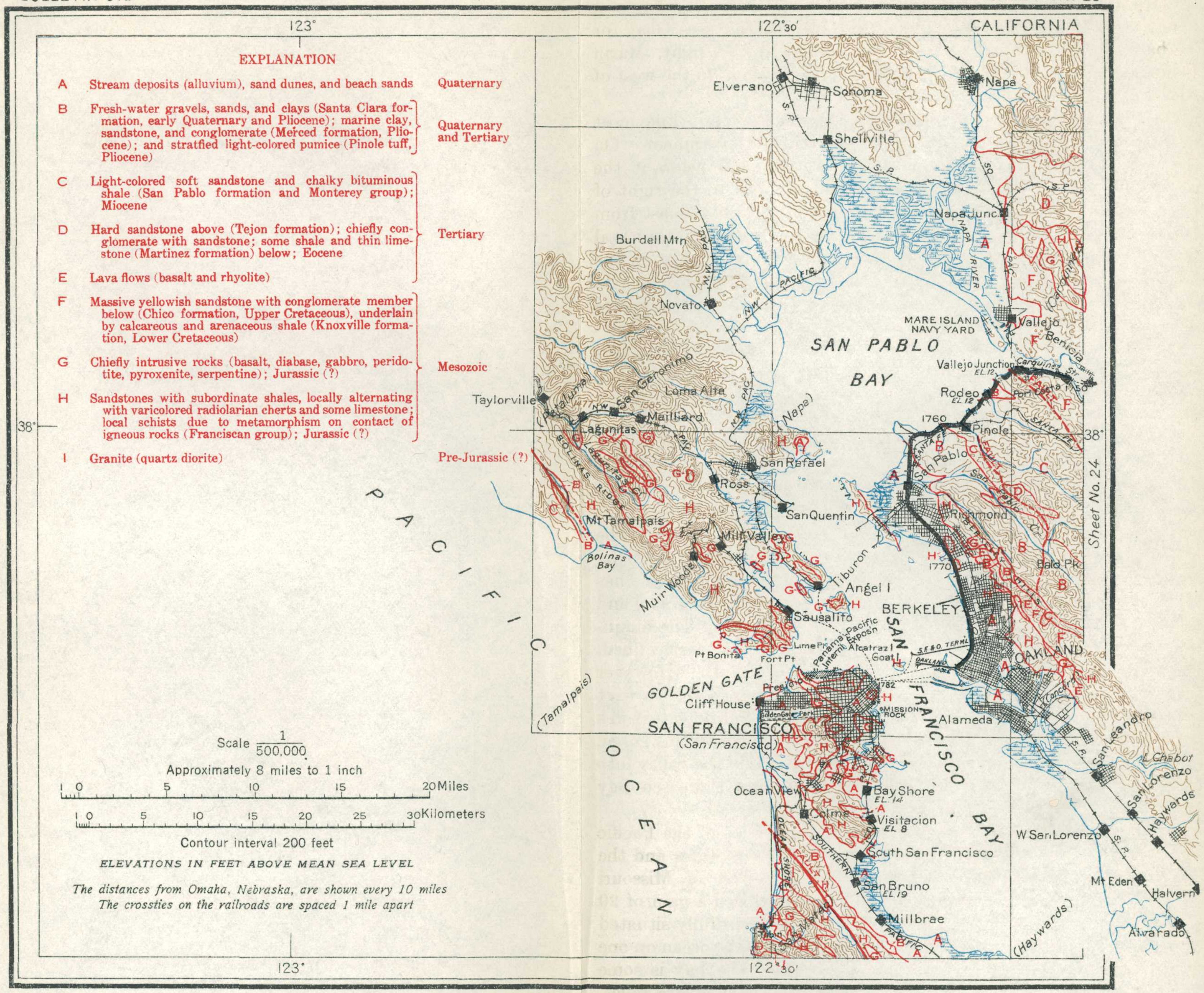


FIGURE 20.–SECTION SHOWING STRUCTURE ALONG THE SOUTH SHORE OF SAN PABLO BAY



The entrance to the bay lies through the Golden Gate, a strait about 5 miles long and a mile wide at its narrowest point.

The site of the city is very hilly, and a line of high rocky elevations run like a crescent-formed background from northeast to southwest across the peninsula, culminating in the Twin Peaks, 925 feet high. Telegraph Hill, in the northeastern part of the city, is 294 feet above sea level. Here stood the semaphore which signaled the arrival of ships in the days of the gold seekers. The city has been laid out without the slightest regard to topography; consequently many of the streets are so steep as to be traversable only by cable cars and pedestrians. The waters of the bay formerly extended westward to Montgomery Street, and most of the level land in the business section of San Francisco has been made by filling.

Golden Gate Park, containing 1,014 acres, and extending westward from the city to the ocean, was a waste of barren sand dunes in 1870, but skillful planting and cultivation have transformed it into one of the most beautiful semitropical public parks in the country. At its west end is the famous Cliff House, overhanging the sea, and a short distance out from the shore are the Seal Rocks, where the great sea lions may often be seen. The Sutro Baths, near by, named after Adolph Sutro, constructor of the famous Sutro tunnel on the Comstock lode, contain one of the largest inclosed pools in the world.

Commerce.

San Francisco Bay is the largest and most active harbor on the Pacific coast. Besides the coastwise routes, the port maintains steamship connections with Australia, Hawaii, Mexico, Central and South America, the Philippines, China, and Japan. The direct foreign trade is chiefly with British Columbia, South America, China, and Japan. Although the export grain business has now largely shifted to the ports of Oregon and Washington, San Francisco's permanence as one of the greatest ports of the country is assured by its advantageous position, its wealth of back country, and its command of trans-Pacific and transcontinental trade routes. Three large railroad systems—the Southern Pacific (with two transcontinental lines), the Atchison, Topeka & Santa Fe, and the Western Pacific—connect it with the East. Lines of the Southern Pacific Co. connect the city with different parts of the State and with the northern transcontinental lines. The Northwestern Pacific serves Mendocino, Sonoma, and Marin counties, on the north, and several smaller lines radiate from different ports on the bay. Only one railroad line, the Coast Line of the Southern Pacific, actually enters the city. The other roads have their terminals in Oakland and other cities around the bay.

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The first settlement on the present site of San Francisco dates from 1776. It consisted of a Spanish military post (presidio) and the Franciscan mission of San Francisco de Asís. In 1836 the settlement of Yerba Buena (yair'ba bway'na) was established in a little cove southeast of Telegraph Hill. The name San Francisco was, however, applied to all three settlements. The United States flag was raised over the town in 1846, and the population rapidly increased, reaching perhaps 900 in May, 1848. The news of the gold discoveries was followed by crowds of fortune seekers, so that by the end of 1848 the city had an estimated population of 20,000. From that time on San Francisco has grown rapidly. The first regular overland mail communication with the East was established by pony express in 1860, the charge for postage being $5 for half an ounce. In 1869 the completion of the Central Pacific Railway to Oakland marked the beginning of transcontinental railway communication.

History.

The city suffered from severe earthquakes in 1839, 1865, 1868, and 1906. In respect to property loss the disaster of April 18, 1906, was one of the great catastrophes of history. The actual damage to the city by the earthquake was comparatively slight, but the water mains were broken and it was consequently impossible to check the fires which immediately broke out and which soon destroyed a large part of the city, including most of the business section. Some 500 persons lost their lives, and the estimated damage to property was between $350,000,000 and $500,000,000. Reconstruction began at once, and the city was practically rebuilt in the three years following the earthquake.

The Ocean Shore Railroad (station at Twelfth and Mission streets) and connecting automobile line afford a good opportunity to see the geology along the shore from San Francisco to Santa Cruz. The return trip may be made by rail or stage across the Santa Cruz Mountains. For 4½ miles north of Mussel Rock (11.9 miles from San Francisco) there is exposed in the bluffs along the coast a remarkable section of the Merced (Pliocene) formation, consisting of about 5,800 feet of highly inclined marine clays, shales, sandstones, conglomerates, and shell beds. In these beds have been found fossil remains of 53 species of marine animals, mostly mollusks, of which three-fourths are still represented by forms living in the ocean to-day. The San Andreas rift (the fracture along which displacement occurred in the San Francisco earthquake of 1906) passes out to sea at the mouth of a little ravine half a mile north of Mussel Rock and is crossed by the railroad. The exposures of the Merced formation along the sea cliffs were much finer before the San Francisco earthquake, which shook down some of the cliffs. From Tobin (18.1 miles) to Green Canyon

Excursions from San Francisco.

(21.1 miles) the bed of the Ocean Shore Railroad is cut in bold sea cliffs high above the water and affords not only fine shore scenery but also an excellent section of rocks that probably belong to the Martinez (Eocene) formation. The contact of these rocks with a large mass of pre-Franciscan granite (quartz diorite), which forms Montara Mountain, a bold ridge that extends southeastward from this part of the coast, is crossed by the railroad between Tobin and Green Canyon. At the north end of Seal Cove, opposite Moss Beach station (24.1 miles), the bowldery and fossiliferous sea-beach beds here forming the base of the Merced (Pliocene) and resting on the granite of Montara Mountain are well exposed.

This delightful excursion may be extended down the coast to Pescadero, and the return made by stage across the range and rift zone to San Mateo; or the traveler may continue down the coast to Santa Cruz and return across the range on the Southern Pacific line either by way of the Big Trees and Los Gatos or by Pajaro and Gilroy.

The characteristic thin-bedded radiolarian chert of the Franciscan group is well exposed about Strawberry Hill, in Golden Gate Park. There are good exposures of the chert also on Hunter Point, reached most readily by the Kentucky Street cars from Third and Market streets. The principal rock of the point is serpentine. A mass of basalt in the sea cliffs on the south side presents a remarkable spheroidal and variolitic structure.

The summit of Mount Tamalpais is very easily and comfortably reached by ferry to Sausalito, electric train to Mill Valley, and a mountain railway to the hotel on the top. The ferry trip is one of the best to be had on the bay. The steamer passes close to the small island of Alcatraz, used as a military prison. To the west may be seen the ocean through the Golden Gate. Angel Island, with its interesting glaucophane schists, serpentine, and other rocks, lies to the right as the boat approaches Sausalito. The sedimentary rocks of both islands belong to the Franciscan group and are chiefly sandstone. The trip from Sausalito to Mill Valley by the Northwestern Pacific Railroad gives the traveler opportunity to see some characteristic bay-shore scenery and particularly to note how the waters of the bay appear to have flooded what was once a land valley. Mill Valley is named from an old Spanish sawmill, the frame of which is still standing. The views obtainable from the scenic railway and from the summit of Mount Tamalpais are extensive and varied. To the south may be seen San Francisco and Mount Hamilton (4,444 feet). To the southeast is Mount Diablo (3,849 feet), through which runs the meridian and base line from which the public-land surveys of a large part of California are reckoned. Nearer at hand is the bay, with its dark-green bordering marshes through which wind serpentine tidal creeks. Close under the mountain to the north is Lake

Lagunitas (an artificial reservoir), and beyond it ridge after ridge of the Coast Range. To the west is the vast Pacific.

From the summit of Tamalpais one sees clearly that San Francisco Bay is a sunken area in which hilltops have become islands and peninsulas. This area is the northern extension of the crustal block whose sinking formed Santa Clara Valley. A later sag admitted the ocean into the valley, and the Golden Gate, formerly a river gorge, became a strait.

Mount Tamalpais has really three peaks: East Peak (2,586 feet), near which the Tavern of Tamalpais is situated; Middle Peak (about 2,575 feet); and West Peak (2,604 feet). From the grassy hills 1½ miles west of West Peak there is a good view of Bolinas Lagoon, though which passes the San Andreas rift, but for close views of the rift topography the visitor should walk or drive through the valley between Bolinas Lagoon and Tomales Bay, where the effects of the movement of 1906 are still in many places clearly evident.

Mount Tamalpais is composed wholly of the sediments of the Franciscan group and the igneous rocks usually associated with them, though it is chiefly sandstone. A mass of radiolarian chert occurs near the tavern, and serpentine may be seen at several places beyond West Peak. To one fond of walking and of marine views, a trip on foot to West Peak, thence down the main ridge to Muir Woods (redwoods), and back across the hills to Mill Valley may be heartily recommended. The distance is probably 8 or 9 miles. The Muir Woods, which bear the name of California's greatest nature lover, form a national monument, presented to the nation by William Kent, now a Member of Congress from the first California district, for the purpose of preserving untouched by the lumberman one area of redwoods. No fitter memorial could be dedicated to the memory of John Muir, whose writings have contributed so much to the movement for preserving in national ownership, for public enjoyment, some of our finest scenic resources.

The earthquake rift.

The geologic event of greatest human interest on the Pacific coast in modern times was the San Francisco earthquake of 1906. It was produced by a sudden movement of the rocks (faulting) along opposite sides of a fracture which may be traced for many miles in the Coast Range. The fissure existed before the earthquake of 1906, and it is evident from the relations of hills and valleys along its course that it has been the scene of earlier and, for the most part, prehistoric movements. The last movement was mainly horizontal and in places amounted to about 20 feet. The San Andreas rift, as this fissure has been called, lies just west of San Francisco, and its course is marked on sheet 25 (p. 224).

The cracks in the soil that mark the line of the last displacement and the parallel ridges and valleys that show older displacements along the fault zone are well displayed in Spring Valley, 13 miles south of San Francisco, and especially near Skinner's ranch, 40 miles northwest of San Francisco.

To reach Spring Valley the visitor should take the Southern Pacific train to San Mateo (18 miles), where a conveyance may be obtained for a trip through Spring Valley along Crystal Spring and San Andreas lakes.

Skinner's ranch can be reached by the ferry to Sausalito and the Northwestern Pacific Railroad to Point Reyes station, from which the ranch is only 2 miles distant, near Olema. In this region may be seen best the earth cracks along the fault line. Near the ranch house there is striking evidence of the horizontal character of the movement that produced the earthquake. The house formerly had two trees in front of it. The fault line, which trends northwest, passes between the trees and the house, and the trees were moved 15 feet to the southeast with reference to the house. There was no perceptible vertical movement nor any change in the water line along Tomales Bay.

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GLOSSARY OF GEOLOGIC TERMS.

Alluvial fan. The outspread sloping deposit of bowlders, gravel, and sand left by a stream where it passes from a gorge out upon a plain. (See Pl. XLII, p. 188.)

Andesite. A lava of widespread occurrence, usually of dark-gray color and intermediate in chemical composition between rhyolite and basalt.

Anticline. An arch of bedded or layered rock suggestive in form of an overturned canoe. (See also Dome and Syncline.)

Badlands. A region nearly devoid of vegetation where erosion, instead of carving hills and valleys of the familiar type, has cut the land into an intricate maze of narrow ravines and sharp crests and pinnacles. Travel across such a region is almost impossible, hence the name.

Basalt. A common lava of dark color and of great fluidity when molten. Basalt is less siliceous than granite and rhyolite, and contains much more iron, calcium, and magnesium.

Bolson (pronounced bowl-sown′). A flat-floored desert valley that drains to a central evaporation pan or playa.

Bomb. See Volcanic bomb.

Breccia (pronounced bretch′a). A mass of naturally cemented angular rock fragments.

Crystalline rock. A rock composed of closely fitting mineral crystals that have formed in the rock substance as contrasted with one made up of cemented grains of sand or other material or with a volcanic glass.

Diabase. A heavy, dark, intrusive rock having the same composition as basalt, but, on account of its slower cooling, a more crystalline texture. Its principal constituent minerals are feldspar, augite, and usually olivine. Olivine is easily changed by weathering, and in many diabases is no longer recognizable. Augite is a mineral containing iron and magnesium and is similar to hornblende.

Dike. A mass of igneous rock that has solidified in a wide fissure or crack in the earth's crust.

Diorite. An even-grained intrusive igneous rock consisting chiefly of the minerals feldspar, hornblende, and very commonly black mica. If the rock contains much quartz, it is called quartz diorite. Quartz diorite resembles granite and is connected with that rock by many intermediate varieties, including monzonite. The feldspar in diorite differs from that in granite in containing calcium and sodium instead of potassium. Hornblende is a green or black mineral containing iron, magnesium, calcium, and other constituents.

Dip. The slope of a rock layer expressed by the angle which the top or bottom of the layer makes with a horizontal plane. (See also Strike.)

Dissected. Cut by erosion into hills and valleys. Applicable especially to plains or peneplains in process of erosion after an uplift.

Dome. As applied to rock layers or beds, a short anticline, suggestive of an inverted basin.

Drift. The rock fragments—soil, gravel, and silt—carried by a glacier. Drift includes the unassorted material known as till and deposits made by streams flowing from the glacier.

Erosion. The wearing away of materials at the earth's surface by the mechanical action of running water, waves, moving ice, or winds, which use rock fragments and grains as tools or abrasives. Erosion is aided by weathering. See Weathering.

Fault. A fracture in the earth's crust accompanied by movement of the rock on one side of the break past that on the other. If the fracture is inclined and the rock on one side appears to have slid down the slope of the fracture the fault is termed a normal fault. If, on the other hand, the rock on one side appears to have been shoved up the inclined plane of the break the fault is termed a reverse fault. (See fig. 12, p. 100, and fig. 16, p. 188.)

Fault block. A part of the earth's crust bounded wholly or in part by faults.

Fault scarp. The cliff formed by a fault. Most fault scarps have been modified by erosion since the faulting.

Fauna. The animals that inhabited the world or a certain region at a certain time.

Fissure. A crack, break, or fracture in the earth's crust or in a mass of rock.

Flood plain. The nearly level land that borders a stream and is subject to occasional overflow. Flood plains are built up by sediment left by such overflows.

Flora. The assemblage of plants growing at a given time or in a given place.

Fold. A bend in rock layers or beds. Anticlines and synclines are the common types of folds.

Formation. A rock layer, or a series of continuously deposited layers grouped together, regarded by the geologist as a unit for purposes of description and mapping. A formation is usually named from some place where it is exposed in its typical character. For example, Denver formation, Niobrara limestone.

Fossil. The whole or any part of an animal or plant that has been preserved in the rocks or the impression left by a plant or animal. This preservation is invariably accompanied by some change in substance, and in impressions the original substance has all been removed. (See Pl. IV, p. 20, and Pl. XIX, p. 75.)

Gneiss (pronounced nice). A rock resembling granite, but with its mineral constituents so arranged as to give it a banded appearance. Most gneisses are metamorphic rocks derived from granite or other igneous rocks.

Granite. A crystalline igneous rock that has solidified slowly deep within the earth. It consists chiefly of the minerals quartz, feldspar, and one or both of the common kinds of mica, namely, black mica, or biotite, and white mica, or muscovite. The feldspar is the kind known as orthoclase, and may be distinguished from quartz by its pale-reddish tint and its property of breaking with flat shining surfaces (cleavage), for quartz breaks irregularly. The micas are easily recognized by their cleavage into thin, flexible flakes and their brilliant luster.

Horizon. In geology any distinctive plane traceable from place to place in different exposures of strata and marking the same period of geologic time. A particular horizon may be characterized by distinctive fossils.

Igneous rocks. Rocks formed by the cooling and solidification of a hot liquid material, known as magma, that has originated at unknown depths within the earth. Those that have solidified beneath the surface are intrusive rocks, or, if the cooling has taken place slowly at great depth, as plutonic intrusive or plutonic rocks. Those that have flowed out over the surface are known as effusive rocks, extrusive rocks, or lavas. The term volcanic rocks includes not only lavas but bombs, pumice, tuff, volcanic ash, and other fragmental materials or ejecta thrown out from volcanoes.

Lithologic. Pertaining to lithology, or the study of rocks. (See also Petrology.) Pertaining to rock character.

Lode. An ore-bearing vein (see Vein); especially a broad or complex vein.

Loess (pronounced lurse with the r obscure). A fine homogeneous silt or loam showing usually no division into layers and forming thick and extensive deposits in the Mississippi Valley and in China. It is generally regarded as in part at least a deposit of wind-blown dust.

Meander. To flow in serpentine curves. A loop in a stream. The term comes from the Greek name of a river in Asia Minor, which has a sinuous course. Most streams in flowing across plains develop meanders. (See Pl. XXXVII, p. 177.)

Metamorphism. Any change in rocks effected in the earth by heat, pressure, solutions, or gases. A common cause of the metamorphism of rocks is the intrusion into them of igneous rocks. Rocks that have been so changed are termed metamorphic. Marble, for example, is metamorphosed limestone.

Monzonite. An even-grained intrusive igneous rock intermediate in character between diorite and granite. It resembles granite.

Moraine. A mass of drift deposited by a glacier at its end or along its sides.

Oil pool. An accumulation or body of oil in sedimentary rock that yields petroleum on drilling. The oil occurs in the pores of the rock and is not a pool or pond in the ordinary sense of these words.

Outcrop. That part of a rock that appears at the surface. The appearance of a rock at the surface or its projection above the soil.

Paleontology. The study of the world's ancient life, either plant or animal, by means of fossils.

Peneplain. A region reduced almost to a plain by the long-continued normal erosion of a land surface. It should be distinguished from a plain produced by the attack of waves along a coast or the built-up flood plain of a river.

Petrography. The description of rocks, especially of igneous and metamorphic rocks with the aid of the microscope.

Petrology. The study of rocks, especially of igneous and metamorphic rocks.

Placer deposit. A mass of gravel, sand, or similar material resulting from the crumbling and erosion of solid rocks and containing particles or nuggets of gold, platinum, tin, or other valuable minerals. The valuable materials in placers have been derived from rocks or veins by erosion.

Playa (pronounced plah′ya). The shallow central basin of a desert plain, in which water gathers after a rain and is evaporated.

Porphyry. Any igneous rock in which certain crystal constituents are distinctly visible in contrast with the finer-grained substance of the rock.

Quartzite. A rock composed of sand grains cemented by silica into an extremely hard mass.

Rhyolite. A lava, usually of light color, corresponding in chemical composition to granite. The same molten liquid that at great depth within the earth solidifies as granite would, if it flowed out on the surface, cool more quickly and crystallize less completely as rhyolite.

Schist. A rock that by subjection to heat and pressure within the earth has undergone a change in the character of the particles or minerals that compose it and has these minerals arranged in such a way that the rock splits more easily in certain directions than in others. A schist has a crystalline grain roughly illustrated by the grain of a piece of wood.

Sedimentary rocks. Rocks formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The sediment may consist of rock fragments or particles of various sizes (conglomerate, sandstone, shale); of the remains or products of animals or plants (certain limestones and coal); of the product of chemical action or of evaporation (salt, gypsum, etc.); or of mixtures of these materials. Some sedimentary deposits (tuffs) are composed of fragments blown from volcanoes and deposited on land or in water. A characteristic feature of sedimentary deposits is a layered structure known as bedding or stratification. Each layer is a bed or stratum. Sedimentary beds as deposited lie flat or nearly flat.

Shale. A rock consisting of thin hardened layers of fine mud.

Slate. A rock that by subjection to pressure within the earth has acquired the property of splitting smoothly into thin plates. The cleavage is smoother and more regular than the splitting of schist along its grain.

Stratigraphy. The branch of geologic science that deals with the order and relations of the strata of the earth's crust.

Strike. The direction along which an inclined rock layer would meet the earth's surface if that surface were level. The outcrop (which see) of a bed on a plain is coincident with its strike.

Structure. In geology, the forms assumed by sedimentary beds and igneous rocks that have been moved from their original position by forces within the earth, or the forms taken by intrusive masses of igneous rock in connection with effects produced mechanically on neighboring rocks by the intrusion. Folds (anticlines and synclines) and faults are the principal mechanical effects considered under structure. (See figs. 12 and 13, p. 100.) Schistosity and cleavage are also structural features.

Syncline. An inverted arch of bedded or layered rock suggestive in form of a canoe.

Talus (pronounced tay′lus). The mass of loose rock fragments that accumulates at the base of a cliff or steep slope.

Terrace. A steplike bench on a hillside. Most terraces along rivers are remnants of valley bottoms formed when the land was lower or when the stream flowed at higher levels. Other terraces have been formed by waves. Some terraces have been cut in solid rock, others have been built up of sand and gravel, and still others have been partly cut and partly built up.

Till. The deposit of mingled bowlders, rock fragments, and soil left behind by a melting glacier or deposited about its margin.

Tuff. A rock consisting of a layer or layers of lava particles blown from a volcano. A fine tuff is often called volcanic ash and a coarse tuff is called breccia.

Type locality. The place at which a formation is typically displayed and from which it is named; also the place at which a fossil or other geologic feature is displayed in typical form.

Unconformity. A break in the regular succession of sedimentary rocks, indicated by the fact that one bed rests on the eroded surface of one or more beds which may have a distinctly different dip from the bed above. An unconformity may indicate that the beds below it have at some time been raised above the sea and have been eroded. In some places beds thousands of feet thick have been washed away before the land again became submerged and the first bed above the surface of unconformity was deposited. If beds of rock may be regarded as leaves in the volume of geologic history, an unconformity marks a gap in the record. (See p. 42.)

Vein. A mass of mineral material that has been deposited in or along a fissure in the rocks. A vein differs from a dike in that the vein material was introduced gradually by deposition from solution whereas a dike was intruded in a molten condition.

Volcanic bomb. A rounded mass of lava thrown out while in a hot and pasty condition from a volcano. A bomb, like a raindrop, is rounded in its passage through the air and may be covered with a cracked crust due to quick cooling.

Volcanic cone. A mountain or hill, usually of characteristic conical form, built up around a volcanic vent. The more nearly perfect cones are composed principally of lava fragments and volcanic ashes.

Volcanic glass. Lava that has cooled and solidified before it has had time to crystallize.

Volcanic neck. A plug of lava that formerly congealed in the pipe of a volcano. When the tuffs and lava flows that make up most of a volcano have been washed away by erosion the neck may remain as an isolated hill.

Volcanic rocks. Igneous rocks erupted at or near the earth's surface, including lavas, tuffs, volcanic ashes, and like material.

Weathering. The group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action of changes of temperature, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil.

ILLUSTRATIONS.

ROUTE MAP.

For the convenience of the traveler the sheets of the route map are so folded and placed that he can unfold them one by one and keep each one in view while he is reading the text relating to it. A reference in parentheses is given in the text at each point where a new sheet should be unfolded.

PLATES.

FIGURES.

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