For about 200 miles the Colorado River flows in a canyon, in one place 6000 feet in depth — the deepest canyon in the world. Some of the grandest scenes in nature are the views looking down into this river-made valley from the canyon edge, or looking upward from its bottom. The internal structure of the earth's crust is here revealed — thousands of feet of strata, layer on layer, appearing one beneath the other. One cannot look into this enormous cut in the earth without realizing the vast work which a river can do when time enough is allowed. Yet it is the work of a young stream still cutting down toward grade.

FIG. 139. — The Colorado Canyon from the bottom. A view showing the wreck of one of Powell's boats in his venturesome trip through the canyon.

Summary. — *Deep, steep-sided valleys of young plateau streams are called canyons. The greatest of these is the Canyon of the Colorado, over* 200 *miles long and, in one place,* 6000 *feet deep.*

55. Mesas and Buttes. — In plateaus there are many flat, table-like surfaces (Fig. 140) faced by steep slopes, often cliffs. These are *mesas*, a Spanish word meaning table. An examination of such a mesa shows that the rock on the top is hard, often lava. These table-top surfaces are due to the fact that the more durable rock layers have resisted denudation; and, since they are nearly horizontal, have held the surface up to a general level, parallel to the stratification.

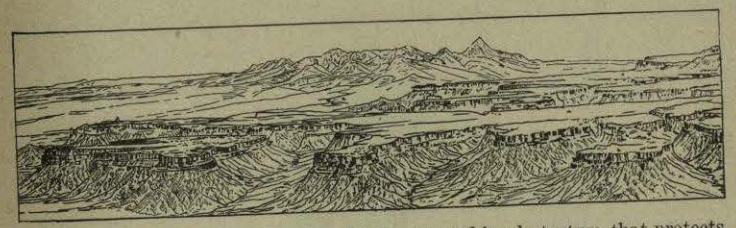

FIG. 140. — Mesa Verde, Colorado. The horizontal hard stratum that protects these mesas from being worn away has a steep slope, while the softer strata beneath have a more gentle slope.

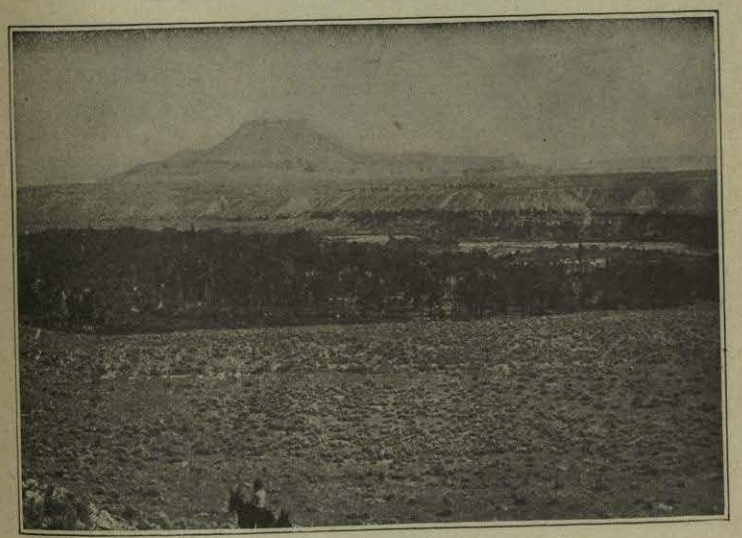

FIG. 141. — Crow Heart Butte, Wind River, Wyoming.

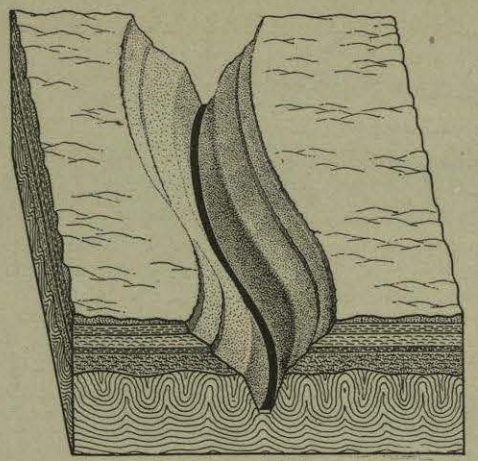

FIG. 142. — A superimposed river, reaching folded rock beneath the horizontal strata of a plateau.

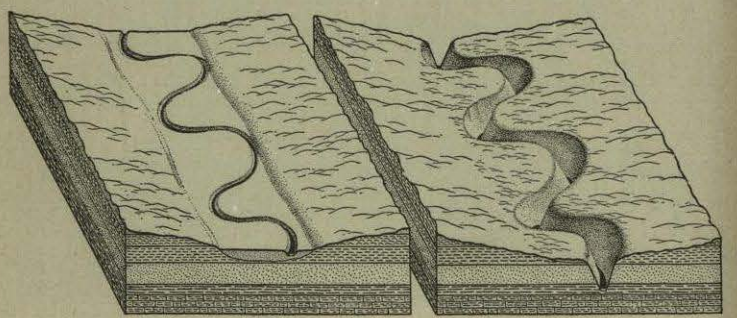

FIG. 143. — A rejuvenated river. In the left-hand figure the stream has reached grade and is swinging over a floodplain in a gently sloping, mature valley. In the right-hand figure the land has been uplifted and a young valley is sunk in the bottom of the mature valley, preserving some of the meanders that the stream had before the uplift. These may be called *entrenched meanders*.

Small detached sections of mesas, cut off by denudation, are called *buttes* (Figs. 141, 144). They, too, are capped by durable layers which have preserved them from being worn down. The presence of these flat-topped butte and mesa areas accounts for the name *tableland*, often given plateaus.

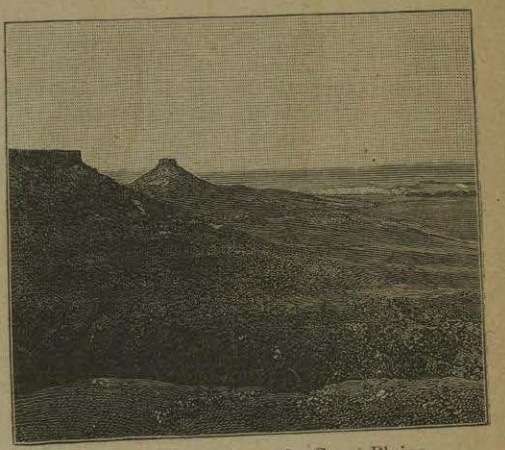

FIG. 144. — A butte on the Great Plains.

Summary. — *Flat-topped areas, called mesas if large, buttes if small, due to the resistance of horizontal beds of hard rock, are common among plateaus, giving rise to the name tableland.*

56. Superimposed and Rejuvenated Rivers. — In cutting into the strata of plains and plateaus, rivers may wear down through the horizontal layers to buried mountains (Fig. 123). Such rivers are said to be *superimposed* on the buried structure (Fig. 142). The Colorado River, for example, has discovered an old, buried mountain mass in one part of its canyon.

An uplift of the land gives a river new life, or rejuvenates it. The stream then cuts a narrow gorge in the bottom of its old valley (Fig. 143). Such a valley is *rejuvenated*, or made young again.

Summary. — *Superimposed rivers are those which cut through one set of layers to another of different position. A rejuvenated river is one made young again by any cause, as by uplift.*

57. Climate of Plateaus. — High plateaus are cold because they reach into cool upper layers of the atmosphere. On the

plateau of Mexico, for instance, the climate is tropical at the base ; coffee is grown on the lower slopes; but grains are the chief crops on top. In the lower Colorado valley, in Arizona, the summer climate is almost unbearably hot, while on the plateau it is pleasantly cool. The plateau of Tibet is so high that it has a cold, disagreeable climate, even in summer.

Plateaus are often associated with mountains, which shut out the rain-bearing winds. Many plateaus are therefore arid, and some, like central Asia and parts of western United States, are true deserts.

Summary. — *Plateaus have a cooler climate than neighboring lowlands ; they are often arid.*

58. Inhabitants of Moist Plateaus. — The plateau at the western base of the Appalachians (p. 80) includes the Catskill, Alleghany, and Cumberland mountains. It is dissected by valleys, often 1000 feet deep (Fig. 145), with sides too steep for cultivation, but, owing to the moist climate, clothed with forest (Fig. 146). There are no true buttes and mesas, and no real canyons; but the surface is, nevertheless, very rugged.

Much of this plateau is a wild region, with a sparse population, and with its forest areas still occupied by wild animals. It is an important source of timber. The scattered farms are poor and, south of Pennsylvania, where the rugged, timber-covered surface interferes with communication with the outer world, there are sections in which the people are very backward. Many cannot read or write; illicit distilling of whisky is one of the industries; and, in some parts, there are family feuds and lawlessness, resulting in much loss of life.

The discovery of coal has led to the opening of parts of this plateau to other occupations than lumbering and the crude farming of the backwoodsmen. In this respect the plateau of western Pennsylvania has advanced far beyond that of West Virginia, Tennessee, and Kentucky. In New

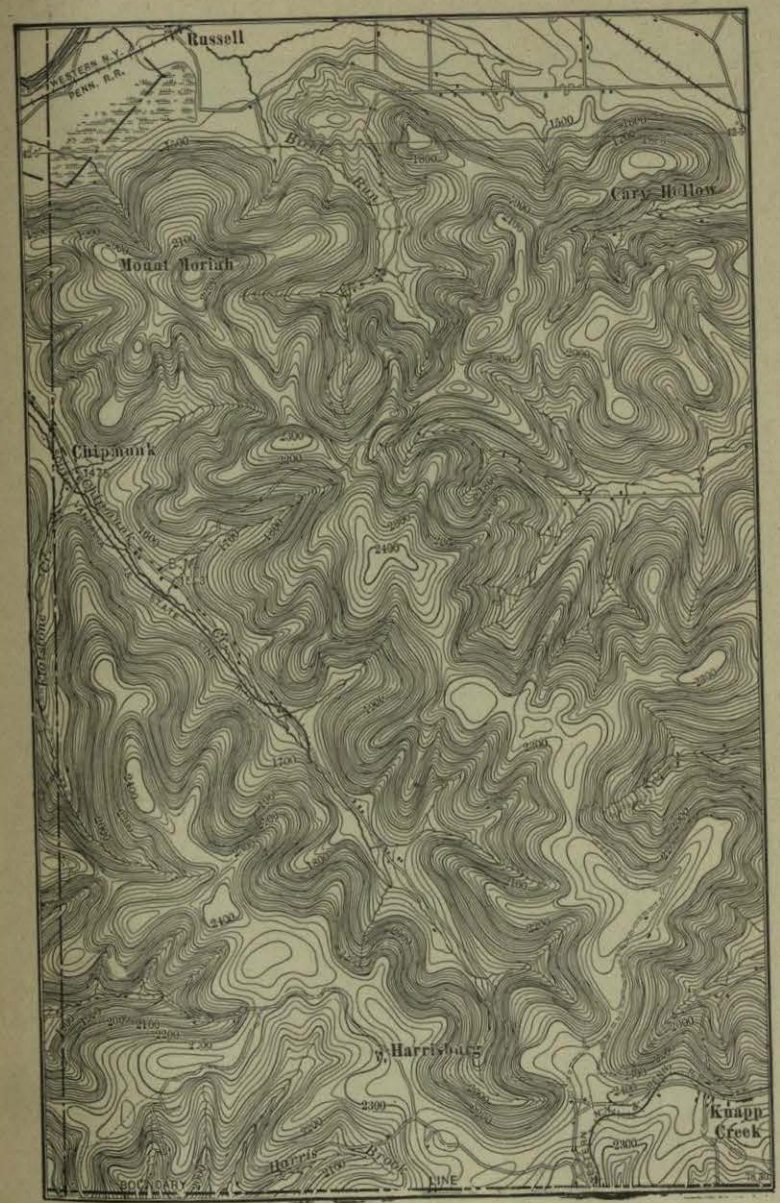

FIG. 145. — The hilly plateau of southwestern New York. (Part of Salamanca Sheet, U. S. Geological Survey.)

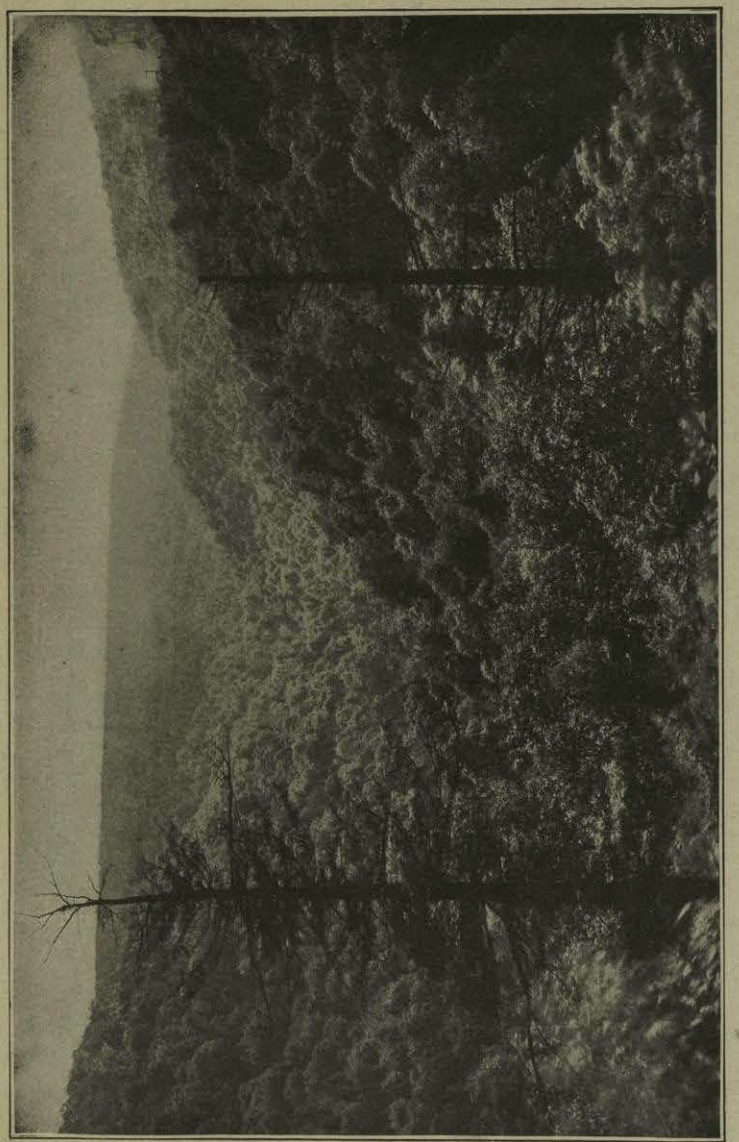

Fig. 146. — The Alleghany plateau with steep, wooded slopes.

York (Fig. 145) the plateau is less rugged, and, consequently, better developed. It has, in large part, been cleared of forest, and farm lands have been developed wherever possible. Yet even here the upland farms are poor in quality.

Summary. — *Rugged, dissected plateaus in moist countries, like that west of the Appalachians, are largely forest-covered, poorly adapted to farming, and, unless influenced by the development of mineral resources, are apt to be occupied by a sparse population, little influenced by the outside world.*

59. Inhabitants of Arid Plateaus. — Because of their ruggedness, coldness, and dryness, arid plateaus are sparsely settled. In the West, large areas of plateau are almost uninhabited except by ranchmen, whose cattle and sheep feed on the sparse growth of grass (Figs. 127, 128).

Because of the dryness there is little farming, except near the mountains where alluvial fans and level portions of the plateau are irrigated by water from the mountain streams. The bottoms of the canyons are rarely wide enough for farms, and it is usually impossible to lead the water out for use in irrigation.

The Indians who occupied the arid plateau of southwestern United States farmed by means of irrigation. For protection from roaming bands of more savage Indians, they often built their homes, or *pueblos*, on the buttes and mesas, which they resemble in color and form. From them they could look out over the country, and be partly protected from enemies by the steepness of the bordering cliffs. Some Indians (Fig. 148) still live in these situations. Other Indians lived in caves in the cliffs, and still others under overhanging ledges, where weather and wind had removed weaker rocks from beneath the more durable ledges. The latter are called *cliff dwellers*, the former *cave dwellers*. These habitations are no longer occupied.

Summary. — *Arid plateaus are usually sparsely settled, the leading occupation being ranching, with farming by irrigation where possible.*

DESERTS.

60. Nature of Deserts. — A desert is a region in which few forms of life can find sustenance. Thus, by reason of cold, the vast expanse of ice in Greenland is a desert; indeed, it is such a one that, in a large part of its area, *no* animal or plant can live. The term *desert* is, however, commonly applied to those lands on which there is so little rainfall that only a few especially adapted animals and plants can live. About one fifth of the land has an annual rainfall of less than ten inches and is, therefore, desert; and fully as much more is arid, having too little rain for agriculture.[1]

It is a mistake to suppose that *no* rain falls in deserts, for there is no land on the earth so desert that it does not have some rainfall. One of the driest deserts is in southern Peru, where, close by the Pacific, a period of seven years has elapsed between rains. Nor is it correct to imagine deserts as dreary wastes of sand and monotonous expanses of plains. It is true that there is much drifting sand, and that most deserts are either plains or plateaus; but deserts also have many bare, rocky slopes, and even mountains (Figs. 150–152). Where the mountains rise high enough, rain falls on their slopes, streams flow down their valleys, and forests clothe their sides.

Summary. — *Deserts are due to cold, and to lack of rain, though even the driest have some rainfall. Most deserts are plains and plateaus, with much sand, though there are also mountains and many bare, rocky slopes.*

61. Drainage of Deserts. — With so little rain there is naturally little drainage. Most of the rainfall either quickly evaporates from the surface or sinks into the soil; but a heavy rain is followed by a rapid run off, because there is little vegetation to check the flow of the water. Heavy rains, known as "*cloudbursts*," sometimes occur, especially in the

[1] For explanation of desert climates, see page 281.

mountains; and the water, running out upon more level land, causes floods, which, however, quickly subside.

Because of these sudden floods, it is dangerous to camp in a dried-up stream bed, or *arroyo*. Railways crossing deserts are often damaged by these floods; crops and houses are washed away; and vast quantities of sediment are brought down. This forms alluvial fans, often very stony near the mountains.

It may be months or even years between rains, so that desert streams are typically intermittent. Those from the mountains have a more regular flow, and some have so large and steady a water supply that they are able to maintain their course entirely across a desert. Thus the Colorado River and the Nile, fed from distant mountains, flow across deserts to the sea.

Most desert streams carry so little water that they lose themselves, or waste away, a few hundred yards, or a few miles, from the base of the mountains in which they are born. Sometimes they terminate in a salt marsh, or *saline;* sometimes in an *alkali flat* (p. 169); sometimes, when there is enough water, in salt lakes. The alkali and salt are brought in small quantities, dissolved in the water, and left when it evaporates. Where salt lakes formerly existed, and on the salines and alkali flats, there are barren and desolate areas of glistening salt or alkali.

Summary. — *Most desert streams are intermittent and subject to occasional floods; but some large rivers, fed among the mountains, maintain their course across the desert. Many streams waste away on the desert and end in salt lakes, salines, and alkali flats.*

62. Wind Work on Deserts. — On deserts the work of the wind (Fig. 147) is more important than that of water. Small dust whirlwinds are common on hot summer days, and even moderate winds drift the sand and dust along the surface. Violent winds raise the sand in the air, causing fierce dust storms which obscure the sky and land, and even endanger life. During such a wind the movement of the sand may entirely change the details of the land surface. The finer dust is often drifted far away, dust from the Sahara having settled in central Europe and on ships west of Africa.

It is this wind work that piles up the sand which every one associates with deserts. The sand is made of small rock fragments weathered from the cliffs (Fig. 151), and brought down by the streams. It is drifted about, and gathered into vast areas of *sand dunes*, which are so difficult to cross that, wherever possible, caravan routes carefully avoid them. The sand dune hills may reach a height of several hundred feet, though usually they are much lower.

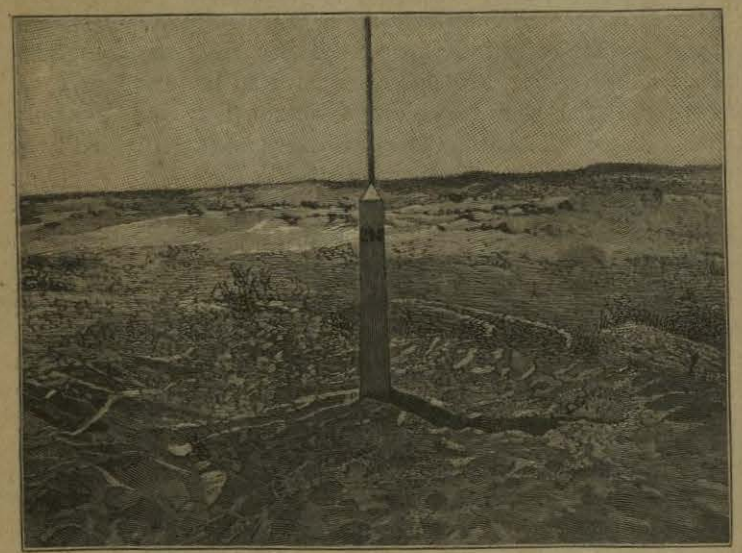

FIG. 147. — Ripple marks caused by winds blowing the sand about in southwestern United States, on the Mexican boundary.

The front is steep on the side away from the wind, and the surface is rippled with sand waves (Fig. 147), formed by movement of the sand before the wind. Sand dune hills slowly change form and position, and cities in central Asia have been buried by their advance.

Summary. — *Winds move the small rock fragments about, accumulating the sand in favorable positions, thus forming belts of sand dunes which are ever changing in form and position.*

63. Life on Deserts. — Deserts offer little incentive to human occupation. The barrenness of the country (Figs. 148–151)

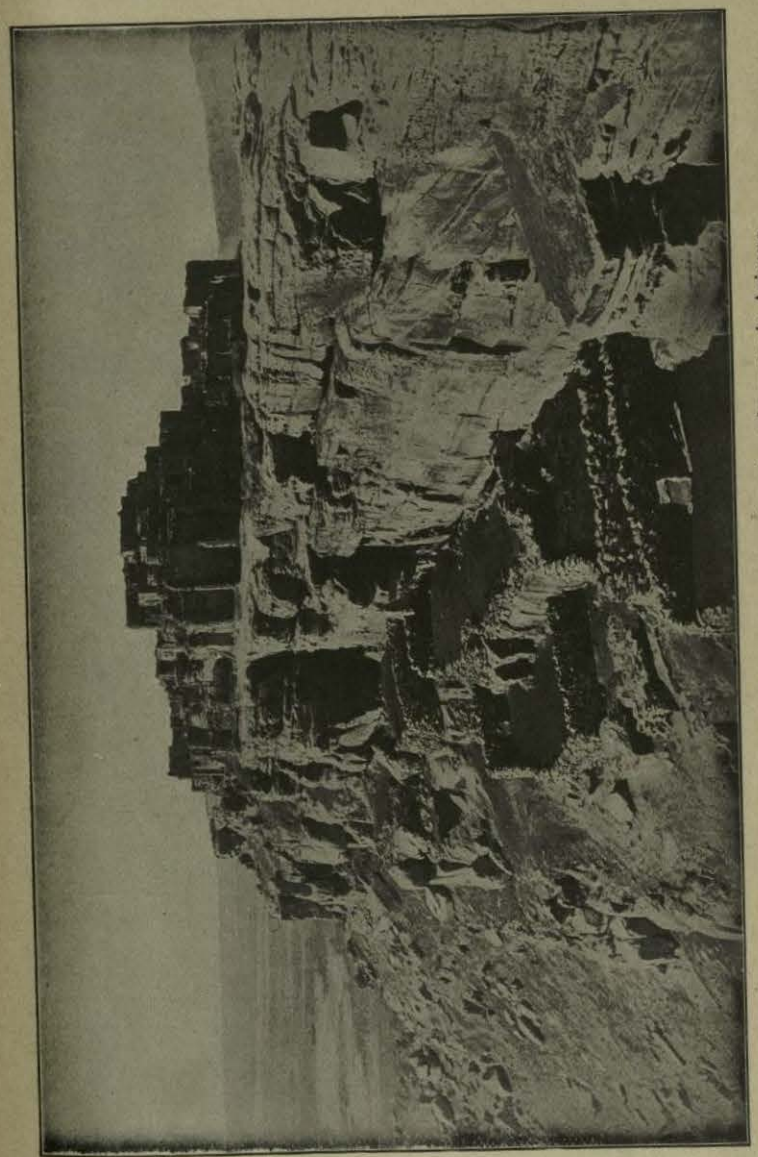

FIG. 148. — The Moqui Indian pueblo on the edge of a mesa in Arizona.

FIG. 149. — Desert of Egypt at the Pyramids.

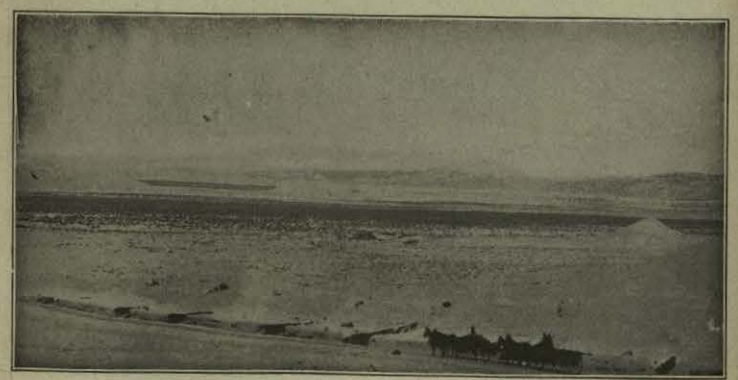

FIG. 150. — Desert near Great Salt Lake, Utah.

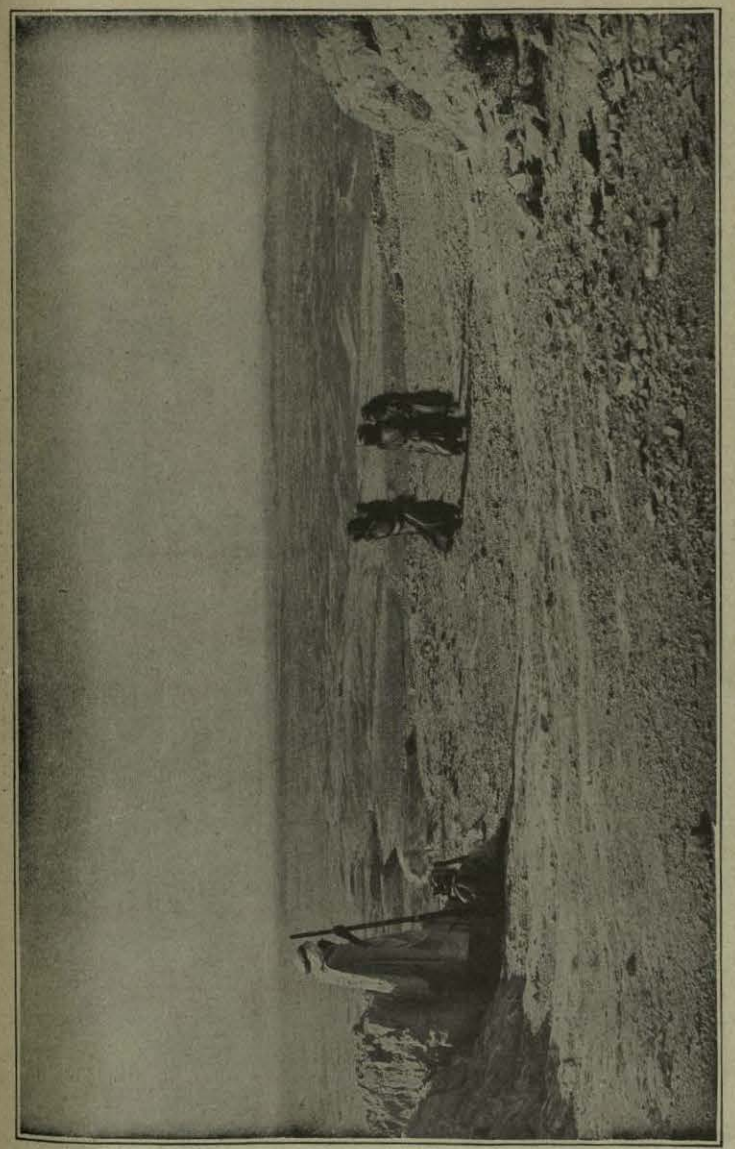

FIG. 151. — A view in the Sahara Desert.

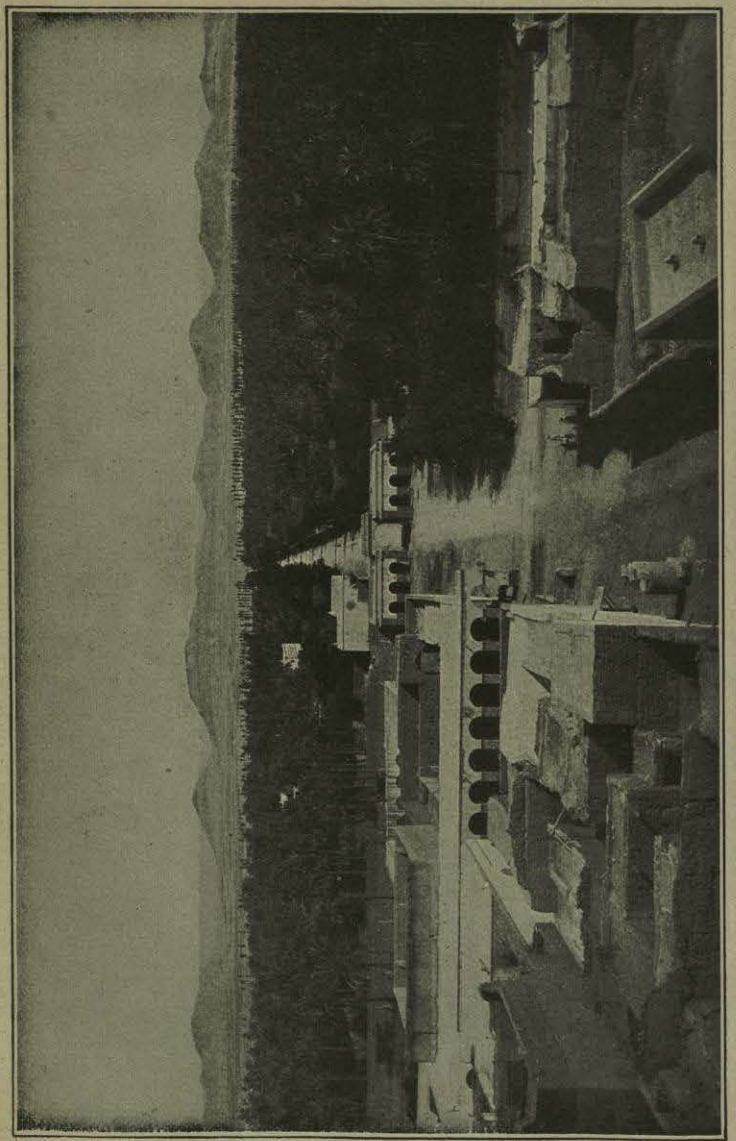

Fig. 152. — Oasis of Biskra in the Sahara.

and sparseness of the population are unfavorable to the development of mineral deposits, and there is little opportunity for other industries. The rainfall is too light for agriculture without irrigation, and only a few parts have a water supply for irrigation. Areas which have water are called *oases* (Fig. 152); these are usually either scattered springs in the desert, or else places where streams descend from mountain canyons and flow out upon alluvial fans. A large stream, like the Nile or Euphrates, causes a large oasis which may support an enormous agricultural population.

A few scattered people find life possible in all the desert lands. In the Old World the desert people (Fig. 526) are *nomads*, or wanderers, who move with their herds from oasis to oasis, to give the animals a chance to feed on the sparse desert vegetation. Such a life of danger and privation develops a hardy, warlike people, with love of freedom and a contempt for the monotonous settled life of the farmer. These people, having learned how to use the camel (Fig. 519), "the ship of the desert," for carrying their burdens, have long been traders and caravan leaders across the deserts. For centuries the chief means of communication between the east and west of the Old World was by caravan. Many of the Bible descriptions refer to desert life, for Palestine is surrounded by desert and is on caravan routes.

Summary. — *Except on the oases, deserts are unfavorable to settlement, being occupied, in the Old World, by a scattered nomadic population, engaged in herding and in caravan trade by use of the camel.*

Topical Outline, Questions, and Suggestions.

Topical Outline. — 46. **Continental Shelf Plains.** — Off North American coast, — width, depth, origin; result if uplifted.

47. **Coastal Plains.** — (*a*) Origin and instances. (*b*) Atlantic coastal plain: extent; structure; artesian wells. (*c*) Agriculture: sandy soil; higher lands; swamp lands. (*d*) Coast line: effect of sinking; fishing; sand bars; navigation. (*e*) Rivers: swamps; lakes; young valleys. (*f*) Fall Line: cause; Indian settlements; location of cities.

48. **The Russian and Siberian Plains.** — Extent; origin; condition of drainage; the tundra; the forest belt; the steppes.

49. **Plains and Prairies of Central United States.** — (*a*) General features: origin; later changes; elevation; slopes; influence on Mississippi. (*b*) Great Plains: climate; grazing; agriculture; timber. (*c*) Prairies: cause; influence on settlement. (*d*) Mineral deposits: kinds; influence on manufacturing. (*e*) Other great plains.

50. **Lake Plains.** — Lake bottoms; drained lake bottoms; Red River valley plains; evaporated lake bottom plains; other classes of plains.

51. **Life History of a Plain.** — Young plain; mature plain; old plain; belted coastal plains, — strata, denudation, result.

52. **Nature of Plateaus.** — Association with mountains; relationship to plains; elevation of certain plateaus; tilted plateau blocks; lava floods.

53. **Sculpturing of Plateaus.** — Life history; effect of arid climates.

54. **Canyons.** — Definition; occurrence; Colorado Canyon.

55. **Mesas and Buttes.** — Mesas; buttes; tablelands.

56. **Superimposed and Rejuvenated Rivers.** — (*a*) Superimposed: meaning; example. (*b*) Rejuvenated.

57. **Climate of Plateaus.** — Coolness; illustrations; arid climate.

58. **Inhabitants of Moist Plateaus.** — Surface features of plateau west of the Appalachians; inhabitants; occupations; coal mining; New York.

59. **Inhabitants of Arid Plateaus.** — Climate; ranching; irrigation; Indian pueblos; cliff dwellers; cave dwellers.

60. **Nature of Deserts.** — Two causes; extent; rainfall; surface features.

61. **Drainage of Deserts.** — Rainfall; run off; "cloud-bursts"; arroyos; effects of floods; intermittent streams; large streams fed from mountains; withered streams; salines; alkali flats; salt lakes; cause.

62. **Wind Work on Deserts.** — Importance; sand storms; source of sand; sand dunes; change in position.

63. **Life on Deserts.** — Mineral; farming; oases; nomads; camel.

QUESTIONS. — 46. What are the conditions on the sea bottom off the North American coast? What would result if it were elevated?

47. Where are coastal plains found? Why? Why is artesian water found in them? What industries are developed on the Atlantic coastal plain? What is the nature of the coast line? Why? What are the evidences of youth? What are the cause and effects of the Fall Line?

48. What is the extent of the Russian and Siberian plains? What is their origin? What proof is there of youth? What are the conditions in the northern, central, and southern portions?

49. What is the general condition of the plains of central United States? What are the conditions on the Great Plains? Why are the prairies treeless? What effect has this condition had? Account for the development of the central plains region. Where else are similar plains found?

50. What has caused the plains of the valley of the Red River of the North? Those near Great Salt Lake? What other kinds of plains are there?

51. State the life history of a plain. Explain belted plains.

52. How are plateaus related to mountains? How do they differ from plains? What is the condition of the rock strata?

53. How does the life history of plateaus resemble and differ from that of plains? What effect has an arid climate on sculpturing?

54. What is a canyon? Describe the Colorado canyon.

55. Explain mesas. Buttes. Account for the name tableland.

56. What are superimposed valleys? What are rejuvenated valleys?

57. How do plateaus affect temperature? Give illustrations. Why are plateaus often arid?

58. What is the condition of the plateau west of the Appalachians? What effect has this on the people? What differences are there from Tennessee to New York? Why?

59. Why are arid plateaus sparsely inhabited? What are the industries? How did the Indians of the Southwest formerly live?

60. State the causes for deserts. What about the rainfall? The surface features?

61. Describe the conditions of drainage in deserts. What is the cause of salt and alkali deposits?

62. Describe wind work in deserts. Describe and explain desert sand dunes.

63. What are the industries of deserts? What are nomads? How do they live? Of what importance is the camel?

SUGGESTIONS. — (1) Make a coastal plain. In a shallow dish make an irregular land surface of clay. Have one portion hilly to represent land, the other part low. Fill the lower portion with water. With a sprinkling pot carefully wash some of the land into the depression, then drain off the water with a siphon. Notice the marginal plain that is built off the land. It is a fair miniature of a coastal plain. Is it perfectly level? What irregularities are there? Why? (2) In the same dish mold a basin of clay, and drop pebbles on the bottom to represent hills. Partly fill with water. Sprinkle clay into the water, and, after it has settled, draw off the water. If clay enough has been added the bottom will be level, quite like a drained lake. What is the nature of this bottom? How does it compare with those described in the text? The conditions which existed in the Great Salt Lake region can be imitated by allowing the water to evaporate, instead of drawing it off. The condition in the Red River valley can be imitated by making one side of the basin of packed snow or ice and allowing it to melt, thus draining the lake.

(3) Make a basin similar to the above, but use salt water (dissolving salt in the water before pouring it in). Then allow it to evaporate. What is the result? This is similar to the conditions which have caused many beds of salt, for example, those of New York, Michigan, Kansas, and the Far West. (4) To make an artesian well. On a gently inclined board (say at an angle of 10°) place a layer of sand and pebbles, two inches thick; cover with a piece of thin cotton cloth, or cheese cloth; and then place on this a layer of clay four inches thick. Extend the clay down over the lower edge and the two sides of the pebble layer, making it so tight that water will not seep through easily. Pour water in at the upper edge of the pebble layer. Now, near the lower end of the board, insert a glass tube six inches long down to the pebble layer (it will be well to leave a small hole in the cloth for this purpose). The water should flow out of the tube as an artesian well does. (5) Make a small plain of clay, sloping in one direction, and slowly sprinkle it with a spray of water. Watch carefully and describe every stage in the wearing away of the plain. (6) Make a much higher plain, to represent a plateau, and note the difference between the wearing away of the two. If a very thin layer is made with a little plaster of paris in it (not too firmly cemented), buttes and mesas may be made by sprinkling. (7) Map studies are suggested in Appendix J.

Reference Books. — TARR, *Physical Geography of New York State*, Chap. III, Macmillan Co., New York, 1902, $3.50; CHAMBERLAIN, *Artesian Wells*, 5th Annual U. S. Geological Survey, p. 131; SALISBURY, *The Physical Geography of New Jersey*, New Jersey Geological Survey, Trenton, N.J., 1895; ABBE, *Physiography of Maryland*, Vol. I, Part II, Maryland Weather Service, Baltimore, Md., 1899; CAMPBELL and MENDENHALL, *West Virginia Plateau*, 17th Annual U. S. Geological Survey, p. 480; POWELL, *Exploration of the Colorado River of the West*, Washington, 1875 (out of print; second-hand stores); POWELL, *Canyons of the Colorado*, Flood and Vincent, Meadville, Pa., 1895, $10.00; DUTTON, *Colorado Canyon*, 2d Annual U. S. Geological Survey, p. 49; also Monograph II, U. S. Geological Survey, Washington, D.C., $10.00.

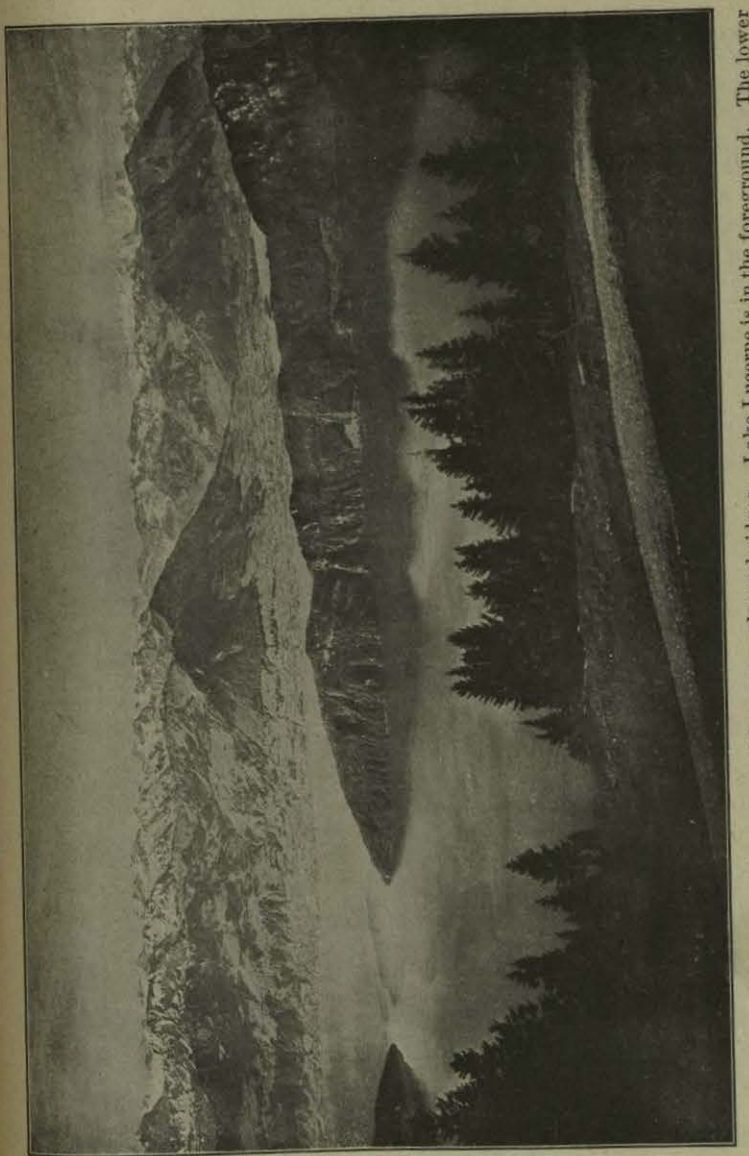

FIG. 153. — A view of an Alpine range with many peaks and ridges. Lake Lucerne is in the foreground. The lower slopes are cleared and cultivated; the higher peaks and valleys, snow-covered; the intermediate slopes, forested.

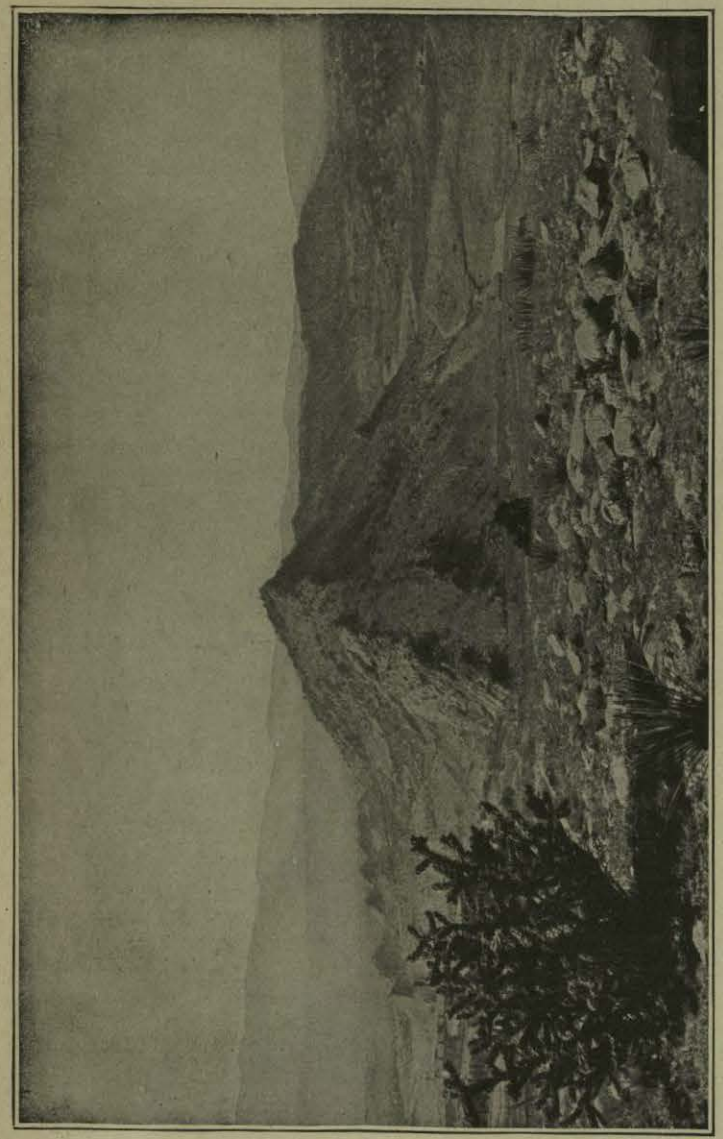

Fig. 154. — A ridge in Colorado, showing the inclined hard strata extending almost vertically into the earth. This is an arid region, and therefore the vegetation is sparse. A cactus bush is seen in the lower left-hand corner, and Spanish bayonet plants farther to the right.

CHAPTER VI.

MOUNTAINS.

64. Introductory. — Mountains contrast strikingly with plains, but resemble dissected plateaus in irregularity of form. The ruggedness and coldness of lofty mountains make them barriers rather than attractive homes. Mineral wealth often induces men to live among mountains, and, in summer, people are attracted to them by the cool climate and beautiful scenery. But, not being suited to extensive agriculture, mountains are never densely settled.

These and other facts furnish reasons why mountains are worthy of study. There are many questions of interest which such a study will answer. Why, for example, are the Alps so high and rugged, the Appalachians so low and ridge-like, and the New England mountains so low and hilly? Why do rivers sometimes cross mountains in narrow gaps while other mountain valleys are broad and flat-bottomed? The following pages answer some of these questions.

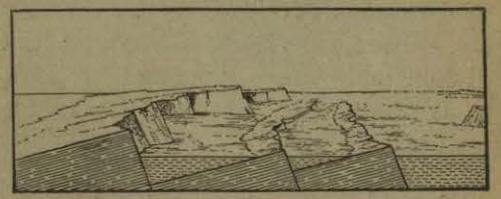

Fig. 155. — Fault block mountains.

65. The Mountain Rocks. — Unlike those of plains and plateaus, the strata of mountains are almost never horizontal. All kinds of folds and faults (p. 37) are found. Some mountains, like many in the Great Basin, are simply faulted and tilted blocks of strata, with the layers inclined in a single direction (Fig. 155). Others, like the