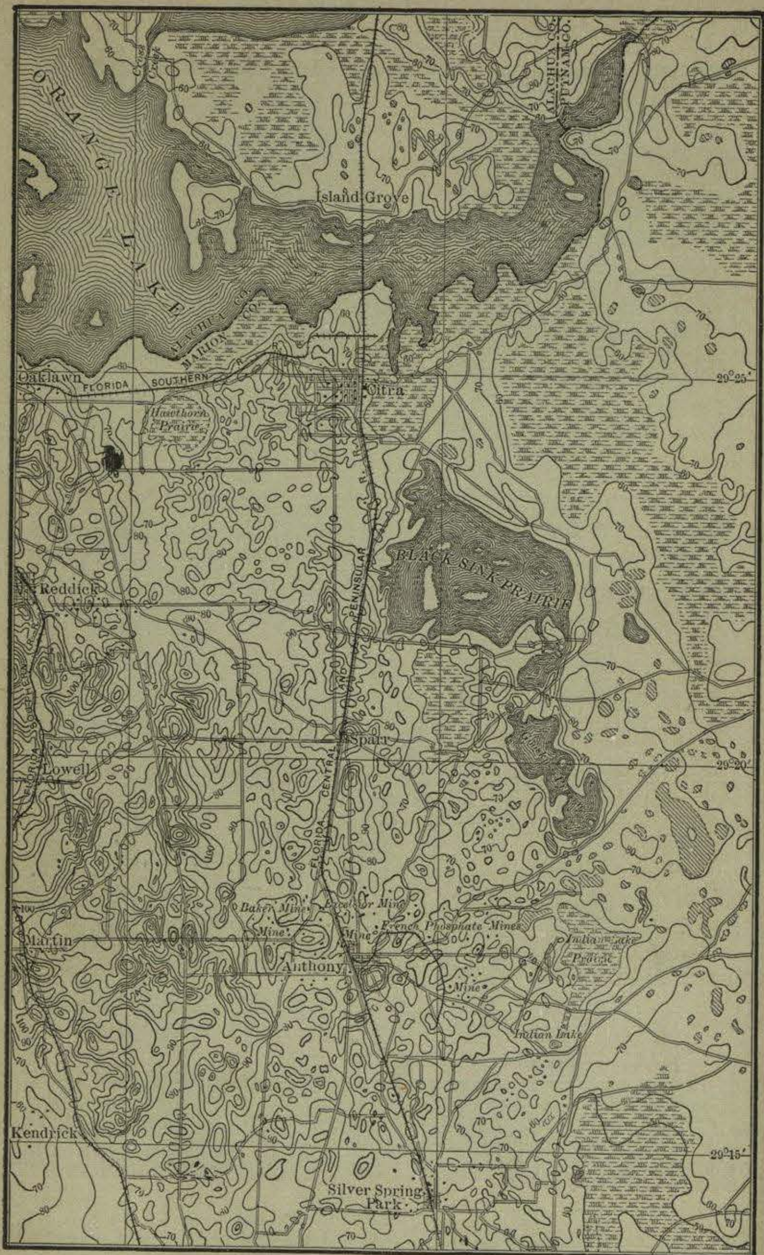

Fig. 78. — Map of a part of the Florida plain where the swamps (indicated by ∗∗) and lakes have not yet been drained by the young streams (see Fig. 79). The lines are contour lines. The meaning of these is explained in Appendix I. (Part of Citra, Fla., Topographic Sheet, U. S. Geological Survey.)

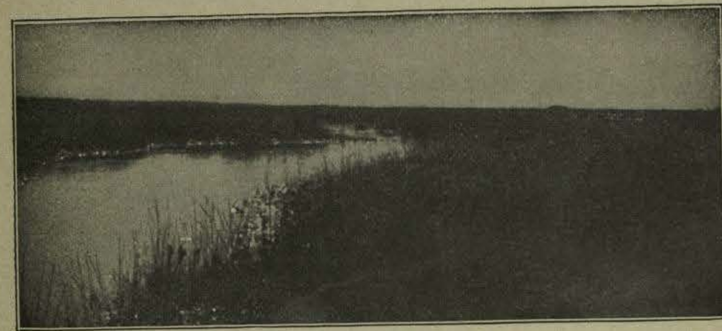

Fig. 79. — A flat-topped, swampy divide in the Florida plain, on which the drainage is so young that the tributary streams have not had time to gnaw back and narrow the divide so as to drain the swamps (see Fig. 78).

Fig. 80. — A young valley (on the right of the center) cut in soft material. The sliding down of the sides has broadened this valley. (Contrast with Fig. 77 in hard rock.)

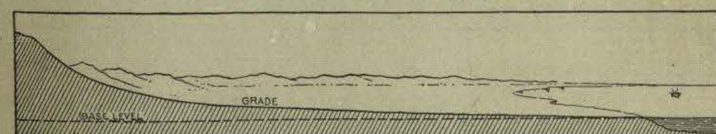

Fig. 81. — Diagram to illustrate the meaning of grade and base level.

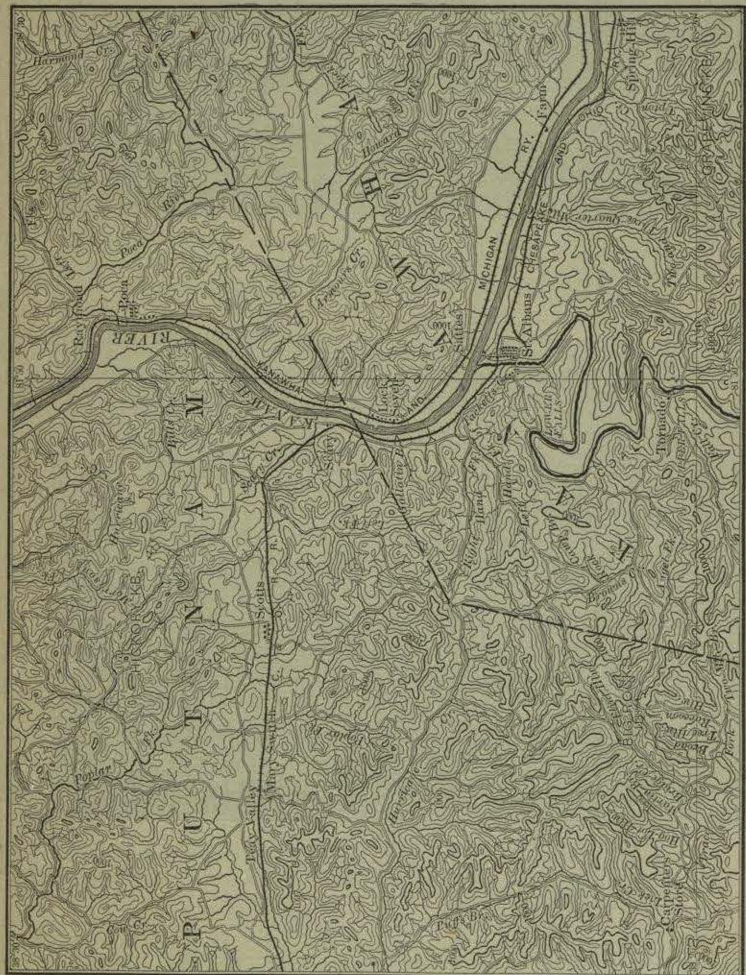

FIG. 82. — Mature valleys in West Virginia. Here there are no lakes, the divides are narrow, the valleys broad, and there are so many tributaries that all the land is drained. Contrast with Fig. 78. (Part of Charleston, W. Va., Topographic Sheet, U. S. Geological Survey.)

steeper slope than necessary, are actively degrading their beds toward grade. It often happens, however, that a stream has too gentle a grade to move its sediment load over. Then, to secure a steeper grade, deposit is made. Most streams on broad floodplains are thus aggrading their valleys.

Summary. — *The grade of a stream is the lowest slope over which the water can move its sediment load. Young streams are degrading their valleys toward this grade; but many streams are engaged in aggrading their course to secure a steeper grade.*

37. Mature Valleys. — When grade is reached by a river, further down-cutting ceases; but weathering of the valley sides continues. This slowly broadens the valley, wearing the sides back and making the slopes less steep (Figs. 83, 85, 86). The broadening of the valley is first accomplished near the mouth; but it slowly extends upstream. Young streams exist for a long time among the headwaters, as young twigs appear on the outer branches of even an old tree.

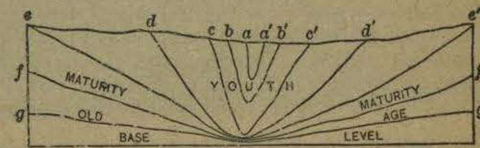

FIG. 83. — To illustrate the broadening of valleys from youth to old age.

In a mature stream, grade has been reached throughout most of its course, and any lakes that may have existed have long since been filled. Nor can there be waterfalls, because the graded stream is no longer cutting into the rock.

Tributaries have developed in such numbers that the divides have become well defined, and all water that falls on the land finds slopes ready for it to flow down (Fig. 82). Again the comparison may be made to a tree, which at first has a trunk and few branches, but, as it grows older, develops an increasing number of minor branches and twigs.

By the development of so many tributaries the number of slopes and the amount of surface exposed to weathering are greatly increased (Fig. 84). These increasing slopes may supply so much sediment to the main streams that they cannot carry it all to the sea. They then begin to aggrade their courses to establish a steeper grade down which to carry the sediment. In doing this they build floodplains (p. 61).

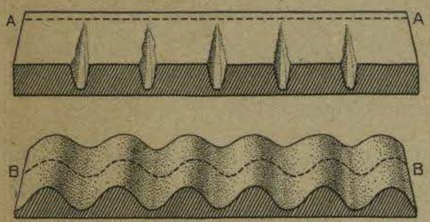

FIG. 84.—To illustrate the increase in slopes as valleys broaden. The line *A A*, drawn on the level surface of a young plain, gradually lengthens to *B B* as the valleys broaden to maturity.

Summary.—*A valley with moderately sloping sides, a fairly well established grade, no lakes, waterfalls or rapids, well-defined divides, numerous tributaries, and floodplains in its lower portion is mature.*

38. Old Valleys.—As valleys grow older, the slopes become more and more gentle (Fig. 83) until the surface is reduced almost to sea level. An old land surface, reduced to the condition of a low, rolling surface, is called a *peneplain* (almost plain).

Many parts of the continents are ancient enough to have become peneplains; but there are numerous accidents which commonly interfere with this result. Of these accidents the most important are uplifts of the land, which continually give to streams new tasks to perform. Therefore, few valleys have passed the stage of maturity.

Summary.—*Old valleys are so broad that the surface is reduced almost to a plain, or to a peneplain; but uplift of the land is so frequent that few regions have reached this condition.*

39. Importance of Valley Form.—Young valleys encourage some of man's activities and interfere with others. The waterfalls furnish power; and the lakes are valuable for navigation, for their influence on the climate of neighboring land, and as sources of food-fish and ice. On the other hand, land


FIG. 85.—Railway crossing the Appalachians along one of the narrow, winding mountain valleys, so steep that the forest has not been removed. This valley has the form of late youth, or early maturity.


FIG. 86.—The Connecticut, at Northampton, Mass.; a broad, mature valley, with gently sloping sides, dotted with farms.

FIG. 87.—An underground river in Howe's Cave, New York (copyright, 1889, by S. R. Stoddard, Glens Falls, N.Y.).

FIG. 88.—Spring where water pours out from a limestone cavern in Iowa.

cut by young valleys is difficult to cross, the valley bottoms furnish poor grades for roads and railways (Figs. 57, 66, 71, 77), and much of the country is unfitted for agriculture.

In contrast to young valleys, mature valleys are the seats of agriculture, and their fertile floodplains are among the best farm lands of the world. Travel across country is easy, and the river valleys are important highways (Figs. 85, 86). Even the rivers themselves, if large, have so gentle a grade that they are navigable. Thus, flourishing farms and thriving towns and cities line the river banks and dot the slopes of mature valleys. This is well illustrated along the Mississippi valley, which offers a striking contrast to the young Colorado valley (Fig. 1).

Summary.— *Young valleys are unfavorable for occupation; but mature valleys are adapted to agriculture and dense settlement.*

40. Springs and Underground Channels. — Where conditions are specially favorable, underground water (p. 39) is led back to the surface, appearing as a spring. Sometimes it comes out along a porous, sandy layer, sometimes along a joint plane. There are many springs along rivers; but they occur also on hillsides and, in fact, wherever favorable conditions direct underground water to the surface.

Some large and permanent springs rise from deep in the ground through fault planes, often bringing heated water to the surface. Such springs often have so much mineral in solution that they are known as mineral springs, and have important medicinal properties. The Hot Springs of Arkansas, and the mineral springs of Saratoga, Carlsbad, and Vichy, are examples of such springs.

Water percolating through soluble rock, like limestone, dissolves the rock along joint planes and bedding planes. This often results in the formation of long, irregular underground valleys, or caverns, like that of Mammoth Cave, Ky. In such a country much of the drainage is underground (Fig. 87).

There are large surface streams with few tributaries, the chief water supply coming from the springs (Fig. 88) that bring the cavern water to the surface.

Entering such a cavern, one passes through a maze of dark, irregular passages, in which it is easy to lose oneself. From the roof hang *stalactites* (Figs. 87, 91) of carbonate of lime, which the water dissolved in its passage through the limestone rock and deposited on emerging into the cavern. In form they resemble icicles. *Stalagmites* (Fig. 91) are built up from the cavern floor by the dripping water, as ice columns are formed under a spout.

FIG. 89. — To illustrate the formation of limestone caves. Water entering the sink holes has formed great vertical cavities, and also horizontal caverns through which it flows, emerging in the form of springs near the natural bridge on the right.

Often the stalactites and stalagmites unite to form columns (Fig. 91), and sometimes, as in the Luray Cave, they assume weird and even beautiful forms.

The surface of a limestone country is pitted with saucer-shaped depressions, known as *sink holes* (Fig. 90). Through these the water drains into the ground, though sometimes the entrance into the ground is clogged, changing the sink hole to a pond. These sink holes are caused by settling of the ground, due to solution of the rock beneath (Fig. 89).

Weathering, lowering the surface, slowly wears away the cavern roofs. Sometimes only a small part of the roof is left, spanning the valley as a *natural bridge* (Fig. 92).

Summary. — *Springs occur where conditions direct underground water to the surface, for example, a porous layer, a joint plane, fault plain (many hot or mineral springs), or a cavern outlet. Caverns occur where underground water dissolves passageways through soluble rock like limestone. The water enters the ground through*

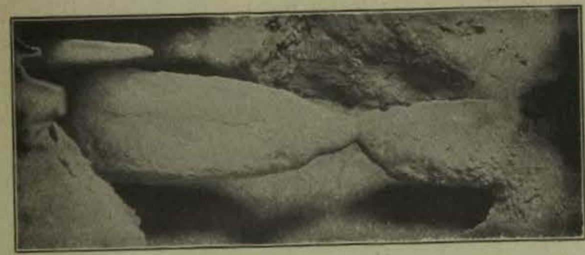

FIG. 91. — A column in a cavern, formed by the union of a stalactite and a stalagmite.

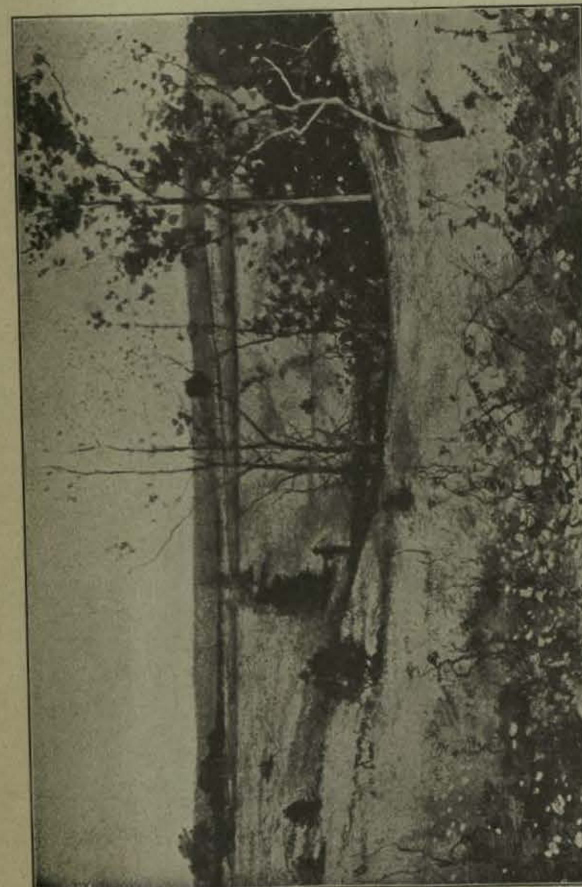

FIG. 90. — A sink hole, near Luray Cave, Virginia. The water flows into the sink hole from all sides and disappears into the ground.

FIG. 92. — Natural Bridge, Virginia. This bridge is a part of an old cavern roof, the remainder having been removed by weathering.

FIG. 93. — Four views of the same stream at different stages, from low water to the time of the flood when the floodplain is completely overflowed. Then a deposit is being made, raising the level of the plain very slightly. (L. O. Towne, Haverhill, Mass., Photographer.)

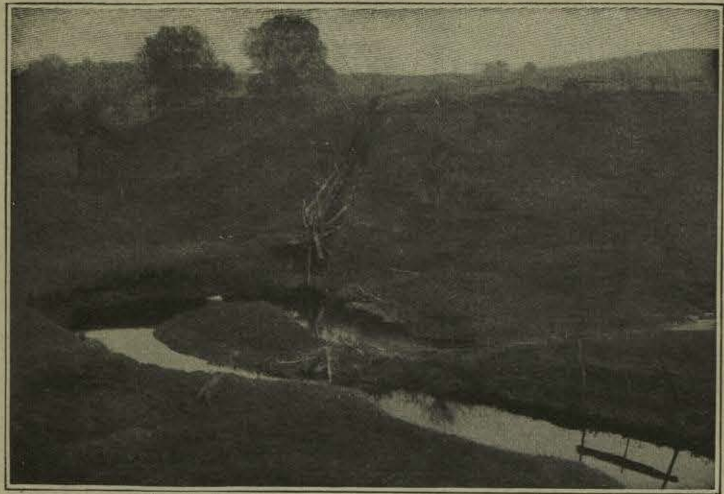

FIG. 94.—A small ox-bow curve in a meadow brook. A cut-off has been started, but brush was put in to stop it from continuing. (L. O. Towne, Haverhill, Mass., Photographer.)

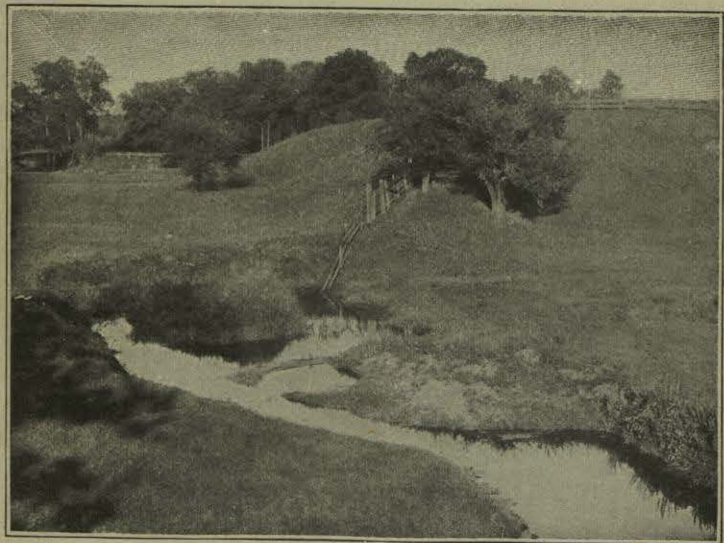

FIG. 95.—The same as Fig. 94 with the cut-off completed in spite of the brush. (L. O. Towne, Haverhill, Mass., Photographer.)

sink holes, passes along an underground course, and emerges as a spring. It deposits stalactites, stalagmites, and columns in the caverns.

41. River Floodplains. — Streams are often bordered by level plains, built of sediment which they have brought. Even a mountain torrent, that is degrading its bed, may have narrow patches of such deposits on one or both sides. Rivers that are aggrading their courses are always bordered by such alluvial plains, or *floodplains*. They are usually bordered by bluffs (Figs. 96, 97, 102), against which the river cuts as it swings over the floodplain. These, being higher and drier than the floodplain, are often selected as the sites for towns and cities, as in the case of Vicksburg on the Mississippi.

FIG. 96.—Canadian river, Oklahoma. Through this floodplain the river sweeps in great curves between bluffs which are seen in the foreground and in the far distance.

Broad floodplains are due to the fact that there is more sediment than can be carried down the grade. Therefore some must be deposited. When such rivers rise and overflow their banks, they submerge the neighboring lowland (Figs. 93, 99), and, with each flood, deposit a layer of sediment, as mud is deposited on a sidewalk when the gutter overflows. This slowly raises the level of the floodplain; and, since it is being built by a broad sheet of water, its surface is made fairly level.

Many broad floodplains, like that of the Mississippi (p. 327), are very fertile; and frequent overflow, by bringing new soil,