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THE CONVEXITY OF HILLTOPS

G. K. GILBERT

In a maturely developed topography, hilltops composed of unconsolidated materials are upwardly convex in profile. Their forms are thus contrasted with the longitudinal profiles of stream beds, which in mature development are concave upward. An explanation of the river profile offered by the writer more than thirty years ago seems to have been generally accepted. Its fundamental principles are (1) that the transporting power of a stream per unit of volume increases with the volume, (2) that transporting power increases with the slope, and (3) that a stream automatically adjusts slope to volume in such way as to equalize its work of transportation in different parts.

In 1892, Davis proposed an explanation of the convexity of hilltops, ascribing it to creep. His article occupied less than a page of Science, and may not have attracted the attention it merited. At any rate Fenneman, in a recent discussion of the same subject, makes no mention either of Davis or of creep; and it occurs to me that a restatement of Davis’ explanation may be timely.

Fenneman ascribes the convex profile to running water, making a distinction between the behavior of water near hilltops and lower down. As I find it difficult to do justice to his analysis in an abstract, I refrain from a comparison of his hypothesis with that of Davis, but refer the reader, instead, to his article which is in the Journal of Geology for November-December, 1908.

The subjoined presentation of the creep hypothesis, while essentially equivalent to Davis’, is independent in respect to various details.

A layer of unconsolidated material resting on a gentle slope holds its position (1) because the particles are arranged so as to support one another, and (2) because of the faintest of slope flow on a moderate flow. Whatever disturbance of motion among them, in the rearrangement of agitation by an arrangement, such a one of these may cause flow of type.

In creep the chief function, and these are carrying, wetting and drying, and extended indefinitely— or the structure of delatation is resisted by it in a single direction or modified during the gravity enters as a constant. Prominent among which alike in growth, also act on soils where promote creep in a more gentle slope their feet push.

Consider now the speaking of mature degradation to be the parts of the slope, two lines in the diagram, Fig. 1, represent surface of the ground epochs. In the interval between the epochs, been no transportation equivalent to the prism been carried past A;
been cut along axial directions, and a volume equivalent to the prism between the surface of the hill and the

Consider now the effect of creep on the lay of the slope. As we are

in a single direction, whether the structure is again the structure described in the previous section, except that, and expansion diffusion is reduced in all directions except outward, and the diffusion which is increased in all directions.

In other words, the effect of creep in the direction of the structure, and that of the structure, would not be altered, but the structure of the expansion of the particles, and the structure of the expansion of the particles, are caused by freezing and thawing, heating and cooling, and these are caused by freezing and thawing, heating and cooling, and these are caused by freezing and thawing, heating and cooling.

Watters' Theory of Hillocks

CONVEXITY OF HILLOWS
$D$ and $B$ has been carried past $B$. The quantity passing each point of the slope has been proportional to the distance of the point from the summit. If the depth of the creeping layer has been uniform, the mean velocity of creep has been proportional to the distance from the summit. On the other hand the impelling force, gravity, depends for its effectiveness on slope, being able to cause more rapid flow where the slope is steeper. Therefore, on a mature or adjusted profile, the slope is everywhere just sufficient to produce the proper velocity. It is greatest where the velocity is greatest, and therefore increases progressively with distance from the summit. In other words the normal product of degradation by creep is a profile convex outward.

If soil creep and carriage by water are the only important processes of transportation operative in a region of maturely sculptured hills, the above analysis seems adequate. On the upper slopes, where water currents are weak, soil creep dominates and the profiles are convex. On lower slopes water flow dominates and profiles are con-

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There is an indirect way of determining the effect of water flow and this follows from the fact that where water drops beat heavily on the surface they cause rain-wash stream flow of water. Particles of vegetation are detached from the summit by the flowing water and are carried to the surface of the sheet but restricted by the slope. This is favored by more rapid flow and lessens the effect of ice. However, this transportation near the surface of the ground, the soil, is a much more potent agent in measuring the present rate of erosion. The rate of weathering is much slower when this transportation is cut off. Consequently, the downward movement of soil is much slower than the downward movement of rock and the effectiveness of water flow is far greater than that of rain-wash stream.
Transportation near the divides, tending to produce a convex profile, lessens the effect of impact. Whether the ordinary result is greater favored by more rapid current but restricted by depth of water, which sheet but restricted by the thoroughness of the current. Lower down is sheeted by the thoroughness of the water, with slight transportation. A downward the shampoo of the water, generally the more rapid current, and at the drops are monotonously small. The drops bear heavily on the upper slopes there is usually also a different drops bear heavily on the upper slopes there is usually also a different direction of the water flow. When rain water, however, then below the direction of water flow.}

Fig. 2—Showing hills illustrating the convexity of divides.

347 CONVEXITY OF HILLOPS.
or greater transportation on lower slopes, tending to produce a concave profile, is not easy to see.

As wind and rain beat are effective only on bare surfaces and surfaces imperfectly clothed by vegetation, while convex hilltops are found alike in forested regions, prairies and deserts, it is evident that their work is not of prime importance in this connection. Soil creep is omnipresent and appears to be competent.

![Fig. 4.—Miniature hills, illustrating the convexity of divides.](image)

The development of gullies on convex slopes when vegetal protection is removed, does not import a transformation to concave slopes and acute water partings, but merely a change in what Fenneman aptly calls the texture of the topography—a reduction of the scale of the drainage pattern and hill pattern. The removal of vegetation gives water flow greater velocity, thereby enlarging the domain of stream sculpture, with associated concave profiles, and reducing the domain of creep and convexity.

Figs. 2, 3, and 4 show mature hill forms developed in homogeneous material. They occur on the floors of hydraulic gold mines at

![Fig. 5.—Erosion and regolith, exposed in a road cut, strike the ground in an oblique representative. The kaolin of the kaolinose strata is far above the “angle of repose.”](image)
CONVERGENCE OF HILLSLOPES
CONVEYERY OF HILLSIDES

The washed-away of the alluvial gravels...
 lesson is conveyed by the presence of pillars of earth each capped by a pebble or other protective particle, but it is not easy to determine whether the work of sculpture consumed little or much time. In this particular case the raindrops were driven by so violent a wind as to be swept up a slope. The wind in question blew for but a fraction of an hour, but in that brief time the rain beat developed on the earthbank (of regolith) a complete system of furrows and ridges parallel to the direction of the wind.

GEOLOGICAL HISTORY.

The pre-Cambrian rocks in the region of Sterling Hill consist of crystalline limestones with interbeds of sandstones and shales and numerous magnetites which, because of theirrc color, are the most prominent feature of the Highlands of the state.

Franklin limestone. - The Franklin limestone consists of various phases is a white, hard rock, sometimes resembling a sandstone or marble, ranging in composition from pure limestone to a dolomite. Some thin beds of sandstone occur among the limestones on Sterling Hill it contains a considerable number of fossils, and there are also present in a well-rounded condition in the limestone, and consequently gives the rock a very hard and gritty feeling.

The Franklin limestone is a member of the Lower Cambrian, and is injected with gneiss and marble, and even fragments of the gneiss, and is injected with gneiss, all of which rocks are a part of the basement of the district. On the other hand, the Franklin limestone, is a member of the Upper Cambrian, locally conglomeratic, and contains small fragments and even fragments of gneiss, and is injected with gneiss, and is a part of the Franklin limestone as an injection. It is many years before the deposits of the Franklin limestone are entirely exposed, and it has been abundantly demonstrated that the gneiss has been abundantly demonstrated to be an injection.

The gneisses.—The gneisses are of a very different nature, and are not of the same age as the gneiss of the Franklin limestone, but are also of the gneiss of the Franklin limestone. In the preparation of this paper, and in the preparation of the paper in the Geological Survey of the United States, I have been much indebted to the study of my associates on the Geological Survey of the United States, and in particular, to the study of my associates on the Geological Survey of the United States, and to the study of my associates on the Geological Survey of the United States.