American Journal of Science

JULY 1940

AGE OF THE SCHOOLEY PENEPLAIN*

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ABSTRACT. The views of Shaw, Johnson, and Ashley on the age and relations of the Schooley peneplain are discussed, and evidence is presented in opposition to some of these views. The conclusion is reached that only one peneplain was formed in post-Paleozoic time in the Appalachians; that this peneplain (Schooley) passes beneath the Cretaceous sediments of the Coastal Plain at the Fall Line and is the same as the "Fall Zone" peneplain; that it was formed chiefly in Jurassic time; that it was not greatly uplifted and subjected to effective erosion until mid-Tertiary time; that remnants of this peneplain still exist on the tops of the mountains.

THE Schooley peneplain has been regarded by most geologists as of early Cretaceous or Jurassic age, but this age assignment has been questioned by some, especially by Ashley, Johnson, Shaw, and Sharp, who suggest that it is much younger. I will briefly review the opinions of these writers and the evidence on which their conclusions are based, and, to meet their well-founded objections to the assumption of the older age of the peneplain, I will offer a solution in its defense.

Shaw,[1] I believe, was the first to question the ages of the Appalachian peneplains. In a paper read before the Geological Society of America he expresses doubt of the validity of the correlation of the Schooley peneplain with the floor beneath the Cretaceous formations on the Atlantic Coastal Plain, because the two surfaces cannot be traced into each other and the gradients of these two surfaces are not in accord. He states that the general slope of the floor of the Cretaceous is 25 to 30 feet to the mile and in the vicinity of Washington it is 100 feet to the mile, whereas the slope of the Schooley peneplain is only 5 to 15 feet to the mile. He also states that, at the

* Published with the permission of the Director of the Geological Survey, U. S. Department of Interior.

† The substance of this paper was read at Harrisburg, Pa., Sept. 1, 1939.

[1] Shaw, E. W.: Ages of peneplains of the Appalachian province: Geol. Soc. Amer. Bull., Vol. 29, pp. 575-686, 1918. (Read before the Society Dec. 27, 1916.)

present rate of erosion, no surface formed in pre-Cretaceous time could survive the general degradation. He concludes, therefore, that "the oldest peneplain of which remnants exist [Schooley] was finished in Tertiary time."

Sharp[2] in a very brief paper supported the conclusion of Shaw, that the upland [Schooley] peneplain is not the same as that which forms the floor beneath the Cretaceous deposits of the Coastal Plain, and he named the latter surface the Fall Zone peneplain. He states that the falls and rapids of the Fall Line or Zone are due to an abrupt change in slope at the intersection of these two peneplains.

Johnson, in a comprehensive paper[3] on stream sculpture, adopts the new name Fall Zone peneplain for the floor of the Cretaceous beds on the Coastal Plain, and states that this peneplain is distinct from, and older than, the Schooley peneplain. He further states that the Fall Zone peneplain was truncated by the later, flatter Schooley peneplain, and that the Fall Line is located at their intersection. The reasons for his belief are stated under five headings, as follows:

1. The change in slope which marks the transition from upland peneplain to pre-Coastal Plain floor is more angular than seems appropriate for monoclinal warping of the upland surface.

2. The great linear extent of the fall-line angle seems to place it in a class by itself.

3. The close approximation of the fall-line angle to the eroded inner margin of the Atlantic Coastal Plain is a necessary corollary of the theory of two intersecting peneplains.

4. The indefinite southeastward descent of the relatively steep pre-Coastal Plain floor clearly differentiates it from the strictly limited descent of the slope of the upland.

5. The degree of preservation of the upland peneplain seems incompatible with the theory that it is as ancient as the floor beneath the Cretaceous of the Coastal Plain.

In this paper also he discusses the regional superposition of Appalachian drainage. The trellis drainage pattern of the Appalachians, in which the trunk streams cut directly across the structural trends of the rocks and cut deep gaps in the

[2] Sharp, Henry S.: The Fall Zone peneplain; Science, Vol. 69, No. 1795, pp. 544-545, 1929.

[3] Johnson, Douglas: Stream sculpture on the Atlantic slope, Columbia Univ. Press, N. Y. Vol. XXII, 1931.

ridges of hard rocks, is generally attributed to regional superposition of the major streams that flowed seaward on the alluvium-covered Schooley peneplain across the older structures. Johnson accepts this principle, but to facilitate the superposition of the streams, he postulates an original westward extension of the Cretaceous and Tertiary Coastal Plain sediments on the Fall Zone peneplain beyond the present position of the Kittatinny or North Mountain, a distance of 120 to 200 miles farther inland than their present limit at the Fall Line. In more recent papers Johnson[4] applies the theory of greatly extended Coastal Plain sediments to explain the deep submarine canyons off the Atlantic Coast, postulating that springs issuing from the Cretaceous strata where they emerge at great depths on the continental shelf may have carved these canyons.

I will discuss the foregoing views and theories, beginning with the last mentioned. The submerged canyons in the continental shelf reach a depth of 10,000 feet beneath the surface of the ocean. To derive sufficient head for springs to emerge at this depth and have power to erode the sea floor, rainwater must enter these beds on the land at a considerable height, probably several thousand feet, above sea level. The floor of the Cretaceous sediments on the coastal plain has an average gradient of 50 feet to the mile, and the postulated landward extension of the Coastal Plain sediments 120 miles or more farther inland would result in mountains 6,000 feet or more in altitude. Johnson admits this by the statement that this postulated Fall Zone peneplain stood high above the Schooley surface. Soft, freshly deposited sediments, such as those of the present Coastal Plain deposits, could not long withstand erosion at this elevation, and Johnson admits that all the Coastal Plain sediments west of the Fall Line would be removed by the erosion that formed the Schooley peneplain.

The western limit of the Cretaceous beds at the Fall Line nowhere stands above 300 feet altitude, and water entering them at this low elevation could have little erosive power as springs at 10,000 feet below the surface of the ocean. Powerful springs could issue from these beds only before Schooley peneplanation, while the Cretaceous beds still remained on the uplifted,

[4] Johnson, Douglas: Origin of Submarine Canyons, Jour. of Geomorphology, Vol. 2, pp. 151-153, 1939. Also paper on same subject, unpublished, read before the National Academy of Sciences in April, 1939.

postulated Fall Zone peneplain, and could have been effective for only a relatively short period of time and with very questionable power of erosion. It seems unwarranted, therefore, to postulate that Cretaceous beds could be the source of artesian water that emerged on the bottom of the ocean as springs with sufficient power to erode the floor of the ocean and excavate deep submerged canyons. It is equally difficult to believe that the parts of the Fall Zone peneplain that were cut on hard pre-Cambrian crystalline rocks and on Cambrian and Silurian quartzites and stood at an altitude of 6,000 feet or more could have been entirely eroded and reduced to the Schooley peneplain level in so short a time. The character of the Cretaceous and lower Tertiary sediments deposited in the adjacent waters, to be discussed later in this paper, is positive evidence that no such greatly uplifted land mass existed and was entirely eroded during this time, as postulated by Johnson.

The Coastal Plain sediments on the Atlantic seaboard at present terminate abruptly along the Fall Line, except for a few questionable deposits of sand and clay ten miles northwest of this line in eastern Pennsylvania. Along the Fall Line there is marked overlap of the Upper Cretaceous and Tertiary formations on older rocks, the overlap increasing toward the northeast in Delaware and New Jersey. Such irregularity of deposition and overlapping of beds indicate proximity to an old shore line. The basal beds of the Cretaceous in the vicinity of Washington and Baltimore are arkoses that contain coarse conglomerates, and similar arkose and conglomeratic beds occur in the overlying Tertiary formations. These conglomeratic arkoses have been interpreted by those who have studied them as near-shore deposits, laid down close to the source of supply. The general opinion of stratigraphers and paleontologists, based on detailed study of these rocks on the Atlantic Coastal Plain, is that the Coastal Plain sediments did not extend any appreciable distance beyond their present limit at the Fall Line.[5] The postulated wide landward extension of these sediments by Johnson apparently is not based on evidence but is proposed solely as a convenience in explaining the superposition of the trunk streams across the older structures.

It is contended by Johnson and others that the Schooley

[5] Lower Cretaceous and Tertiary Deposits of Maryland, Maryland Geol. Surv., Lower Cretaceous Volume, pp. 81-83, 1911; Eocene volume, pp. 47, 54, 89, 90, 1901.

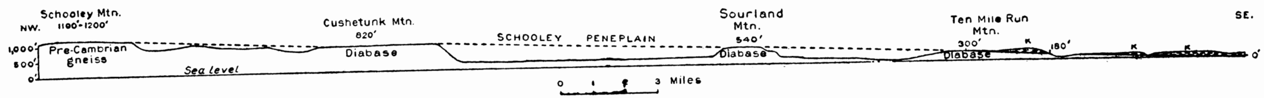

Fig. 1A. Profile section from Schooley Mountain southeastward across New Jersey showing Schooley peneplain passing beneath Cretaceous sediments on the Coastal Plain in Ten Mile Run Mountain. K, Cretaceous sediments.

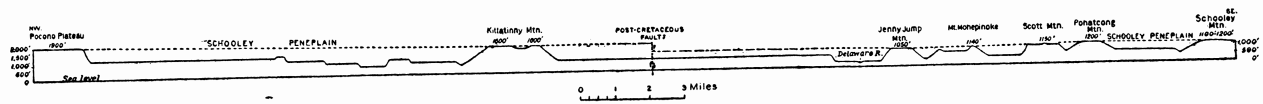

Fig. 1B. Profile section from Pocono Plateau, Pennsylvania, southeastward to Schooley Mountain, New Jersey, showing a possible post-Cretaceous fault offsetting the Schooley peneplain.

peneplain, represented by remnants of level ridge-tops in the Appalachians, is not the same as the "Fall Zone" peneplain which forms the floor of the Cretaceous sediments of the Coastal Plain, chiefly because these two surfaces cannot be traced into each other and the gradients of the remnants of these surfaces are not in accord. Remnants of the Schooley peneplain are not preserved over most of the Piedmont because of the lack of hard beds that could withstand the later erosion. Therefore the remnants of the peneplain surface on the ridges of the Appalachians are separated from the Fall Line, where the "Fall Zone" peneplain emerges, by a belt many miles wide that increases in width southwestward in which no remnants of the peneplain exist. In eastern Pennsylvania and adjacent parts of New Jersey, where W. M. Davis first studied the problem and reached his conclusion that the Schooley peneplain passes beneath the Cretaceous of the Coastal Plain and forms its floor, the Triassic diabase and associated baked shale in the Piedmont, which are more resistant to erosion than the older crystalline rocks of the Piedmont, make many hills that are flat-topped and accord in elevation with that of the peneplain level. A profile section (Text Fig. 1A) across these hills shows a gradual descent of flat remnants of the peneplain surface on hill tops from the type locality on Schooley Mountain, New Jersey, 1,100 to 1,200 feet altitude, to Cushetunk Mountain, 820 feet, Sourland Mountain, 540 feet, and to Tenmile Run Mountain, where the floor beneath basal Cretaceous beds emerges at the surface at 300 feet. The gradient of this surface is approximately 50 feet to the mile, about the same as the slope of the floor of the Cretaceous beds on its eastern margin. Westward from Schooley Mountain to Jenny Jump Mountain the peneplain surface is flatter, or nearly horizontal, possibly due to downwarping adjacent to a postulated post-Cretaceous fault,[6] for the peneplain surface on Kittatinny Range, only ten miles farther west, stands at 1,600 feet altitude, showing an abrupt rise of 400 feet. (See Text Fig. 1B.) However, that is a separate problem, which I will not discuss here. At the only place, therefore, where the Schooley peneplain can be traced by its remnants across the Piedmont to the Fall Line, this surface certainly appears to be the same as that beneath the Cretaceous sediments of the Coastal Plain. The available evi-

[6] Stose, G. W.: Possible post-Cretaceous faulting in the Appalachians: Geol. Soc. Amer. Bull., Vol. 38, pp. 493-504, 1927.

dence, therefore, favors the view that the so-called Fall Zone peneplain and the Schooley peneplain are one and the same.

It is an accepted fact that at some time after the Schooley peneplain was formed it was arched up along an axis parallel to the Blue Ridge uplift. This uplifted surface must have been approximately horizontal along the crest of the arch and inclined toward the Mississippi Valley and toward the Atlantic on its borders. It is probable that at its margins the gradient was considerably steeper than near its crest, and that the slope of 5 to 15 feet to the mile, which the remnants of this surface on the Appalachian ridges now have, may have increased to 50 feet or more to the mile where the plain passes beneath the Cretaceous beds at the Fall Line, many miles to the southeast.

One of the strongest arguments for the Jurassic or early Cretaceous age of the Schooley peneplain is that the development of such a widespread peneplain must have required a length of time greater than that represented by any stratigraphic break within the Coastal Plain sediments. Such widespread erosion of all the rocks at the surface, including the resistant Cambrian and Silurian quartzites, to a gently hilly surface like that of the postulated Schooley peneplain, could have been possible only during the great time break represented by the unconformity and period of planation that produced the smooth floor beneath the Cretaceous deposits. According to this evidence it would have been formed largely in Jurassic time. I am convinced that there was but one complete widespread peneplain formed in the Appalachians since the great deformation and uplift of the Paleozoic rocks at the close of the Pennsylvanian, and I believe that that peneplain is represented by the remnants of a peneplain (Schooley) on the tops of the mountains of the Appalachians, that it passes beneath the Cretaceous deposits of the Coastal Plain as the so-called Fall Zone peneplain, and that these peneplains are one and the same.

On the other hand, the most convincing argument against the Jurassic or early Cretaceous age of the Schooley peneplain is that put forth by Shaw, Johnson, and Ashley, namely, no surface could survive the erosion and general degradation which has taken place since that time. Ashley[7] in a recent paper

[7] Ashley, George H.: Survey Bureau study may upset calculations of Mountains' ages, Pa. Dept. Inter. Affairs, Monthly Bull., Vol. 7, No. 2, pp. 13-20, 1939.

briefly states his views on this subject, and in a later paper,* read at the celebration of the 20th Anniversary of the present Topographic and Geologic Survey of Pennsylvania held at Harrisburg, Pennsylvania, September 1, 1939, he presented evidence in the form of many lantern slides of topographic features and topographic maps, in support of his conclusions. Some of these conclusions may be summarized as follows:

1. That the peneplains in the Appalachians are much younger than they are generally believed to be (1/10 as old, according to the statement in the program for the 20th Anniversary meeting, and 1/100 as old, as stated in his January, 1939, publication).

2. That the even tops and level crests of ridges and dissected plateaus in the Appalachians, generally believed to be remnants of an old peneplain only slightly reduced in altitude by erosion, are instead remnants of a level surface that has been lowered by a process of uniform reduction by erosion from a former peneplain that stood much higher, and thus only reflects that surface.

3. That gaps in ridges of hard resistant rocks are not necessarily formed by the down cutting of channels of streams superposed from a peneplain or coastal plain surface transverse to the structure of the rocks, but their locations are due primarily to local weakness of the rocks caused by sharp folds or faults, and such gaps, therefore, may be caused by stream piracy or other erosion processes.

4. That lower level surfaces that are generally considered to be younger partial peneplains developed only on the softer rocks have instead been produced by local base levelling behind land sills, probably not tied to stages of sea level.

In the first part of the paper read at the Anniversary celebration, Ashley stated that "most of the mountain tops are so level crested for such long distances that it seems incredible that they are not remnants of a peneplain surface" and "the idea that these level surfaces coincide with the peneplain surface has been very persistent," but later in the paper he presented evidence to support his view that these level-topped ridges have been greatly lowered by uniform erosion and their level character preserved, and do not actually represent the peneplain surface. I shall endeavor to prove, however, that many such level

* In typewritten form, September, 1939.

FIG. 1A.

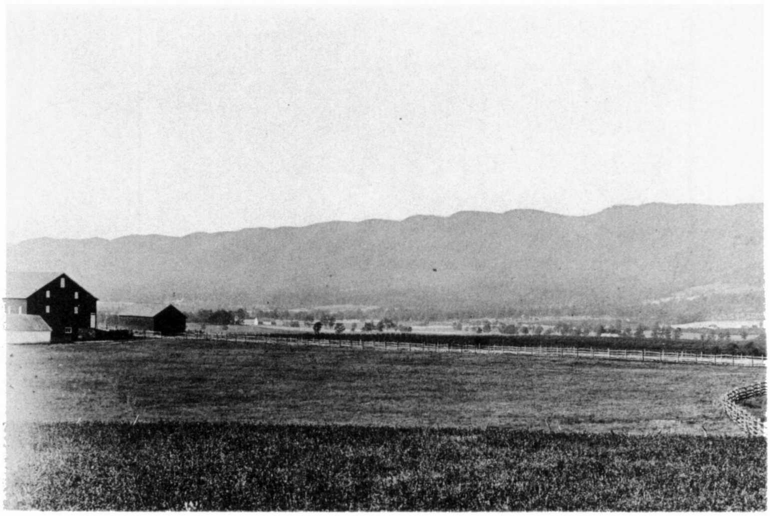

FIG. 1B.

FIG. 1A. Schooley peneplain preserved on Cross Mountain in the distance. Cove Mountain at the right has a knobby crest at a much lower level.

FIG. 1B. Cove Mountain, showing a knobby crest of a knife-edge ridge when eroded below the peneplain level.

surfaces and ridge tops are actual remnants of the Schooley peneplain surface but little reduced in altitude.

Text figure 2 is a contour map of the surface of the Big Flat on top of South Mountain, east of Chambersburg, Pennsylvania, where an area six miles long and three miles wide preserves a nearly flat level upland surface 1,900 feet to 2,100 feet in altitude, which truncates the edges of upturned and folded Cambrian quartzites and shales. The flat part of the upland surface

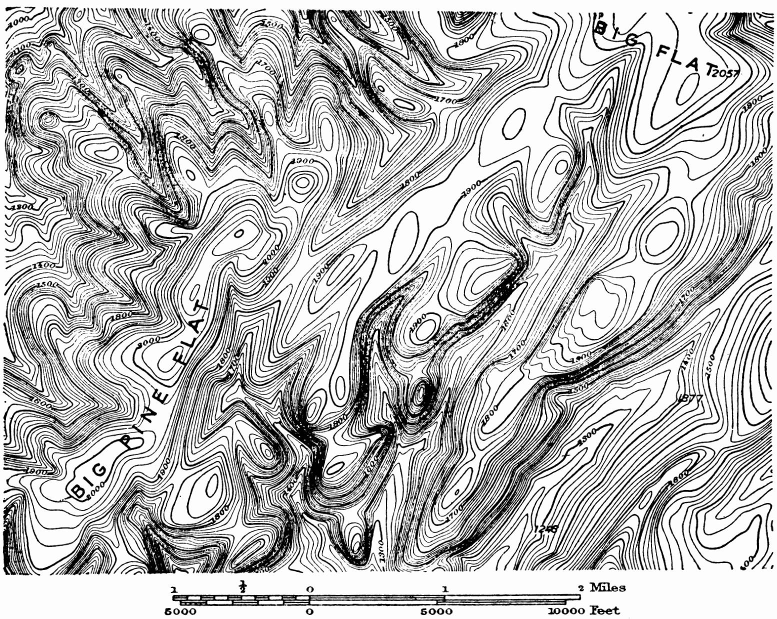

Fig. 2. Contour map of Big Flat and Big Pine Flat on South Mountain, east of Chambersburg, Pennsylvania, showing nearly flat level surfaces at 1900 to 2100 feet altitude, representing the Schooley peneplain.

is underlain by quartzites, and the longitudinal valleys are cut in the shale. I believe that the flat surfaces are remnants of the original peneplain, little reduced in altitude, which here may have had an original relief of 200 feet, the higher parts, formed on the more resistant Montalto quartzite, being less reduced than the lower parts cut on the Weverton quartzite. The extent, level character, and smoothness of this upland surface is even more striking in the field than on the map. Ashley points out that the inclination of hard beds, and therefore the width of their outcrop on a level surface, determines their resistance to erosion and applies this principle to account for the different altitudes of level tracts of the present surface which he regards as having been lowered by erosion from the original level of the peneplain. I picture a peneplain as a generally

Fig. 3. Contour map of Big Mountain, Tuscarora Mountain, and Cove Mountain, east of McConnellsburg, Pennsylvania, showing parts of Schooley peneplain over 2400 feet altitude.

level surface cut on the softer rocks, above which may rise low ridges composed of the harder rocks, for it is impossible, in a reasonable allotted time, to remove all traces of relief due to hard rocks. On these peneplain surfaces, therefore, there would be low ridges of quartzite, broken in places by low saddles and swales where the rocks are weakened by faults and sharp folds, and these ridges would have greater relief where the outcrops are wider or are reinforced at the plunging ends of folds. That such relief may have been as much as 400 or

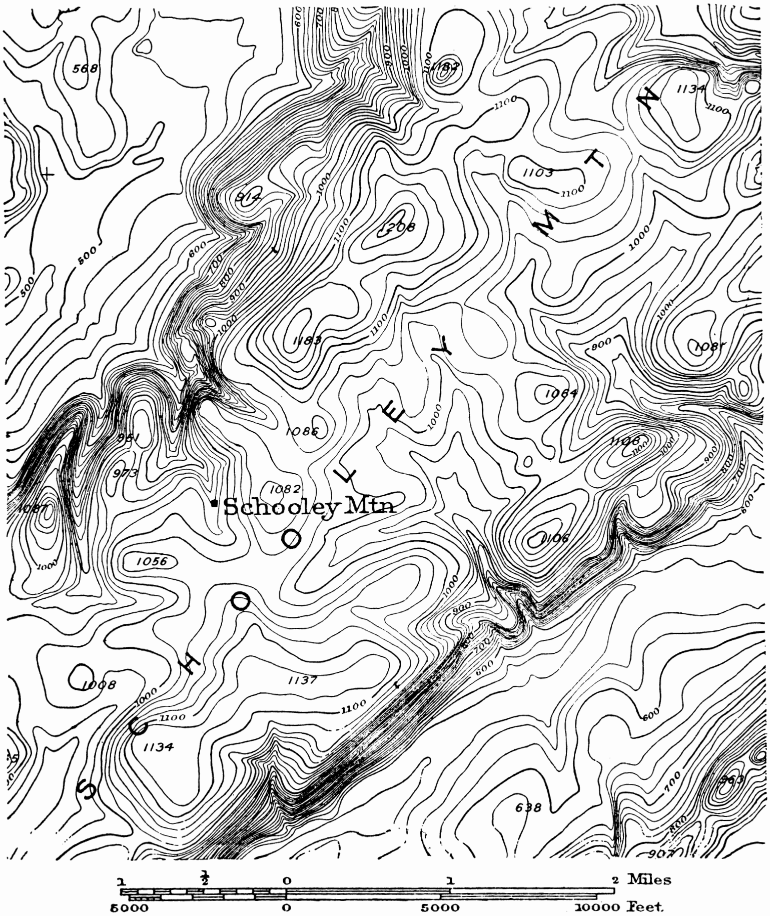

Fig. 4. Contour map of Schooley Mountain, type locality of Schooley peneplain.

500 feet and still be part of the original peneplain seems probable.

Text Fig. 3 shows a more dissected remnant of the Schooley peneplain formed on folded Silurian quartzite. The flat top of Big Mountain and the peak two miles to the south stand at 2,400 + feet altitude, somewhat higher than the general peneplain level of the ridge tops. These higher peaks evidently

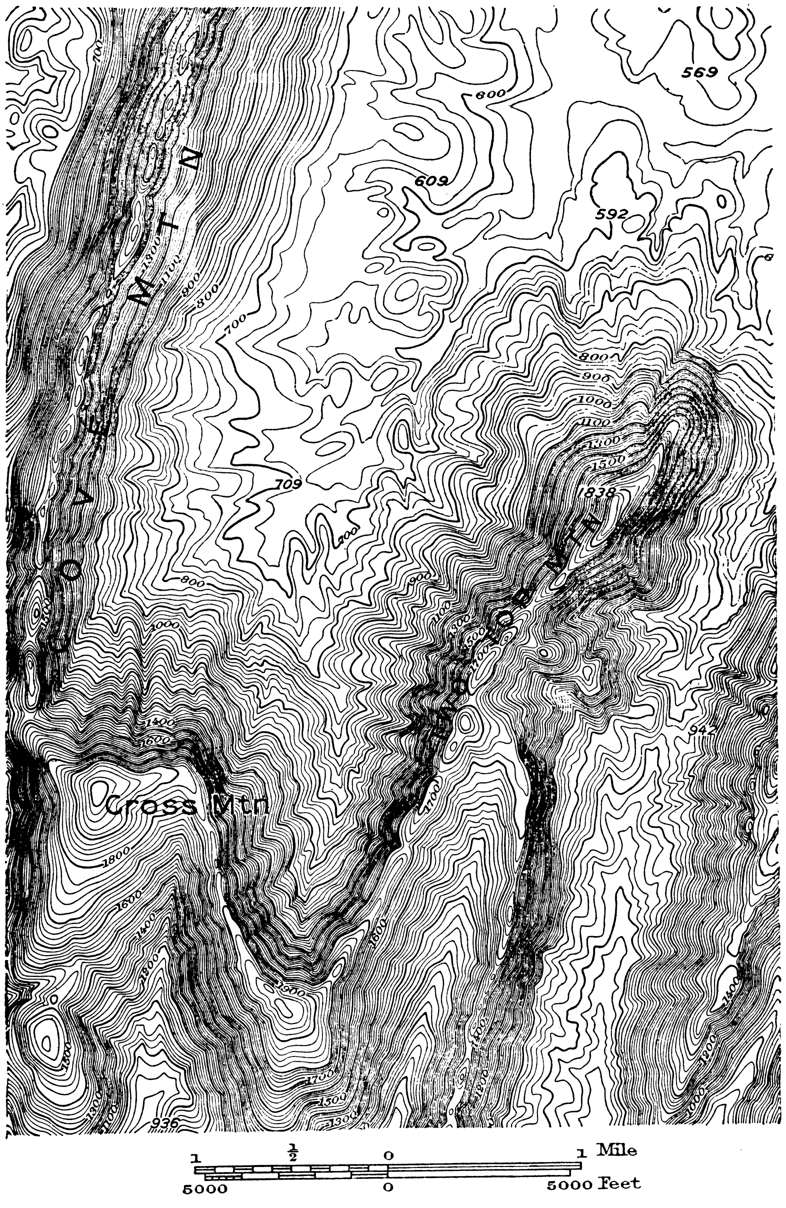

Fig. 5. Contour map of mountains southwest of Mercersburg, Pennsylvania, showing Schooley peneplain on Cross Mountain and serrate knife-edge ridge of Cove Mountain.

were not completely reduced to the peneplain level because of the greater resistance to erosion of the quartzite where its band of outcrop was widened at the ends of pitching folds. Big Mountain is the crest of an anticline and the high peak to the south, a syncline. The original relief on the peneplain here may have been 450 feet.

One of the most convincing examples of an uneroded Schooley peneplain surface is that on Schooley Mountain, New Jersey, the type locality of this peneplain. This upland surface (Text Fig. 4) is two and one-half miles wide and over ten miles long, and is cut on pre-Cambrian folded gneisses. The present upland surface at 1,050-1,150 feet altitude has an irregularity of about 100 feet, which relief may have been original. A few streams have trenched it another 100 feet. As seen on the ground it is a remarkably flat surface.

I do not believe it possible to materially lower a flat level surface or a flat-topped ridge by erosion and still preserve its level character, as is suggested by Ashley. Erosion does not effectively attack the top of a ridge composed of upturned quartzite, but attacks its sides, gradually reducing its width until it eventually becomes a knife edge. Further erosion produces saddles and gaps in the knife-edge ridge at the heads of side drainage. Text figure 5 shows such a knife-edge ridge eroded below the level of its former peneplained crest, whereby a distinctive comb ridge of knobs and saddles is produced, not an even crest at a lower level. (See Plate I, Figs. 1A and 1B.) An uplifted broad level surface would be attacked similarly by sapping at its edges and be gradually reducing in size, and not be lowered to a lower level plain by uniform erosion of its surface.

There is still to be considered the problem of how to account for the preservation in the present topography of remnants of a peneplain formed in late Jurassic time, and the arguments of Shaw and Ashley, that a peneplain uplifted in early Cretaceous time and subjected to erosion since that time could not survive denudation, are apparently sound. It is evident, therefore, that if the peneplain was formed in late Jurassic time, it was not uplifted and subjected to effective erosion immediately after it was formed but at a much later time, possibly in the mid-Tertiary or even later. If this were the case, the peneplain might withstand erosion to the present without complete destruction. There is no known physiographic evidence of the exact time when destructive erosion began. In earlier papers I have followed Keith in recognizing an intermediate partial peneplain at a lower level on the tops of mountains and called Weverton. This peneplain was believed to have been formed in mid-Cretaceous time on the supposition that uplift of the Schooley peneplain occurred at the beginning of the Cretaceous. That such intermediate flat areas with deeply weathered rock at the surface do exist in places in the Appalachians cannot be denied, but they could have been formed during halts in the elevation of the Schooley arch in Tertiary time, and not in the mid-Cretaceous. As a solution of this problem I here suggest that, although the Schooley peneplain was formed largely in Jurassic time and its eastern margin was submerged and was covered by non-marine deposits in Lower Cretaceous time, the landward part of the peneplain was not uplifted sufficiently to be materially eroded until mid-Tertiary time.

An examination of the Coastal Plain deposits may throw some light on the subject. The sediments of the Lower Cretaceous in Maryland and Delaware are largely arkosic sands with kaolinized feldspar and clays, derived from disintegrated crystalline rocks exposed on the adjacent part of the peneplain surface. The Upper Cretaceous beds are of similar composition but of finer texture, with less arkose and more clay, and the uppermost beds are largely marl with still less detrital material. The Eocene is likewise a marl and greensand with little detrital material; and the lower beds of the Miocene (Calvert formation) are similarly marls and diatomaceous earth. Apparently none of these sediments was derived from a land uplifted and subjected to active erosion. The higher beds of the Miocene (Choptank, St. Marys, and Yorktown formations) are largely composed of sand and sandy clay, with an absence of marl, indicating greater uplift and active erosion of the adjacent land. The Yorktown formation is markedly unconformable in Virginia, overlapping southward all the older formations and resting on the crystalline rocks in southern Virginia. The Coastal Plain sediments therefore indicate an absence of active erosion of the land until the mid-Miocene and not until that time was the Appalachian region uplifted and subjected to intensive erosion. Davis[8] evidently realized

[8] Davis, W. M.: The geologic dates of origin of certain typographic forms on the Atlantic slope of the United States. Bull. Geol. Soc. Am., Vol. 2, pp. 554 et seq., 1890.

this when he propounded his theory of the Schooley peneplain, for he states "The date of the completion of the New Jersey [Schooley] peneplain . . . is well defined. . . . it is found to descend below the oldest of the Cretaceous beds." The highlands were "worn down to less and less relief and when the whole of Cretaceous time had elapsed the highlands must have reached the even surface now so conspicuous. . . . Erosion of the surface may have continued into Tertiary time."

The attitude of the Coastal Plain sediments shows that uplift and tilting of these beds was more pronounced after Cretaceous time than during it. The Lower Cretaceous beds in the Trenton area of New Jersey[9] dip eastward 40 to 50 feet to the mile and the Upper Cretaceous, 35 feet to the mile, representing a tilting of only ten feet to the mile during the Cretaceous. Eocene beds are absent here, and the Miocene beds, which unconformably overlie the Cretaceous, dip eastward 10 to 15 feet to the mile, indicating a tilting of 20 to 25 feet to the mile in post-Cretaceous and pre-Miocene time. Conditions in Maryland[10] indicate that nearly all the tilting of these beds took place in pre-Eocene time. Here the Lower Cretaceous beds have a general dip of 40 feet to the mile, locally steeper near the Fall Line, the Upper Cretaceous, 35 feet to the mile, the Eocene, 12½ feet to the mile, and the Miocene, 11 feet to the mile. The marked change in dip and the tilting of these beds, therefore, preceded the Eocene. It is evident from these facts that the Coastal Plain deposits were tilted chiefly at the close of the Cretaceous and preceding the Eocene epoch. This tilting was apparently limited to the Coastal Plain region, for the character of the sediments deposited in the coastal waters shows that the adjacent land was not greatly uplifted until mid-Tertiary time.

If the final uplift and arching of the Schooley peneplain took place in mid-Tertiary time, as is indicated by the character of the Coastal Plain sediments, effective erosion of the peneplain surface would be limited to later Tertiary and Quaternary time. The peneplain, where cut on resistant rocks such as Cambrian and Silurian quartzites and Triassic diabase and associated baked shales, undoubtedly could withstand erosion during this length of time without material reduction in alti-

[9] Trenton Folio, U. S. Geol. Survey, Geologic Atlas, No. 167, p. 11, 1909.

[10] Lower Cretaceous, Upper Cretaceous, Eocene, and Miocene volumes of the Maryland Geol. Survey. 1901-1916.

tude, and remnants of the peneplain surface might still be preserved on the summits of the mountains.

If the peneplain surface passed beneath the Lower Cretaceous sediments, this part of the peneplain must have been formed in pre-Cretaceous time. It is probable that the part of the surface not submerged in the coastal waters also was reduced to nearly the same level plain at this time, and the further reduction of the low hills on its surface in Cretaceous and early Tertiary time must have been little because of its low relief and slight elevation. The Triassic rocks, of Upper Triassic age, were also bevelled by this peneplain. So the Schooley peneplain was probably formed largely after late Triassic sedimentation and before the Lower Cretaceous deposits were laid down, and may be said to be largely Jurassic in age.

In summary, my conclusions are: Accordant level crests of ridges and mountains in the Appalachians represent actual remnants of the Schooley peneplain surface little reduced in altitude; this peneplain passes beneath the Cretaceous sediments of the Coastal Plain at the Fall Line and is the same as the so-called Fall Zone peneplain; the Schooley peneplain was cut chiefly in Jurassic time; its surface was only slightly uplifted on the Schooley arch in Cretaceous and early Tertiary time, during which period the exposed part of the peneplain surface was possibly further reduced toward a level plain while fine sands, arkoses, clays, and marls were being deposited on its submerged border; the main uplift of the Schooley arch took place some time in the mid-Tertiary, and not until this time did effective erosion of the Schooley peneplain surface begin; remnants of this surface still exist on the tops of mountains in the Appalachians because it has been exposed to effective erosion only during later Tertiary and Quaternary time; remnants of a lower level surface on the mountains (Weverton peneplain) represent a partial peneplain formed still later in Tertiary time.

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