methods of scientific observation and experiment in the various branches of research may be developed a critical attitude in judgment, a power of observation and a capacity for orderly arrangement; while a knowledge of the questions with which science as a whole is concerned in the past, present and the future, fosters the broad outlook which, in combination with these qualities, is essential in successful dealing with the problems of life. We doubt, however, whether much of the science teaching in schools, either primary or secondary, could be regarded as science for citizenship instead of science for specialists, and we should welcome a movement which would broaden its scope and change its character.—*Nature.*

THE FALL LINE OF THE EASTERN UNITED STATES

THE fall line is one of the most significant physiographic features of the eastern United States, but its origin has long been a mooted question. The fall line is not particularly striking in its physical expression but its east-facing slope gives rise to a remarkable series of falls, rapids or deflections in the streams which flow from the Appalachian province across the Coastal Plain to the Atlantic Ocean.

The fall line, or fall zone as it may more appropriately be called, has been commonly recognized as extending for more than 800 miles, from central Georgia to somewhere in the neighborhood of New York harbor, and following the contact between the crystalline rocks of the Piedmont area and the soft sedimentary formations of the Coastal Plain. All the early geologists and physiographers assumed that the fall line was a natural outcome of streams crossing the line of contact between two areas, one of resistant rocks and the other of relatively non-resistant rocks. This apparently adequate explanation was long given credence and, indeed, to-day many still hold to it. But it must be rejected in the light of the fact that the upper portions of the streams on the Piedmont are as well graded as the lower portions on the Coastal Plain. For if the falls were due to difference in the rate of stream development on areas of unlike rock resistance, the upper courses of the rivers should manifestly be in physiographic youth while their lower courses should be physiographically more mature. This is, however, not the case.

It was soon recognized that the fall line was not explicable solely on the basis of difference in resistance to stream downcutting in two petrographic provinces, so in 1888, W. J. McGee set forth the hypothesis that the fall line was due to monoclinal flexing or faulting. This theory appears to have been accepted by N. H. Darton, N. M. Fenneman, Cleveland Abbe, Jr., Isaiah Bowman and many others. Joseph Barrell, however, clearly showed that while faulting does occur near the fall line in one or two places, there is no evidence of displacement throughout most of its length, particularly in places where some of the most pronounced stream declivities occur.

W. M. Davis in his "Physical Geography" (published in 1898) sets forth a very ingenious hypothesis, which if true is entirely adequate to explain the fall line. On page 127, of this book, Dr. Davis gives in essence the following explanation: Before the Piedmont and Coastal Plain were uplifted the rivers had cut valleys of gentle slope leading to what was then base-level—the shore-line along the outer (eastern) edge of the Piedmont. After emergence, the extended rivers rapidly entrenched their lower courses in the non-resistant sediments of the Coastal Plain, while downcutting proceeded very slowly in the hard rocks of the Piedmont. These new valleys of the lower courses of the streams, worked headward until they encountered the resistant rocks beneath the Coastal Plain sediments near its inner margin, where downcutting was checked. Thus the middle portion of the stream, between the gentle upper reaches on the Piedmont and the gently sloping lower entrenched portion in the Coastal Plain, possesses a relatively steeper slope and hence is marked by falls and rapids.

Davis's explanation is thus based on the assumption that the surface of the Piedmont is continued beneath the sedimentary formations of the Coastal Plain, and this embodies the necessary implication that the gradients of the Piedmont portions of the streams are less than the slope of the upland peneplane surface.

In order to analyze the problem quantitatively, the writer constructed many projected surface profiles across the Piedmont and Coastal Plain at right angles to the fall line, plotting on the profiles the outcrops of the various geological formations together with the depths of well borings in the Coastal Plain to determine the slope of the crystalline basement. Several different vertical exaggerations of scale were used in order that the various elements of the relief might be studied to best advantages.

The profiles show especially well the peneplain nature of the Piedmont upland and the New England upland. These uplands should probably be considered as two sections of the same peneplain (probably Tertiary in age). The slope of this Piedmont-New England peneplain surface varies from 5 feet per mile in Georgia to 18 feet per mile in Maine. The slope of the crystalline basement below the Coastal Plain varies from 36 feet per mile to 85 feet per mile, showing clearly that the Piedmont-New England upland surface is not continued beneath the Cretaceous formation of the Coastal Plain. The much greater slope of the crystalline basement below the Coastal Plain makes the marked angle formed by the intersection of these two surfaces recognizable even when a small vertical exaggeration is used.

When records of scattered well drillings along a line in the Coastal Plain are plotted, they seem to indicate that the crystalline basement closely approximates a plane surface. Very probably the surface of the crystalline basement is a buried peneplane developed during pre-Cretacic (Jurassic?) times. The slope of this buried and tilted Jurassic peneplane emerges from beneath the Coastal Plain sediments, and continues upward along the face of the fall line belt of the Piedmont, being revealed through the stripping away of the Coastal Plain sediments by erosion. The width of this stripped zone is slight, varying from 2 to 4 miles along the Piedmont. In New England, however, the Coastal Plain is entirely removed (except that portion which is below sea-level), leaving a stripped zone varying from 5 to 15 miles in width. The exposed edge of this old Jurassic peneplain is continued across the bottom of the Gulf of Maine with a width of about 15 miles.

Several writers have long known that the slope of the Piedmont is not continued beneath the Coastal Plain and that there are two upland slopes in New England; indeed, Davis himself has recognized this and commented on it. But what is vastly more significant, it has not been recognized that since this is true no falls could result from the conditions embodied in Davis's theory. If, as Davis suggested, the Piedmont rivers had established very gentle gradients leading to an ancient shore-line near the present "fall line," the upland profile and the stream profile must have been intersected at that point. After the emergence of the Coastal Plain, the extended rivers must have entrenched themselves in the soft Coastal Plain sediments until they had established nearly level channels in their lower courses, whereas downcutting proceeded very slowly in the crystalline rocks of the Piedmont. This would have resulted in a broken stream profile in which the stream in the outer (eastern) Piedmont would have been entrenched but little below the upland surface, while in the western Piedmont and the Coastal Plain it would have been greatly entrenched.

But actual profiles show that the streams are entrenched as far below the upland surface in the eastern Piedmont as in the western Piedmont. If this fact is applied to a diagram showing the Piedmont surface as being continued beneath the Coastal Plain it gives only a simple concave stream profile which could yield no falls and rapids whatsoever. Thus the postulate of an ancient shore-line at the fall line is untenable, and the break in stream gradient is only incidentally related to differential entrenchment in areas of unequal rock resistance.

On the other hand, the profiles show that there is a marked break in the slope of the Piedmont-New England upland, and it is at this point that the streams which are *uniformly* entrenched below the upland surface exhibit the break in their gradients.

The fall line zone, therefore, lies along the outer edge of the crystalline area (the Piedmont-New England Upland Province), where there is a break in the slope of the land due to the intersection of the recently exposed margin of the old, tilted Jurassic peneplain and the newer Tertiary peneplain of the uplands. Since the gradients of the streams are closely related to the profile of the land, this break is sufficient to account for falls and rapids.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

PRECIPITATION OF THE VIRUS OF TOBACCO MOSAIC

IN an attempt to free the virus of tobacco mosaic from as much contaminating material as possible a method has been devised whereby the freshly cut diseased tobacco tissues are frozen, allowed to thaw, and then subjected to high pressure. The juice obtained, after being centrifuged, at about 2000 r.p.m., contains no large particles in suspension, but is highly infectious.

When two volumes of acetone (c. p.) at $-8°$ C. are added to one volume of the juice held at about 0° C. a flocculent precipitate is thrown out and rapidly settles. The supernatant liquid can be almost completely decanted within two minutes after adding the acetone, leaving the precipitate in the bottom of the container. More water may then be removed by rinsing the precipitate with acetone (c. p.) at $-8°$ C., decanting the acetone and then removing the remaining acetone with absolute ether at $-8°$ C. by rinsing twice and thoroughly draining off the ether. The precipitate thus obtained is readily soluble in distilled water. Experiments in which young tobacco plants were inoculated with this solution showed it to be highly infectious. The first supernatant liquid decanted, on the other hand, when centrifuged to free it from all traces of the precipitate and diluted with two parts of distilled water proved to be non-infectious. The dilution was made in order to bring the