reading and may have no connection whatever with a high area. There seems to be the utmost confusion in Dr. Hann's writings in which he uses barometer maxima and minima or the above indiscriminately. It is very certain that the whole meteorologic world has understood definite high and low areas, ordinarily called anticyclones and cyclones, in all these expressions.

Second, the point I made is by no means a trivial one, as the following figures from Dr. Hann show. I will take the two colder months, Feb. and March, from his table.

Temperature Fahr. at base of Sonnblick during high and low areas:

	HIGH AREA.	LOW AREA.
Feb.	33.8°	23.4°.
March	39.2°	22.8°.

I submit that temperatures 10.4° and 16.4° *higher* in a high area (anticyclone) than in a low area (cyclone) are not trivial.

Third, Dr. Hann himself shows that the usual law holds in the Alps, for in the latter part of this same paper there is a table giving the temperature in high areas 16°.5 F. and in low areas 35°.4, or a difference of 18°.9 in exactly the opposite direction from that previously demonstrated.

I am inclined to think that these serious contradictions throw a cloud over this investigation, and it is of the utmost consequence that this be explained, but if it is not, then the original contention, that temperature in the Alps is higher in high areas than in low areas, must be abandoned.

H. A. HAZEN.

Washington, D. C.

Meandering Rivers in Missouri.

PROF. WM. B. DAVIS'S letter, in *Science* of November 19, contains much that it suggestive relating to the extent and phases of past denudations over the area of the Ozark uplift. In my letter of July 21, however, to which his is a reply, it was not so much my object to attempt to fix the age of the Osage River, or to define the changes of level that have taken place, as it was to raise the question whether a past base-levelling was necessary to explain the meander phenomena of this and the other rivers referred to. I there undertook to explain how the sinuosities of such streams might develop in a country which was not base-levelled. Mr. Davis, with characteristic candor, accepts this as an "important correction" to his explanation. Briefly, and expressed in general terms, the view advanced was: that, under certain conditions of declivity and stratigraphy, streams will acquire trenched meandering courses irrespective of whether the country be a flat plain or not, and irrespective of whether the lines of flow at the beginning of these conditions were decidedly sinuous or only gently curving. In any case, the radius of *developed* meanders will, of course, be proportional to the volume of the river.

This conclusion seems to follow logically from the premises that all rivers exert a sapping as well as a corrading action; or, in other words, that they tend to erode laterally as well as vertically. To produce these special results it is necessary that the declivity be not so great that lateral wear become altogether insignificant as compared with vertical wear; or that stratigraphic conditions be not such as to entirely thwart these tendencies

of running water. In a strongly flexed region, for instance, the drainage is largely controlled by the attitude of the rocks. A country of horizontal strata of moderate resistance, such as those of the Ozark plateau, is particularly favorable to the development of a swinging course. Where soft and hard beds, like shales or limestones and cherts, alternate, we can readily conceive how a stream of comparatively rapid fall may move or expand its meanders considerably while cutting only a slight depth through underlying resistant beds. Did time and space permit it would be interesting to elaborate further and to trace the effects of other modifying conditions. Without being prepared at present to express final conclusions, it seems to me probable, however, that the presence of such streams as the Osage over the Missouri-Arkansas plateau can be assigned to local conditions of declivity and stratigraphy.

Whichever hypothesis be advanced it is, of course, necessary for its acceptance that other facts of the geological history of the region be reconcilable with it. As I view the question at present, such reconciliation seems more readily effected on the hypothesis I have advanced, than on Professor Davis's. The exceptions I took to his, that the country had been base-levelled in Tertiary times, are not objections against mine. But, whether Mr. Davis be right or not as to the volume of erosion (leaving out of consideration the resultant forms) and as to the earth movements that have taken place since Paleozoic time, the explanation which I offer stands equally good.

I do not mean by this, however, to beg the questions of the extent of Mesozoic denudation and of the oscillations which have taken place since the Paleozoic period. There have undoubtedly been changes of levels; such were necessary to bring the Cretaceous and Tertiary rocks of the Mississippi embayment to their present altitudes; but I do not think the differential movements within the limits of Missouri have been very great. While the seas existed in which the post-Paleozoic deposits of Kansas and Colorado were laid down, the drainage of a part of Missouri probably flowed in that direction. With the uplift of the western area, certain readjustments of drainage must have taken place over Missouri. When I stated in my last letter that the sculpturing of the topography must have been uninterruptedly in progress from the end of the Paleozoic to the present time, I meant that Missouri had been essentially a land surface since that time. Probably the larger features of its drainage system were blocked out at the beginning of this period of emergence. This statement is not at all opposed to the idea that changes of level or readjustments of drainage took place during that period. Just what was the exact sequence of events, or the nature of the changes, I do not feel prepared to say. More critical field studies, better knowledge and more careful consideration of the geological history of surrounding areas is necessary before anything like the full story can be told. With such knowledge as we have, however, I am not inclined to accept the hypothesis of a wide base-levelling such as is required, if all of the sinuous streams of this region are assigned to that cause; and this especially when another hypothesis seems adequate to explain the phenomena in question.

ARTHUR WINSLOW.

Office State Geological Survey, Jefferson City, Mo., March 5, 1894.

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