ART. XLVI.—*Remarks on the Drift of the Western and Southern States, and its relation to the Glacier and Iceberg Theories;* by EUG. W. HILGARD, Ph.D., State Geologist of Mississippi.

IN a recent paper on the Quaternary formations of Mississippi (this Journal, May, 1866), I have expressed my views concerning the remarkable formation designated as the "Orange Sand," in my Report on the Geology of Mississippi.

The admirable exposition of the whole subject of the Post-tertiary formations in Dana's Manual of Geology, to which I have since been enabled to refer, as well as the portion of Dana's Address before the American Association in 1855, relating to that period, suggest to me with greater clearness the points to be settled in establishing the presumed correspondence of the Orange Sand of the Southwest to the recognized drift of the Northwest. On this subject I now propose to offer a few additional remarks.

I have not perhaps, in the paper referred to, been sufficiently explicit, in comparing the Orange Sand to the northern drift in general, without specially mentioning as its supposed congener, the drift of the Northwest, particularly that of Illinois, Wisconsin, Iowa and Missouri. That the drift of New England, as described by Hitchcock and Dana, can be satisfactorily accounted for on the glacier theory alone, few who have delved among the ancient and modern moraines of Switzerland will question.

But the Western drift deposits, even so far north as Iowa, as Hall's observations show, and still more in Illinois and Missouri, differ seriously in their structure both from the New England moraines, and from the lines of blocks apparently left by the glacier melted *in situ*. In the West the "erratic" blocks, both rounded and angular, are commonly found imbedded in deposits distinctly stratified over considerable areas, and consisting of gravel, sand, or even clay; and the pebbles accompanying them are not the irregular, scored and scratched forms of the moraine pebble, but clearly rounded by aqueous action.

Where a moraine has not, subsequently to its formation, been violently shoved forward by an unusual advance of the glacier, some semblance of stratification may occur, in consequence of great regularity in the rolling down of the detritus. But such

an appearance rarely extends connectedly beyond a few yards, nor is it likely it ever should, however stupendous the scale of the glacier. Nor will any one, acquainted with moraines and their material, be likely to mistake an aqueous deposit for a moraine, or *vice versâ*.

In Desmoines county, Iowa, according to Hall, the drift consists of "partially stratified deposits of clay, sand and gravel, with boulders of primary and secondary rocks irregularly distributed through the mass, though usually most abundant in the lower portion." These boulders in the description of Lee county are spoken of as "worn and rounded masses" of various rocks, occurring in distant localities. We have the same in Henry county; in Van Buren, this deposit furnished "a mass of siliceous wood," which "presented none of the water-worn characters of a boulder; but the angles were as sharp and well defined as if it had never been removed from the spot where it was at first buried." In Washington county, again, we find mentioned "a heavy deposit of drift material presenting the usual characteristics of this formation, and consisting of irregularly stratified beds of sand, gravel and clay, with an average thickness of from forty to sixty feet."

The above, taken *verbatim* from Hall's Iowa Report, might serve as a very fair description of a good portion of the Orange Sand of Mississippi, the only difference being the greater size of the boulders in the more northern locality; a merely quantitative variation.

In Missouri the phenomena are the same. The drift there, according to Swallow, is "a heterogeneous stratum" (but a *stratum* still!) "of sand, gravel and boulders, all water-worn fragments of the older rocks." Some of these are derived from localities as far distant as "St. Peters river, about 300 miles north of St. Joseph. But the paleozoic fragments are usually from localities near where they rest.... and are as *completely rounded* as those from more distant points."

The latter remark is interesting, as it shows precisely what I found to be the case in the eastern pebble belt of Mississippi. The pebbles there are almost exclusively derived from the siliceous group of the Carboniferous, which occurs only in patches farther northward, but underlies the pebble strata themselves (Miss. Rept., p. 17, ff.).

But Swallow goes on to say that "there are other deposits, particularly in the middle and southern parts of the State" (*sic!*) "which are not genuine drift, and yet they bear a greater resemblance to that than to any other formation, and occupy the same stratigraphical position."

This, also, is precisely the predicament of the Orange Sand deposits.

As for the drift of Illinois, I am unable to refer to the Reports of that State; but my own early recollections of it such as it exists in St. Clair county, place it in precisely the same category with the drift of Iowa and Missouri. Only I remember distinctly the occurrence in it, of *angular* boulders of syenite, greenstone and quartzite.

Nevertheless, most of the material by far, in all these cases, is *water-worn;* it is, more or less irregularly but distinctly, *stratified; no glacier scorings* are mentioned, either on the pebbles or on the adjacent rock.

The *glacier theory alone* cannot, therefore, account for these deposits north of the Ohio, any more than for the Orange Sand delta south of it. And even as far south as Vicksburg, the action of *water alone* is inadequate to account for the transportation of the boulders found in these beds.

Dana's remark (Manual, p. 554) that "while the glaciers were disappearing, many a stream or lake would have existed to stratify the drift, and cause denudation in elevated places," points no doubt to the true explanation of these phenomena: but it does not go far enough to satisfy existing facts. Agassiz has observed that "the melting snows of the declining glacier epoch" may have been instrumental in the formation of the river terraces; but Tuomey was, I believe, the first to point out, that the Southern drift may have been formed in consequence of the *sudden* melting of the northern glaciers (Second Report on the Geology of Alabama, ed. Mallet, p. 146); such as would have resulted from a first, rapid depression of so huge a mass of ice below the snow line.

The assumption of a pretty *rapid* depression seems necessary to account for the immense volumes of water required to produce the observed effects, and also to explain the possibility of inland transportation of boulders by floating ice—if indeed, after a depression of near 500 feet below the present level in the latitude of Montreal, *inland* it could be called. Though comparatively but slightly depressed at its mouth, the more immediate valley of the Mississippi would have formed a deep irregular gulf, filled with ice-cold water by the enormous influx from the glacier region forming its northern shore; whose icebergs would thus be floated southward in a medium unfit for the permanent existence of any fauna likely to be fossilized, viz: ice-cold fresh water in a state of violent flow.

That the action must at first have been extremely violent, is proved by the deep erosion of the underlying formations, and the transportation and subsequent redeposition in mass, of their materials, more or less altered; which is exhibited on so extensive a scale in Mississippi. But for the fact that wherever the

more ancient strata were readily susceptible of denudation, they have entered largely, at times almost exclusively, into the composition of the Orange Sand strata, we might suppose that the surface of the former (which appears to be at least equally as hilly as the present one) had been denuded by atmospheric agencies during the glacial period of elevation.

When, after the subsidence of the first rush, the velocity of the water had so far diminished as to render it capable of forming stratified deposits, these would naturally possess the mixed character resulting from a twofold mode of transportation—by water, and by floating ice—the former, no doubt, in many cases, succeeding the latter, and, by the grinding action of the smaller gravel and sand, transforming the angular blocks first dropped into the rounded boulders characterizing the drift of Iowa and Missouri, and faintly represented by their scattered congeners in the Orange Sand delta.

It would thus seem that the grandly simple means of a single elevation and re-depression in the northern latitudes, to which the phenomena of the ancient glaciers and sea-beaches point us, will equally satisfy the conditions required for the formation of the Western and Southern Drift. Down to the later stages of the northern re-depression, the predominant slope would everywhere be southward, so as to collect in the Mississippi valley the glacier waters, not only of the whole extent of northern territory now tributary to it, but probably also those of the present arctic slope of British America, and a portion of that now tributary to the St. Lawrence. Hence the comparative absence of stratified drift from the Northern Atlantic slope of the United States; and its presence, on the contrary, on the sea border of the Southern States, as stated by Tuomey, *l. c.*

As to the Champlain epoch, it would seem to be represented in its *later* part only, by that which in the Western and Gulf States has formed the "second bottoms." In the Mississippi Valley the formation of the latter has clearly been preceded by a period of comparative quiet succeeding the stormy times of the drift proper, and giving rise, successively, to the deposits of the Bluff or Loess, and the superincumbent Yellow Loam. These ought to be contemporaneous with the earlier stages of the Champlain epoch in New England and Canada; and their great difference of character might, it seems to me, be explained on the simple and probable supposition, that in the more southerly regions the depression took place somewhat later, even as, obviously, it was vastly less in extent. The Bluff formation of the valley of the Mississippi bears the most obvious relations to the present channels of the larger rivers, and it contains the vestiges of a fauna proving that the deluge of ice-cold water had

ceased; while yet the volume of water carried by those channels greatly exceeded that which corresponds to the era of the second bottoms, south, or to the bottom prairie of Missouri.

The only sea-beach terrace now existing on the Gulf coast, and with which the second bottoms show a manifest confluence of level and material, is from 18 to 24 feet above tide-water. But the evidences of sea-beach or tidal action extend far back into the interior (Miss. Rept. p. 29), so that in fact, the second bottom of the Pascagoula exhibits *that* structure, and not the usual one resulting from flowing water, throughout its course. The same structure, moreover, extends to some elevation into the bordering uplands, where these sands overlie the Post-pliocene beds and Orange Sand.

The present beach terrace of the gulf coast cannot, therefore, be considered as the true measure of the amount either of depression during, or re-elevation subsequent to, the Champlain epoch. Whether the great absolute elevation of some of the Orange Sand ridges of Mississippi and Alabama (probably exceeding in some cases, 700 feet) necessitates the assumption of even a greater depression than the present beach-marks would indicate, the known facts are hardly adequate to determine.

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