ORIGIN OF LOESS—A CRITICISM.

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INTRODUCTION.

A RECENT paper by Russell[1] has brought the loess question again into serious consideration. The paper is addressed to all who have occasion to deal with the deposits called loess, and to the many who, the author fears, have pictured the Mississippi Valley loess as "a gigantic dunelike ridge extending from the Ohio River to Louisiana, with a high scarp facing the Mississippi and a gentle eastward slope leading to a feather edge some 10 to 15 miles away."[2] Readers of the paper will profit by the somewhat historical treatment of the subject and will find the extensive bibliography useful.

According to the author, the loess question has been particularly troublesome chiefly for two reasons: application of the term to too wide a variety of deposits, and insistence on eolian origin. General agreement on the former proposition can be anticipated, but probably not on the latter. The author champions a new process hitherto neglected or unknown, which he calls loessification. Given appropriate source material, soil creep and its associated processes, acting through a downslope distance of 0.2 to 0.3 of a mile, is said to effect the high degree of size-sorting characteristic of loess. Loessification is essentially complete when subsurface water has introduced sufficient calcium carbonate to serve as a weak cement which halts further creep (or colluviation). Subsequent loss of essential characteristics by weathering is called deloessification. The partially loessified product and other silts resembling loess are classified as loesslike materials.

Russell defines loess as "unstratified, homogeneous, porous, calcareous silt; it is characteristic that it is yellowish to buff, tends to split along vertical joints, maintains steep faces, and ordinarily contains snail shells. . . At least 50%, by weight, must fall within the grain size fraction 0.01-0.05 mm., and it must effervesce freely with dilute hydrochloric acid."[3] In the

[1] Russell, R. J.: 1944, Lower Mississippi Valley Loess: Geol. Soc. America Bull., Vol. 55, pp. 1-40.

[2] Op. cit., p. 34.

[3] Op. cit., pp. 4-5.

lower Mississippi Valley, this material is interpreted as having been derived by loessification chiefly from the backswamp clays of the higher Pleistocene terraces where these have been slightly dissected. Loess mantles the erosional slopes but "commonly fails to reach the summits of the slopes above them."[4] The function and importance of soil creep and allied processes in loess formation deserve more careful consideration than they have received in the past. However, the process of loessification as described will not convince the critical reader because some of the stated effects are definitely at variance with the processes as generally understood. More complete data may eliminate some of the objections, though others now appear more serious.

PROBLEMS OF LOESS DERIVATION.

Russell describes the parent material, backswamp deposits, as typically calcareous clay 50 feet or more in depth. "Silt and coarser sediments are restricted mainly to natural levees. . . Sedimentary complexity along the meander belts contrasts with simplicity in the backswamps . . . [whose deposits] . . . are formed from the finest mechanical sediments."[5] He mentions later that "in typical backswamp deposits there is less sorting, and, on the whole, much finer material."[6] Russell does not report any grade-size analyses of the backswamp deposits, and the reader wonders how much silt, of which 50 per cent by weight falls within the grade-size fraction 0.01-0.05 mm., can be derived from a given quantity of backswamp clay. Apparently the ratio of parent clay to derived silt is high. As the clay must come from levels above the erosional slopes which the loess now mantles, from what parts of the terraces did the clay come? Removal of the requisite amount of clay by soil creep should have involved considerable topographic alteration, though Russell does not mention any such effects nor comment on their absence.

PROBLEMS OF SORTING.

Russell states that "the loss of finer particles goes on at all stages of colluviation and is intensified by churning movements. Surface washing probably contributes to some degree."[7] Also,

[4] Op. cit., p. 9.
[5] Op. cit., p. 13.
[6] Op. cit., p. 26.
[7] Op. cit., p. 24.

"vertical translocation of smaller solids is essentially equivalent to that taking place in the differentiation of the A-horizon of a soil. Surface losses of finer material occur for various reasons."[8]

Loessification is not now in progress in the lower Mississippi Valley, but the author cites no evidence other than his assertion that "churning movements" were extensive or were effective in size-sorting. The reader may easily visualize churning as tending to mix the several grade-sizes rather than to segregate them. With increasing perviousness as loessification proceeds, removal of clay by surface washing would seem to entail at least some gullying with consequent loss of much silt. The "various reasons" might include wind action, but the attempt is to avoid appeal to eolian processes.

Presumably the major part of "vertical translocation of smaller solids" was downward, and they must have been left behind at the bottom during the sorting process. As mentioned above, the relative quantity of these smaller sizes must have been large. Somewhere on the slopes, beneath the partially loessified material, this vast amount of clay should be segregated. The author reports no attempt to locate such an accumulation. Gravel underlies some of the loess and a few stones occur in the basal portion of the latter. However, any churning movements involved in loess formation apparently did not destroy the well-defined basal contact. Downward migration and loss of the smaller sizes should make those sizes progressively more abundant downward in the transitional phases and even in the completed product, inasmuch as "residual concentration of coarser materials . . . continues until . . . mass movement is checked by cementation."[9] The author does not adequately consider this possible field relationship.

PROBLEMS OF MINERALOGY.

Discussion of the minerals involved in loessification is somewhat vague. Russell sees the beginning of loessification in "weathering and pedogenic processes . . . [which convert the upper part of the terrace material into] . . . brown loam that . . . creeps freely on slopes."[10] But he offers no explanation for the statement that "parent materials, well advanced in

[8] Op. cit., p. 30.
[9] Op. cit., p. 38.
[10] Op. cit., p. 38.

loessification, differ mainly with regard to carbonate enrichment, not with regard to constituent particles."[11] After having undergone weathering and pedogenic processes, the "individual minerals ordinarily appear fresh and angular, . . . [and consist] . . . mainly of primary mineral and rock particles. . . Quartz grains are predominant. Calcite grains are conspicuous. Minor amounts of rock fragments, various heavy minerals, and other minerals characteristic of floodplain deposits are present in varying proportions."[12] These statements imply a fairly extensive mineral suite in which loessification should have produced significant changes. In the absence of explanation, the reader must wonder whether "weathering and pedogenic processes" really have no effect on rock fragments and minerals characteristic of floodplain deposits of the lower Mississippi.

The occurrence of calcite grains and their relation to carbonate enrichment raise questions not answered in the paper. Calcite seems to be listed among the detrital minerals supposedly segregated from the parent material which, however, is said to be noncalcareous and to have undergone weathering. As their origin under these conditions seems impossible, perhaps they were developed as a consequencc of carbonate enrichment. If so, what is the process by which discrete calcite grains develop in a porous matrix? If they are concretionary forms, at what stage of enrichment do they appear? What is the grade-size distribution of calcite in the deposit?

Russell states that the carbonate content of loess has been found to range from approximately 4 per cent to 36 per cent. As this carbonate is supposed to be introduced after sorting and terminates the sorting process, a deposit in which 50 per cent, by weight, would be included within the prescribed grade-size limits with 4 per cent of added carbonate might fail to meet the grade-size requirement when the added carbonate amounts to 36 per cent.

PROOFS OF ORIGIN.

Russell cites chiefly two facts as proof that the loess was derived by colluvial processes. One is the apparent gradation into the terrace formations, and the other is the mechanical analyses which "commonly show a tail of fine grain sizes far

[11] Op. cit., p. 29.
[12] Op. cit., p. 30.

beyond the coarse silts that constitute an overwhelming proportion of each sample."[13] From the photographs accompanying the paper, the "loesslike" intermediate material appears to grade into the leached loess overlying the calcareous loess, and apparent continuity into the "brown loam" on the terrace may mean only simultaneous development of soil on the loess and on the uppermost materials on the terrace. No evidence indicates that secondary-carbonate enrichment ever extended throughout the deposit now classed as leached loess, and the thickness of the latter seems to be comparable to that of the noncalcareous intermediate material. Analyses of these two phases show considerable similarity, and the possibility that both may have originated by postglacial weathering of a common source material seems a worthy hypothesis. At least their relationship should be clarified.

Occurrence of a "tail of fine grain sizes" seems to prove merely that some finer grade-sizes accumulated along with the coarser, and not that they represent necessarily a lingering residuum after such sorting as churning and colluviation can produce. Their occurrence also emphasizes the questionable propriety of defining the deposit as homogeneous.

No field or laboratory fact cited seems to disprove eolian origin for the loess in the lower Mississippi Valley. On the contrary, all the features seem compatible with the concept of wind transportation, with marked lodgment of the sediment in the dissected areas along the margins of the windswept terraces. The finer grade-sizes could have adhered to the coarser during transportation, or they may have lodged among the coarser as sand becomes entrapped among pebbles. Contemporaneous soil creep is probable. Detrital carbonate grains could be the chief source of secondary carbonate. It still seems "improbable that a material with such striking physical and field relationships has more than one origin."[14]

The loess problem appears to be as much involved with indistinguishable "fact, opinion, and hypothesis"[15] as before. Loessification must remain an hypothesis unless it can be supported by evidence more convincing.

[13] Op. cit., p. 26.
[14] Op. cit., p. 34.
[15] Op. cit., p. 33.

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