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A Theory of the Loess

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Some years ago in an article entitled "The Loess and Its Fossils,"[1] the writer advanced certain opinions the modification of which seems to be called for by subsequent investigation and thought.

In that paper it was shown, principally from a study of the fossils, that the theory of the lacustrine origin of the loess, held with very few exceptions by American writers,[2] is untenable, and that the origin of the loess in violent fluviatile floods, also sometimes suggested, is equally improbable, and the theory was there offered that the deposit was formed in ponds and lakes similar to those which were formerly abundant in northern Iowa, and by quiet overflows of the sluggish prairie streams.

Although it is extremely probable that certain limited portions of the unmodified loess were deposited in this manner, the theory does not account for the most extensive deposits which usually cap the highest hills, especially along our streams which so often seem to cut their channels through the highest ridges. This difficulty led the writer to further investigation, which led to the conclusion that wind was the prime agency concerned in the formation of these deposits, and that Richthofen's theory of the formation of the Chinese loess, tempered and modified in important particulars, will account for all the phenomena of the loess of the Mississippi valley.

That the loess is not of aquatic origin is indicated by the following facts:

[1] *Bull. Nat. Hist. S. U. I.*, Vol. II, pp. 93-98.

[2] Prof. Calvin, in *Iowa Geol. Survey*, Vol. IV, p. 84, recently suggested the aeolian origin of a part of the loess in Allamakee county.

First.—The land area during the period of the formation of the loess was large as is shown by the remains of great numbers of terrestrial molluscs.[3]

Not only the number of species but the number of individuals of the terrestrial forms is much greater, a fact especially significant since the pond molluscs are all very prolific and had the conditions been favorable to their development much greater numbers of the fossils should occur.

That the shells of the loess were deposited *in situ* and were not carried any great distance by water has already been pointed out by the writer.[4]

Second.—The occurrence of dry region molluscs, such as *Succinea lineata*, *Pupa atticola*, *Patula cooperi*, etc., has also been pointed out.[5] The great majority of the remaining species occur now in a living state throughout Iowa and eastern Nebraska, more particularly in wooded regions. Most of them do not seem to require an excess of moisture, but thrive under present conditions.

Third.—The deposits often occur so high above the surrounding region that it is difficult to conceive of the manner in which water laden with the fine silt could reach the places of deposition.

Fourth.—The siliceous and other particles which the loess contains are generally angular and often show a freshness of fractures which would scarcely appear in particles which had been rolled and washed about by the waters.[6]

Fifth.—The distribution of the loess is better accounted for by the consideration of the action of winds, and by the distribution of the forest areas, as will be shown in the following pages.

The fact that stratification and lamination sometimes appear in the loess, showing the action of water, together with the presence of aquatic molluscs, can also be accounted for under the wind theory; for, as now, so at the time that the deposits were being formed, ponds and lakes of various sizes were scattered over the state, and much of the dust carried out in clouds over these bodies of water would have been deposited in them.

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[3]See *Bull. Nat. Hist. State Univ. Iowa*, Vol. I. p. 209, *et seq. Succinea verilli* and *Pupa decora* should be stricken from the list, and *Pupa holzingeri* Sterki should be added. This species is rather rare in the loess of Nebraska, but in the living state it is quite common in both Iowa and eastern Nebraska.

[4]*Bull. Nat. Hist. S. U. I.* Vol. II, pp. 95 and 96.

[5]*Ibid.* p. 93.

[6]See also Prof. R. D. Salisbury's report in *Ark. Geol. Survey*, Vol. II, pp. 225, 226.

That such bodies of water existed, though, as before stated, not of the extent required by the lacustrine theory, is also shown by the distribution of the pond mollusca, which are found in bands or layers similar to those which may be observed on the edges of our small ponds to-day. These layers are usually of but slight vertical extent, showing that the ponds did not persist during the entire period of deposition of the loess, but, like the ponds of to-day, were subject to changes. But if the water area was not great, comparatively little of the material carried by the winds could be deposited in this manner, and as a matter of fact we find comparatively little loess which shows such origin.

Secondary loess, which had been subsequently eroded and re-deposited on lower lands by running waters, and which usually shows stratification, should not, of course, be considered in this conection.

In the consideration of any theory of the mode of deposition of the loess, two propositions, which seem to be capable of satisfactory demonstration, should be borne in mind, namely, that the loess was deposited under climatic conditions essentially the same as those which prevail in the same region to-day; and that the deposition was slow and continued through a period of considerable extent.

That the first of these propositions is true is shown by the molluscs which furnish the most satisfactory evidence of the character of the conditions supporting life during that period. The same species, with but very few exceptions, which occur in the loess, exist in abundance now throughout the region under consideration, the distribution of the fossils being exactly such as may be observed under present conditions. If, for instance, we compare the modern molluscan fauna of eastern Iowa with that of eastern Nebraska, we find certain differences which are almost exactly duplicated in the loess faunas of the two regions.[7]

For instance, *Succinea lineata* W. G. B., the common succinea of eastern Nebraska, is also the most common succinea of the loess of that region, whereas *Succinea avara* Say, the most common succinea of eastern Iowa, is also the most common species of the genus in the loess of the same region.

The majority of our species show a like distribution,[8] plainly

[7] No reference is here made to the Lamellibranch and Prosobranch fluviatile faunas, which seem to have spread into the region in question from their center of distribution in the southeast comparatively recently.

[8] The loess fossils of Europe are likewise like the modern forms inhabiting the

indicating conditions not essentially different from those which now prevail.[9]

Additional weight attaches to the evidence of these molluscs when we consider that they are in themselves witnesses to an abundant flora of the period, for with scarcely an exception they are purely herbivorous, and frequent places in which shade, protection and food are furnished by abundant plants.

The presence of a vigorous vegetation is further attested by the leaching of peroxide of iron from the loess soil and its deposition in tubules and concretions.[10]

That the amount of moisture was not excessive has already been pointed out. The great preponderance of terrestrial molluscs, at least some of them, now capable of living and multiplying in regions even drier than that under consideration, and the majority of them living abundantly in our state to-day, is certainly significant.

But even if we grant that the average temperature was somewhat lower than at present, and the amount of moisture somewhat greater—conditions by no means essential to the phenomena of the loess—it cannot be questioned that the climate of the loess was sufficiently mild to support an abundant fauna and flora from the very beginning of the formation of these deposits. Glacial conditions certainly no longer existed, for sufficient time must have elapsed after the recession of the glaciers to clothe these prairies with verdure, for the mollusc remains are found in the lowermost portions of the deposits and the favorable conditions necessary for their development must have existed from the very beginning. The prevailing conditions being then essentially the same as now, and the topography of the continent being essential as we find it to-day, it seems fair to assume that the prevailing strong winds were, as now, northwesterly. This point will again be emphasized.

The truth of the second proposition that the loess was deposited slowly is supported by the following facts:

[9] The writer formerly leaned toward the conclusion, drawn by McGee and Call in a paper on the loess of Des Moines, that the occurrence of depauperate forms was proof of a much colder climate than now prevails, but he has since found recent forms of several of the species common in the loess which exhibit great variation under different conditions even in the same locality. For example, shells of living *Mesodon multilineata* Say, from different points in the immediate vicinity of Iowa City, vary from 15 to 26 mm. in greater diameter, while fossils of the same species from the same region now in the writer's possession vary from 12 to 23 mm. This variation seems to be purely local and cannot be assigned to general climatic conditions. This was suggested in the writer's paper to which reference has already been made, p. 93, footnote 2.

[10] See *Le Conte's Geology* pp. 136, 137.

First.—The vertical distribution of the molluscs. The writer has already shown[11] that these molluscs were most probably deposited *in situ*, and sufficient time must have elapsed at least for the production and developement of the successive generations.

Second.—The fineness and homogenity of the loess material. This is of importance, for had the deposits been made quickly by powerful concentrated agencies, whether wind or water, much more coarse material would have been mingled with the fine debris.

Third.—No plant remains of undoubted loess origin occur. As the plants undoubtedly existed during the entire period the deposition must have gone on so slowly that ample time was given the plant remains to crumble in decay and mingle with the soil.

With these propositions as an aid let us consider the following conception of the formation of the loess deposits:

The region formerly covered by the glaciers remained a vast drift-covered plain after the recession of the glaciers.

No loess was to be found, but the surface material consisted of unassorted drift, here and there heaped up in ridges and moraines. Streams soon cut their way through this material[12] and ponds more or less numerous remained in the depressions of the plain.

The climatic conditions having so improved, plants, at first the smaller forms, spread over the plain, and soon trees, in whose shades numerous molluscs lived and prospered, appeared in narrow lines along the streams, the surface conditions being not unlike those of the northwestern portions of the state to-day. Forests gradually spread over portions of the area, principally along the river-valleys and on hillsides in the manner pointed out by Prof. Macbride.[13]

When vegetation, especially the forests, had gained a foothold, then commenced the deposition of the loess.

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[11] *Bull Nat. Hist. S. U. I.*, Vol. II, p. 95.

[12] If it be true that our streams generally follow the highest ridges of the drift, even without reference to the loess, i. e. if the streams run in *glacial* ridges (and the writer knows of some cases where this is true), then the fact can be accounted for by the theory offered in the paper by McGee and Call already cited, pp. 22-23, but the theory fails when applied to the loess because of the climatic conditions required.

[13] See paper: *Forest Distribution in Iowa and its Significance, in this volume.*

It is but fair to say that the theories thus presented by Professor Macbride and the writer, while leading to the same results, were developed from different standpoints along entirely independent lines of investigation.

The strong northwesterly winds blowing over the prairies, which during a part of the year at least were quite dry, gathered up clouds of sand and dust. The coarser material was blown and rolled about on the surface, the constant grinding furnishing renewed supplies of finer material, while this finer material was carried higher, being finally swept over the forests, and there deposited.[14]

That this is not a fanciful view of the work actually performed by winds has been nicely demonstrated in eastern Iowa during the past two years. High winds prevailed during considerable portions of both years, the dry spring of 1895 being particularly remarkable in this respect, and observations upon the material so transported were made in Johnson county. In the northern prairie portion of the county, beyond Solon, fine sand was heaped up in open places, in some cases to a depth of over a foot, within twenty-four hours, while fine dust only was carried into adjacent groves, and was there deposited upon every available surface to a depth of not less than one mm. The writer's observations of the effect of the winds which so prevail in Nebraska also confirm this.

That this fine material now constituting the loess, was so deposited in forests is further shown by its distribution. That the loess and the original forest area in eastern Iowa almost exactly coincide is a well established fact, which has been demonstrated beyond question by McGee.[15]

The forests are found along the streams, and also principally on the southern and eastern slopes of the hills, and the loess is found in exactly the same situations.

Indeed it has often been suggested that there is something peculiar to the loess which renders it favorable to the development of the forests—whereas the fact seems to be that the forest is especially favorable to the deposition of the loess if lying adjacent to or near drift-covered plains.

That the forest could have preceded the loess is shown by the fact that scrub growths of bur oaks have been able to gain a foothold along the shores of some of our northern (Iowa) lakes and streams in a purely glacial soil, thus forming the nucleus of a forest in comparatively recent time, while in the same region in groves evidently somewhat older a thin layer

[14] Interesting observations were made in 1894 by F. H. King (see *Eleventh An Rep of the Wisconsin Agr. Ex. Sta.*, p. 292 *et seq.*) upon the effect of winds on vegetation in drifting soil which bear out the conclusions presented in this paper.

[15] U. S. Geol. Sur., 11th Ann. Rep., Part I, pp. 296, et seq.

only of loess-like soil is found.[16] Quite important too is the argument furnished by the physical properties of the loess material. This in eastern Iowa is always very easily eroded, so much so that upon cleared hillsides it is often impossible even for bluegrass to gain a foothold, and failure has been the universal result of all attempts to cultivate such slopes. This being the case it seems hardly probable that trees, which require more time to become established than do smaller plants, could have gained a foothold upon these unstable hilltops had they been formed. The organic matter which undoubtedly accumulated in these forests gradually decayed, mingled with the alluvium brought by the winds, and was finally consumed in leaching iron oxides from the lower strata of deposit.

Other, smaller, vegetation no doubt effected the deposition of fine alluvium in the same manner, but to a lesser degree, and by the aid of this probably were formed the thin layers of loess which sometimes occur in prairie country.

The element of time still remains to be considered. Without an attempt at exact computations, attention is simply called to the fact that in eastern Iowa the loess in no place exceeds fifty feet in thickness, the average being probably about ten or twelve feet, and that if we assume, for example, the deposition of a minimum of one mm. a year, the time required for the formation of the entire deposit would not be unreasonably great.

The deposition of loess material is no doubt going on in this manner to-day, and the investigation of this phase of the subject is worthy the attention of the most careful observers. The foregoing statements apply particularly to the loess of eastern Iowa. In the western part of the state and in eastern Nebraska much thicker deposits occur, which differ in many respects from the loess of eastern Iowa.

The western loess is thicker, coarser, with more siliceous material, and the writer has found it more frequently interlaminated with sand. That it is much less easily eroded because of this difference in composition is a well known fact.

From the general topographical and climatic relations which exist between the eastern and western regions to-day, it is probable that during the loess period, as now, the western region was drier (a fact also attested by the rather greater abundance of dry-region molluscs in its loess), and that strong winds were

[16] A further investigation of the soils in prairie groves of this kind is contemplated during the coming summer.

of more frequent occurrence than in the eastern region. The stronger winds and drier climate would coöperate in effecting the transportation of larger quantities of alluvium, which would also be somewhat coarser and more siliceous. The frequent interlamination of sand with the loess can be accounted for by more violent storm-periods.

The writer has seen such alternating deposits of sand and loess in Cuming county, Nebraska, near the margin of the Sand Hill country, which clearly show wind-action.

Much could also be written of the changes which probably took place after the deposition of many of the beds of loess, of the denudation of some of the hills, the modifications of the deposits by erosion, and kindred subjects, the discussion of which in connection with this question would be legitimate and desirable, but this would extend this paper beyond reasonable limits, and is therefore postponed.

The consideration of the facts herein briefly presented leads, then, to the conclusion that the loess is of æolian origin, and that it was deposited principally in forests and to a lesser extent in dense growths of smaller plants, while proportionately small quantities only were carried directly into the waters and there deposited.

PERFECT FLOWERS OF SALIX AMYGDALOIDES ANDS.

B. SHIMEK.

A native specimen of *Salix amygdaloides* Ands. growing in Iowa City, produces peculiar flowers which seem to be worthy of mention.

Whereas all *Salicaceae* habitually produce dioecious flowers, this specimen has, for at least three successive seasons, borne flowers most of which are perfect.

The accompanying figures will give a clearer idea of these peculiar flowers.

The hairy bract is shown at the extreme left; next to this is the narrow dark honey-gland (there are really three such glands in line in each flower) here occupying an unusual position, as in willows the honey-gland is normally in the axil of the pedi-