1982

Clay In Loess And Clay Content Of Loessial Soils In Southeastern Nebraska

David T. Lewis
University of Nebraska-Lincoln

Laurence E. Brown
Soil Conservation Service

1982. *Transactions of the Nebraska Academy of Sciences,* X:43-47.

CLAY IN LOESS AND CLAY CONTENT OF LOESSIAL SOILS IN SOUTHEASTERN NEBRASKA*

David T. Lewis and **Laurence E. Brown**

Department of Agronomy
University of Nebraska-Lincoln
Lincoln, Nebraska 68583

Soil Conservation Service
Salina, Kansas 67401

Clay content of Peorian loess and of control sections in soils formed from this loess was determined along transects perpendicular to loess sources in southeastern Nebraska. Maps showing geographic location of areas of equal clay content in the loess and in the control sections were constructed to show relationships. In the parent loess, clay content and distance from source were significantly linear in relationship. In coarser-textured loess relatively near the source, clay content of control sections of soils formed in the loess were also linear. In loess more distant from the source, little relationship between clay content in control sections and distance of parent loess from source was evident. The overall relationship between clay content of control sections and distance was quadratic. Apparently in more clayey loess farther from the source, pedogenic factors other than parent-material clay content dominates the reasons why clay content in loessial soils differs. The maps are useful in development of soil surveys within the study area of southeastern Nebraska.

† † †

INTRODUCTION

Loess of Peorian age (Schultz and Stout, 1945; Lugn, 1962; Reed and Dreeszen, 1965) is parent material for soils throughout much of southeastern Nebraska. For example in Lancaster County, 65% of upland soils formed in this loess (Brown, 1980). These loessial soils are similar in many ways, for they formed under rather uniform conditions of climate, vegetation, time, and topography as well as parent material. However, these soils are not all the same. Major differences in content and distribution of clay in the solum, and differences resulting from altered drainage and aeration of the soil, because of the differences in clay content, exist within the soils of the region. Directly or indirectly, clay content of the parent loess governs to a large degree clay content of the soil formed in the loess. Therefore, if regions of uniform clay content within the parent loess are mapped, predictions of the geographic occurrence of soil series that differ mainly because of differences in clay content and factors associated with this difference are possible. This was the reason for this study. The aim was to map clay content of loess and soils in that loess to facilitate the completion of soil surveys in the region.

The region included much of Cass, Gage, Johnson, Lancaster, Nemaha, Otoe, Pawnee, and Richardson counties in Nebraska. The area is within the Sharpsburg-Marshall, the Wymore-Pawnee, and the Marshall-Monona soil associations (Elder, 1969). Loessial soils are mainly within the Monona, Marshall, Sharpsburg, and Wymore soil series. These soils are Mollisols and differ mainly in the amount of clay in their subsoil, called the "control section." They are underlain at depths of usually >1 m by loess. This loess is the C horizon of the soil profile. Clay contents of control sections are usually 26 to 30% for the Monona, 31 to 36% for the Marshall, 37 to 42% for the Sharpsburg, and 42 to 48% for the Wymore soil series. Soil properties resulting from decreased drainage and aeration as clay content increases are also apparent as differences among these soils. Loess sources in the region were probably the valleys of the Platte and Missouri rivers (Reed and Dreeszen, 1965).

Established hypotheses suggest that clay content of loess and of loessial soils increases with distance from the source of loess (Smith, 1942; Hutton, 1947; Ruhe, 1969 and 1973; Frazee, Fehrenbacher, and Krumbein, 1970). Thickness of loess mantle and rate of loess deposition also decrease as distance from the source increases (Kollmorgen, 1963). A thin, slowly deposited loess weathers more rapidly than a thicker,

*Published as Journal Series No. 5614, Agricultural Experiment Station, University of Nebraska-Lincoln.

more rapidly deposited loess. Therefore, even though its clay content was initially similar to that of a thicker loess, weathering within the thin loess increases its clay content within a relatively short time (Hutton, 1947; Springer, 1948), assuming clay-forming minerals exist within the loessial silts. Hence, in an idealized situation within the study area where clay content of loess mainly governs differences in upland soils that form, Monona soils should exist nearest the source of loess followed by Marshall, Sharpsburg, and Wymore soils in sequence as distance from the source increases. Following the intent of the study, location of map boundaries between these major soil areas should be more apparent once clay content of loess across the region was established. In addition, the relationship between clay content of loess and the clay content of loessial-soil control sections could be clarified.

MATERIALS AND METHODS

Forty-seven soil sampling sites were located along transects perpendicular to loess sources in the region. Sites were on

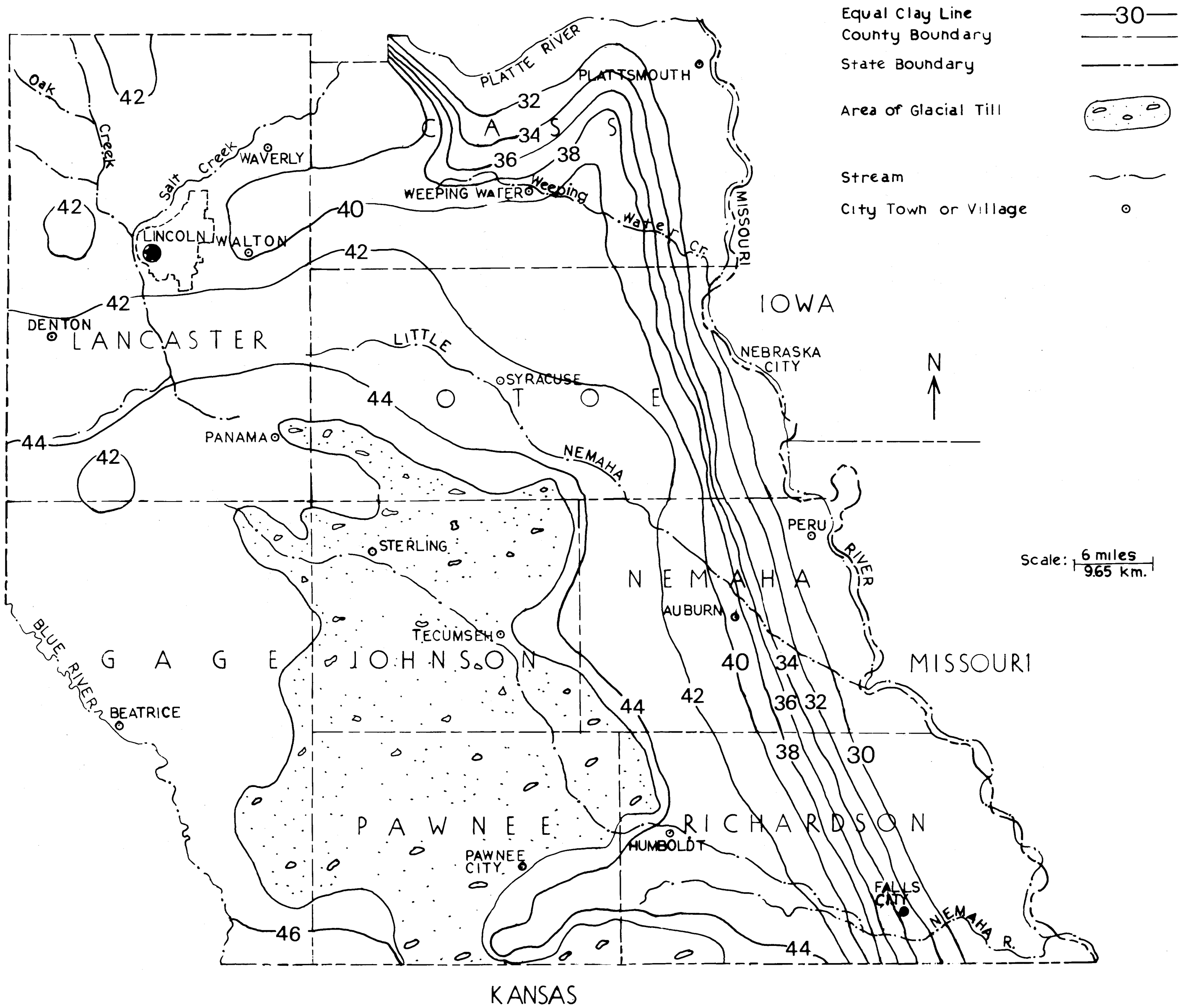

FIGURE 1. Iso-clay lines connecting equal average clay content in the control sections of the soil profile.

linear, upland slopes with gradients of 4 or 5%. Convex slopes and narrow, convex divides were avoided as sample sites because erosion on these landscape components has usually severely altered soil properties. No sample was taken in parts of the study area where loess is very thin and mantles only narrow, convex divides on a glacial till landscape (Figs. 1 and 2).

Sample sites were selected to be representative of the landscape. Several pedons at each sampling site were examined to determine the pedon modal for that site. A soil profile was exposed by digging a hole, horizons were described (Anonymous, 1975), and samples of each were taken. Care was taken to sample the C horizons well beneath the solum, where they showed no apparent effect of soil formation, and represented the parent loess.

Clay content was determined by the pipette method (Anonymous, 1967). Samples were treated with sodium acetate to remove carbonates and with sodium dithionite to

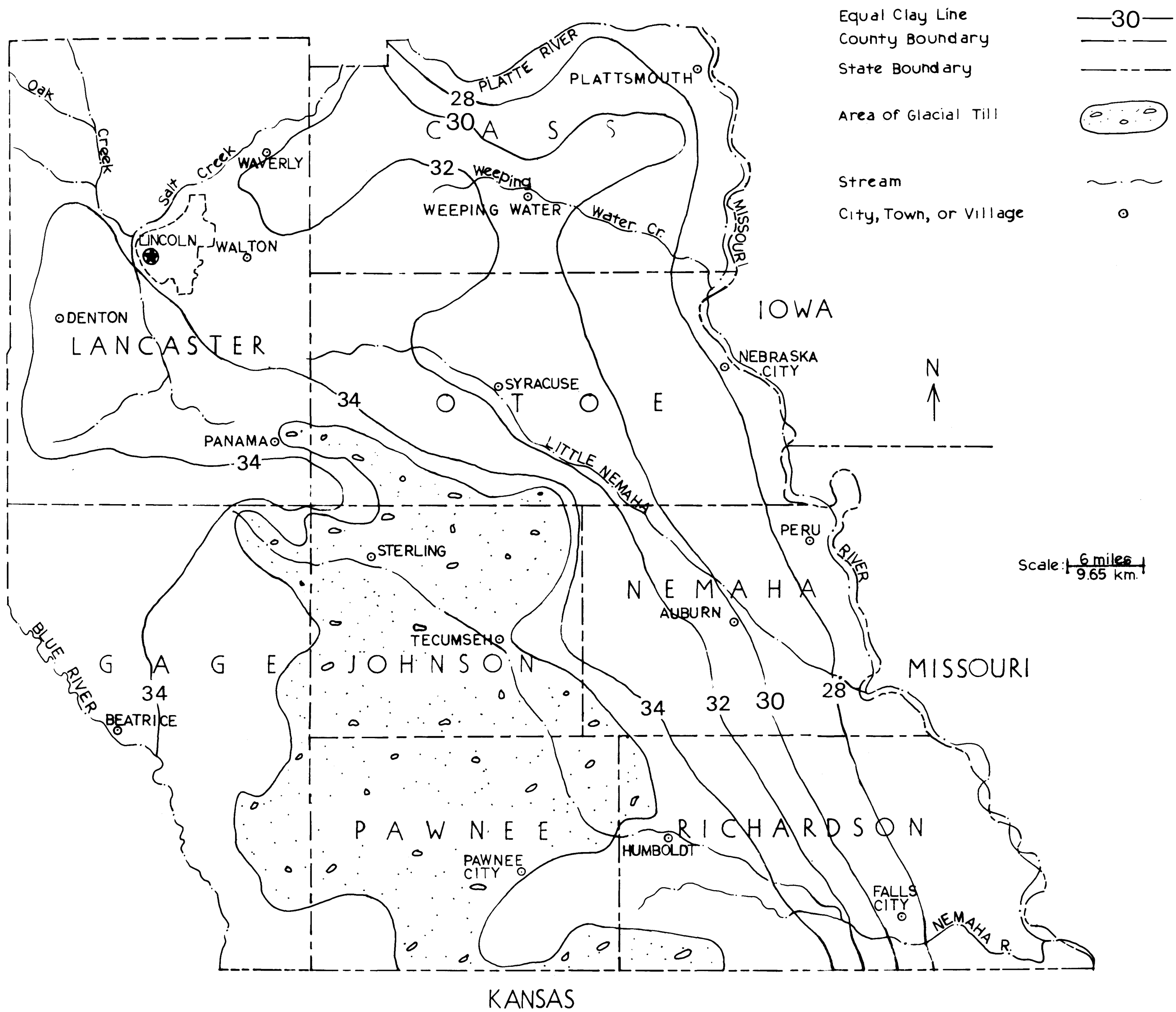

FIGURE 2. Iso-clay lines connecting equal clay content in the C horizons of the soil profile.

remove iron prior to dispersion with sodium hexametaphosphate. Samples with known clay content were run as check samples with the study samples. Weighted averages of control sections were calculated. Selected control sections were either the argillic horizon, its top 50 cm, or the profile depth from 25 to 100 cm (B1, B2, and B3 horizons usually) (Anonymous, 1975). Clay contents of control sections and of parent loess (C horizon) were plotted on base maps of the study area. Lines joining points of equal clay distribution were established on the maps so that geographic areas of soils and loess with certain ranges in clay content could be visualized (Figs. 1 and 2).

RESULTS AND DISCUSSION

Maps constructed following the described procedure are presented in Figures 1 and 2. It is apparent that a relationship exists between clay content of control sections of soils and that of the parent loess (C horizon). A tendency for clay content of soils and loess to increase with distance from presumed source is also evident. This tendency is more apparent near the source than farther from it. Statistical analysis suggests that while the relationship between clay content of the loess and distance from the source is significantly linear, that between clay content of control sections and distance from source is quadratic. This suggests that factors other than clay content of the parent loess in part govern clay content in the control sections (Fig. 3). These calculations indicated that for control sections, 62% of the variation in clay content could be attributed to variation in clay content of parent loess. The remaining variation must be accounted for by pedogenic factors such as those described by Al-Janabi and Drew (1967), Lewis and Drew (1973), Al-Barrak and Lewis (1978), or by factors as yet unexplained. Others (Hanna and Bidwell, 1955) have suggested that variation in soil clay content is wholly dependent on that of the parent loess. In the loess of lower clay content (<32%) or within the area east and north of the 32% clay line for C horizons (Fig. 1), relationship between distance from source and clay content of soil control sections was linear. Apparently in soils formed in the coarser-textured loess, clay content of parent loess is the significant determinant of clay content of control sections. In the finer-textured loess farther from the source, other factors become effective. One may be the rate at which loess was deposited differentially on a sloping landscape far from the source and the stimulus this had on the rate of weathering and consequent clay formation in the soil (Al-Janabi and Drew, 1967).

It is evident from Figures 1 and 2 that within the areas of 32 to 34% clay in the loess, control-section clay contents may vary from about 40% to nearly 47%. In the past, loess thickness and colors that suggest lack of adequate drainage have been associated with higher clay contents of loessial soils (Al-Janabi and Drew, 1967). This relationship was not

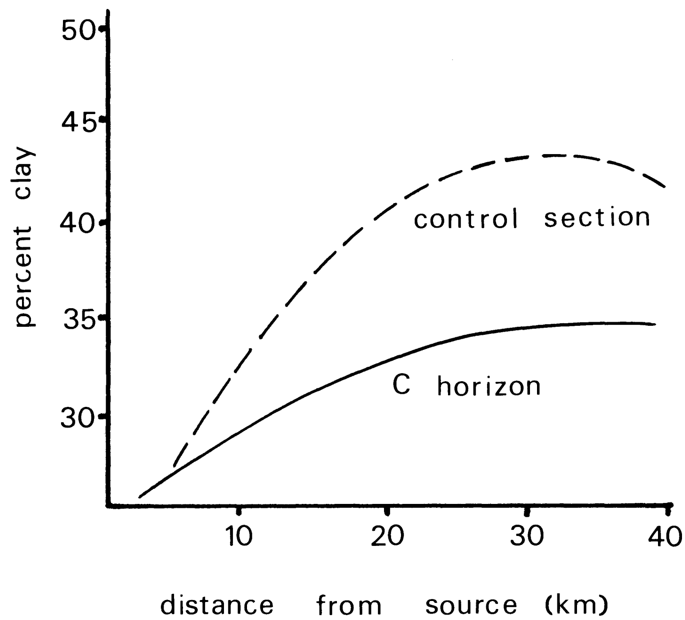

FIGURE 3. Effect of distance from loess source on clay content of parent loess and soil profile control sections.

evident in this study. Loess at all sites sampled was in excess of 250 cm thick. In addition, loess with grayer hues (2.5Y or 5Y–Munsell system) was not higher in clay content than browner loess, nor were soils with high clay contents in their control sections consistently associated with the grayer Peorian loess.

CONCLUSIONS

It appears that within the area of coarser-textured loess (⩽32% clay) a significant relationship between distance from loess source and clay content of soil control sections exists. Therefore, boundaries separating major areas of Sharpsburg from Marshall soils as well as boundaries separating major areas of Marshall from Monona soils may be established. Here, soil clay content may be explained entirely by clay content of the parent loess. Beyond distances from the source greater than that of the 32% clay line (Fig. 1), the relationship is sufficiently unclear to warrant hesitation in predicting the occurrence of Sharpsburg or Wymore soils based on the clay content of parent loess.

REFERENCES

Al-Barrak, S., and D. T. Lewis. 1978. Soils of a grassland-forest ecotone in eastern Nebraska. *Journal of the Soil Science Society of America,* 42:334-339.

Al-Janabi, A. M., and J. V. Drew. 1967. Characterization and genesis of a Sharpsburg-Wymore soil sequence in southeastern Nebraska. *Proceedings of the Soil Science Society of America,* 31:238–244.

Anonymous. 1967. Soil survey laboratory methods and procedures for collecting soil samples. *Soil Survey Investigation Report of the United States Department of Agriculture, Soil Conservation Service,* 1:1–42.

_____. 1975. Soil taxonomy. *Agricultural Handbook of the United States Department of Agriculture, Soil Conservation Service,* 436:1–759.

Brown, L. E. 1980. *Soil survey of Lancaster County, Nebraska.* Lincoln, United States Department of Agriculture, Soil Conservation Service: 174p.

Elder, J. A. 1969. Soils of Nebraska. *Resource Report of the University of Nebraska Conservation and Survey Division,* 2:1–60.

Frazee, C. J., J. Fehrenbacher, and W. Krumbein. 1970. Loess distribution from a source. *Proceedings of the Soil Science Society of America,* 34:296–301.

Hanna, R. M., and O. W. Bidwell. 1955. The relation of certain loessial soils of northeastern Kansas to the texture of the underlying loess. *Proceedings of the Soil Science Society of America,* 19:354–359.

Hutton, C. E. 1947. Studies of loess derived soils in southwestern Iowa. *Proceedings of the Soil Science Society of America,* 12:424–431.

Kollmorgen, H. L. 1963. Isopachus map and study on thickness of Peorian loess in Nebraska. *Proceedings of the Soil Science Society of America,* 27:445–448.

Lewis, D. T., and J. V. Drew. 1973. Slick spots in southwestern Nebraska—patterns and genesis. *Proceedings of the Soil Science Society of America,* 37:600–606.

Lugn, A. L. 1962. The origin and sources of loess in the Central Great Plains and adjoining areas of the Central Lowland. *University of Nebraska Studies,* new series, 26: 1–105.

Reed, E. C., and V. Dreeszen. 1965. Revision of the classification of Pleistocene deposits of Nebraska. *Bulletin of the Nebraska Geological Survey,* 23:1–65.

Ruhe, R. V. 1969. *Quaternary landscapes of Iowa.* Ames, Iowa, Iowa State University Press: 169–195.

_____. 1973. Background of model for loess derived soils in the upper Mississippi River Basin. *Soil Science,* 15: 250–253.

Schultz, C. B., and T. M. Stout. 1945. The Pleistocene loess deposits of Nebraska. *American Journal of Science,* 243:231–244.

Smith, G. 1942. Illinois loess: variations in its properties and distribution. *Bulletin of the Illinois Agricultural Experiment Station,* 490:139–184.

Springer, M. E. 1948. The composition of the silt fraction as related to the development of soils from loess. *Proceedings of the Soil Science Society of America,* 13:461–467.