PETROGRAPHIC STUDY OF CARY OUTWASH IN POTTER, WALWORTH, AND BROOKINGS COUNTIES, SOUTH DAKOTA

K. Y. Lee
State Geological Survey, Vermillion

ABSTRACT

A detailed textural study of the Cary outwash in Potter, Walworth, and Brookings counties shows that the outwash deposits of sand and gravel were formed in a sequence of three glacial conditions. First, normal glacial meltwaters deposited the finer sand and gravel; then flood conditions caused coarser material; then the more normal glacial conditions caused a return to finer sand and gravel deposition. The average weight percentage of each grain size limit of the outwash sediments is about 8 percent cobble, 48 percent pebble, 10 percent granule, 33 percent sand, and one percent silt and clay. The constituents of the coarse detritus, ranging from cobble to granule in size, average 47 percent limestone and dolomite, 32 percent igneous and metamorphic rocks, and 21 percent shale, ironstone, and sandstone. The sand and silt fractions are composed mainly of rounded to sub-rounded quartz with accessory minerals. On the basis of the physical properties, the sand and gravel, which occur throughout the outwash, are good water-bearing sediments, and fine materials for road and building construction.

INTRODUCTION

The petrographic study of the Cary outwash in Potter, Walworth, and

TABLE I

GENERALIZED GEOLOGIC SECTION FOR THE SURVEYED AREAS IN POTTER, WALWORTH, AND BROOKINGS COUNTIES

Recent			Alluvium
Pleistocene	Wisconsin	Mankato	Not present
		Cary	Till (20-45 ft.)*, Outwash (2-158 ft.), Lake Sediments (4-10 ft.)
		Tazewell	Till (12-50 ft.)*, Outwash (5-105 ft.)
		Iowan	Till (20-113 ft.), Outwash (5-38 ft.)
	Pre-Wisconsin		Not exposed

* Exposed thickness

[1]Publication authorized by the Director, South Dakota Geological Survey.

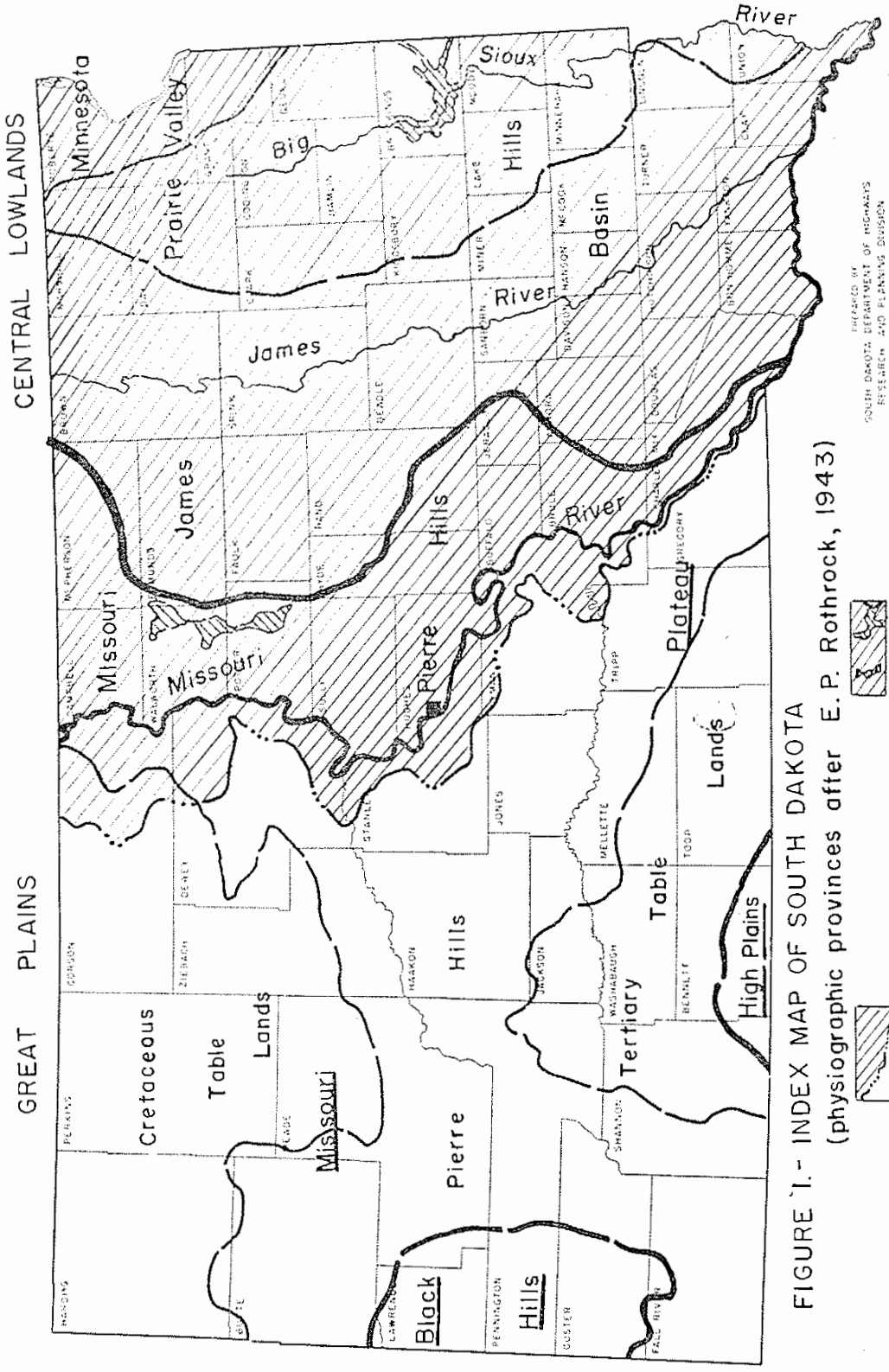

FIGURE 1.- INDEX MAP OF SOUTH DAKOTA
(physiographic provinces after E. P. Rothrock, 1943)

Brookings counties (Fig. 1) was undertaken in conjunction with the investigation of the economic geology of Wisconsin glacial drift by the South Dakota Geological Survey during the summers of 1955, 1956, and 1957 (3, 4, 5). The Cary Drift is one of the subdivisions of Wisconsin stage (Table I). The outwash deposits of sand and gravel in the surveyed area cover about 223 square miles.

PETROGRAPHY

Generally speaking, the petrographic study of the Cary outwash sediments includes texture, composition, structure, conditions of transportation and deposition, and source.

Texture

Texture is one of the major physical properties of clastic sediments, and consists of the study of the sorting coefficient and median diameter by size analysis; the sorting coefficient is generally an index of the range of conditions present in the transporting fluid, and the median diameter is controlled commonly by the strength of current that moved the material to the site of deposition. Nevertheless, both of them are influenced directly by the configuration of pre-outwash landforms.

The significance of the degree of sorting is that it indicates the distribution of uniform size present in a sediment, shown by the cumulative curves (Fig. 2). According to Trask (7), well-sorted sediments have a sorting coefficient (SO) less than 2.5; moderately sorted sediments range from 2.5 to 4.0; and poorly sorted sediments have values larger than 4.0. Accordingly curves 1, 3, and 4 indicate that the outwash sediments are very well-sorted, and were formed by a current of uniform strength. Curve 2 has a value of SO larger than 4, and indicates that this outwash sediment was poorly sorted, and was formed chiefly by a current of variable strength. On the basis of size distribution, the average weight percentage of the rounded to sub-rounded Cary outwash sediments is about 8 percent cobble, 48 percent pebble, 10 percent granule, 33 percent sand, and one percent silt and clay; they show SO values of the cobble-granule size detritus averaging 4.5, and of the sand fraction averaging 1.9; thus the Cary outwash deposits range from poorly sorted to well-sorted. The median diameter of the Cary outwash fragments ranges from 0.26 to 130 mm, and averages 9 mm, which indicates that the principal grain size is pebble. Therefore the outwash sediments required a fluctuating turbulent current to move them to the site of deposition.

Generally the cobbles and granules are more or less segregated as to size; for example, in the middle part of the outwash the coarse material is comparatively predominant, whereas in the upper part or near the base of outwash, the gravels are commonly intercalated with rather abundant sand lenses. As mentioned by Cooke, James, and Mawdsley (1), there is a general relation between thickness of the bed and the coarseness of cobble (and roundness) in any given district. The thinner outwash gravels are usually made of smaller, better-rounded pebbles and granules; however there is a

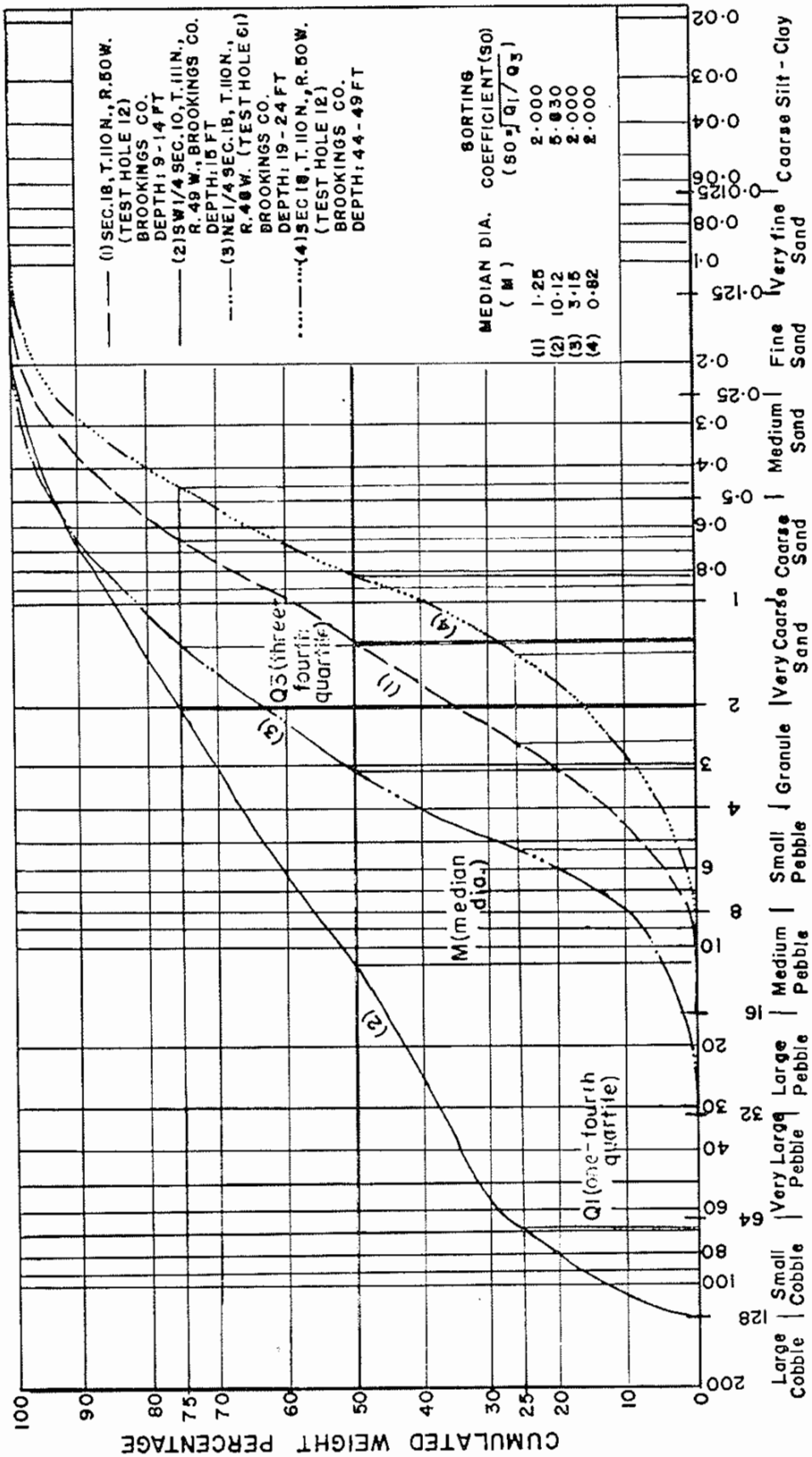

FIGURE 2.- CUMULATIVE CURVES SHOWING GRAIN-SIZE FREQUENCIES OF SOME SELECTED CARY OUTWASH SEDIMENTS

progressive decline in size of the cobbles and pebbles as the outwash is followed along the strike away from the place of maximum thickness of the pre-outwash channel fillings.

Composition

The Cary outwash is made up of 1) coarse rock fragments of cobble-granule, 2) median sand detritus, and 3) fine silt and clay. Of these the coarse fraction of rock fragments is the principal material; the sands with some silt and clay are subordinate in amount. Accessory minerals are generally sporadically present throughout the masses of sand and silt.

The rock fragments of Cary outwash consist chiefly of three major rock types: 1) calcareous rocks (limestone and dolomite), 2) crystalline rocks (igneous and metamorphic types), and 3) clastic rocks (shale and sandstone). The composition of the coarse detritus, ranging from cobble to granule in size, averages 47 percent limestone and dolomite, 32 percent igneous and metamorphic rocks, and 21 percent shale, sandstone, and ironstone. The sand and silt fractions are composed mainly of quartz, with accessory minerals (chiefly tourmaline, zircon, garnet, hornblende, augite, olivine, and iron-oxides).

Structure

The structure of Cary outwash deposits shows good tabular and lenticular cross-bedding in the sand fraction. The coarse gravels are commonly intercalated with silt and sand lenses, in which cut-and-fill structure is well-developed. Imbrication of flatter pebbles and cobbles is generally present, and shows the direction of current movement.

Conditions of Transportation and Deposition

The Cary outwash sediments were moved and deposited mainly according to the Rubey's "Impact Theory," which states that the weight of the coarsest materials transported by the current is related to the sixth power of the velocity (6). Accordingly the "Impact Theory" is tentatively indicated by the median diameter of the outwash (Fig. 2). As to the result of this study, the Cary outwash deposits were formed in a sequence of three glacial conditions. First, normal glacial meltwaters deposited the finer sand and gravel with a median diameter less than 2 mm (Fig. 2, Curve 1), then flood conditions caused coarser material with a median diameter larger than 2 mm (Fig. 2, Curves 2 and 3), then the more normal glacial conditions caused a return to finer sand and gravel deposition (Fig. 2, Curve 4). Both the upper and lower parts of the Cary outwash deposits were formed under normal glacial conditions, with transitional glacial and flood conditions in the middle part of the outwash body.

Source

According to the gross composition, the Cary outwash was derived directly from the Cary till, which is composed to a large extent of fragments of Paleozoic sediments and Precambrian granitic rocks from the north, and to a minor extent of local Cretaceous sediments.

ECONOMIC VALUE

On the basis of the physical properties, the Cary outwash sand and gravel are generally suitable for road and building construction due to the lower value of the plasticity index, and they are good waterbearing sediments to yield an adequate water supply in the surveyed areas.

CONCLUSION

The petrographic study of the Cary outwash shows that the textural data reflects not only the conditions of transporting current, but also the configurations of depositional environment. Generally the configuration of the pre-outwash channels plays a major role in the deposition of outwash; the supply of the Cary outwash materials in association with some diastrophic movement might have aggrevated the processes of deposition during the Cary ice retreat.

ACKNOWLEDGEMENTS

The writer expresses special gratitude to the South Dakota Geological Survey for providing the opportunity for this research, to Dr. A. F. Agnew, Director of the South Dakota Geological Survey, for his reading of the manuscript, and to Dr. R. E. Stevenson for generously sharing his knowledge of the Cary drift in eastern South Dakota.

BIBLIOGRAPHY

1. Cooke, H. C.; James, W. F.; and Mawdsley, T. B., Geology and Ore Deposits of the Routh-Harn-Canaw Region, Quebec Geol. Survey, Canada, Dept. Mines, Mem. **166,** 105-106 (1931).

2. Flint, R. F., Pleistocene Geology of Eastern South Dakota, U. S. Geol. Survey, Prof. Paper **262,** 168 (1955).

3. Lee, K. Y., Geology and Shallow Water Resources of the Blue Blanket Valley and Hoven Outwash, Potter County, South Dakota, S. Dak. Geol. Survey, Rept. Invest., **80,** 57 (1956).

4. Lee, K. Y., Geology and Shallow Water Resources Between Hoven and Bowdle, South Dakota, S. Dak. Geol. Survey, Rept. Invest., **83,** 58 (1957).

5. Lee, K. Y., Geology and Shallow Ground Water Resources of the Brookings Area, Brookings County, South Dakota, S. Dak. Geol. Survey, Rept. Invest., **84,** (1958).

6. Rubey, W. W., The Force Required to Move Particles on a Stream Bed, U. S. Geol. Survey, Prof. Paper **189-E,** 121-141 (1938).

7. Trask, P. D., "Origin and Environment of Source Sediments of Petroleum," 323, Gulf Pub. Co., Houstin (1932).