[AMERICAN JOURNAL OF SCIENCE, VOL. 259, MARCH 1961, P. 207-210]

DRAINAGE ALIGNMENT IN WESTERN SOUTH DAKOTA*

EVERETT M. WHITE

South Dakota State College, Brookings, South Dakota

ABSTRACT. Northwest-southeast stream alignment in western South Dakota coincides with the prevailing wind direction. This alignment appears to be due to the periodic accumulation of locally derived eolian sediments in drains which are not aligned. Because of this deposition, unaligned drains are not elongated by water erosion as rapidly as those which are aligned. Eolian sediment can be derived locally and deposited when the prairie vegetation is destroyed by fire or weakened by drought.

INTRODUCTION

The northwest-southeast alignment of the tributary streams of the eastflowing rivers of western South Dakota and of streams in other plains states has been attributed to wind action. The prevailing winds are from the northwest. Although Russell (1929, p. 255) considered other modes in the area where Pierre shale is the upper formation, he suggested the alignment probably was induced by sand dunes in an earlier period. Baker (1948, p. 8) proposed that the drainage pattern was caused by the integration of deflation basins. Later, Flint (1955, p. 159) discussed the dune and deflation hypothesis and concluded:

> "Although some form of eolian control seems the probable explanation of the lineated topography, the exact mechanism of stream development is not yet clear."

Soil studies in the area where Pierre shale is the main soil parent material have helped to establish the mechanism.

DISCUSSION OF THE DUNE HYPOTHESIS

As pointed out by Flint (1955, p. 159), " . . . longitudinal dunes are not present in most of western South Dakota in which the parallel drainage pattern occurs." Thus, the alignment would have to be relict from the time the dunes migrated across the area. Any drainage entrenchment would follow the ancestral aligned channel. However, the short, geologically young tributaries of the White and Bad Rivers tend to be aligned. Their alignment cannot be attributed to some historic event. Crandell (1958, p. 50) concluded the drainage alignment was formed from middle Pleistocene time to the present.

DISCUSSION OF THE DEFLATION HYPOTHESIS

Deflation basins formed in weathered shale are numerous in broad upland areas between the eastflowing rivers in western South Dakota. According to Baker (1948, p. 7), wind erosion may have been more active during the glacial epochs. Some of the basins may have been initiated at the same time as some of the frost features found in the soils of the area. Baker (1948, p. 8) suggests the basins may be enlarged by the eolian removal of material that is powdered and flocculated by desiccation following ponding. If rain were sufficient to cause ponding, vegetation should be abundant at the edge of the basin by the time it became dry. This vegetation should collect any aggregates of clay

* Approved for publication by the Director of the South Dakota Agricultural Experiment Station as Journal Series No. 466.

moved by saltation so that a dune would form. None have been found either at the southeast edge of the few basins examined in the field or reported in the literature about this area. It is doubtful that much sediment could be removed from the basins by winds without a dune's forming unless the vegetative cover was absent. Crandell (1958, p. 49) observed a dense growth of vegetation in basins which were swamps or ponds earlier in the season.

Contrary to the idea of " . . . deposition by winds in ridges with depression scouring . . . " (Baker, 1948, p. 8), the soils usually are thinner on the narrow ridges than in the adjacent upland valleys or basins. The reverse should be true if deposition occurred on the ridges. In addition, no olive-colored eolian mantle of Pierre sediments has been found on soils formed from Tertiary bedrock that occur south of Pierre-derived soils. If large quantities of clay sediment had been removed from the soils, parna should have been deposited as in Australia (Butler and Hutton, 1956).

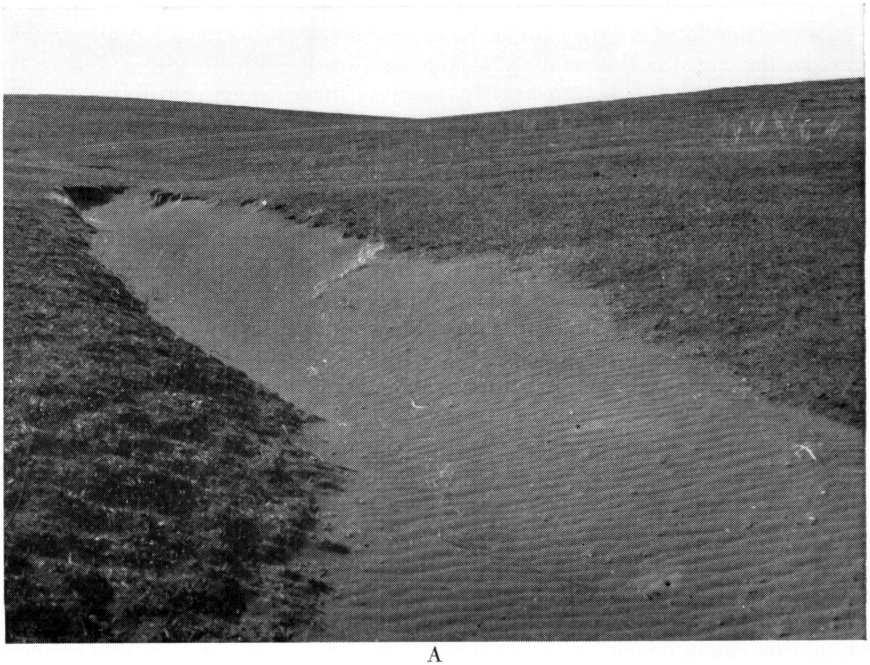
The quantity of material removed by deflation cannot be estimated at this time. Fine sediment should be available for deflation because soft aggregates of clay would be abraded if moved for great distances by saltation. Clay dunes may not form because of this abrasion.

PROPOSED MECHANISM FOR STREAM ALIGNMENT

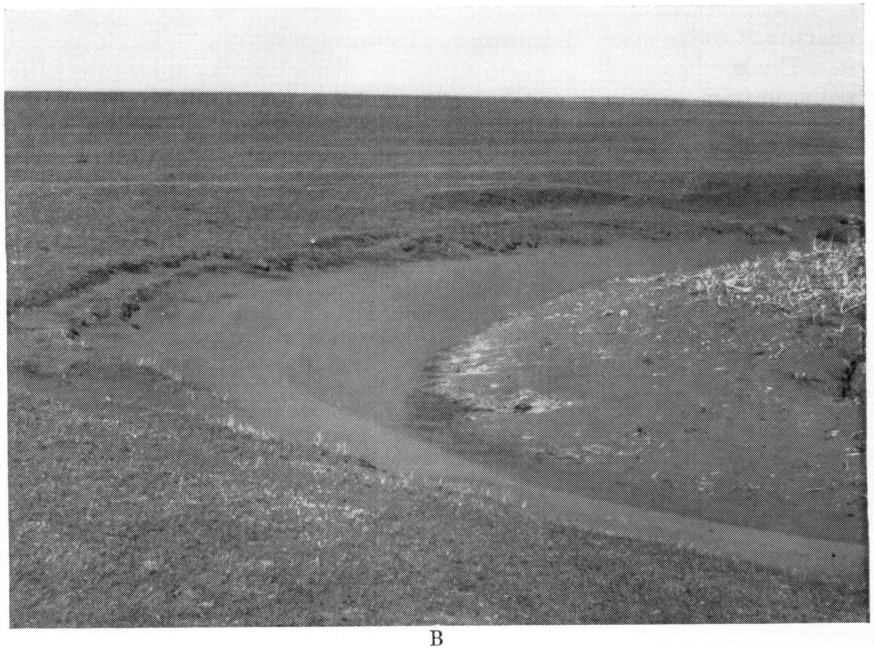
Wind erosion is restricted to periods when prairie vegetation is not abundant enough to protect the soil surface. This could occur during prolonged droughts or following prairie fires. Two areas where the vegetation had been destroyed by prairie fires were examined in the spring of 1959. The first area (northwest part T. 5 N., R. 24 E., Haakon County) had the vegetation burned in the fall of 1958. The soil surface was unprotected except for the short, partly burned crowns of the grasses. The soil surface of the second prairie fire area (northwest of Vivian, South Dakota) was similar to that in the first. The fire near Vivian was on April 6, 1959, when northwest winds attained velocities up to 65 miles per hour.

Wind-transported aggregates of clay were deposited in both fire areas. The eolian deposits range from a fraction of an inch to about three feet thick. No accumulation of eolian sediment was found on the ridge tops or on smooth slopes. Most of it occurred in drainageways which were oriented in some direction other than northwest-southeast (pl. 1A). Those drains oriented northwest-southeast did not accumulate any eolian material except where there was either a shallow entrenched channel meander which curved away from this direction or where a short, shallow gully had formed in the otherwise channel-free drain. In these meanders or short gullies eolian material had accumulated below the bank along the northwest side of the channel. The eolian material was mainly clay in the upper part, but a mixture of clay and partially burned grass segments were in the lower part. This filling of meanders which were not oriented northwest-southeast also occurred along a small, intermittent, aligned stream (Sec. 33, T. 107 N., R. 79 W. Lyman County) which had a gently sloping valley more than a half mile wide (pl. 1B). At several sites, where a small drain without a distinct channel branched headward into two smaller drains, the one of these in the aligned direction received no sediment, whereas the

PLATE 1



A



B

Wind-transported aggregates of clay have accumulated in a shallow gully of an east-west-oriented drain (A) and in the northwest part of a meander in a northwest-southeast-oriented, intermittent stream (B).

other accumulated a thin mantle. Later in the season, western wheatgrass had grown through the thin mantle to help stabilize it against erosion. Before the area was settled and grazed heavily, many of these drains probably supported tall-grasses (prairie cordgrass, switchgrass and big bluestem) with fibrous root systems capable of stabilizing an eolian mantle in a short time.

The destruction of the protective prairie cover by fire was more widespread before the area was settled. Many prairie fires caused by lightning are extinguished by man each year. From personal observations in a three-year period, much of the lightning occurs with local thundershowers which do not yield enough precipitation to moisten the grass thoroughly. Fires started during these showers would burn large tracts of prairie before they would be extinguished by natural processes. The prairie usually is dry and will burn readily in the late summer or autumn and early spring. Prior to settlement, fire probably destroyed the prairie cover of an area every few years. Then the unprotected soil surface could be eroded by winds.

It is postulated that the stream alignment is caused by the deposition of locally derived eolian silt and sand-size aggregates of clay in drainageways. Small drains oriented northwest-southeast at the heads of streams would not accumulate the mantle, so that water erosion could progress more rapidly in them than in the unoriented drains which collected the eolian sediment. Any deviation away from the direction of the prevailing winds by the small creeks would be counteracted by the accumulation of eolian material in this segment of the channel. Larger streams and rivers would not be affected by the small quantity of eolian material deposited in their channels.

This mechanism for stream orientation allows water to erode most of the sediment from the area by the downcutting of the oriented drains and by slope retreat. Winds would transport small amounts of sediment and deposit most of it locally in certain landscape positions. The unequal deposition of these eolian sediments would control the direction and rate of elongation of small drains.

References

Baker, C. L., 1948, The Pennington-Haakon County central boundary area with general discussion of its surroundings: South Dakota Geol. Survey Rept. Inv. 64, 28 p.

Butler, B. E., and Hutton, J. T., 1956, Parna in the Riverine plains of south-eastern Australia and the soils thereon: Australian Jour. Agric. Research, v. 7, p. 536-553.

Crandell, D. R., 1958, Geology of the Pierre area, South Dakota: U. S. Geol. Survey Prof. Paper 307.

Flint, R. F., 1955, Pleistocene geology of eastern South Dakota: U. S. Geol. Survey Prof. Paper 262, vi, 173 p.

Russell, W. L., 1929, Drainage alignment in the western Great Plains: Jour. Geology, v. 37, p. 249-255.