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Open-file report 79-563 OFR/WRD

Prepared as part of the field trip guide book for the Fifth Annual William T. Pecora Memorial Symposium, in collaboration with the Remote Sensing Institute, South Dakota State University

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Contents

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Illustrations

A geohydrologic overview for the

Pecora Symposium field trip, June 1979

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Introduction

The settlement and development of South Dakota has been closely related to both its mineral and water resources. In 1874 the discovery of gold in the Black Hills led to the opening and development of the area west of the Missouri River. Towns and farms both here and east of the Missouri were located near dependable water supplies which the settlers learned were not as plentiful as in the more humid areas in the east. Although there is still much dry-land farming and cattle raising throughout the State, the expansion of agriculture has depended heavily on the development of controlled water supplies. Water from flowing artesian wells was extremely important to early settlers and developers. Today, thousands of these wells still supply an important part of the water on which South Dakota's agricultural, tourist, and industrial economy thrive.

The Big Sioux basin's primary industry is agriculture; it also contains a majority of the State's light manufacturing, food processing, and wholesaling industries.

South Dakota covers an area of 77,000 square miles and has a population of 660,000. The Big Sioux basin covers about 12 percent of the State and has a population of 171,000, 26 percent of the State's population.

Climate

The climate of South Dakota is a continental type, characterized by large seasonal and daily variations in temperature, low average winter precipitation, and marginal to adequate growing-season rainfall. The area is dominated by cold air masses from the north in winter and by warm air masses from the south in summer. Numerous rainstorms, associated with weather fronts, supply much of the precipitation during spring and fall.

The average annual precipitation in South Dakota is about 18 inches; it ranges from less than 13 inches in the northwestern corner of the State to about 25 inches in the southeastern corner. The annual precipitation in the Big Sioux basin is about 23 inches but the annual precipitation varies widely around the average. The variability of annual precipitation is apparent from figure 1 which shows the yearly streamflow of the Big Sioux River near Akron, Iowa.

Figure 1.--Yearly streamflow on the Big Sioux River at Akron, Iowa.

Physiography

About 60 percent of South Dakota is in the Great Plains physiographic province; the eastern part of the State is in the Central Lowlands physiographic province. All but a small area in the northeastern part of the State is drained by the Missouri River. The Missouri's western tributaries are eastward and northeastward flowing streams.
Most of the eastern part of the State is drained by the southward-flowing James, Vermillion, and Big Sioux Rivers. Two small areas in the northeastern corner of the State are part of the Hudson Bay and Upper Mississippi drainage. The principal streams and their relative discharges are shown schematically in figure 2.

The physical divisions of South Dakota are shown in figure 3. The area of the field trip lies within the Coteau des Prairies. It is the most conspicuous topographic feature in eastern South Dakota--a massive highland within the Central Lowlands Province that stands between the Minnesota River-Red River lowland and the James River lowland. The eastern slope of the Coteau is a striking escarpment which, in its northern part, reaches a height of 800 feet above the lowlands and has an average slope of about 200 feet per mile.

Figure 2.--Average discharge of the principal streams in South Dakota.

Figure 3.--Physical divisions of South Dakota.

The French explorers and fur traders named this highland the Coteau des Prairies. Catlin (1840, p. 144-145) who saw the Coteau des Prairies in 1835 described it thus: "This wonderful anomaly in nature, which is several hundred miles in length, and varying from fifty to an hundred in width, is undoubtedly the noblest mound of its kind in the world: it gradually and gracefully rises on each side, by swell after swell, without tree, or bush, or rocks, . . . and is everywhere covered with green grass, affording the traveller, from its highest elevations, the most unbounded and sublime views of--nothing at all,--save the blue and boundless ocean of prairies that lie beneath and all around him, vanishing into azure in the distance, without a speck or spot to break their softness."

This description is still true today although farm buildings and trees are also part of the picture in many areas of the coteau.

The Coteau des Prairies is a flatiron-shaped steep-sided plateau some 200 miles long, pointing north. It slopes to the south from an altitude of 2,000 feet at the north to 1,500 feet at the south. There is a gradual decrease in relief toward the south. The top of the coteau has a regional slope to the west with its western margin generally 100 to 200 feet lower than its eastern margin.

A topographic linearity nearly parallel to the scarp-like margins of the highland was formed by moraines developed along the lateral margins of two lobes of glacial ice held apart by the wedge-shaped bedrock highland between them.

The Big Sioux River is the only large stream that drains the Coteau des Prairies. The river has its origin about 40 miles south of the point of the flatiron and flows along a path that approximates the central axis of the coteau. The river's course seems to have been developed during one of the glacial ages when glacial melt water flowed southward, confined between the two glacier lobes that flanked the coteau. Most of the tributaries to the Big Sioux are from the east.

Lakes, ponds, and marshes dot the surface of the Coteau des Prairies. Unlike the minor streams, these lakes are more abundant west of the Big Sioux River than east of it. There are over 200 lakes on the coteau with Lake Poinsett, located northwest of Brookings, being the largest natural lake in the State.

Geohydrology

South Dakota is underlain by consolidated to semiconsolidated sedimentary rocks of Paleozoic, Mesozoic, and early Tertiary age. They are mantled in the northern and southern plateaus (fig. 3) by semiconsolidated to unconsolidated sediments of later Tertiary age; and in all the area east of the Missouri River by glacial drift of Quaternary age. The sedimentary rocks of Paleozoic and Mesozoic age form a shallow basin lying between structually high areas represented by the Black Hills in the west and the nearly buried Sioux Quartzite ridge in the east.

The Coteau des Prairies is composed of bedrock formations and a mantle of loose glacial drift. Both contain aquifers which are largely independent of each other. The drift contains glacial aquifers composed of outwash sand and gravel. The areal extent, water quality, and hydrologic properties of the bedrock aquifers are generally quite different from those of the glacial aquifers.

The bedrock of the coteau is composed of a series of Cretaceous sedimentary rocks and the Sioux Quartzite of Precambrian age. The Sioux Quartzite occurs as a partially buried ridge, running east and west across the Big Sioux basin through Minnehaha County. The flanks of the ridge slope steeply away to the north and south. The quartzite ridge is rather like an island rising within a surrounding sea of sedimentary rocks.

North of the Sioux Quartzite ridge, the bedrock of the basin consists of a series of formations which include, in descending order, the Pierre Shale, the Niobrara Formation, the Carlile Shale, Greenhorn Limestone, Graneros Shale, and the Dakota Sandstone. South of the ridge, the Pierre Shale has been eroded and the other formations in the series subcrop beneath the glacial drift in turn, abutting against the ridge like roofing shingles.

In addition, there is a group of Ordovician- to Cambrian-age sedimentary formations wedged between the Dakota Sandstone and the Precambrian rocks under the southern end of the basin.

Where the quartzite is fractured it yields up to 10 gal/min of water to wells. Yields from the Dakota Sandstone range from 10 to 1,000 gal/min. The other formations yield only limited amounts of water and have little potential for development.

All of eastern South Dakota is covered by varying thicknesses of glacial drift that was deposited from the great continental ice sheets which covered most of North America during Pleistocene time. The drift can be divided into three general categories: (1) till, (2) loess, and (3) outwash. Glacial till consists of a heterogeneous mixture of silt, sand, and rocks ranging in size from pebbles to boulders. Till constitutes the largest component of the glacial drift, covering perhaps 60 to 70 percent of the surface and providing the parent material for most of the basin's soils. Occasionally, adequate stock and domestic wells can be developed in till, but it is generally not a dependable source of water.

Loess consists of fine sediments, mainly silt with minor amounts of clay and sand. Because of its vertical permeability, loess has a tendency to stand in steep slopes even when there is no vegetation to hold it in place. Loess deposits of varying thicknesses are found throughout the basin, but they are most common in the southern third where they locally reach a maximum thickness of 50 feet. Loess is not a dependable source of water in the Big Sioux basin.

Outwash was formed by the glacial melt waters transporting, sorting and stratifying the sand, gravel, and silt washed from the till. The size and thickness of the outwash deposits vary considerably, ranging from long narrow lenses a few feet thick to large plains covering several townships and reaching 100 feet in thickness. The outwash deposits are very porous and permeable and are generally excellent sources of ground water.

Eastern South Dakota has been subjected to four separate glaciations which are, from oldest to youngest, the Nebraskan, Kansan, Illinoian, and Wisconsin. Each of these glaciations left extensive deposits of drift. The Nebraskan and Kansan deposits have been completely buried and are not found at the surface except where erosion has stripped away the younger deposits. The Wisconsin drift is the most extensive surface deposit, covering all of the basin, except at its southeastern corner where the Illinoian drift generally is found at the surface.

Deposits of Wisconsin age cover 80 percent of the basin's surface. The topographic differences are probably the best way to distinguish between the Wisconsin and Illinoian deposits. The older Illinoian deposits have been subjected to erosional forces longer, thus their soils and drainage patterns are more fully developed. The Illinoian deposits have a mature drainage pattern with well developed streams and few lakes, marshes, or undrained depressions. The younger, less developed, Late Wisconsin deposits have numerous lakes, marshes, sloughs, and potholes and very few well-developed streams. The Early Wisconsin deposits are of intermediate age and have a transitional topography, although there are no closed depressions.

The location of the Big Sioux River between the Late Wisconsin deposits to the west and the Illinoian and Early Wisconsin to the east separates the areas of distinct differences in drainage patterns discussed earlier.

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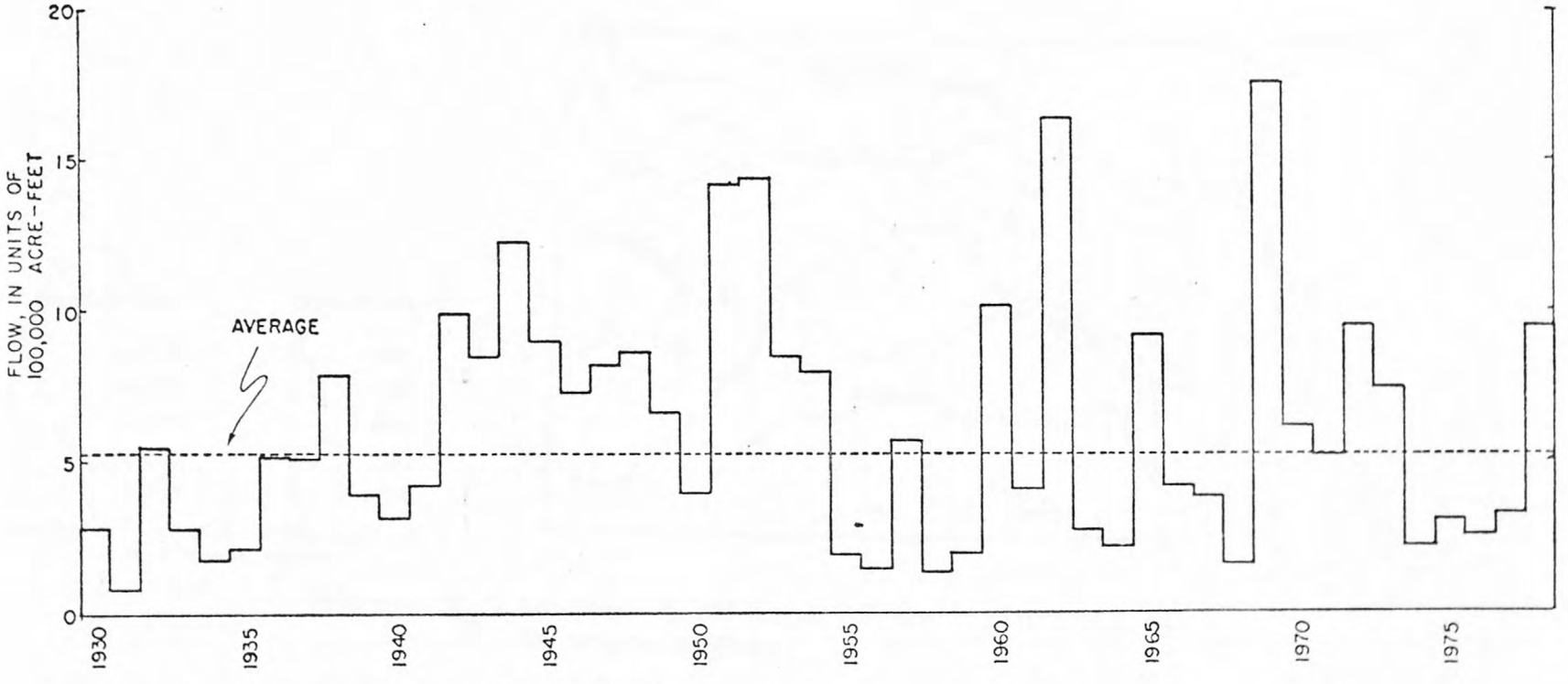


FIGURE 1. Yearly stream flow on the Big Sioux River at Akron, Iowa.

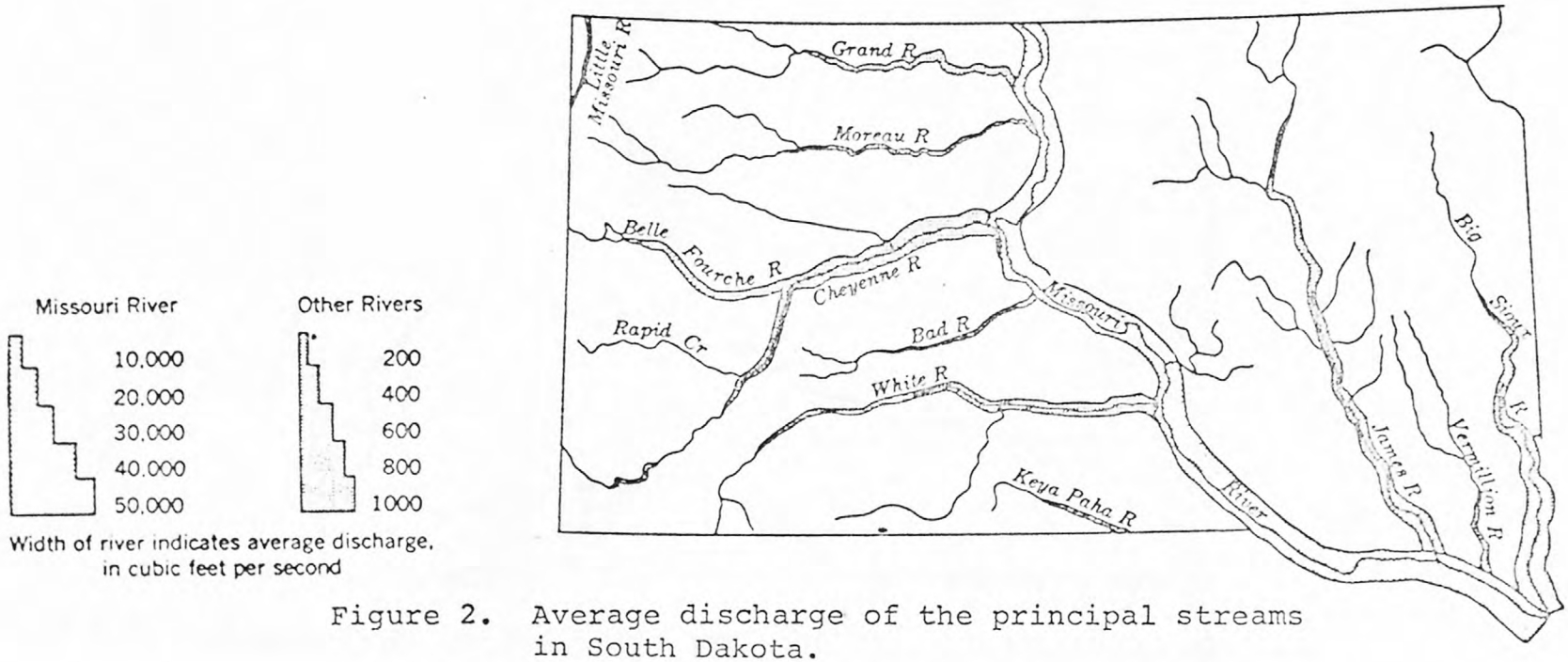
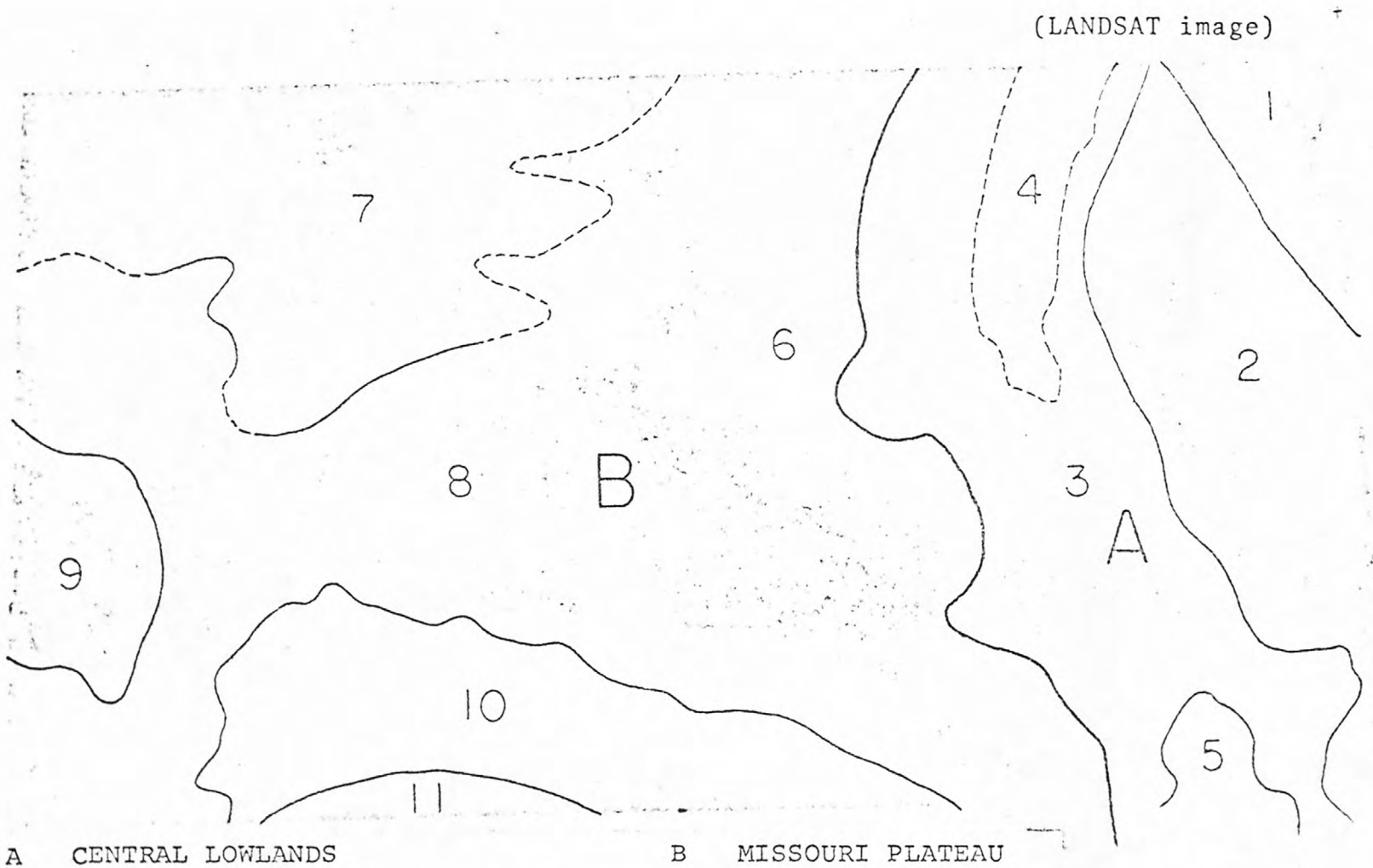


Figure 2. Average discharge of the principal streams in South Dakota.



A CENTRAL LOWLANDS

1. Minnesota River-Red River lowland
2. Coteau des Prairies
3. James River lowland
4. Lake Dakota plain
5. James River highlands

B MISSOURI PLATEAU

6. Coteau des Missouri
7. Northern plateaus
8. Pierre Hills
9. Black Hills
10. Southern plateaus
11. Sand Hills

Figure 3. Physical divisions of South Dakota.