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HYDROLOGIC ATLAS OF THE BLACK HILLS, PENNINGTON COUNTY, SOUTH DAKOTA

INTRODUCTION

The following is a brief outline of ground water characteristics in Pennington County, South Dakota. It is by no means inclusive of all the work done by individuals and groups over the past 125 years. The intent is to give a general introduction to significant aspects of ground water, as they relate to the area of the west-central portion of the county, and a more specific introduction to the work of members of the Department of Geology and Geological Engineering as funded by the West Dakota Water Development District.

N. H. DARTON (U.S. Geological Survey)

In 1895, Nelson Horatio Darton arrived in the region to begin his studies of the hydrology of the northern Great Plains. He was directed to this effort by Mr. C. D. Walcott, Director of the U.S. Geological Survey, in order to conduct an appraisal of the water resources of the West (Ref).

In the succeeding 35 years, Darton and several colleagues produced many geologic folios with geologic maps and reports that focused on the Black Hills and adjacent areas. Darton recognized early in his work that the sedimentary formations from which water might be obtained beneath the prairies were exposed within the Black Hills. His studies identified and named most of the formations present there and indicated that four of them comprise the major sedimentary aquifers. From oldest to youngest, these are:

1. the Cambrian/Ordovician Deadwood Formation;
2. the Mississippian Pahasapa Limestone (the Madison aquifer);
3. the Pennsylvanian/Permian Minnelusa Formation, and;
4. the Cretaceous Inyan Kara Group (the Lakota Formation and the Fall River Formation combined) (see Figure 1).

Many other formations may also contain some amount of ground water. In the central Black Hills, ground water is contained in the Precambrian igneous and metamorphic rocks.

This work led to Darton's 1909 publication in which cross sections (Figure 2) across the east flank of the Black Hills uplift show the relative relationships of these units, the areas in which water enters them (the recharge area), and the development of Artesian systems (in which water rises in a well to the surface) beneath the prairies to the east. Diagrammatic examples of such cross sections are still shown in all introductory geology text books.

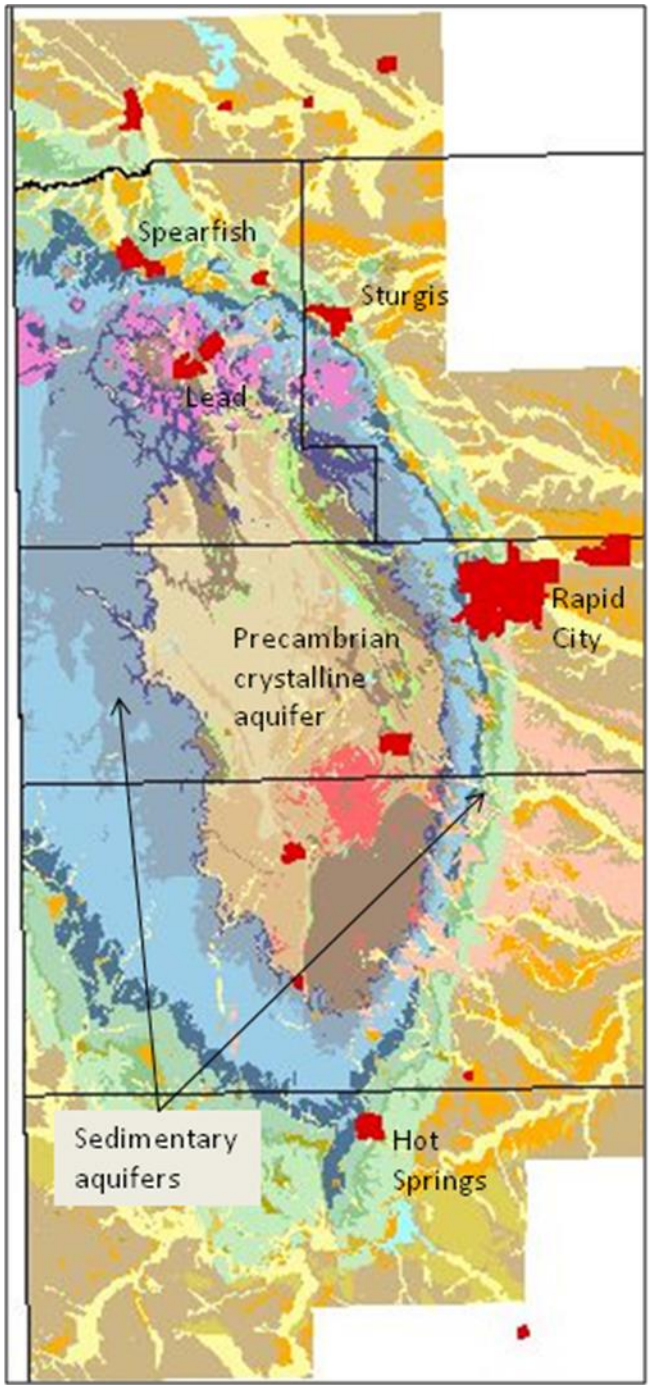

Figure 1. Generalized geologic map of the Black Hills and adjacent plains. The oval pattern shown in shades of blue and green is the area of surface exposure of sedimentary aquifers. The varied colors in the central part of the map indicate rock types comprising the Precambrian crystalline aquifer/"basement" of the Black Hills (Map courtesy of South Dakota Geological Survey).

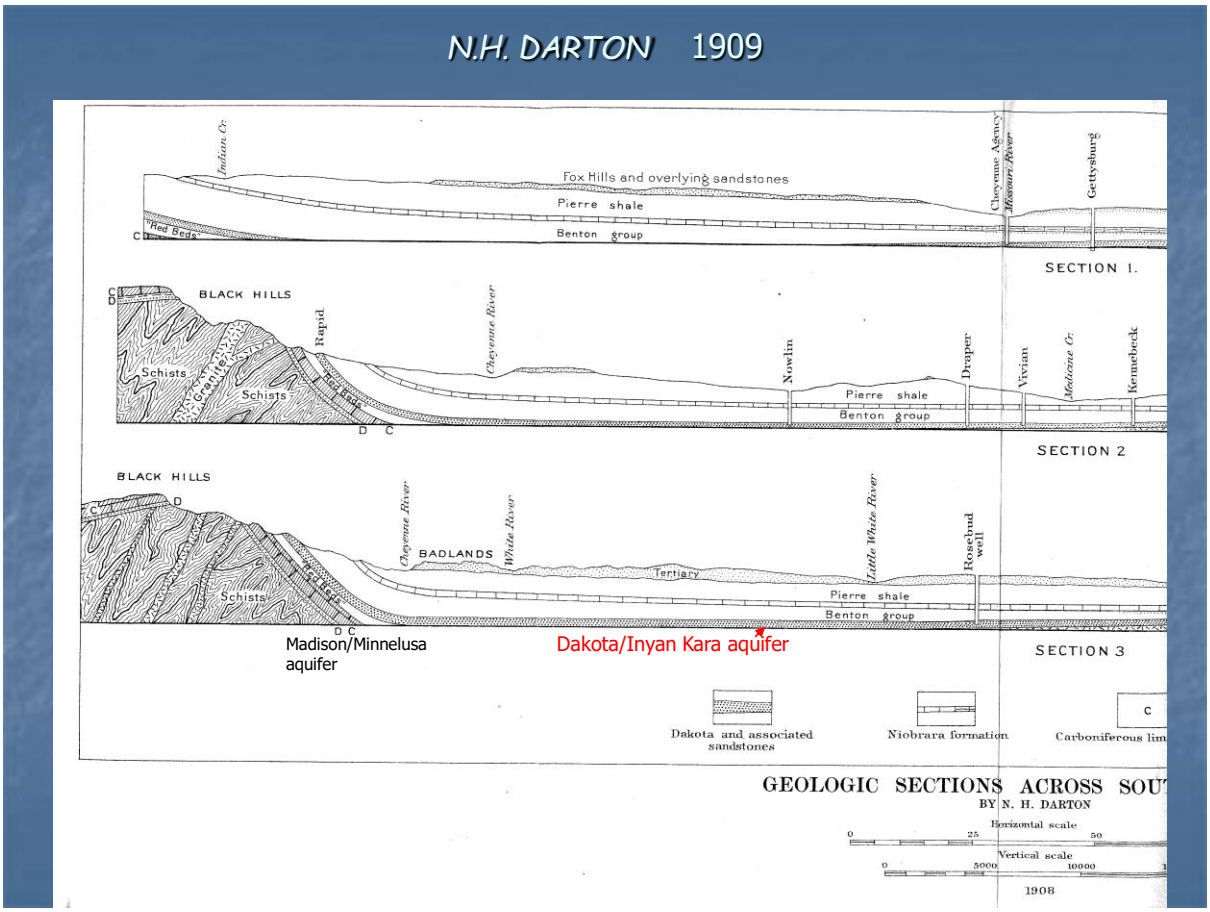

Figure 2. Cross section of the eastern flank of the Black Hills as prepared by N.H.Darton (1909).

U.S. GEOLOGICAL SURVEY/SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES/WEST DAKOTA WATER DEVELOPMENT DISTRICT

During the period 1990-2002, the U.S. Geological Survey, in cooperation with the South Dakota Department of Environment and Natural Resources and the West Dakota Water Development District, conducted a study "…to assess the quantity, quality, and distribution of water resources within the Black Hills area." The results of the study were published as Water-Resources Investigations Report 03-4049 and Hydrologic Investigations Atlas HA-747.

The second of these publications, titled "Atlas of Water Resources in the Black Hills Area, South Dakota", expanded on previous studies to collate an excellent overview of the hydrology of this area, including western Pennington County. It presents sections on hydrologic processes, ground water and surface water resources, hydrologic budgets, and specifics on the flow systems of the Madison and Minnelusa aquifers. Examining this publication is a must for anyone wishing to gain an understanding of ground water in this area.

One of the figures in this publication, shown here in a modified form as Figure 2, provides a model for the major aquifers and expands the cross-sections of Darton into a three-

dimensional block diagram. This figure is essentially a diagrammatic view of surface- and ground-water relations in western Pennington County.

Rain and snow falling in the Black Hills are removed by one or more of three possible methods – evaporation, run-off in streams, or by sinking into the underlying rock masses. The area in which the water enters the underlying rocks is called the recharge area.

Sedimentary aquifers

Ground water occurs in sedimentary layers (formations) along the eastern and western parts of the hills. Those formations (aquifers) with the greatest capacity to absorb substantial amounts of water are the Deadwood Formation, the Madison Limestone/Pahasapa Limestone, Minnelusa Formation, Minnekahta Limestone, and the Inyan Kara Group. Each of these aquifers extends eastward beneath the plains.

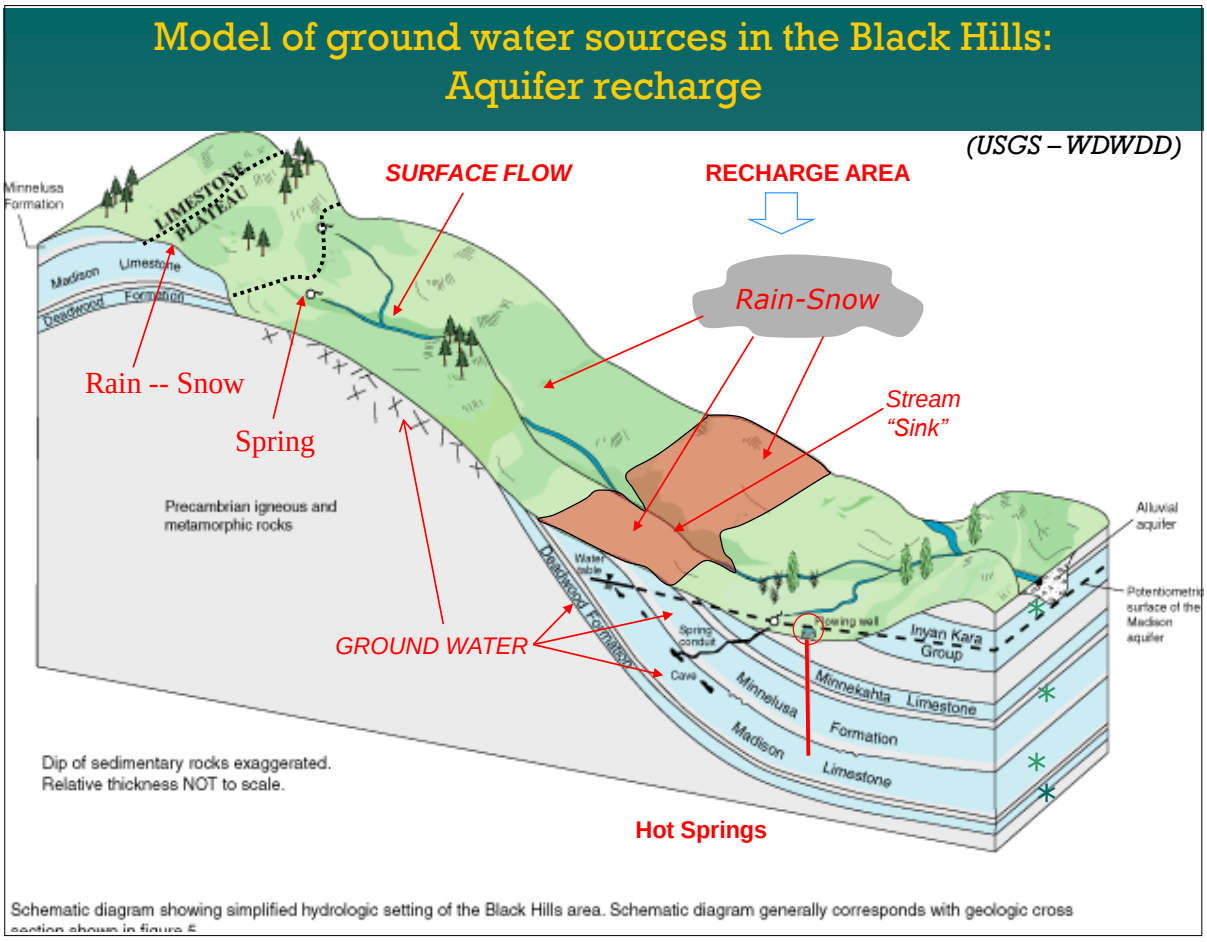

Figure 3. Three-dimensional diagram of the aquifers of the Black Hills (view to the northwest) showing major aquifers of the Black Hills (adapted from Carter and others, 2002).

The portion shown in red on Figure 3 represents the area in which the Madison and Minnelusa aquifers are exposed to the surface and is called the recharge area for these formations.

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY/ WEST DAKOTA WATER DEVELOPMENT DISTRICT

The information presented in the maps and descriptions shown in this web site are the result of a combined effort of the West Dakota Water Development District and the Department of Geology and Geological Engineering at the South Dakota School of Mines and Technology. They involve two separate studies, one relating to the sedimentary aquifers and their recharge areas (Figures 1 and 4) in the Rapid City-Black Hawk-Rockerville area, the second to the quality of water in the Precambrian crystalline aquifers in the central portion of the Black Hills.

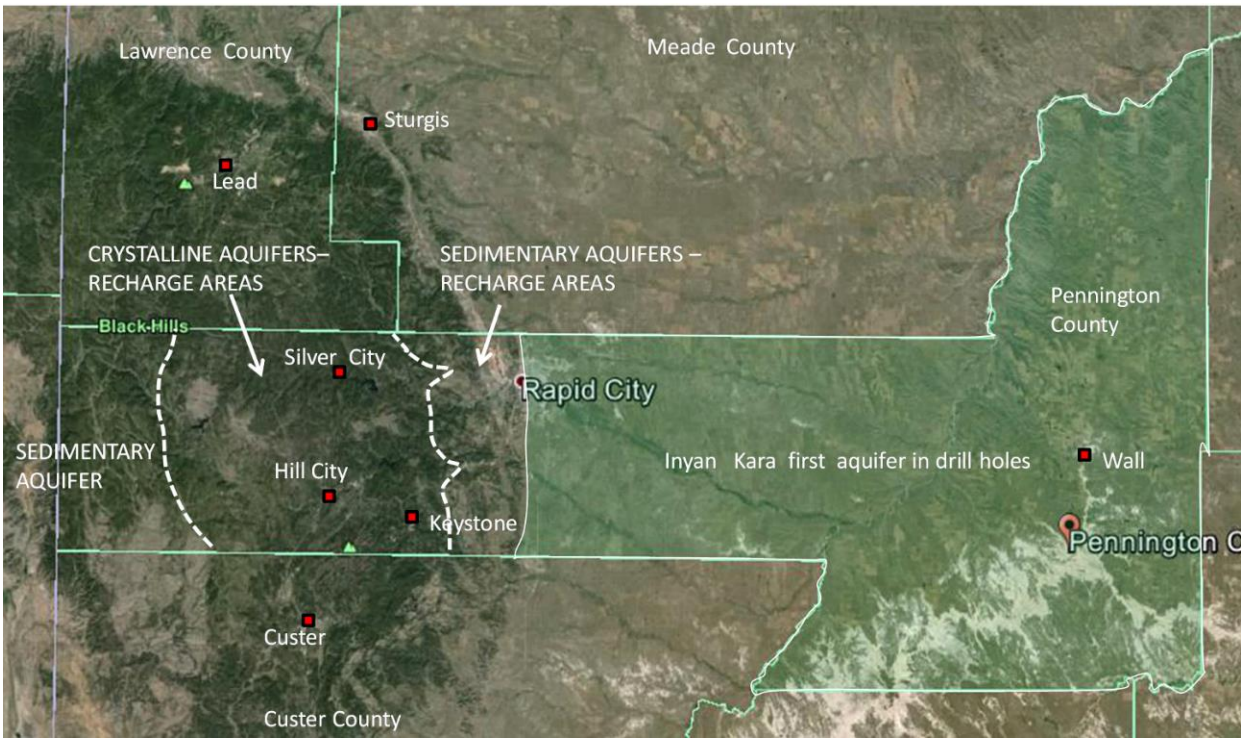

Figure 4. Map view of aquifer divisions of Pennington County, South Dakota (Google map as base).

Study I Sedimentary aquifers

Purpose

In 1999, graduate students and staff members of the Department of Geology and Geological Engineering at the South Dakota School of Mines and Technology began a study directed toward an understanding of the vulnerability (i.e., risk of contamination) of sedimentary aquifers along the eastern flank of the Black Hills. This area was, and still is, undergoing extensive urbanization, thereby generating a concern about the potential for pollution in the aquifer recharge areas. The study was funded by the West Dakota Water Development District and Mr. Van Lindquist, Administrative Manager of this organization, participated in the planning stages.

Location

The base map shown on the home page of this web site shows the locations of the selected quadrangles, excluding the Rapid City East and Rapid City NW quadrangles. These quadrangles contain the major recharge area for the sedimentary aquifers along the east flank of the Black Hills and much of the recharge area for the crystalline aquifers in the center of the Hills.

Methods

The study involved four phases, each centered upon the use of 1:24,000-scale U.S. Geological Survey maps as the base. Ten such maps were selected for individual study.

Phase1. Prepare a Geologic map of each quadrangle in order to accurately locate the recharge areas of each aquifer. These maps were prepared by geologists working in the field to observe the rock units. Many of them relied heavily upon the mapping of Dr. Jack Redden, a faculty member in the Geology and Geological Department at the SDSTM. The work was digitized and most of the maps are available on the South Dakota Geological Survey web site.

Phase 2. Prepare Structure Contour maps for each aquifer. The elevations of the upper surfaces of each aquifer were determined from the geologic map and from intersections in existing water wells. The products were contour by hand and digitized in a GIS format;

Phase 3. Prepare Depth-to aquifer maps. Such maps allow a determination of the drill depths for each aquifer at specific locations. The depths are determined by subtracting the structural contour elevations from the surface topographic map elevations. The products are presented in a GIS format;

Phase 4. Prepare Aquifer Susceptibility maps. Such maps, based upon the natural characteristics of sedimentary rocks, define the inherent ability of the aquifers to absorb fluids. The products were digitized in a GIS format;

Phase 5. Prepare Aquifer Vulnerability maps. Such maps provide ratings for several factors having potential for contamination of the aquifers. The products were digitized in a GIS format;

Study II Crystalline aquifers -- Water quality

Purpose

In 2012 a second study was initiated for the crystalline (Precambrian) aquifers of the central Black Hills. The study focuses on chemical quality of privately owned wells. The water was analyzed for components considered to pose potential harmful risks for private well users. These were:

Hardness
Iron content
Sulphur content

Arsenic content
Nitrogen content
Total coliform bacteria
Total fecal coliform bacteria

Methods

Sample collection: By visiting home owners on a one-on-one basis, water samples were collected from private wells drilled into Precambrian metamorphic and igneous rocks.

Sample analyses: The samples were analyzed in Rapid City the day following their collection at Mid-Continent Testing Laboratories.

Sample presentation: The results from approximately 180 private well samples (a total of 200 samples were collected to include duplicates and repeats on wells which tested positive for fecal coliform bacteria) were entered into tables and analyzed using a GIS format.

The values were then contoured and presented on the 1:24,000-scale map base, along with illustrative tables of the values used. To assure the privacy of individual home owners, no results were shown for specific locations.