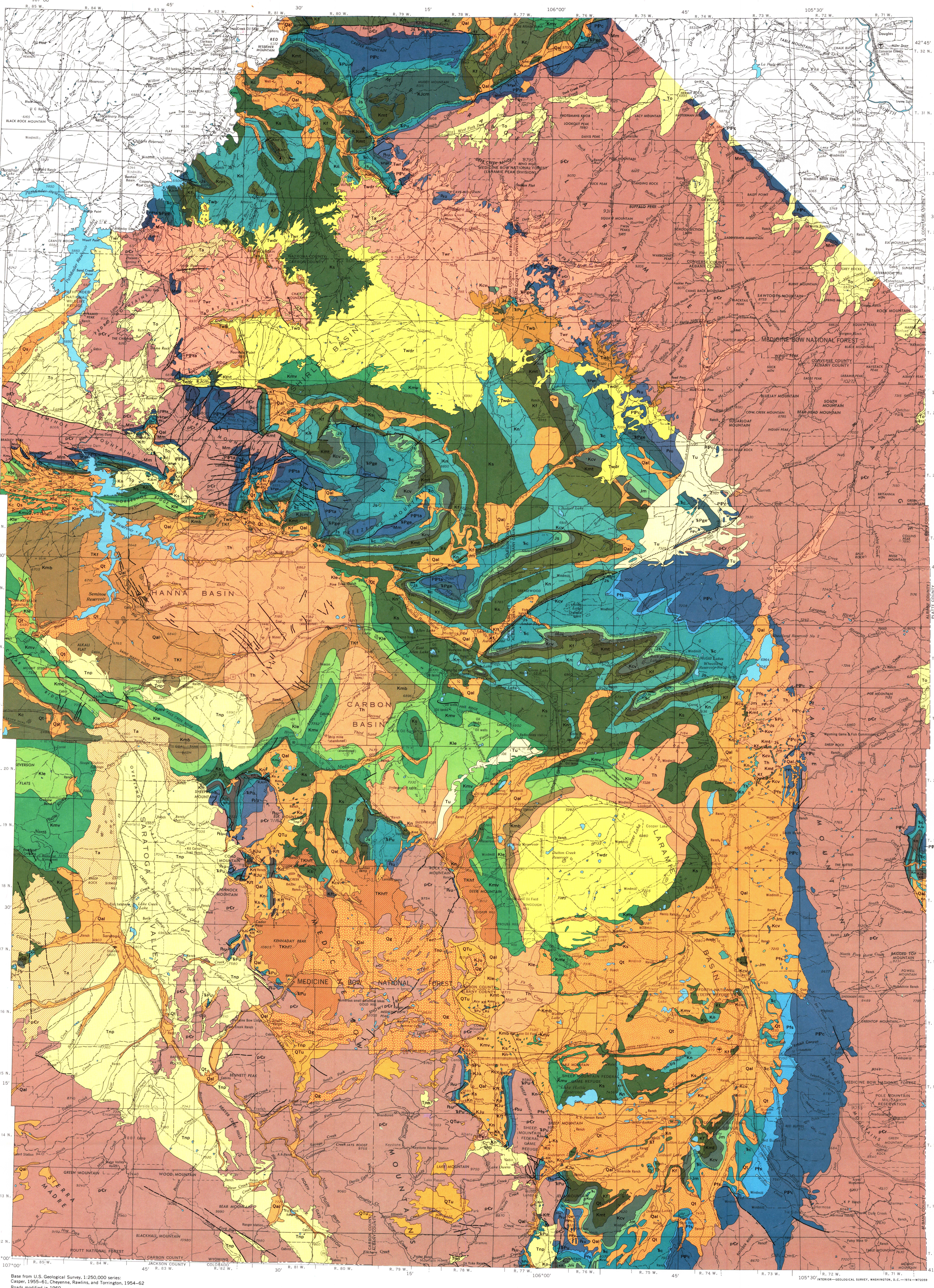
PREPARED IN COOPERATION WITH THE
WYOMING STATE ENGINEER



Base from U.S. Geological Survey, 1:250,000 series:
Casper, 1955–61, Cheyenne, Rawlins, and Torrington, 1954–62
Roads modified in 1969

Geology compiled by Marlin E. Lowry, 1969

SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

1973 MAGNETIC DECLINATION FOR THIS MAP VARIES FROM 13°30′ EASTERLY FOR THE CENTER OF THE EAST EDGE TO 14°30′ EASTERLY FOR THE CENTER OF THE WEST EDGE

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1974—W72059

EXPLANATION

UNIT 8 — Pleistocene and Holocene (QUATERNARY)
- Qal — Alluvial deposits
- Qt — Terrace deposits
- Qs — Windblown sand
- Qg — Glacial deposits

UNIT 7 (TERTIARY)
- Pliocene: To — Ogallala Formation
- Miocene: Ta — Arikaree Formation
- Oligocene: Twr — White River Formation
- Eocene, Upper and middle Eocene: Twb — Wagon Bed Formation
- Eocene, Lower Eocene: Twdr — Wind River Formation
- Tnp — North Park Formation
- QTu — Quaternary and Tertiary rocks undivided
- Tu — Tertiary rocks undivided

UNIT 6
- Paleocene: Th — Hanna Formation. *May also be Eocene in the Hanna Basin only*
- Paleocene: TKf — Ferris Formation
- TKhf — Hanna and Ferris Formations
- Upper Cretaceous: Kmb — Medicine Bow Formation
- Upper Cretaceous: Kle — Lewis Shale. *Includes Fox Hills Sandstone*
- Upper Cretaceous: Kmv — Mesaverde Formation

UNIT 5 (CRETACEOUS)
- Ks — Steele Shale
- Kn — Niobrara Formation
- Kc — Cody Shale
- Lower Cretaceous: Kf — Frontier Formation
- Lower Cretaceous: Kmt — Mowry and Thermopolis Shales
- Kft — Frontier Formation and Mowry and Thermopolis Shales

UNIT 4 (CRETACEOUS, JURASSIC)
- Kcv — Cloverly Formation
- Jm — Morrison Formation
- KJcm — Cloverly and Morrison Formations
- Js — Sundance Formation. *Includes Nugget Sandstone of Jurassic (?) and Triassic (?) age in northwest*
- KJu — Cloverly, Morrison, and Sundance Formations undivided

UNIT 3 (TRIASSIC, PERMIAN)
- ₹c — Chugwater Group
- ₹Pge — Goose Egg Formation
- Pfs — Forelle Limestone and Satanka Shale
- ₹Pu — Triassic and Permian rocks undivided

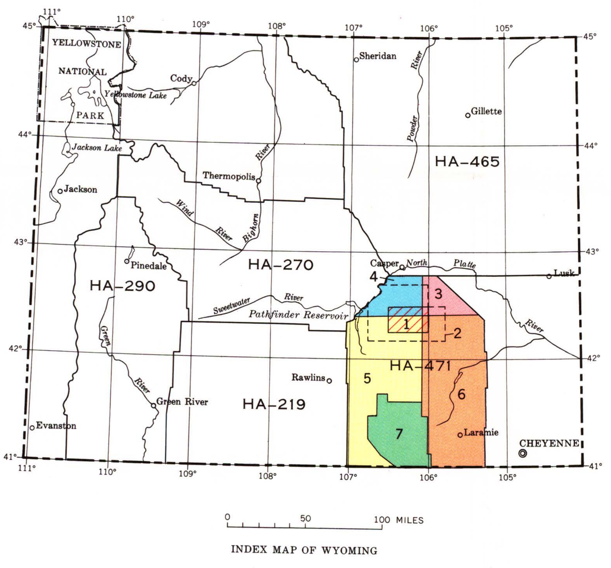
UNIT 2 (PENNSYLVANIAN, MISSISSIPPIAN)
- PIPta — Tensleep Sandstone and Amsden Formation
- PIPc — Casper Formation
- Mm — Madison Limestone. *Includes Flathead Sandstone of Cambrian age in northwest*
- Pzu — Paleozoic rocks undivided

UNIT 1 (PRECAMBRIAN)
- p€r — Precambrian rocks

Contact
Dashed where approximately located

Fault
Dashed where approximately located, dotted where concealed. U, *upthrown side;* D, *downthrown side*

Thrust fault
Dashed where approximately located, dotted where concealed. T, *upper plate*



INDEX MAP OF WYOMING

SOURCES OF GEOLOGIC MAPPING

Area of this investigation and areas for published reports in this Hydrologic Atlas series. The source used in compilation of the geologic map, indexed, is as follows:

1. Harshman (1968)
2. Denson and Harshman (1969)
3. Love and others (1955)
4. Weitz and others (1954)
5. Weitz and Love (1952)
6. Love and Weitz (1953)
7. Houston and others (1968)

INTRODUCTION

This report describes the results of one of a series of reconnaissances of large areas in Wyoming that are being made in cooperation with the Wyoming State Engineer. The report area is in southeastern Wyoming; the Laramie Basin is in the southeast, the Shirley Basin in the north-central, and the Hanna Basin in the west-central part of the area. The area includes, and is nearly outlined by, the northern part of the Southern Rocky Mountains. The purpose of the study was to obtain a general knowledge of the availability and quality of ground water, and to summarize flow characteristics and quality of water in the major streams.

Several investigations describing water resources have been made that include all or parts of the area. These are Darton and others (1910), Morgan (1947), Littleton (1950), Visher (1952), Robinson (1956), Burritt (1962), Matthai (1968), Saulnier (1968), Crist and Lowry (1972), and Wahl (1970).

OCCURRENCE OF GROUND WATER

Occurrence of ground water in the area is controlled by the geologic formations and structure. Formations composed, in part, of sand or coarser material will yield water to wells because of primary (intergranular) permeability. The yield of water from sandstone will depend on the size and sorting of the grains and the cementation between the grains. Primary permeability occurs only in the clastic sedimentary rocks.

Secondary permeability, which results principally from fracturing and (or) solution, occurs in consolidated rocks and is most apt to be present in the vicinity of folds and faults. However, in some areas rocks near folds and faults may be less permeable than elsewhere because of compaction during deformation or cementation by mineralized fluids.

Of the yields tabulated through 1968, all of those in the order of 100 gpm (gallons per minute) or more from wells and springs in consolidated rocks in the area are attributed to secondary permeability. Similar yields are possible from consolidated rocks with only primary permeability by penetrating large thicknesses of saturated rocks.

Tremendous quantities of water are present in rocks underlying the area. Considering only the sandstone, which may average more than 10 percent porosity, there would be in excess of 64 acre-feet of water stored in a sandstone 1 foot thick and 1 mile square.

The water-bearing properties of the formations shown on the geologic map are summarized on Sheets 2 and 3.

To simplify the discussion of the ground water and its relation to geology, rocks are divided into eight units. Each unit generally consists of rocks that originated in a similar environment and, therefore, have somewhat similar water-bearing characteristics and contain water of similar quality. Some of the divisions between units are arbitrary in order to have a minimum number of units composed of contiguous formations. For instance, the Lewis Shale of marine origin is included with formations deposited in a predominantly continental environment. Units are numbered from oldest to youngest.

Areas where the top of a given unit is 1,000 feet or less below land surface are shown on Sheet 2 for Units 1 through 4. The intent is to show broad areas where a unit may occur at this depth; however, it is cautioned that minor structure and local relief may have considerable effect on actual depth to the unit. In addition to the areas shown on Sheet 2, Units 1 through 4 are within 1,000 feet of the surface in some localities where structure is complex and local relief is great. These areas are not shown on the map because the selection of a well site in these areas is too critical to generalize on small-scale maps. In many areas the dips of the formations are nearly vertical and a hole could be drilled to considerable depth without penetrating strata different from that at the surface.

USE OF GROUND WATER

Most of the wells in the area are used for domestic or stock supplies. Ground water is used for public supplies by the towns of Medicine Bow, McFadden, and Elk Mountain. Laramie used 3,424 acre-feet of water from wells and springs and 927 acre-feet of surface water in 1966 (Rechard and Lane, 1968, p 27). About 5,000 acre-feet of water was pumped for irrigation in the Saratoga valley in 1968. Few irrigation wells have been drilled outside of the Saratoga valley.

QUALITY OF GROUND WATER

The quality of water differs not only between aquifers but also within a given aquifer and is the result of three dominant changes—solution, cation exchange, and sulfate reduction.

Recharge from precipitation is low in dissolved solids and, because it is in equilibrium with the atmosphere, it contains a small amount of carbon dioxide which reacts with the water to form a dilute solution of carbonic acid. As the water moves into an aquifer, the acid attacks the more soluble minerals resulting in an increase in dissolved solids in the water. The more soluble minerals are calcium, magnesium, and sodium compounds. Calcium compounds are the most abundant; therefore, in most shallow wells and springs near the recharge area, the water is generally a calcium bicarbonate type and dissolved solids are less than 500 mg/l (milligrams per liter). One of the most easily dissolved minerals is gypsum (calcium sulfate) which is present in large amounts in Unit 3 and as a minor constituent in several other units. Calcium and sulfate concentrations increase as the water moves through the formations from recharge areas toward points of discharge, and a calcium sulfate type water results that may be high in dissolved solids. The calcium bicarbonate and calcium sulfate type waters, and the magnesium and sodium counterparts, are solution products.

Cation exchange is a reaction in which a sodium ion replaces either a calcium or magnesium ion because of the greater ionic activity. This reaction occurs where exchange materials are available. Because the reaction is an exchange, high sodium waters of this type are those that have been in an aquifer the greatest length of time; they are typical of some deep aquifers, and of points more distant from recharge areas.

Sulfate reduction is a process by which sulfate is reduced in the presence of hydrocarbons. This reaction accounts for the presence of hydrogen sulfide (H_2S), with its rotten-egg smell, in water from many wells. It also produces high bicarbonate concentrations.

SUMMARY OF AVAILABILITY OF GROUND WATER

Ground water suitable in quantity and quality for stock use is generally available at depths of 500 feet or less, except in areas where rocks of Unit 5 are the uppermost saturated rocks. Rocks of Unit 5 are poor aquifers, and in areas underlain principally by these rocks water in alluvial deposits along ephemeral streams should be considered as a source of water. Water is also available from rocks underlying Unit 5 but, because of the great depth, development to date has been largely from oil-exploration holes that were completed as water wells.

Wells yielding as much as 1,000 gpm have been developed from rocks of Units 2, 3, 7, and 8. Additional wells with yields in this order are most likely to be developed in Units 2, 7, and 8.

Most wells for which data are available are used for stock or domestic supplies. These wells are drilled only deep enough to supply water for the intended purpose. In most areas, greater yields than those shown on Sheets 2 and 3 are possible by tapping additional aquifers at greater depth or by improved well construction and development.

WATER RESOURCES OF THE LARAMIE, SHIRLEY, HANNA BASINS AND ADJACENT AREAS, SOUTHEASTERN WYOMING

By
Marlin E. Lowry, Samuel J. Rucker, IV, and Kenneth L. Wahl

1973