Figure 1. The fractures in granites and other "hard rocks" at the core of mountain ranges are excellent aquifers or reservoirs for snowmelt. Because they are irregular, the trick is to hit a fracture that yields enough water to supply a residence when drilling a well.

How geology affects your well water quality

By Tony Hoch

Anyone considering purchasing land to build on should determine the property's water availability.

If you ask a geologist, he or she can probably make an educated guess whether a water well that will provide good quantity and/or quality can be drilled at a given location.

This is based on the fact several generalizations can be made with respect to ground water and rock types, juxtaposition to a mountain range, location in a mountain valley, or proximity to a perennial stream. The geologic materials into which a well is drilled can vary in porosity and permeability, governing the amount of water yielded; they can also vary in chemical composition or solubility, which may affect the chemistry of the well water.

The ultimate source of ground water is pure precipitation; the big questions are: "How long has the water been in the ground?" and "With what kinds of rocks and minerals has it been interacting?"

All rocks dissolve in water, adding salts, hardness, and alkalinity. Of the common rock-forming minerals, quartz and feldspar (the major minerals making up granites in Wyoming's major mountain ranges) are the most resistant to weathering (slowest to dissolve), whereas salts like gypsum and halite (rock salt) are the easiest to dissolve and add total dissolved solids (TDS) to the water solution, and, hence, reduce water quality.

The pre-Cambrian-aged "basement," composed of granites and other hard rocks that formed from magmas deep in the Earth's crust before about 600 million years ago, forms the core of most of Wyoming's major mountain ranges. These rocks are very slow to dissolve and are often fractured. When the rock is exposed at the land surface, the snowmelt and rainwater infiltrate into fractures and remain very dilute and of very high quality for drinking water. The problem is these rocks are hard to drill into, and hitting a good water-yielding fracture system is hit and miss. If the driller does hit a water-bearing fracture, water production may support individual homes but is often too marginal to support municipal and community wells (Figure 1).

Layered on top of basement granites are younger sedimentary rocks such as limestones, sandstones, and shales. These are often exposed at the edges of Wyoming's great valleys or basins such as the Bighorn, Wind River, Powder River, Green River, and Laramie basins (Figure 2). These are the off-white, tannish,

Figure 2. Extensive, thick limestone and sandstone layers exposed near the edges of Wyoming's great basins are often the best producing sources of high quality drinking water.

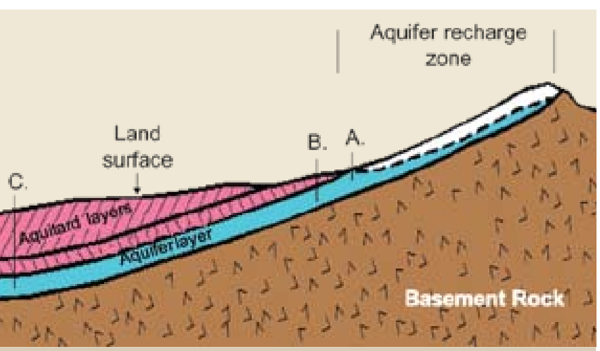

Figure 3. This is the cross section of a typical Wyoming basin and mountain range. The permeable aquifer rock layer is exposed on the flank of the mountains and provides an area for rain and snowmelt to recharge ground water. Wells A. and B. are near fresh recharge water and provide good drinking water. Well C., drilled thousands of feet deep into the same formation, yields water high in dissolved solids because water has been in contact with the rock for thousands of years.

or reddish colored, layered rocks you might see when beginning to ascend a mountain pass.

The term "basin" implies these sedimentary rocks are folded like a bowl with the rim exposed at the edge of the mountains (Figure 3). In the middle of the basins, the same rock unit with surface exposure at the basin's edge may be 10,000 to 20,000 feet below the land surface.

Some of the best well water sources in the state are in the exposed sedimentary rocks at or near the basin's edge. Sandstones are comprised of cemented sand grains (usually quartz and feldspar) that don't dissolve very rapidly, and the rock has good porosity and permeability for wells. Limestones contain minerals that dissolve relatively easily (calcite), making large fractures or cave systems called karst, which can contain and transmit large quantities of fresh water. When exposed next to a mountain range, limestone and sandstone aquifers capture large quantities of snowmelt and make for some of the best quality and quantity water supplies around, as they are continually recharged. Due to their vast size – hundreds of square miles in lateral area and hundreds of feet thick – these are resistant to intermittent drought. Fine-grained sedimentary rocks known as claystones or shales are often "interbedded" within layers of sandstone or limestone (Figure 4). These are notoriously poor sources of good drinking water due to low permeability and the fact the minerals in these rocks tend to "stew" in ground water and attain very high levels of TDS. Similarly, formations of sandstone or limestone that yield good drinking water near the recharge zone at the land surface may yield very poor water quality when buried 5,000 or 10,000 feet in a basin where the water does not circulate and get fresh recharge.

Filling many of the basins in Wyoming, on top of older limestones and sandstones, are thick layers of clayey rock and shale, sometimes known as "gumbo," which make terrible aquifers in terms of water quality due to the high salt content and low permeability.

Finally, there is a class of aquifers extremely important in Wyoming known as alluvial aquifers (Figure 5). Alluvium is the gravelly sediment deposited by the most recent geological activity of glaciers and rivers. Alluvium can be highly permeable and, when associated with surface waters like streams, irrigation canals, and reservoirs, acts as a shallow aquifer for drinking and irrigation water. Wells drilled in alluvium are typically shallow, on the order of tens of feet, and water quality may closely resemble that of a nearby river or irrigation ditch. These are good wells in "normal" precipitation years but may be susceptible to drought if the river or ditch dries up for several years in a row.

Good advice on well drilling, water quality, and water yield may be obtained from a local geologist or hydrologist who can interpret geologic maps and find records on other wells drilled nearby. Another great source of information is from the local well drillers themselves, particularly the companies that have worked the area for a while. General information on laws and permits can be obtained from the Wyoming State Engineer's Office (contact information is at http://seo.state.wy.us or [307] 777-6150). Databases on well locations, depth, and water quality are maintained by the Wyoming Water Resources Data System (www.wrds.uwyo.edu/) at the University of Wyoming.

Figure 4. This unfractured and relatively impermeable shale layer acts as an aquitard, protecting the aquifer below from contaminants released on the land surface.

Figure 5. This solar-powered stock water well is drilled only a few feet deep in the middle of an arid basin. It is situated only a few hundred feet away from a perennial stream and taps into sands in the stream's flood plain, which is saturated with river water. The cottonwoods in the background are a sure indicator of shallow ground water.

Geologist's Terminology

Mineral – chemically uniform, crystalline, solid-like quartz, feldspar, calcite, or garnet.

Rock – aggregate of minerals.

Porosity – pore space or voids in rock that can contain fluids.

Permeability – ability of water to flow through rock.

Aquifer – large volume of rock that can contain water in its pores or fractures and through which water may flow (good porosity and permeability).

Aquitard – layer or volume of rock not permeable to water. Aquifers are often bounded by one or more aquitards.

Recharge zone – area on land surface where fresh water in the form of rain or snowmelt may fill an aquifer.

TDS (total dissolved solids) – amount of dissolved salts and other inorganic and organic substances in drinking water. Snowmelt can have less than 50 part per million (ppm) TDS, whereas seawater or water in shale formations can be greater than 50,000 ppm.

Tony Hoch is manager of the Laramie Rivers Conservation District and can be reached at (307) 721-0072 or tony.hoch@wy.nacdnet.net.