THE AMERICAN WELL OWNER

⭑ INFORMATION AND ADVICE ABOUT GROUND WATER, WELLS AND WATER SYSTEMS ⭑

A Quarterly Publication of the American Ground Water Trust© - 2005 Number 4

Independent Authority on Ground Water

Sinkholes—How Do They Form?

MESSAGE FROM THE PUBLISHER

"Gutta cavat lapidem, non vi sed saepe cadendo"
(Hugh Latimer, 1549)

The drop of rain maketh a hole in the stone, not by violence but by oft falling.

The quote from one of Latimer's sermons in 16th century England shows that he had a basic understanding of the long time scale of geological processes! Slow but constant dripping can have an impact. Latimer probably did not appreciate the role of chemical solution in eroding stone, but he had the right idea about the cumulative effects of small impacts.

In this issue of *THE AMERICAN WELL OWNER*, the phenomenon of sink-holes requires us to have an understanding of geologic processes. The sinkholes that may suddenly appear on today's landscape have their origins in the slow chemical erosion processes over tens of thousands of years. The trigger for the sinkhole to appear may be related to very recent events such as over pumping of ground water or diversions of storm water that result in the collapse or flushing-out the sediment "plugs" of ancient solution cavities, some of which probably evolved when climate and sea-levels were different from those of today.

While ground water is a renewable resource and many aquifers are "filled-up" on an annual basis, we must recognize that some of the water in our major aquifers, which is liberated for our economic use by 21st century pumps, originated as 16th century raindrops.

Respect for geologic time scales can provide a useful context for understanding today's resource issues where storage volumes and replenishment time scales are vital for ground water development decisions.

Andrew Stone

American Ground Water Trust

Sinkholes are depressions or actual holes into the ground surface. Shapes vary from wide and shallow to narrow and deep and all combinations in between. They form in regions where the bedrock geology is comprised of carbonate rocks (or saltbeds) that are susceptible to being dissolved by water. In the USA, sinkholes related to limestone occur in Florida, Texas, Kentucky, Alabama, Missouri, Tennessee and Pennsylvania. Sinkholes are known as dolines in France and sumideros in Spain and Latin America.

The basic mechanism for creating a sinkhole involves the dissolution of the calcium carbonate ($CaCO_3$) from acidic water. [Gypsum, dolomite and marble rocks can also be affected by solution.] Rainwater (H_2O) is naturally acidic because it contains a small amount of carbonic acid (H_2CO_3) that forms when rain drops absorb carbon dioxide (CO_2) from the atmosphere. Acidic rainwater and surface water runoff move underground as ground water following the natural openings, cracks, fissures and fractures within bedrock. Over time, some of the flow paths become wider as more and more carbonate is removed. However, because carbonate rocks are rarely pure limestone, the spaces created by solu-

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Helping communities, residents, businesses and farms, that use water wells, maintain safe, reliable, cost-effective water supplies and ensure a sustainable local environment.

tion may be partly filled by non-carbonate minerals such as clay, quartz and feldspar. It is common for these residual minerals to clog or partially block some of the pathways creating a complex sub-surface drainage pattern.

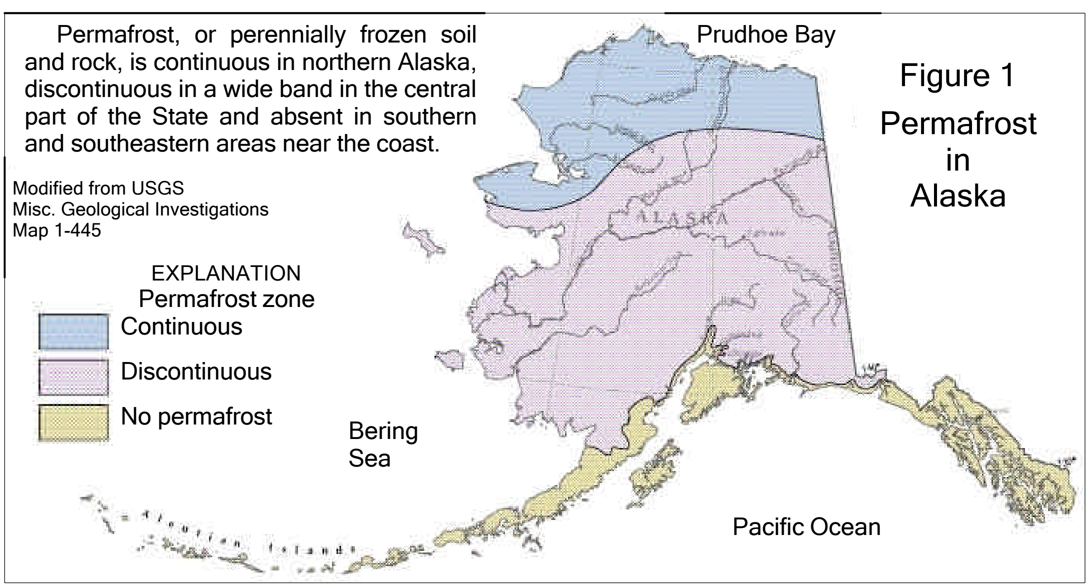
Carbonate rock is dissolved until the acidity of the water is neutralized (used up) to a pH of 7. Continued solution of limestone over geologic time has resulted in very complex cave systems in some areas. These cave systems, many of which developed at times when sea levels were much lower than today, are often connected to the surface by zones of dissolved rock. Many of the sinkholes appearing today on the land surface were formed over thousands of years and have been plugged up with clay with no sign on the surface that there is a zone of dissolved rock below. Recent changes of ground water levels (up or down) resulting from pumping or flooding events can trigger a subsurface “washout” of the plug, resulting in a catastrophic collapse at the surface. Some dramatic sinkhole occurrences have “swallowed” houses and cars and disrupted roads and pipelines.

The US Geological Survey is actively involved in identifying sinkhole risk areas and in studying the links between sinkhole formation and human activities. For more information on sinkholes development: 1) United States Geological Survey information: http://ga.water.usgs.gov/edu/sinkholes and 2) Kochanov, W.E., 1999, Sinkholes in Pennsylvania: PA Geological Survey, 4th ser., Educational Series 11, 33 p (www.state.pa.us).

Ground Water in Alaska

Sixty percent of Alaska’s drinking water is from wells, with 90% of the state’s water utilities relying on ground water. While the southern parts of the state adjacent to the Pacific Ocean don’t experience extreme cold, the frigid temperatures of the interior and north provide challenges for the development of ground water supply. Much of what we know about ground water in the cold north comes from US and Canadian military engineers. The establishment of permanent military bases and defense systems in the Arctic required permanent settlement in climatically hostile areas. The cold temperatures cause the ground to be frozen for most of the year with a thawing of the top layers for a few weeks in the summer; the only permanently unfrozen water supply is often deep underground. Permafrost, (permanent frost) is the technical name for frozen ground. The map of Alaska (Figure 1) shows permanently frozen ground to the north of a discontinuous permafrost area. Permafrost may extend to depths over 2,000 feet in the Alaskan Arctic Plain near Prudhoe Bay. In the Discontinuous zone, the frozen ground is separated by places where the ground is unfrozen.

The seasonal changes from frozen to unfrozen make the region’s hydrology complicated. Permafrost conditions may create seasonal perched ground water zones that develop during the summer thaw. Subsurface ice melts in the soil & rock layers near the ground surface to form ground water. The typical vegetation in these areas is called Tundra. The seasonal thawing, with frozen (and impermeable) ground below, gives rise to vast boggy areas with temporary pools and lakes of melt water.



Permafrost, or perennially frozen soil and rock, is continuous in northern Alaska, discontinuous in a wide band in the central part of the State and absent in southern and southeastern areas near the coast.

Figure 1 Permafrost in Alaska

In discontinuous permafrost regions, bubble-like shapes of unfrozen ground are called taliks (Figure 2). Closed-taliks remain unfrozen through the year and may contain ground water. Ground water is found in open-taliks that occur under small deep lakes and some streams. Through-taliks are zones of no permafrost where unfrozen sediments allow water to infiltrate from the surface.

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In northern Alaska, permafrost is at shallow depths under small, shallow lakes; intermediate depths under small, deep lakes and small to large surface streams; and is very deep or absent under large lakes, major rivers and the ocean.

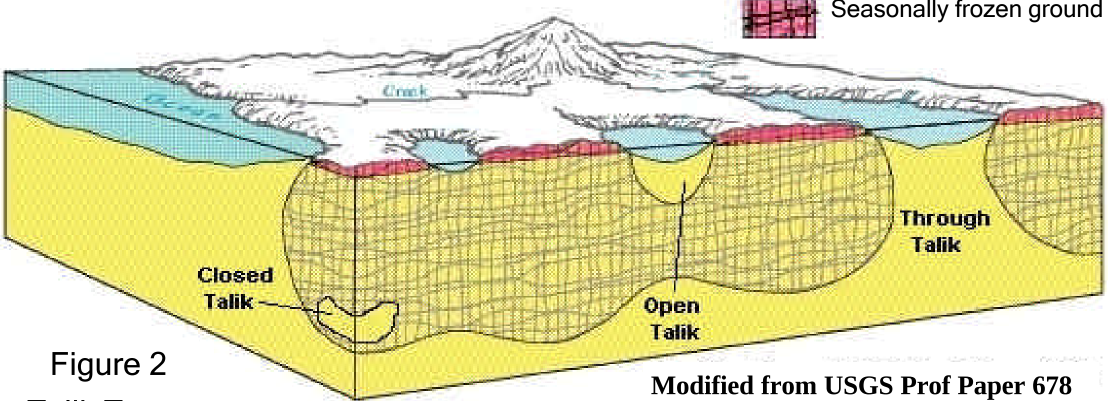


Figure 2
Talik Types

Modified from USGS Prof Paper 678

Wells in permafrost areas must be planned to intercept through-taliks or to penetrate to depths below the permafrost. Drilling a water well in permafrost zones requires extra preplanning. The drilling fluids must be carefully formulated and managed and must be kept near freezing to prevent melting around the casing. Once a well is started, drillers want to complete the process without stopping to avoid the risk of freeze-up. Drilling in winter is often preferred for permafrost areas because the frozen ground gives a stable base for the drilling equipment. Once installed, wells may need to be heated or continuously pumped to prevent freeze up. Water is typically piped from wells to the point of use via insulated (and often heated) conduits called utilidors.

Ground water supply from Alaska's aquifers ranges from extremely small thaw bulbs (talik) in permafrost to large regional aquifers, such as the Cook Inlet and Tanana Basin Aquifers. The extensive permafrost around the state provides challenges to the development of ground water resources but because streams & rivers are seasonally frozen, and many streams contain fine sediments, ground water sources are the best option for year-round water supplies. In many parts of Alaska, mountainous topography limits the size of aquifers. The state's huge size and sparse population of 1 person per square mile means that much of the ground water potential in the state has yet to be mapped and assessed.

Some Alaskan springs flow year round, and in winter months can cause large mounds of ice to form. These ground water "icings" are common throughout the state. An interesting wildlife connection to ground water occurs in southeast Alaska where warm ground water reaching to the Chilkat River allows the river to stay unfrozen in the early winter, and the late season run of salmon attracts thousands of bald eagles to gather to feed on the fish.

WHAT IS A WATER QUALITY MCL? . . . continued from back page

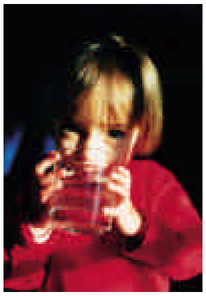
The current list of primary and secondary MCLs can be accessed on the following EPA link: http://www.epa.gov/safewater/mcl.html#micro .

State environmental agencies may also set MCLs. The state's standards must be at least as stringent as the EPA MCL. New Jersey for example has set a limit for arsenic at 5 parts per billion, (ppb), which is a lower limit than the EPA 10 ppb level. Most states use the federal MCLs to regulate the water quality from public water utilities.

The 1996 amendment to the SDWA required the EPA to publish a list of currently unregulated contaminants (Contaminant Candidate List, CCL) every five years. The EPA is required to evaluate at least five of the candidates every 3-1/2 years to determine if they should establish a MCL or can be dropped from the CCL. The second CCL ("CCL2") was published in February 2005 and includes 42 chemicals and 9 microbial candidates.

There are over 80,000 different chemicals in daily use in the USA. Only 100 of these are currently regulated for MCL drinking standards!

Private well owners have the privilege of controlling their own water supply, but also the responsibility of ensuring that the water is safe to drink. If you would like to know more about how to protect your well water and what to test for, please click on the Trust's web site: www.privatewell.com.



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AMERICAN GROUND WATER TRUST
16 Centre Street, Concord, New Hampshire 03301
☎ (603) 228-5444 ✯ 🖷 (603) 228-6557
TrustInfo@agwt.org ✯ www.agwt.org

TOPICS IN UPCOMING ISSUES

- Aquifer Storage and Recovery Basics
- Arsenic - Regulatory Update
- What is Safe Yield?

What Is A Water Quality MCL?

MCL stands for Maximum Contaminant Level. The Environmental Protection Agency under the Safe Drinking Water Act (SDWA) has the responsibility to develop MCLs for drinking water in the USA. A "primary" MCL is the highest concentration of a substance that is allowed in drinking water. Primary MCLs are based on human health risk. They are set as close as feasible to the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLs are also determined with consideration for the best available treatment technology and the cost of implementation by public water supply utilities.

Secondary MCLs in drinking water are currently set for fifteen substances based on aesthetic (non-health risk) criteria such as the concentration threshold likely to cause staining or create a foul odor or taste.

MCLs are determined through consideration of
1) Occurrence (both natural and anthropogenic sources of the contaminant)
2) Exposure conditions (how a person may be exposed - skin contact, inhalation or ingestion)
3) Exposure situations (work, home, recreation, etc.) and
4) Health impacts from exposure (what types of diseases may develop and are they acute or chronic).

Extensive epidemiological studies, risk assessments and probability analyses of the effect of contaminants on animals are used to quantify an MCL. In some cases, assessments of the health effects on human populations affected by natural occurrences of a substance are considered (e.g., arsenic in Taiwan and Bangladesh).

MCLs are legally enforceable for public water supply systems, which provide water to at least 15 connections or 25 persons at least 60 days out of the year (most cities and towns, schools, businesses, campgrounds, and shopping malls are served by public water systems). MCLs are not enforceable for private wells, but it is recommended that private well owners test their water and compare the results to the MCLs. Some states do set standards for private wells, so well owners should check their state requirements.

In 1977 when the first primary MCLs went into effect under the SDWA, standards for coliform bacteria, ten inorganic chemicals (including some metals), six organic compounds (including some pesticides), turbidity (or murkiness) and radiological contamination (e.g., radium) were included. The SDWA was amended in 1986 and again in 1996. Today there are primary MCLs for 6 microbiological organisms, 16 inorganic chemicals, 53 organic compounds and 7 disinfectants and their byproducts (i.e., chlorine, chloramines, chlorine gas, trihalomethanes, haloacetic acid, chlorite and bromate).

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