A beginner's guide to geologic hazards

Article by Paul Martz

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The subject of geologic hazards gets a lot of media attention every time there is an earthquake in California, (or a minuscule, on the scale of things, volcanic eruption like Mt. Saint Helens), but not a lot of discussion most of the time.

However, right here in Central Colorado, especially at this time of year and continuing through the summer, we have some fairly significant risks to health and safety that result from natural geologic processes. Most of these constitute a small physical danger, (although I recently did some work near a quarter-million-dollar house that I wouldn't let my family spend a night in if the owners were to give it to me). There are, however, a number of less dramatic, but still hazardous conditions, present in Chaffee and surrounding counties that are a result of our mountain geology.

The most frequently encountered geologic hazard in the spring is rock on the highway. While frost wedging usually results in fragments only large enough to be hazardous to tires and the underside of a vehicle, significantly larger, and I mean much larger, debris can wind up on the highway.

In the spring of 1996 while traveling west on Highway 50 above Garfield, I encountered a whole flotilla of stones in the center of the westbound lane where the freeze-thaw cycle and gravity had deposited them. I called the Sheriff's office from the Monarch Crest and reported what I thought was a fairly serious threat to life and automobile. Less than an hour later going back to Salida, I was quite astonished to see Deputy Sheriff Hoff standing beside an errant piece of the public domain that was bigger than a Volkswagen Beetle. It was resting squarely in the uphill lane a half mile from the debris I had reported, and it had not been present sixty minutes earlier. Fortunately, however, that well-rounded rock hadn't hit a passing car (nor rolled down the roadway colliding with oncoming traffic like a sort of Thor's bowling ball).

What put all this material into motion is a process called frost wedging. It is the result of water's expansion as it crystallizes and becomes ice. Yes, ice is technically a mineral, whereas, water is not. Why? Ice has a uniform crystal structure and water, being a liquid, doesn't.

When water seeps down into pores and fractures in "solid" rock and then expands upon freezing, it exerts an enormous pressure against the material around it. Now, this might initially result in a movement of less than a thousandth of an inch, but as the crack enlarges and holds a larger volume of water, the amount of movement increases with each frost cycle. Give it a few years, aided by the vibration of passing traffic, and you get to see a patrol car parked at significant risk on the down hill side from a "bundi" (that's an Aboriginal word for stone by the way) right in the middle of the highway.

Frost wedging is also the same process that continually brings stone to the surface in fields. The overlying soil offers less resistance to movement than the earth beneath the rocks, so they move upward in response to pressure resulting from ice formation on their lower side.

Readers of the *Denver Post* will frequently see mention of bentonite and swelling soils, particularly on the west side of the metroplex. Highlands Ranch got its recent 15 minutes of fame when *National Geographic* published a picture of it illustrating high density development in the midst of former rangeland. But fifteen years earlier the nearby Ken Caryl Ranch development got attention from geoscientists and geotechnical engineers when a large number of new homes started sinking. This was not a new problem to home builders in the Denver area, just one that was underestimated at Ken Caryl Ranch and other subdivisions to the north of it. The culprit was a clay that results from glass formed during volcanic eruptions. Remember that a mineral has a regular crystal structure, but volcanic glass doesn't. It too is a fluid, albeit a very viscous one.

The trouble-maker at Ken Caryl Ranch was a clay called bentonite, and when it soaks up water it can cause substantial problems. If you live in Salida, downtown Buena Vista, or Poncha Springs you don't have to worry about bentonite, however, because those places rest upon compacted river rock. But there are areas in the county where bentonite is present.

Anyone who has ever driven up Droney Gulch on County Road 255 or the lower portion of Spiral Drive after a rainstorm will discover a couple of properties intrinsic to bentonite. When bentonite gets wet, it gets slick and sticky. (It is actually added to some high pressure greases to increase lubricity and to keep gunk from adhering to whatever the grease is supposed to protect from friction).

A roughly forty-million-year-old sequence of interlayered volcanic ash and lake beds known as the Dry Union Formation crops out on the west side of the Valley from south of the Little River to well north of Nathrop. In places it reaches from the South Arkansas river right to the base of the Sawatch Range escarpment. The Spiral Drive road, however, is cut into younger volcanics that contain both ash and mudflow breccia which also contain clays.

Bentonite has another property that makes it both commercially useful, and very destructive to poorly designed foundations: it swells when it gets wet. The individual clay particles, called platelets, absorb water and spread apart as a result. This process results in a less dense, sticky glop that will swallow a house over time. Once the clay platelets get wet and expand, soils which contain them no longer absorb water. This process can, and has, resulted in some expensive septic leach fields for homes built over the Dry Union Formation because percolation rates are obviously affected.

Anyone who has ever sat in the mountains at or above timberline on a calm, still day has probably heard the random crashing of loose rock falling. Ice and water continuously act to reduce big bundis into smaller ones. This material goes by the name of talus, and talus tends to move downhill under the pervasive influence of gravity.

Where the bedrock is particularly hard, dense, and resistant to fracturing, the resulting talus can become a rock glacier of large angular fragments. While the surface appearance of such an accumulation may appear to be stable, I was once nearly killed by an avalanche of this material triggered by another geologist crossing such a glacier a few yards higher up than I was.

It will be more than a few additional years before I forget the shaking and roar of that slide -- or the fact that I set an Olympic record for rock-hopping as I got out of its way with a fully loaded pack of samples. But my point is that the release occurred suddenly and without any prior warning. The other guy just happened to step on one wrong rock, and the whole mess started moving.

Most people carrying heavy packs and wearing tool belts have better sense than to walk across rock glaciers, but even in a "T" shirt and shorts it's hard to dodge a rock slide. Let the lower person get way

out in front of you -- before you start moving.

All this talk about loose rock, gravity and water brings me back to the house my kids would never be allowed to sleep in. Not only does it have all the fire hazards discussed by Kirby Perschbacher and Ed Quillen in Issue #8 of *Colorado Central*, it sits, along with several other houses, just below the mouth of a canyon that drains an extensive area of talus that's resting temporarily on glacially oversteepened slopes above treeline. In other words it has every form of natural disaster hanging over it. In dry years there's the threat of fire. And in wet years, geology and gravity combine to create a menace that offers less warning than a pillar of smoke. I am referring to torrential mud flows.

A mudflow several years ago wiped out an entire small city in Colombia. They are frequently associated with volcanoes, and in Indonesia they regularly kill significant numbers of people and cause extensive damage to crops. I once watched a brand new Ford Bronco float several hundred yards down a normally dry streambed when its driver attempted to cross one. (Yet another example of where 4-wheel drive won't take you). The driver was lucky to survive, and did so only because the vehicle pitched off to one side of the flow and came to a rest in a place where we could pull her out of the car.

The mudflow danger to the home I mentioned earlier is not related to volcanism. It is, however, a case where time has hidden the evidence of the threat. This house and its neighbors sit within heavy pine and aspen growth on a cone of debris that has been carried from the canyon mouth during the twenty thousand years since the last ice retreat. The stream that carried this material is now a seasonal runoff channel for the snowpack in its upper basin. Additionally, that stream flows off to one side of the debris pile, rather than across the top as it formerly did.

Anyone who has lived in Colorado, or anywhere else in the mountains has seen the effects of avalanches. Snow is ice which together with its entrapped air is more than 15% lighter than water. An avalanche is a gravity flow of snow and air mixed together. One has only to drive up to St. Elmo in the winter to witness the destructive power of such a mixture of ice crystals and air flowing rapidly down a steep slope. Trees, large rocks, cars, and buildings get carried away by them.

Now imagine a flow of material that is two times ***heavier*** than water, and weighs thousands of times more than the biggest avalanche, and you begin to get a perspective of the threat involved. In terms of warning, avalanches at least flush out their chutes every few years and provide a regular reminder of their potential hazard. The size and number of trees within the area of danger near this home, however, serves to hide the fact that a threat has been increasing slowly over a very long period of time.

The risk is that a thunderstorm will get hung up in the catchment basin and dump its moisture load torrentially on the large volume of accumulating talus resting on those steep slopes. While such storms happen occasionally every summer, and sometimes there's even flash flooding on such slopes without serious consequences occurring -- when you have slopes that have been producing talus for a long period of time, and a large amount of water is suddenly added, a mudflow can result. Soil, clays, sand, and rocks as big as railroad cars get fluidized in a gravity driven flow of material whose density can reach 2.2 times that of water.

Nothing made by man is going to stop such a force. Even the dense forest around these homes can not resist or protect them from one of these events.

The third potential danger to this house is an air rafted rock slide. Our valley is a portion of the Rio Grande Rift, a fracture in the earth's crust that is widening and deepening with time. The Mediterranean Basin, Red Sea, Gulf of California and the African Rift Valley are all examples of this type of geologic

structure. Rifting is the product of fault activity and faults are the cause of earthquakes. In the past ten years we have had several small earthquakes attributed by the Geological Survey as stress relief due to erosional unloading of the Sawatch Range. However, there is ample evidence of more intense displacement resulting from faulting associated with the rift system nearly everywhere in this valley. A geologically recent displacement of more than 40 feet is present along the Sangre de Cristo escarpment within a mile of Highway 50.

I don't know what movement of that magnitude would translate into on the Richter scale, but it would definitely be a significant number. Such an event in or near the catchment basin or the escarpment just above the homes in question could trigger an airborne debris flow -- but this is only one of many locations within the county where steep slopes have significant amounts of loose material built up on them. Many mountain dwellings share the potential for this type of geological phenomenon.

An airborne debris flow is rock and soil that has a layer of air trapped beneath which serves as a transport mechanism of great efficiency. Airborne rock falls can travel miles in a matter of minutes. An event of this type should be considered extremely rare, even on a worldwide basis. However, they occur without warning and have claimed lives in North America within this century. Nearly any glaciated valley holds this potential threat, and as people insist on moving farther into the mountains, they put themselves at significantly greater risk from what are admittedly rare events.

Even though it is obvious from the heavy vegetation that such an event has not occurred within our lifetimes, it is unfortunately true that that only increases the likelihood that it may happen in the future. These are not gradual or reoccurring events like seasonal flooding on major rivers, but rather sudden unpredictable, catastrophes. It's a matter of putting oneself in harm's way and then waiting for it to happen.

Whether it be rock falls from frost wedging, bentonite, mudslides, or air-rafted rock slides, the Rocky Mountains offer a host of geologic hazards, and I can't overstress how much simpler and safer it is to consider them -- before you build a home in their domain.

Paul Martz of Poncha Springs holds a master's degree in geology from the University of California at Davis, and has worked as an exploration geologist for several Fortune 500 companies. Among other things, he now owns and operates Headwaters Geologic Consulting in Poncha Springs. In his second installment next month, Martz will discuss floods and long-term geologic hazards in various Stupid Zones hereabouts.

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