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Not My Fault: Earthquakes can have unexpected consequences

Lori Dengler for the Times-Standard
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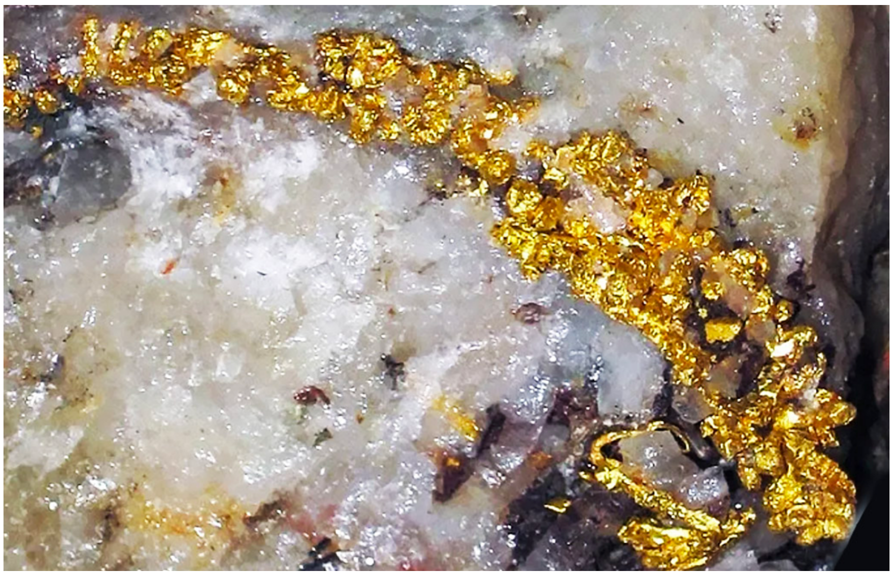

Concentrations of gold in quartz like this sample from the Red Mountain Mining District near Ouray, Colorado may be the caused by repeated earthquakes.

The consequences of earthquakes are sometimes different than what you might expect. On August 28th, a magnitude 6.1 earthquake occurred off the coast of El Salvador. It was felt throughout the Country and by some in neighboring Guatemala and Honduras, but the shaking wasn't strong enough to cause damage to structures. However, fifty injuries were reported – all caused by stings when the shaking dislodged a beehive.

A very different type of earthquake consequence came out in the journal Nature Geoscience on September 2 of this year. Christopher Voisey of Monash University in Australia and colleagues reported a connection between earthquakes and gold accumulations. Gold and earthquakes may seem like a very large stretch. How could there be a link?

Gold is a wonderful element, highly esteemed since ancient times for its brilliance, malleability, inertness, and rarity. It is one of the few metals that occurs concentrated in its elemental state often in quartz veins and alluvial (gravel and cobble) deposits. How does it get there?

The origin of gold as an element goes back to the early stages of galaxy formation and the scientific consensus is that most of the gold on our planet has been here since the time of consolidation. There has never been much gold and if it were evenly distributed, we'd never be able to mine and recover it.

More than 75% of the gold mined and used by humans comes from “orogenic gold deposits.” Orogenesis is mountain building. It’s a complex process that I won’t describe here, but it always involves stress as the land is pushed upwards and higher temperatures than at the ground surface. The high pressures and temperatures cause rocks to recrystallize or metamorphose.

When mountain building cooks and squeezes rocks, a small percent of the rock does melt. These hydrothermal fluids readily carry some minerals including gold and concentrate them in veins and seams in the metamorphic rock. The biggest producer of metamorphism? Convergent plate tectonic boundaries. We can thank over one hundred million years of the North American and the ancient Farallon plate grinding against one another along the U.S. West Coast for creating the California gold rush of the 19th century.

The connection between gold, plate tectonics, and mountain building has been recognized since the 1990s. The Volsey paper takes it one step further. Why do gold-rich veins inevitably lie within quartz, and not occur uniformly in other minerals that make up mountains?

Quartz is an extraordinary mineral. The third most common mineral on the earth’s surface, it is the only cone quite content to exist in high or low temperature environments. You can find it in granite, the result of crystallizing molten rock, in metamorphic rocks formed at high temperatures, and on almost every beach in the world, perfectly stable at surface conditions.

Quartz also has interesting chemical and electrical properties. It is the only abundant piezoelectric mineral on earth. Piezoelectricity is the ability of materials to generate a voltage when stressed. The relentless slow squeeze of plate collisions won’t generate piezoelectricity. But another process at convergent plate boundaries can. About 80% of the world’s earthquakes occur in subduction and collision zones. Earthquakes quite capable of triggering piezoelectric responses.

Volsey’s team ran a series of experiments to see how quartz submerged in a gold-bearing solution would respond. They repeatedly deformed the crystals at stress levels similar to what would occur in earthquakes and then examined the quartz under a scanning electron microscope. They were delighted to find gold depositing in cracks and on the quartz surface.

Volsey’s explanation is that earthquakes stress creates a voltage in quartz. The release of electrons from the quartz is picked up by the gold in solution making it more likely to settle on surfaces. The earthquake also causes cracks in the quartz, the perfect crevasses for the gold to settle into. The process is repeated over millennia, the fractures in the quartz opening again and again in subsequent quakes and the gold continuing to accumulate. The next time you put on that gold bracelet, earing, or tie clip, please give a brief thankyou to earthquakes.

Other earthquake oddities are not as economically important but are also awe inspiring. Many North Coast residents observed unusual lights in the night sky during the large aftershocks of the April 1992 Cape Mendocino earthquake. A Ferndale woman described a glowing orange blob pouring out of her backyard during the shaking. Some people saw bursts of orange glows in the distances. The most unusual description came from a fisherman many miles off the coast that night. The water began to glow. The glow increased until after a few minutes he was in the midst of a glowing aqua ocean. The glow continued for more than an hour before it slowly began to fade.

Earthquake lights are a hard phenomenon to pin down. Different processes may contribute including sources in the rupture zone, near the surface and in the atmosphere. Fault rupture is dynamic, producing localized high temperatures and pressures as the fault grows. A 2014 paper by Thériault and colleagues in Seismological Research Letters proposed that complex chemical reactions take place in that environment, producing currents that may reach the ground surface and are strong enough to ionize the air and excite emissions in the visible range.

Earthquakes can also have a profound effect on rivers and subsurface water in ways that might surprise you. The most famous story of river flow and earthquakes comes from the February 1812 New Madrid earthquake centered in SE Missouri where accounts describe the Mississippi River flowing backwards for several hours and piling up waters upstream. When the flow turned it created a flood that jumped the banks and flooded the adjacent valley and a Chickasaw village, creating Reelfoot Lake.

Reelfoot is not the only lake to be created by seismic activity. Earthquake Lake in Montana was created in 1959 by a large landslide that dammed the Madison River. 1812 is also not the only account of a river reversing flow due to an earthquake. Fisherman described the flow reversing for several minutes on the Mad River in December 1954 during the M6.5 earthquake.

Subsurface water is also disturbed by earthquakes. Liquefaction is the process by which seemingly solid ground suddenly behaves like a liquid. In areas of saturated loose sediment most often near bays, coastlines, and riverbanks, shaking causes compaction of sand grains forcing water upwards. During shaking the solid framework of grains resting upon each other is disturbed and suddenly the ground behaves like a muddy swamp. Sometimes, water squirts onto the surface in small fountains called sand boils.

Large earthquakes almost always affect the water table. In some areas wells will suddenly drop and in others the water will rise. It's not a random pattern. Al earthquakes involve slip on a fault. This produces a four-lobed pattern around the fault. In areas where fault slip reduces pressure, water subsides. In areas where pressure increases during slip, the water rises. Often temporary, there have been cases where dependable water wells have permanently dried up.

This is only a small sampling of unexpected earthquake phenomena. Some pose no hazard, but liquefaction and river flow reversal can cause damage. Most structures are designed to withstand liquefaction, but roads are not. Roads are also vulnerable to slip-outs. Feel an earthquake while fishing or enjoying river activities, especially one that is noticeable and lasts a long time? I would get away from the water and return another day.

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