Alicia Rosales
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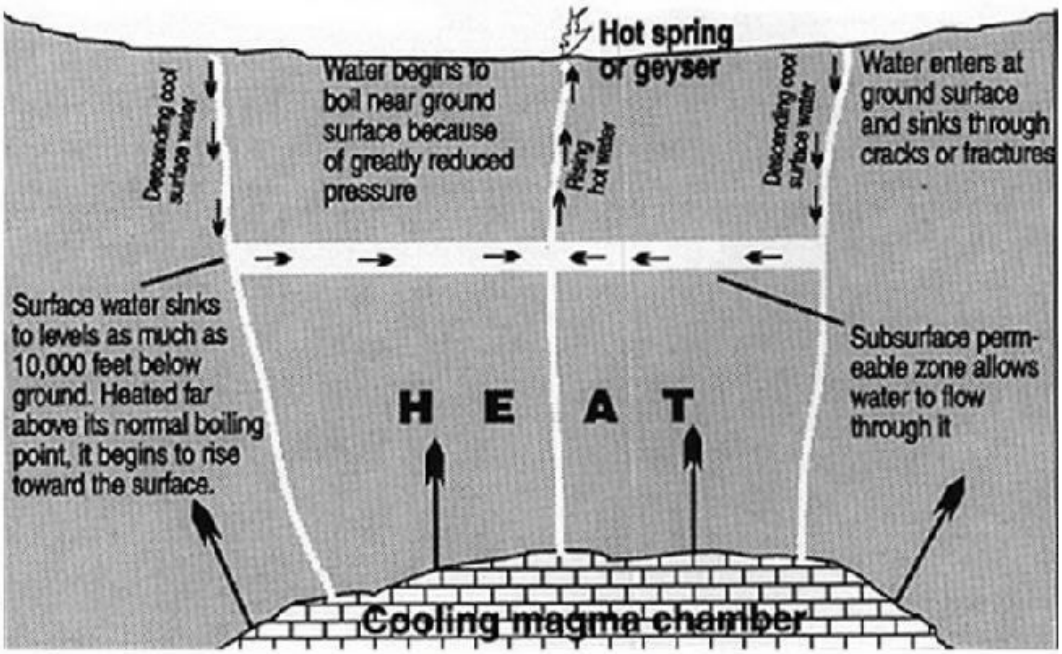
Hot Springs: One of Nature's Many Wonders

It's the end of a long day, and you've been working hard. You get home in search of a way to shake off the stress and relax your mind and muscles. Some people might take advantage of technological advances and turn on the television. Some people might just grab some lemonade and listen to peaceful music. Then there are the people who turn to the wonders of water. They are the ones who head to the bathroom and fill up the bath tub with nice, hot, soothing water and lay back and leave the world behind. Imagine sitting in a bath not inside a cold, white bathroom, but rather outside with a beautiful landscape of mountains and pines. Sure some spas offer rooms that would create such a situation…but what if you could just sit back and feel a cool breeze, the sun shining on your face and be serenaded by real, live birds? What if it was all possible? Depending on where you live, you might have the chance of enjoying the wonders of a natural hot spring. If not, one can pleasure themselves on vacation. But is that all? No! There is much, much more to hot springs than the fact that they make great outdoor bathtubs. If you take interest in extraterrestrial life, the beginning of life on earth, clean energy sources, earth processes, beauty in nature, and ecology (and so many other topics!) it is encouraged that you to read on. Even if none of the above appeals to you, take the time to gain some knowledge and maybe even find yourself impressed and/or intrigued with what hot springs have to offer.

For those who have never experienced a hot spring, they are rather interesting features to observe. The air surrounding them is filled with an odd (and to some unpleasant) smell of something similar to rotten eggs. In cooler areas more steam will be present, in warmer regions, less steam will be visible. At some hot springs, a wide variety of colors may be observed. The one visited by my class (Hot Creek, located in California) occurred next to a mountain originated stream, and appeared quite normal with a few areas of steam. A pool off to the side displayed a bright aqua blue shade. We came prepared in our swim attire, and set foot in one part of the stream. It was lukewarm, and soothing even on that summer day. Further into the stream, there was an area that appeared to be bubbling out, like a very low pressure fountain. Water emanating from that spot was very warm to hot. Up the stream came mountain water, snowmelt, and was very cold. Certain areas of the stream alternated between the hot and cold water, for a very fascinating experience. If one placed their hand on the sand on the bottom of the stream, it felt warm to the touch, but if one stirs up the sand and digs a little deeper, it can be very hot. Hot springs are mostly unique for quite an obvious reason; while much of the water on earth is cool or cold, hot springs are warm or hot. Such an oddity must have an explanation. It all starts from within our planet, Earth.

The earth is divided into three layers of rock strength; the outer two named the asthenosphere and lithosphere. The lithosphere is the outermost layer and is relatively cool compared to other layers, and much stronger. The thin lithosphere is divided into “plates” or sections. These plates, called tectonic plates, lie on top of the next layer down, the asthenosphere. The asthenosphere is like hot “goo”. This hot goo is molten rock; it is called magma. Areas where the magma has come closer to the surface of the earth can be displayed by volcanism. Sometimes areas of volcanism occur near plate boundaries and sometimes they occur where the asthenosphere is especially hot, areas called hot spots. Examples of these are the Hawaiian Islands and Yellowstone Park. Both locations are not particularly close to plate boundaries, but do exhibit volcanism. An example of volcanism near a plate boundary would be the Long Valley Caldera in California; it is in this region where Hot Creek is found. If you have a place where there is volcanism, you have a place where you might be able to find a hot spring. (Skinner, 1999)

Water in hot springs is generally originated from precipitation. Be it rainfall or snowmelt, water seeps into the earth. At a certain point, it is heated up by magma close to the earth’s surface. Heated water is much less dense than the rock that it surrounds it, and thus it rises to the surface, in the form of a spring. The water is carried in conduits; through the water table, fractures in sedimentary rock and other passages where the water can flow. Other hydrothermal features include geysers and fumaroles. Geysers are recurring spouts of hot water, as compared to springs which usually gush and produce a pool of hot water continuously. Old Faithful in Yellowstone National Park is an example of a fairly regular erupting geyser. Fumaroles emit gases and steam. They look similar to spouts of steam from a tea kettle as rise from a rock surface. They are also known as solfataras. (Watson, 1997)



Hot Spring System (Brock, 1994)

Similar Features at Yellowstone National Park

left - Black Growler Steam Vents; fumaroles

below - Old Faithful Geyser

(Watson, 1997)

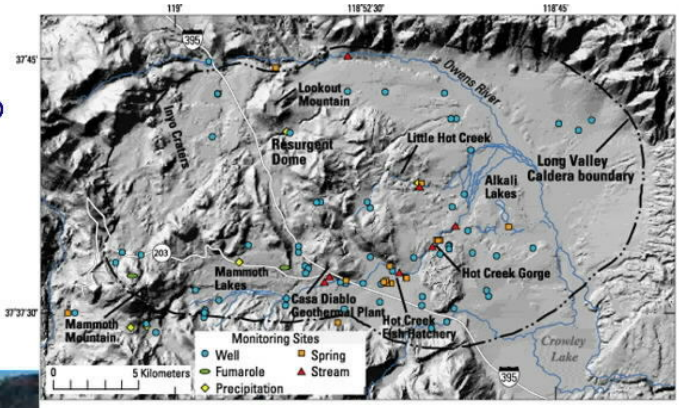
Physical and chemical characteristics of hot springs can vary from spring to spring. They can vary in temperature, flow rates, composition, and other properties. The United States Geological Survey (USGS) has various monitors set up to record hot spring

conditions. These monitors can in be found in regions such as the Long Valley Caldera. Some outside factors that would affect a hot spring include: precipitation, ground water levels, geothermal power plants, earthquakes, the tides and atmospheric pressure. In the Long Valley Caldera, the water can reach 220° C where it comes in contact with young volcanic rock. (Farrar, et al. 2003) A spring in Arkansas spouts out from the earth at 143°F. It also releases 850,000 gallons of water each day. (Conners, 1998)

Observing Hot Springs

right - Long Valley Caldera map of monitering sites

below - Hot Creek Fish Hatchery AB Weir (FHAB) monitering station



Photos by

above - (Farrar, 2003)

left - M. Sneed 2002
(Long Valley Web Team, 2003)

Composition is the chemistry of the hot spring. As the hot water comes to the earth surface it dissolves away at rocks and carries minerals in solution. Because of this, the water may be high in minerals. Elements that can be found in hot springs include: arsenic, boron, chlorine, silica, sulfur, and radium, as well as many others. To be considered a “mineral spring”, a spring must have 400 ppm (parts per million) of dissolved solids in its waters. (Brock, 1994)(Mountain Nature, 2003) It is the sulfur in the water that causes the notorious rotten-egg smell one might experience when visiting a hydrothermal system. The chemistry of the water also affects the acidity/alkalinity of the water. Water from hot springs in Yellowstone National Park varies from 1.3-9.4 in pH. A pH of 7 is considered neutral, neither acid nor alkali. (Brock, 1994)

If hot springs present such harsh conditions, it would seem that there would be little or even no life that could survive, let alone thrive in such an environment. Surprisingly, there are some life forms that take to the hot springs quite well. There are only a few types of animal life that exist on or near hot springs. It is rare that fish would survive in hot springs due to high temperatures or acidity, though there are occasionally fish downstream where the water may be colder or less acidic. One type of life that can be found at springs is the ephydrid fly. There are several species of these flies that live their life around the springs. *Ephydra bruesi* occur around springs that are not high in acid; preferably neutral or slightly alkaline water. They lay orangey-pink eggs on the microbial mat (discussed later) where the larvae hatch and consume the microbial mat for

nutrients. These flies can handle up to 109°F as adults. Two other species, *Ephydra thermophila* and *Scatella paludum*, live near hot springs where acidity is higher. Though they can live in hot springs with weaker acidity, they appear at more acid springs because of competition is less of an issue. The acidity they can handle is a pH of 2 or greater. They survive by consuming algae in the waters. Because of the flies, certain spiders prey near hot springs, leaping out onto the spring to capture the mature ephydrids. The flies are also preyed upon by killdeer, a species of bird. It is found that the birds will eat both the acidic and the non-acidic species. There are also several parasitic insects that are hosted by the ephydrids; as you can see there is a complex little web formed by the animal life near the springs. (Brock, 1994)

Photos by

left - Thomas D. Brock
below - National Park Service

(Brock, 1994)

Animal Life

above - Wolf Spider

right - Ephydrid flies and orange-colored eggs

In addition to life easily visible such as flies and birds, there are several other life forms not so easily detected by the eye. Ironically, they are very obvious to the eye, if you know what you're looking for. If you look at pools of hot springs, you may see various bright colors. Blues, greens, reds, yellows…but what causes these beautiful colors? Prokaryotes, Bacteria and Archaea, dominate life within the pools. Photosynthetic bacteria, cyanobacteria, cause many of the bright colors you might see in a hot spring. You might know chlorophyll to be green, but other pigments that protect the bacteria from sunlight cover the color of the chlorophyll in these organisms. If you visit a spring during the winter months when it is likely to be cloudy, you may see a greener color in the pools. The bacteria will produce fewer carotenoids, the red, orange and yellow pigments that they use to protect themselves from sunlight. Even though bacteria can survive in such hot conditions, the ultimate in heat survival is the Archaea. They can withstand temperatures up to 240°F! Because of there capacity to survive such heat, they are called hyperthermophiles. Another thing cyanobacteria cannot withstand is acidity. But, where there is acidity, yet another life form can thrive. This life form is algae. They

cannot handle near as hot conditions (the upper limit is 133°F, but they can handle acidity. One form, *Cyandium caldarium*, can actually deal with an acidity of pH 0. (Brock, 1994)

Beautiful Colors

below - Fountain Paint Pots

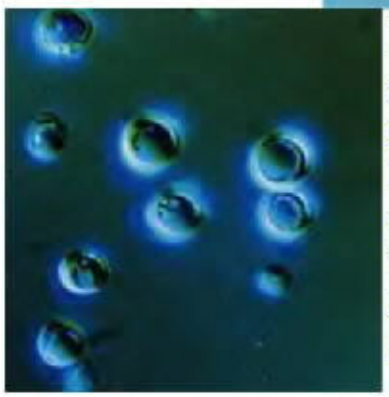
right - Grand Prismatic Spring

Photos by

above - Russ Finley

left - Thomas D. Brock
(
Brock, 1994)

Photos by Thomas D. Brock (Brock, 1994)

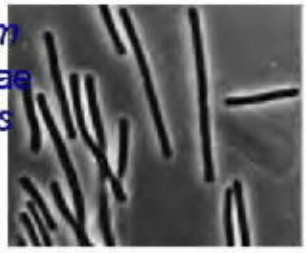


Little Life

above - bacteria found in hot springs

left - *Cyanidium caldarium*, algae

right - *Thermus aquaticus*, bacterium



What can a hot spring do for you? Humans have had various sorts of interaction with hydrothermal features throughout history, continuing even today. Indigenous peoples were some of the first to use hot springs. Europeans later came in, and often considered the pools to be dynamic in curing certain ailments. (Mountain Nature, 2003) There is little information on the actual affects of the water, though if one searches the web for "hot springs resorts," there is an abundance of resorts who claim that their water will help people's aches and pains. If anything else, the water is soothing because of its warmth. Some have even believed the waters to be healing if consumed. Though there can be dissolved arsenic in hot springs, it would probably take long-term exposure to create any serious health problems. Bathing in the springs would be almost entirely safe. (WHO, 2001). After bathing myself in hot springs, I can say it was an enjoyable and soothing experience. I also report that I do not feel ill (as a possible result of arsenic) or that any health condition I have (allergies, etc.) has somehow disappeared because of my short immersion in the water of Hot Creek.

Within the past decades, there have also been certain technological advances that have arisen due to hot springs. One of which is geothermal power. It has been used in some parts of the world for more than half a century, but is relatively new to the United States. Geothermal plants take heated water from the earth to turn turbines, and then the cooled water is sent back into the earth. Energy from the turbines creates a useful power source. While the system is considered "green" (it does not harm the environment), it is not very efficient and cannot serve very many people. (Skinner, et al. 1999)

Energy From Hot Springs

left - fumarole near geothermal plant in Mammoth Lakes, CA

below - Mammoth Pacific Geothermal energy plant

Photos by Alicia Rosales 2003

Another hot spring derived technology involves the minute life forms in the pools. Many biotech businesses come to Yellowstone National Park in search of samples of bacteria and Archaea. While they do occur in other regions of the world, the species at Yellowstone National Park are most abundant and easily accessible, due to the protection of the park system. One species, *Thermus aquaticus*, is especially famous. It used to be thought that DNA and proteins could handle little heat. *Thermus aquaticus* has proved otherwise. A form of bacteria, it will survive at a temperature up to 173°F. It abilities have been used so that DNA can be multiplied at a very high rate. Taq polymerase, that *Thermus aquaticus* produces, can be used for a variety of things. It has been used in the medical world as well as in the growing world of forensics. Since its discovery, there is now a three billion dollar industry built upon its uses. (Brock, 1994) It is amazing that such a tiny creature could have such an impact. There are still other examples. A hot spring in Idaho has Archaea that live off of hydrogen and carbon dioxide, instead of oxygen or organic carbon sources. Because of theses qualities displayed by the Archaea, some scientists believe that it might be quite similar to forms of life possibly on other planets. Other planets may not have large amounts of oxygen or organic carbon, and so life like Archaea might exist there. These Archaea, along with certain bacteria, are also being used for potential pollutant breakdowns. They have been used for oil and various chemical spills. They are being researched to study how they handle substances toxic to other life. Such research will help humans by possibly being used to clean up pollutants. (Chapelle, et al. 2003)

In addition, hot springs are tourist attractions. Even if the smell is unappealing they provide beautiful colored pools and in general, an amazing feature of earth that I believe everyone should experience. Two of the first three national parks in the world were based around hot springs: Rocky Mountains Park, in Canada, and Yellowstone National Park, in the United States. (Mountain Nature, 2003) It is no wonder; hot springs are certainly worthy of being protected for future generations. I now highly encourage you to visit a hot spring on your next vacation. Whether you sit in the pools and relax, or simply enjoy from a boardwalk, think about all the things that hot springs offer to you and other life forms!

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