Minerals of the Sierra Nevada: Western Mineral Deposits and Veins.

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Abstract:

Quartz, feldspar, mica, amphibole, pyroxene, and calcite are families of common forming rock in the Sierra Nevada mountain range. The formation of these various families of rocks is dependent upon the materials contained within the cooling lava. The minerals present within the lava are also a determinant of how fast the flow will cool. But how is this truly accomplished? The purpose of this paper is to understand the formation of minerals and ores within the Sierra Nevada mountain range, along with the way certain rocks can lead to identification of valuable minerals within the area. It will work to answer questions such as how a vein of mineral ended up in a certain area and not another, along with other baffling natural mineral phenomenons.

Starting with a short history of the Sierra Nevada mountain range, the paper will lead through the California gold rush that put San Fransisco on the map and explain certain identification tactics used by the miners of the time. Gold being a key mineral found in the range due to past history of the mountains, helps to explain other mineral deposits. Concluding with why these processes are relevant to human nature and growth.

The Sierra Nevada Mountain Range

The first evidence of this historic mountain range is 500 million years old (Hill, 1975). Though this may seem quite old, it is in fact not. On a geological time line, this is relatively young, much younger than the earth. Some features currently present in the area are only a couple hundred years old. New enough to be considered still dangerous. The Sierra range is being built off volcanic activity resulting from plate tectonics. As the

Pacific plate subducted beneath the North American plate, the rock melted and pushed its way to the surface, creating what is now seen as the Sierra Nevada mountain range.

The bending and moving of the earth created what is seen today: large granitic structures built up by the volcanic activity. Previously the mountains built up from the sea floor and the rock was forming the mountains was cooled lava flows. Now, the mountain range shows off it's granite underbelly, rock that would not have been seen during the time when the mountains first formed. Granite is formed from magma cooling beneath the surface, evidence of a volcano that had the potential to erupt but never did. Erosion is a processes of time that slowly brings the mountains down and exposes the new faces of the mountains. This is not the only means by which the land has been worn down over the years. When the age of ice carved through the area, it created distinctive features into the rock such as moraines, rounded rock outcroppings, and areas where rocks from higher in the mountains are placed where they do not seem to belong. Weight and movement of the ice brought about changes within the range. The combination of external elements as well as continuing volcanic activity in the area formed what is visible today. The range runs over 400 miles up and down the eastern side of California, extending it's reach into Oregon (see Fig. 1).

Figure 1 – The Sierra Skyline [Figure adapted from Modern Sierra Nevada: Mt. Whitney

Crest, 2005]

Mining in the Sierra Nevada

Ores used for everyday life are located everywhere. Gold is commonly called the metal found "'where you find it'" [Hill, 1975], meaning small quantities are everywhere. The difference between mining anywhere and mining in the Sierra is the quantity. Much more gold has been deposited within the Sierra Nevada range. Located on the Melones fault zone, Jamestown is a major mining town sitting right on the Mother Load of the Sierras [Ashley and Savage, 2001]. It is a classic example of how much gold is located in the Sierras because of how much gold was brought out of the mines. Gold deposited by various constructional forces also helped formed the mountains and by looking at the way the gold was deposited, geologist can create a theory on how the mountains formed or which process occurred first.

Several open face mines make up Jamestown, and over half a million troy ounces[1] of gold has been mined out between 1986 and 1994 [Ashley and Savage, 2001]. Figure 2 contains an example of the ore pulled from the ground, though not from the Sierra Nevada range, it represents what the miners were looking for. Though mining corporations are still in existence today, people no longer make prospecting into their career hoping to strike at rich. Everything is commercialized in the world today and if someone wanted to become and prospector they could just join a mining company. The corporations took over the mining business in the Sierra Nevada shortly after the major movement of the gold rush ended. Many of the current day prospectors do it for a hobby, it would not pay off to make it into a lifestyle unless the person works with a current

1One troy ounce is equivalent to 31.1035 grams.

corporation.

Figure 2 -- Western Australian Archaean lode gold ore (8cm x 5cm). 500' level, Great Boulder mine, Kalgoorlie. Photo: S Humphreys © Australian Museum. [Figure reproduced from geoscience: the earth, 2004]

The Gold Rush

In 1848, James Marshall found gold along the American River starting off a major epidemic of people moving to California. Before this time, few people found there way to California, but the idea of discovering gold drove over half a million people to the state. The rush of people did not occur overnight, many were hesitant to believe the story of gold until the winter of 1848. President James Polk announced, "'The accounts of the abundance of gold in the territory are of such extraordinary character as would scarcely command belief were they not corroborated by authentic reports of officers in the public service'" [The Gold Rush: Fever]. This got everyone riled up, making plans to head for the west.

Major gold deposits are usually found deep underground, but this gold was different. Because of the relative ease of accessibility of the gold, it was even more alluring to the common man wanting to get rich quick. Not all fortunes were made by mining the gold. Because of the unique position California was in, becoming part of the

states after the gold was first discovered, it was considered a free state, free for the taking [The Gold Rush: Gold Country]. Many people looked west and saw opportunity. Some saved their money out in California and then moved back east with their earnings. However, the miners were the main focus for all out in the gold country.

The miners said they could tell the gold bearing veins from the barren veins when they went to mine in the Sierra Nevada. The mining process started with this knowledge (see Fig. 3). Though an experienced miner might be able to see a difference within the veins, there is no guarantee that all the veins that looked at first glance to be of the gold bearing type actually contained gold. Many miners knew as they headed out to try and strike it rich, they would not succeed. But the hope of becoming one of the lucky few drove the prospectors on.

Figure 3 – Typical Mining Cycle [Figure reproduced from Mudd, 2004]

As gold became more difficult to just find, miners started forming loose knit groups to build dams and further expose what gold was left. These were considered the start of formal mining companies in California. In the mid 1850s, the remaining miners were all employees of the corporations that moved in [The Gold Rush: Changes]. The gold rush changed life for many people and helped build California into what it is today.

It was shaped by adventurers for adventurers [The Gold Rush: Impact]. San Fransisco was brought from a tiny country town into a booming suburb that made the world jealous within just a couple of years.

Mineralization in the Sierra Nevada

How did the gold actually get into these veining systems? Many years of geological processes that bent, twisted, and formed the Sierra Nevada seen today helped with the depositing process. It is stated in the abstract by Jia, Li, and Kerrich that "gold mineralization occurs primarily within domes and reverse-fault systems" which indicates that these processes have taken place sometime in the history of the Sierra Nevada [2001]. These processes of gold mineralization would create pockets instead of veins which was apparent in the Sierra Nevada, but not what miners commonly looked for. There were some miners looking for the pockets using the tunnel mining technique, but this technique is more complicated than using a vein to lead the way.

Within the encyclopedia the definition of mineralization is "the process where a substance is converted from and organic substance to an inorganic substance" [wikipedia]. Hydrothermal fluids are the key to what makes this definition valid. The fluid runs through cracks within the already set rock and cools while it is moving along. Once the fluid hits a certain temperature, the metal dissolved within the fluid will "fall out" of solution, forming a layer along the sides of the crack. Minor flaws in the surface of the crack walls also help in the mineralization process. The flaws act as a support for minerals to get caught in as the solution flows over and minerals fall out. It could be said these flaws are acting as a catalyst in the formation of the new rock. As the minerals fall out, more can build on top of what is already there, building sold crystalline structures on

top of the existing structures.

The flow of hydrothermal fluids can also explain how the gold ended up in the river system as well. Water is always looking for the lowest point it can drain in to, other fluids follow under the same laws. Gravity constantly pulling down on the liquid helps bring them down to the point where no potential energy is contained within the liquid and it can just sit. This applies to the hydrothermal fluid as well, pulling it through the path of least resistance, which could have formed the riverbeds the miners worked in. This is dependent upon whether or not the hydrothermal fluids flowed out of the rock and onto the surface. Evidence of this could have undergone transformation in the millions of years of existence of the mountain range due to weathering, water flow, lava flow, and other natural processes.

Figure 4 represents a quartz vein outcropping from Mineral County, Nevada. Quartz is the mineral that heals faulting. The Mother Load is a major faulting area within the Sierra Nevada and would make sense that quartz veining exists. These faulting areas and other cracks within the cooled magma filled with ore bearing solutions that mineralized as they passed through [Hill, 1975]. These quartz structures are found at varying levels of metamorphic rock which range in age. This argues several stages in mineralization of the veins. Veins are formed from the alteration of previous rock formations, cracks from faults or earthquakes, and the flow of hydrothermal fluids. The combination of all these showed the miners the way to possibly attaining their dream to become rich by following the signs of the quartz by the way the quartz mineralization occurred.

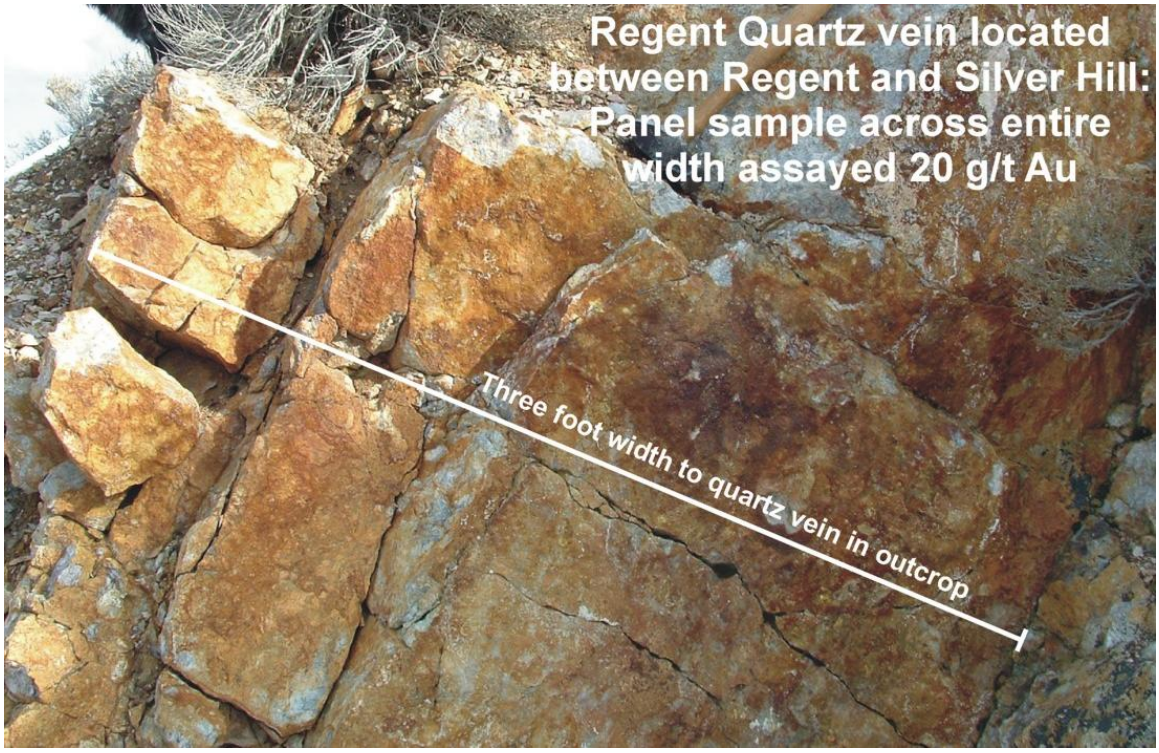

Figure 4 – Quartz outcrop [Figure adapted from Keegan Resources Inc., 2006]

Earthquakes help alter the rocks to allow mineralization to occur through the flow of fluids. As the plates shift to keep the world in equilibrium, earthquakes occur, sometimes causing cracks at the faulting points. Cracks also occur if the rock is twisted or bent. The crystal lattice structure of solid materials is highly stable and does not readily break apart. Rock has to be heated to incredibly high temperatures before melting into the semi-liquid form called magma or lava. This is why the rock would break or crack under the pressure from the movement of the earth. Pressure is formed because tension is placed upon the solid structure, trying to pull it apart or twist it in some other direction than it originally sat in.

Human Dependence on Mining

The world uses thousands of natural resources everyday: gas, metal, wood, etc.

Without the mining industry, many of these products would not be readily available. Gold is a major part of the economy. This metal is used as a form of currency, this is why it was so valuable to the miners. When settlers first came to America, they traded the Native Americans services or goods for other services or goods. In the new economy, currency is traded for goods or services. According to Ally, coming into the first world war "gold had been firmly established as the pivot to the monetary system of world capitalism" [1991]. The more of the currency a person has, the more important they are. This type of thinking is why everyone wants to get rich. They believe the more money they have, the better off they will live and the happier they will be.

But where would the world be if there was no mining industry? Other techniques for making certain things and different currency would have been brought about, but items like cookware, used in everyday living, would not exist because there would be no way to get the supplies to make the objects. Obtaining natural gas for fuels is a mining-like process as well: drilling into the earth to reach the object desired. Things in the world are taken advantage of with no thought as to where they are manufactured, what they are manufactured from, or where supplies come from. Not everything is artificial; resources, though some are renewable, are not infinite. The world known today would not be the same without the mining industry and other industries like it. In the future, the things taken advantage of now will be more valuable due to supplies running lower as more are used.

Conclusion:

Hundreds of millions of years ago the Sierra Nevada mountain range started forming. Because of the way the earth moves, the mountains can be seen today. The

processes that built the mountains brought along with it metals and minerals that help support life; within the mountains and around the world. In the beginning of the mountain creation, the area was nearly uninhabitable because of constant volcanic activity as well as a point in which the mountains froze over. The present day Sierra Nevada is relatively nice with several towns on either side of the range.

Gold, which made California and San Fransisco famous, came from the Sierra Nevada mountains by way of mining. The reason the state grew so fast was because of the gold rush. California was not part of the United States until shortly after the discovery of gold. This is why Californian gold mining was so popular, there were no land restrictions nor political restrictions on the gold. Sutter, the reason Marshall originally discovered the gold, never wanted anything to do with the gold; he wanted to become a rich man by means of a farming company, but because of the gold rush, he never succeeded in his dream.

The gold, along with other minerals, were deposited into the mountain range by geological processes. It was not simply that the mountains upraised and then the minerals were deposited, but it was a series of events that led to the locations of materials and rocks within the mountains. Deposits came during the formation process as well as after destructional processes, like erosion, started taking effect. The earth is in a constant state of motion and natural movements occur that rearrange the land. The formation of cracks allow for hydrothermal fluids to flow through the rocks and create veining systems that deposit metal ores within the split. Minerals build up, filling in the cracks with solid crystalline structures. Quartz crystals form with the minerals, depending on what mineral is contained with the quartz, the quartz will form different colors. Miners said they were able to tell the gold barring quartz from the non-gold barring quartz by the color. This

was never a solid guarantee. Quartz with no other mineral or metal contained within it forms last. This suggests that the metals act as a catalyst for quartz formation, just like a flawed surface would act as a catalyst for mineral build up as the fluid flows through a crack.

The mining industry is a major part of civilization today. Without the earth's natural resources, lifestyles would be completely changed. Humans are dependent upon this industry to live and the gold rush was a spark to a few major corporation forming.

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