

## **Cation Substitution in Copper Bearing Minerals: Particularly Focused on the Minerals from Michigan's Keweenaw Peninsula**

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**Background:** Over the past couple weeks, it has become abundantly clear that this region of the world that we are studying is almost incomprehensibly complex and multi-layered. The Keweenaw Peninsula in the Upper Peninsula of Michigan has been influenced by several geologic events and records a significant rifting event during the Precambrian at around 1.1 ga. The Keweenaw peninsula is one of the best districts for mining native copper (and other copper-bearing sulfides as well). The purpose of this project is to look and observe the cation substitution that is the theorized mode of deposition for the native copper in the region. What happens, in essence, is that in the lava flows that underlie most of the Keweenaw Peninsula contain dissolved cupriferous hydrothermal fluids. When the lava flows were brought to the surface, there was volatile degassing of the sulfur dioxide from the lava, and this created the sulfur-deficient atmosphere that was needed to precipitate the native copper as opposed to the sulfides. Copper sulfides are minerals that have both copper and sulfur bonded with each other (albeit in different ratios). Therefore, the native copper is the major form of copper mineralization in the region. There are very few samples of chalcocite, bornite or covellite from the area, and this is supported by the sulfur-poor samples taken from the lava flows.

**Research Methods:** To analyse the samples that we have in our collection (chalcocite, bornite and covellite), we used a machine that help us do XRF. This stands for X-Ray Fluorescence, which is the process of picking up the fluorescence different atoms give off when struck by x-rays. There is a much more technical explanation but the basic concept is that there is a specific wavelength of fluorescence that is given off when a x-ray strikes an atom. This fluorescence is picked up by the machine and given back in the form of a mass percent (out of 100%). This is calculated for all the atoms in a sample and then this is given back as semi-complete picture of what the sample is made of. The XRF does not do any damage to the sample, so it can be used without fear of damage to even very fragile specimens.

**Results:** At this time, we have only just started to work on the analysis of the data that we have collected thus far, although it seems that our original intent for the research has some surprising results. At the start of this project, we just wanted to analyse the XRF data and see what kind of conclusions we can draw from the data, but there are some interesting trends starting to show up. Now, we seem to be detecting some sort of background "trace elements" in some of the samples. We can possibly correlate these trace elements to specific locations and then use that data to make a map of different chemical signatures to better locate specific samples.

**Personal Application:** When I applied to work in this project with Dr. Sparks, I had almost no knowledge of the region, of the mineralogy or the time frame in which the events are taking place. This project has really helped me start to visualize what is going on in this region, not only physically but also on an elemental level. It is also amazing to work with people who really share my passion and can encourage/help me out when I come across something that I am not familiar with. It is truly an amazing opportunity and I'm very thankful for the experience.