

# Sulfur Content and Isotopic Composition of Lichen Species. Bullion Mine; Basin, MT

Jade A. Marks<sup>1</sup>, Lisa M. Pratt<sup>2</sup>, Seth A. Young<sup>2</sup>

<sup>1</sup> BSES Program, Indiana University <sup>2</sup> Department of Geological Sciences, Indiana University

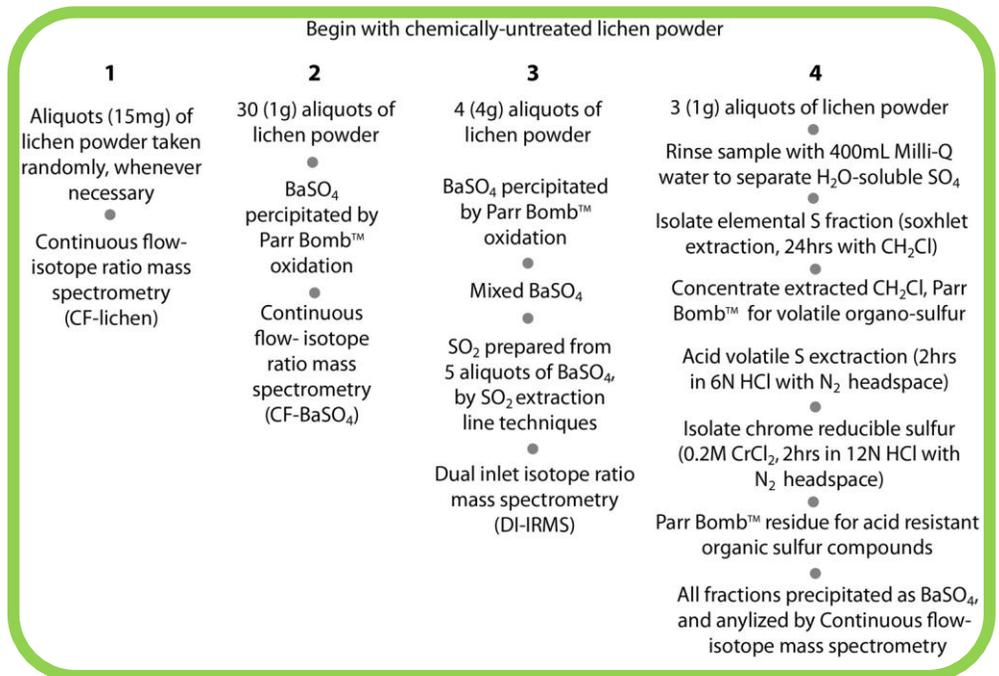


**Figure 1: Photograph of lichen species *Letharia columbiana* collected at Bullion Mine, Jefferson Co, MT. July 2010. One of six lichen species analyzed in this study.**

Lichens are useful indicators of environmental impact due to their tendency to accumulate trace metals into their bodies (thalli) and their ability to go dormant under adverse conditions (Brodo, 2001). Changes in species richness and distribution, stable isotopic compositions of carbon and sulfur, and heavy metal concentrations within the lichen thallus can vary temporally and spatially with industrialization, disturbance, and associated contamination (Batts, 2004). This research project involves an exploratory analysis of sulfur concentration, sulfur ( $\delta^{34}\text{S}$ ) isotopes, and heavy metal concentrations in six common lichen species collected at an abandoned precious metal mine in central Montana. Results will help to evaluate the potential of lichens as bioindicators for human disturbance in remote mountainous areas.

The field site for this project, Bullion Mine, is a reclaimed mine in the Basin Mining District; Jefferson County, Montana.

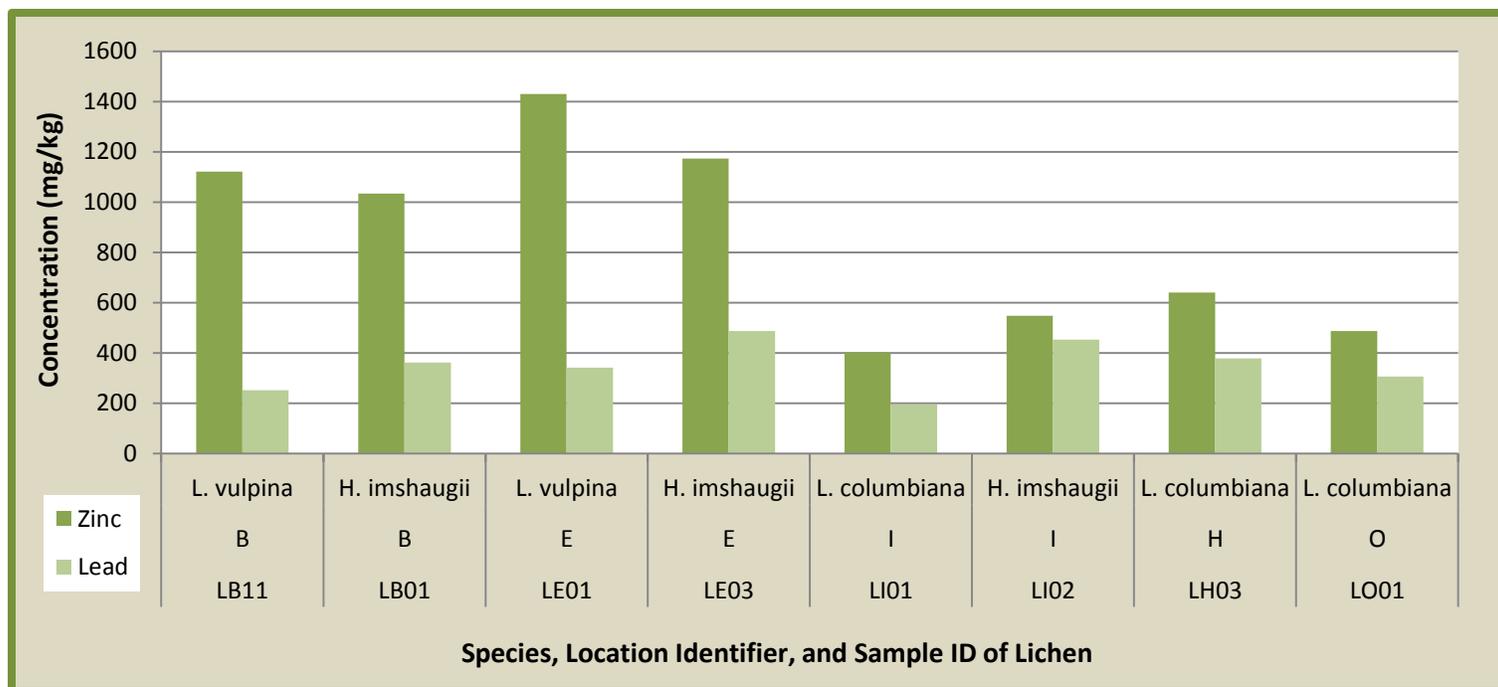
Bullion was mined intermittently for gold and silver from 1897 to 1955. The ore body contains a variety of metallic sulfides including pyrite, galena, sphalerite, tetrahedrite, and arsenopyrite, as well as an abundance of quartz and siderite (Fey, 2000). The weathering of these minerals releases sulfur into the environment, which can be traced using stable isotopes. In 1999 Bullion became a Superfund National



**Figure 2: Four methods for extracting S from the lichen thallus. Methods 1-3 are described in Yun (2004). Method 4 is modified from Lefticariu (2006). Methods 1, 2, and 4 are used in this study. Figure adapted from Yun 2004.**

Priorities List site with initial cleanup being completed in 2002. The site is still actively monitored by the Environmental Protection Agency (Metesh, 1994).

Twenty-six samples, consisting of six different lichen species, were collected from eleven living trees at radial distances of 300-800 feet from the center of Bullion Mine. Sampling sites were chosen within a roughly radial pattern, as allowed by disturbance and abundance of lichen. Lichens were identified using chemical tests, the investigation spore structure under a dissecting microscope, and by examining the structure of fruiting bodies. Unpulverized specimens were analyzed on an Eltra CS-2000 carbon-sulfur determinator to provide preliminary data on C/S ratios in different lichen species. Three methods were used to extract sulfur from the lichen thallus; direct input into a CE Instruments EA 110 elemental analyzer, oxidative combustion via Parr® Oxygen Bomb, and sequential sulfur extraction. Three samples were selected for sequential extraction, which allows for the removal of various oxidation states of sulfur through a series of wet chemistry techniques. Sequential extraction uses both organic solvents and strong acids to liberate the sulfur. Twenty-three samples were oxidatively combusted in a Parr® Bomb stainless steel reactor. Sulfur released during oxidative combustion was recovered as barium sulfate and analyzed for  $\delta^{34}\text{S}$  using a Finnegan MAT 252 isotope ratio mass spectrometer. Eight samples were analyzed for heavy metal concentration using an AAnalyst 800 Atomic Absorption Spectrometer.



**Figure 3: Concentration of zinc and lead (mg/kg or ppm) in eight lichen specimens from five different sample locations. Concentrations determined by atomic absorption spectroscopy on an AAnalyst 800. Data plotted from left to right in order of increasing radial distance from the center of the field area. Lichens collected from Bullion Mine, Jefferson Co. Montana. July 2011. Analyzed April 2011.**

Preliminary C/S ratios suggest that these lichen specimens do not contain abnormally high concentrations of sulfur for biological material. The dominant chemical fractions of sulfur in the lichen specimens are yet to be determined. AAS analyses detected trace amounts of cadmium, copper, zinc,

lead, and chromium in the thallus of all lichen specimens. These concentrations vary between species and with distribution across the field area. Preliminary data does not confirm the extent to which the lichens growing near the Bullion Mine were affected by anthropogenic disturbance. However, sequential extractions and S purification, followed by measurements sulfur isotopic compositions will enable a more accurate assessment of the usefulness of lichens as indicators of biological incorporation of contaminant elements in isolated and remote mining operations. A geospatial analysis of heavy metal concentrations will serve to confirm potential metal sources and to explain the observed variations between species.

**Works Cited:**

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