ABSTRACT: Hand samples within the upper paleokarst unit of the Mission Canyon Member of the Madison Group were collected from mineralized areas on Big Pryor Mountain and East Pryor Mountain, Montana and the Little Mountain area, Wyoming. Vein fill material and brecciated host rock were prepared and sent to the stable isotope lab at the University of Michigan for carbon and oxygen stable isotope analyses. Some samples examined using Field Emission Scanning Electron Microscope with an EDS Energy-Dispersive x-ray Spectrometer, Cathodoluminescence microscope and a standard petrographic microscope reveal several episodes of fluid migration. Comparing these isotopic values with the value of carbonates that precipitated from Mississippian-aged ocean waters gives an indication of the diagenetic processes that have affected δ13C and δ18O values of the carbonates in the mining districts. Results from the δ18O values of the late-stage calcite vein material sampled have the most negative δ18O values (-11.99 to -23.48 ‰) and a wide range of δ13C values (-1.40 to -0.20‰). The δ18O values for the late-stage calcite veins are depleted relative to the brecciated host rock, indicating that fluids were not in equilibrium with the host rocks and that the system was open to outside fluid flow. This isotopic depletion together with the presence of disseminated sulfides as well as ytterbium (a rare earth element) detected by EDS, suggests that the fluids were hydrothermal in nature.

STATEMENT OF PROBLEM: The uranium-vanadium mines in the Pryor Mountain and the Little Mountain mining districts are hosted in the Madison Formation. Are these deposits a product of diagenetic or metamorphic diagenetic processes? What is the relative timing of these events? What paleo-geographic setting does this area of the Madison Limestone represent? Would it fit the description for favorable deposit formation? Is this area overprinted by earlier or later processes? Which model best describes the overall characteristics of these deposits?

RESEARCH QUESTIONS: What is the exact nature of structural control on these deposits, if any? Can breccia pipes be traced deeper than the upper 200 feet of the Madison Limestone? How mineralized have the breccia pipes? What was the relative timing of these events? What paleo-geographic setting does this area of the Madison Limestone represent? Would it fit the description for favorable deposit formation? Is this area overprinted by earlier or later processes? Which model best describes the overall characteristics of these deposits?

HOW ISOTOPES HELP ANSWER THESE QUESTIONS: Using stable isotopes of carbon (δ13C) and oxygen (δ18O) can help characterize water sources which produced the veins of calcite and dolomite present in the mining districts. Some of the older uranium-vanadium mineralizations are present within the fracture fill material and the calcite veins have U, V and REE in the mineral. Knowing the temperature of the fluids may help to determine how the uranium-vanadium minerals were formed.

METHODS: Field Work: The field sites were visited to see the aspect and exposure of the abandoned mines in the Pryor Mountain area, Montana and Little Mountain area, Wyoming; samples were collected from dumps and outcrops of selected mines in the two mining districts.

Initial and Ongoing Analytical Work: 

- Scanning Electron Microscopy (SEM) imaging and x-ray elemental analysis (with EDS – Energy Dispersive x-ray Spectroscopy) – a ray mapping and backscattered electron imaging (SEI) to identify different phases present in minerals.
- 4-Ray Diffusion analysis (SND) – quick way for distinguishing the high temperatures.
- Stable Isotope analysis (δ13C/δ18O) – used to help characterize water sources future.
- Strontium isotopic geochemistry (Sr39/Sr87) – useful in documenting deep brines that are highly radioactive (presumably from the crust).

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