The development of successful strategies to explore for new deposits of the many metals needed by modern industrialized society requires an in-depth understanding of the processes that lead to the formation of economic mineral occurrences. Geologists have learned much about ore-forming processes through studies of existing ore deposits. However, ore deposits represent the integrated history of processes that have occurred over hundreds of thousands to tens of millions of years, and it is often difficult to identify the individual processes and their relative timing in the overall ore-forming system. DUSEL offers a unique opportunity to study ore-forming processes in a controlled environment.

The Mississippi Valley-Type (MVT) hydrothermal deposits represent important sources for zinc, lead, copper, cadmium and other important base metals. These deposits are thought to form when warm, metal-bearing fluids flow from deeper portions of sedimentary basins to shallow and cooler regions. Several processes have been suggested as the depositional mechanism in these deposits, including decreasing temperature, fluid mixing, water-rock interaction, and combinations of these mechanisms. While one or more of these processes appears to be more likely in some deposits, a consistent model for ore-formation has not evolved.

We propose to simulate ore-forming processes in MVT deposits in DUSEL. A block of fresh rock approximately 10^6 to 10^9 cubic meters in size will be isolated within DUSEL. The physical and chemical properties of the rock mass will be characterized using a variety of invasive (drilling) and non-invasive (GPR, electric, seismic, etc) techniques. Following this initial stage, fluids having well-constrained properties (temperature, composition) will be injected into the rock mass. Quantitative collection and analysis of the injected fluids will be conducted to determine bulk changes as the fluid moves through the rock mass – this information will permit mass balance calculations to determine the total amount of metals removed as the fluids flow through the rock. Fluids with different physical and chemical properties will be injected into different parts of the rock mass to investigate the contribution of fluid mixing and fluid-rock interaction on the ore-forming process.

The active experiments are expected to last for several years to several decades. These experiments will involve researchers with expertise in structural geology, tectonics, ore geology, rock mechanics, geophysics, seismology, geobiology, hydrogeology, mining geology and mining engineering, among others. At the completion of the experiments, the rock mass will be mined back, with continuous mapping and characterization of the face to identify the occurrence of metal mineralization within fractures. These results will be interpreted with respect to the known physical and chemical environment during fluid injection. These data will be used to develop a better understanding of ore-forming processes in MVT deposits, which in turn will contribute to the development of more realistic (and successful) models to explore for new deposits.