Trace Mississippi Valley-Type Lead-Zinc Mineralization: Origins and Relationship to Mid-Continent MVT Ore Districts

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Abstract

The North American mid-continent is known for its large Mississippi Valley-type (MVT) ore districts. Deposits with the same mineralogy but at much smaller scales, known as trace MVT occurrences, are also widespread throughout the mid-continent, and have been found in Paleozoic strata ranging from the Cambrian to the Pennsylvanian. This research attempts to determine if trace MVT occurrences differ from their ore district counterparts in magnitude of scale only, or if the two types of deposits are formed from fundamentally different processes. Lead isotope compositions of the trace sphalerite matrices indicate that a significant portion of the Pb was derived from igneous basement, but a lack of collinearity with the mid-continent MVT ore districts indicates that the basement-derived Pb was diluted by Pb from other sources. Negative $\delta^{34}S$ values of trace sphalerite matrices favor incomplete biological or thermochemical reduction of seawater sulfate reservoirs, and a lack of correlation between Pb and S isotopes shows they were not transported together to the site of mineralization. Primary, sphalerite-hosted fluid inclusions have T_h values and salinities that suggest trace MVT occurrences did not form as a result of regional trends of both cooling and dilution. The compositions of these fluid inclusions resemble sphalerite ore-stage mineralization rather than gangue-stage fluids, but the general lack of detectible methane suggests conditions that precluded the presence of abundant reduced sulfur. Similar sphalerite matrix compositions show that any differences between trace and ore district fluids in major and minor element composition did not affect the ability of the trace fluids to transport metals in solution. Forest City basin trace occurrences have Cl/Br ratios which indicate several of them precipitated from brines derived from evaporatively concentrated seawater, but do not constrain seawater age. Reaction path models showed that trace occurrences from the FCB could be evolved from any Paleozoic-aged seawater, but trace fluids from the Greater Upper Mississippi Valley and Illinois basin regions were successfully modeled only by Devonian brines. Collectively, any variations observed do not appear to have been mitigating factors in controlling the scale MVT mineralization, but low to undetectable methane concentrations indicate either that metal-rich fluids did not encounter large quantities of organic matter, or that conditions during trace mineralization were too oxidizing for reduced sulfur to have been abundant.