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A preliminary comparison of the Silesian-Cracow Mississippi Valley-type district (southern Poland) with Mississippi Valley-type districts in North America

The Polish Geological Institute and the United States Geological Survey are conducting geological and geochemical studies of the Mississippi Valley-type (MVT) ore deposits in the Silesian-Cracow zinc-lead district in Upper Silesia, southern Poland. This study was supported in part by the M. Skłodowska-Curie II Fund, established by contributions from the governments of the United States and Poland. These studies are intended to provide new information on the genesis of the ore and controls on the distribution of ore deposits for this important ore district. This should be considered a „descriptive progress report” on our investigations in the Silesian-Cracow district because many geochemical, isotopic, and fluid inclusion data were unavailable at the time this paper was prepared. Nevertheless, the new observations and data on the district provides an opportunity to reexamine existing concepts on the genesis of the ore deposits and suggests new constraints on the process of ore emplacement.

The results from this research together with previous studies provide a basis for comparing the Silesian-Cracow ore district with deposits of the Mississippi Valley-type in North America which include: Tri-State, Northern Arkansas, Central Missouri, Viburnum Trend, Upper Mississippi Valley, East Tennessee, and Central Tennessee districts in the US and Pine Point, Daniels Harbour, Polaris, and Nanisivik districts in Canada.

The major controls on ore deposition in the Silesian-Cracow district appear to be a combination of dolomite to limestone transition, shale edges, faults, and pre-ore

karst breccias. These same ore controls are also observed to varying degrees in most of the MVT deposits of North America. Evidence suggests that ore-bearing dolomite was formed prior to sulfide minerals and unrelated to the deposition of sulfides. The important breccias that host much of the ore in the district are believed to be pre-ore karst features which were later enlarged, replaced, and altered by sulfide deposition. Many ore textures, including breccia-hosted ore, can be interpreted as products of fabric-conservative sulfide replacement. Hydrothermal brecciation is common in the district but less important than sulfide replacement of pre-ore breccia. Faults played a critical role as ground preparation to produce enhanced fracture-controlled permeability for stratigraphic fluid flow and pathways for ascent of ore fluids.

Fluid inclusion studies show that the ore fluid was highly saline, with final melting temperatures between -13.9 to -29.4°C corresponding to 19 to significantly greater than 23 wt. % NaCl equivalent salinity. Homogenization temperatures are from 45 to 140°C . These fluid inclusion characteristics are similar to those of the other MVT districts, however preliminary data determined for larger inclusions indicate that homogenization temperatures may be relatively low compared to most other MVT districts. Fluid inclusion gas analysis shows that the dominant gas is CO_2 lesser amounts of H_2S and CH_4 . The total gases in the fluid inclusions are less than 1.5 mole %. Gas compositions of the fluid inclusions appear to contain two distinct compositions, one containing $\text{CO}_2 + \text{CH}_4$ and the other containing $\text{CO}_2 + \text{H}_2\text{S}$. Highly variable salinity together with apparent bimodal fluid inclusion gas compositions are consistent with fluid mixing as an ore depositional process.

Lead isotopes suggest a crustal source with a homogenous lead isotopic composition. In addition, homogenous lead isotopes in the district require ore deposition to be a short-lived event, rather than multiple, extended process. Although the model-lead age for the ore is Triassic, the presence of ore minerals in Upper Jurassic rocks and in faults that displace Upper Jurassic rocks, requires ore deposition to be post-Upper Jurassic in age.

Sulfur isotopes have the widest range of values of those reported from Mississippi Valley-type lead-zinc districts and they suggest multiple sources for the sulfur. In addition, some galena from the Silesian-Cracow district contain the lightest sulfur isotopes ($-18.6 \delta^{34}\text{S}$) reported for any MVT district. Sources for the isotopically light sulfur possibly include diagenetic sulfides in the source rocks or biogenic and/or incomplete thermochemical reduction of sedimentary sulfate.

The Silesian-Cracow ores contain a wide variety of trace and minor elements. Compared to other Mississippi Valley-type districts, sphalerite from the Silesian-Cracow district contain the widest range in Fe, Cd, and the second widest range in Ag. The most important host for Ag is dark-colored sphalerite; either early granular sphalerite or dark banded Schalenblende which can contain as much as 350 ppm. Very little Ag is found in finely banded tan sphalerite which was deposited between these stages of dark sphalerite. Although interpretations of the data are preliminary, the wide range in concentrations of minor and trace metals in sphalerite and an apparent lack of district or paragenetic correlations of metal enrichment are consistent with multiple sources of the metals or local variations in the geochemical environment (e.g., activity of reduced sulfur) at the site of mineral deposition.

The features of the Silesian-Cracow district are remarkably consistent with the characteristics of Mississippi Valley-type districts throughout North America. However, each district has its own set of characteristics that sets it apart from other districts. Compared to North American Mississippi Valley-type districts, the Silesian-Cracow shares many features with Pine Point, Northern Arkansas, Tri-State, and Polaris districts.

Correction. When this article was written, only Laser Ablation Induction Coupled Plasma Mass Spectrometry (LAICPMS) data was available for galena samples. Subsequent determination using emission spectrographic and ICP emission spectrophotometric techniques reveal that the Bi concentrations determined in galena samples using LAICPMS are in error and that Bi concentrations in all galena samples are generally 50 parts per million or less. Atomic masses of the most abundant natural isotopes of Pb and Bi are 208 and 209 respectively. The presence of massive amounts of Pb caused detector saturation which probably caused the error. By modifying the mass scan routine to omit the 207 and 208 Pb isotopes the error for Bi determination is avoided.

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