Anomalous lead isotopes of a galena from the Upper Mississippi Valley zinc-lead district

A. A. Sicree — Earth & Mineral Sciences Museum, Pennsylvania State University, University Park, PA 16802, USA

H. L. Barnes — Department of Geosciences, Pennsylvania State University, University Park, PA 16802, USA

S. R. Hart — Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA

The distributions of lead isotopes in the Upper Mississippi Valley (UMV) district are known both across the district from bulk analyses and paragenetically from ion microprobe measurements. Both of these distributions are simple compared to those in the Tri-State (Kansas-Oklahoma-Missouri), and Southeast Missouri districts (Hart, *et al.*, 1983; Deloule, *et al.*, 1988; Crocetti and Holland, 1989). The exceptional simplicity of the UMV lead isotope distributions provides direct evidence of the sources of the lead and the processes that generated their anomalously high concentrations of radiogenic isotopes.

Analysis of lead isotopes

Lead isotopes within a single galena crystal from the UMV district were measured by S.R. Hart by the method of Hart, *et al.*, (1983). The sample, W-13, containing this crystal, is from the east end of the north limb of the South Hayden orebody near Shullsburg, Wisconsin, (S22, T1N, R2E). The South Hayden orebody is located near the center of the UMV district in dolomites and limestones of the Middle Ordovician Platteville Formation. $^{207}Pb/^{206}Pb$ data obtained on the M.I.T.-Harvard-Brown Cameca IMS-3f ion microprobe for a traverse from the center of a galena crystal to its perimeter are shown in Fig. 1. Because data obtained from the perimeter of the crystal represent greater masses than points closer to the centre, these data were recalculated to be representative proportionally of the mass of galena deposited again from the core outward. The results for $^{207}Pb/^{206}Pb$ are given in Fig. 2.

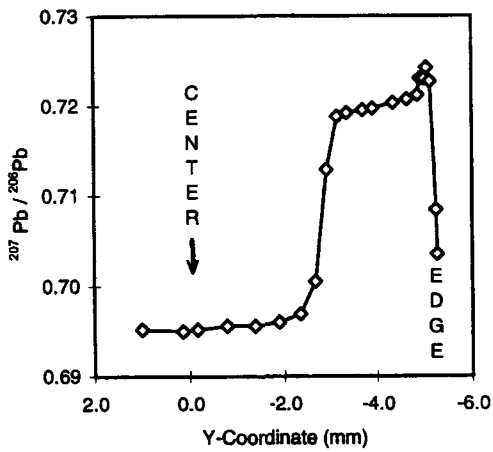

FIG. 1. $^{207}Pb/^{206}Pb$ data for a traverse across the growth centre to edge of a galena crystal.

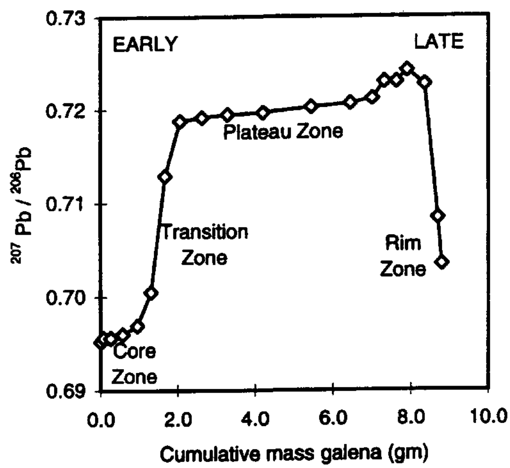

FIG. 2. Data from Fig. 1 recalculated to represent the relative mass of galena.

Lead isotope paragenesis

Deposition of lead in the core of sample W-13 began with the lowest (most radiogenic) $^{207}Pb/^{206}Pb$ values, followed by a rise to a plateau which persisted until near the edge of the crystal where $^{207}Pb/^{206}Pb$ then rises slightly before dropping abruptly. Plateau values for $^{207}Pb/^{206}Pb$ are about 0.720, near the integrated mass average value of 0.716. Consequently, the bulk of the crystal was deposited at the plateau concentration ratio. Together with the more-radiogenic core ($^{207}Pb/^{206}Pb$ = 0.696), this variation need reflect only two sources that contributed radiogenic leads to the district.

The isotopic paragenesis of Fig. 2 quantifies the relative mass of lead during each stage of deposition. The core accounts for 11% of the total mass of the crystal, the transitional zone 13%, and the plateau level, 56%. The late, or rim, stage first rises slightly by deposition of an additional 15% then decreases dramatically in the last 5%. Leads with progressively decreasing radiogenic (rising $^{207}Pb/^{206}Pb$) character account for 95% of the crystal mass. Overall, the crystal shows a remarkably simple $^{207}Pb/^{206}Pb$ profile without oscillations or discontinuities.

Radiogenic leads and thicknesses of strata

Whole crystal isotopic analyses for UMV galenas ($^{206}Pb/^{204}Pb$ data from Millen, *et al.*, 1995) were compared with the thicknesses of the strata underlying each sample to test for correlations that would identify possible source rocks for UMV radiogenic leads. In general, the radiogenic contents are independent of formation thickness, except for the Cambrian Mt. Simon Sandstone which shows a negative correlation between formation thickness and radiogenic content, indicating that the Palaeozoic rocks beneath the district were not the source of the radiogenic leads. However, there is a strong positive correlation between decreasing depth to the Precambrian basement and increasing radiogenic content, implying that the underlying granitic rocks were a radiogenic lead source. Depth to the basement apparently controls the complex regional distribution of lead isotopes.

Radiogenic leads accumulated in both the Precambrian basement (from the time of initial crystallization about 1.5 Ga – Van Schmus, *et al.*, 1996) and the basal Mt. Simon until these rocks were penetrated by the UMV ore solution at 0.27 ga (Brannon, *et al.*, 1992). Model ages from the lead isotopes are compatible with transport of lead from these sources.

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