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Pb Isotope Variations in Shale Fractions from the Mid-Continent U.S.: Insights into Maturity, Composition, and MVT Mineralization

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Shale is composed of inorganic material, extractable organics (bitumen), and 'non-extractable' organics (kerogen). This study examines the Pb isotope compositions of shale fractions from 13 samples representing the Ouachita Mountains, the Ozarks, and the Forest City-Cherokee basins in the mid-continent United States. A total of 39 fractions have been analyzed. The Pb isotope signatures of different fractions within the same rock vary, and the bulk-rock isotope composition often does not fully represent all fractions. These variations in Pb isotope signatures are likely influenced by the thermal maturity of the rock. Samples exhibiting significant differences in isotopic composition between fractions, along with generally higher radiogenic signatures, seem to belong to high thermal maturity regime. The fractions of the Pennsylvanian-age shale from the Forest City and Cherokee basins exhibit relatively low radiogenic signatures. In contrast, the kerogen and/or inorganic components of specific shale units from the Ouachita Mountains (Ordovician and Mississippian) and the Ozark Plateau (Devonian-Mississippian) are highly radiogenic, suggesting a potential genetic link to the Mississippi Valley-type (MVT) Pb-Zn ores. This link between black shales and MVT ores has long been thought to exist because of (1) the presence of mature hydrocarbon and brine fluid inclusions within many MVT ores, (2) the association of the hydrothermal fluids that are linked to MVT ore formation with organic compounds and oil-like droplets, and (3) the highly radiogenic nature of the ores.