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$^{40}Ar/^{39}Ar$ Dating of Zn-Pb-Ag Mineralization in the Northern Brooks Range, Alaska

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Abstract

The $^{40}Ar/^{39}Ar$ laser step-heating method potentially can be used to provide absolute ages for a number of formerly undatable, low-temperature ore deposits. This study demonstrates the use of this method by determining absolute ages for Zn-Pb-Ag sediment-hosted massive sulfide deposits and vein-breccia occurrences found throughout a 300-km-long, east-west–trending belt in the northern Brooks Range, Alaska. Massive sulfide deposits are hosted by Mississippian to Pennsylvanian(?) black carbonaceous shale, siliceous mudstone, and lesser chert and carbonate turbidites of the Kuna Formation (e.g., Red Dog, Anarraaq, Lik (Su), and Drenchwater). The vein-breccia occurrences (e.g., Husky, Story Creek, West Kivliktort Mountain, Vidlee, and Kady) are hosted by a deformed but only weakly metamorphosed package of Upper Devonian to Lower Mississippian mixed continental and marine clastic rocks (the Endicott Group) that stratigraphically underlie the Kuna Formation. The vein-breccias are mineralogically similar to, but not spatially associated with, known massive sulfide deposits. The region's largest shale-hosted massive sulfide deposit is Red Dog; it has reserves of 148 Mt grading 16.6 percent zinc, 4.5 percent lead, and 77 g of silver per tonne. Hydrothermally produced white mica in a whole-rock sample from a sulfide-bearing igneous sill within the Red Dog deposit yielded a plateau age of 314.5 Ma. The plateau age of this whole-rock sample records the time at which temperatures cooled below the argon closure temperature of the white mica and is interpreted to represent the minimum age limit for massive sulfide-related hydrothermal activity in the Red Dog deposit. Sulfide-bearing quartz veins at Drenchwater crosscut a hypabyssal intrusion with a maximum biotite age of 337.0 Ma. Despite relatively low sulfide deposition temperatures in the vein-breccia occurrences (162°–251°C), detrital white mica in sandstone immediately adjacent to large vein-breccia zones was partially to completely recrystallized. The $^{40}Ar/^{39}Ar$ age spectra and inverse isochron plots of the multicomponent whole-rock sandstone samples are more complex than those of single minerals. However, different minerals have different Ca/K and Cl/K ratios and closure temperatures, and these properties were used to identify portions of spectra dominated by argon release from specific minerals. $^{40}Ar/^{39}Ar$ laser step-heating analyses of Late Devonian sandstone whole rocks produced spectra that record a two-stage resetting history: a Carboniferous hydrothermal event first and later Mesozoic to Tertiary events, which are in agreement with geologic constraints. The $^{40}Ar/^{39}Ar$ ages and the similar mineralogy, lead isotope composition, and relative stratigraphic positions support the interpretation that the shale-hosted massive sulfide deposits and most vein-breccia occurrences are temporally and genetically related, and that they are different expressions of Carboniferous basinal dewatering.

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