Economic Geology, v. 100, pp. 225–252

U-Pb Zircon Ages and Pb Isotope Geochemistry of Gold Deposits in the Carolina Slate Belt of South Carolina

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Abstract

Volcanic rocks of the Persimmon Fork Formation host the largest known gold mines of the Carolina slate belt. U-Pb (SHRIMP) zircon ages have been obtained from rocks closely associated with pyrite-enargite-gold deposits at Brewer (quartz-topaz rhyolite breccia from the argillic alteration zone in the Brewer pit and felsic ash-flow tuff from the quartz sericite alteration zone), from the disseminated and semimassive pyrite-gold deposits at Haile (crystal lithic rhyolitic ash-flow tuffs from the Champion pit), and from the Ridgeway deposit (felsic ash-flow tuff from the stratigraphic host of the North pit gold deposit). Generally, the zircons are fine grained, fractured, and contain crystal imperfections (corrosion, inclusions, and pits). $^{206}Pb/^{238}U$ zircon spot ages for all deposits span a wide range, mostly from 400 to 760 Ma. Inclusions and cores indicative of inherited domains in the zircons were not found, and only a few analyses range from 1.1 to 1.8 Ga. A distinct xenocrystic zircon population was not identified. The $^{206}Pb/^{238}U$ weighted age averages of zircon indicate the following crystallization dates for the volcanic and volcaniclastic rocks closely associated with the gold deposits: 550 ± 3 Ma for Brewer, 553 ± 2 Ma for Haile, and 556 ± 2 Ma for the Ridgeway deposit. These zircon crystallization ages represent close estimates of the age of the original gold mineralizing events. Younger zircon spot ages can be attributed to the effects of Paleozoic regional metamorphism.

Pb isotope compositions of sulfide minerals (galena, pyrite, enargite, sphalerite, chalcopyrite, and molybdenite) and silicate minerals (K-feldspar, and sericite) in the gold deposits help to constrain the sources of fluids and metals during the mineralizing events. The deposits are pyrite rich, containing multiple generations of pyrite, including early-crystallized pyrite that is closely associated with the original gold mineralizing event, as well as recrystallized pyrite formed in response to Paleozoic metamorphism. Pb isotope compositions of pyrite span a wide range, including the most radiogenic values for the sulfides. Galena and K-feldspar are not abundant but where present they are typically the least radiogenic minerals. Galena has a limited range of Pb isotope compositions that are representative of the gold deposits as a group ($^{206}Pb/^{204}Pb$ = 18.020–18.326, $^{207}Pb/^{204}Pb$ = 15.550–15.639, $^{208}Pb/^{204}Pb$ = 37.605–38.286). Values of $^{207}Pb/^{204}Pb$ straddle the average crustal Pb growth curve, consistent with contributions involving the mantle and continental crust. Whole-rock Pb isotope compositions of volcanic and volcaniclastic rocks of the Persimmon Fork Formation nearly match the range for sulfides in the gold deposits. Subtle regional contrasts in Pb isotope compositions exist among the deposits. Sulfide minerals from Barite Hill (e.g., galena $^{206}Pb/^{204}Pb < 18.077$) in southern South Carolina are generally less radiogenic than sulfides from Ridgeway ($^{206}Pb/^{204}Pb > 18.169$), Haile ($^{206}Pb/^{204}Pb > 18.233$), and Brewer ($^{206}Pb/^{204}Pb > 18.311$) in northern South Carolina. Because Pb isotope compositions of basement rocks from Grenville massifs in the southern Appalachians and sulfide minerals from the gold deposits do not match, a direct genetic connection cannot be established. Diversity in values of $^{206}Pb/^{204}Pb$ and the relatively high values of $^{207}Pb/^{204}Pb$ suggest that the deposits evolved adjacent to or closely related to continental blocks, perhaps linked to a back-arc tectonic setting. Among potential younger analogues of the slate belt gold deposits are the sulfide deposits of the Okinawa trough in the western Pacific. Mantle-derived isotopic contributions were more important at Barite Hill in southern South Carolina, the least radiogenic among the deposits where oceanic crust had developed, than at Brewer, Haile, and Ridgeway in northern South Carolina where rifting thinned the continental crust.

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0361-0128/01/3494/225-28 $6.00