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Carboniferous Orogenic Gold Deposits at Pataz, Eastern Andean Cordillera, Peru: Geological and Structural Framework, Paragenesis, Alteration, and $^{40}Ar/^{39}Ar$ Geochronology

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Abstract

The Pataz province forms the central part of a ≥160-km-long orogenic gold belt extending along the Eastern Andean Cordillera in northern Peru and has produced a total of 6 million ounces (Moz) gold from vein-type deposits during the last 100 yr. The deposits present several recurrent and typical field characteristics, including (1) at a regional scale, location of the mineralization in low-order structures within a 1- to 5-km-wide structural corridor east of a major north-northwest–striking lineament and in spatial association with the north-northwest–striking margins of the 330 to 327 Ma Pataz batholith; (2) at the mine scale, strong lithological controls of the vein geometries and styles, the lodes occurring as fairly continuous ≤5-km-long quartz veins inside or along the margins of the batholith or as branching and bedding-concordant narrow ore shoots within adjacent folded Ordovician turbidite sequences; (3) consistent orientations of veins, in particular within the batholith, where more than 80 percent of the quartz veins are emplaced in north- to northwest-striking, east-dipping, brittle-ductile deformation zones; (4) a consistent Au, Ag, As, Fe, Pb, Zn, ±Cu, ±Sb, ±Bi-Te-W metal association and a sulfide-rich paragenetic sequence, with a first stage composed of milky quartz, pyrite, arsenopyrite, and ankerite and a second stage of blue-gray microgranular quartz, galena, sphalerite, chalcopyrite, Sb sulfosalts, electrum, and native gold, followed by barren calcite-dolomite-quartz veinlets; and (5) hydrothermal alteration of the vein wall rocks, consisting of pervasive muscovite alteration with minor chlorite, carbonate minerals, and pyrite associated with strong bleaching in plutonic rocks, and of weak muscovite and chlorite alteration in sedimentary rocks.

Structural analysis of the deposits outlines four synchronous sets of mineralized fractures in the Pataz district. The predominant north- to northwest-striking, east- to northeast-dipping system, which is generally located in reactivated reverse faults, accounts for more than 80 percent of the gold resource of the district. Three subordinate systems include, in decreasing order of economic importance, (1) east-west–striking flat extensional veins, (2) bedding-concordant veinlets in east-west–striking and north-dipping to north-south–striking and east-dipping limbs of long wavelength folds in Ordovician sedimentary rocks, and (3) weakly mineralized roughly east-west–striking, sinistral vertical faults. The vein orientations of the four structural sets are compatible with a triaxial strain model, with the main shortening axis P oriented at 080°/15°, an intermediate axis oriented at 165°/00°, and a subvertical extensional T axis oriented at 255°/80°. Under these conditions, the richest ore shoots are preferentially sited in sinistral pull-aparts, which occur at the intersection of either north-south–striking lodes or extensional lodes with roughly east-west–striking vertical faults.

$^{40}Ar/^{39}Ar$ dating of the granodiorite-monzogranite bodies of the Pataz batholith provides good plateau ages at 329.2 ±1.4 and 328.1 ± 1.2 Ma for biotite separates, which are similar to a published 329 Ma U/Pb age for the granodiorite. A muscovite and a biotite sample from an aplite dike yielded plateau ages at 322.1 ± 2.8 and 325.4 ± 1.4 Ma, respectively. Muscovite samples from alteration intimately associated with the gold mineralization yielded three $^{40}Ar/^{39}Ar$ spectra with low-temperature staircase-shaped patterns followed by plateau segments at 314 to 312 Ma. These ages, analytically indistinguishable at the 2σ level, are considered to be the most probable ages for the mineralization event. Three other plateaulike ages between 305 and 288 Ma have been obtained and are interpreted to reflect partial argon loss during late fluid circulation associated with the intrusion of Late Cretaceous monzonite porphyries.

The age determinations are inconsistent with a genetic link between the 314 to 312 Ma Pataz gold deposits and the 330 to 327 Ma calc-alkaline Pataz batholith, or with the 327 to 319 Ma aplite dikes, or the Late Cretaceous porphyry magmatism. Instead, the overall homogeneity of the structural, mineralogical, and geochemical characteristics of the deposits over the ≥160-km-long mineralized belt and the geotectonic evolution suggest that gold mineralization is linked to a large-scale thermal event that occurred in a thickened collisional belt undergoing uplift tectonics.

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