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Lithological and structural controls of disseminated-type orogenic gold mineralization in high-grade metamorphic turbidites from the Central Zone of the Damara Belt, Namibia

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ABSTRACT

We report the characteristics and controls of low-grade gold-sulfide disseminations in the Twin Hills prospects, the Central Zone of the Damara Belt in Namibia, that combines to a large (>12 km strike length) zone of mineralization. The host rocks are subvertical, tightly folded and transposed, amphibolite facies metaturbidites (cordierite-biotite metapelites and quartz-biotite metapsammites) that form the subvertical limb of a regional-scale syncline. Sulfide and gold grains are finely dispersed in the host rocks or form networks of quartz-sulfide veinlets. Zones of economic-grade gold mineralization are associated with fine-scale quartz-sulfide (pyrrhotite > arsenopyrite ≫ pyrite) vein stockworks. Morphology and deformational textures of the mineralized vein networks suggest their formation during flexural-slip folding and the progressive transposition of the metaturbidites into the regional, ENE trending steep foliation. The more competent metapsammites promoted fracturing while ductile strain during flexural-slip was localized into the schistose metapelites. As a result, economic-grade mineralization is best developed in well-bedded, compositionally heterogeneous parts of the metaturbidites that experienced pronounced strain partitioning. Metapelite-dominated packages, in contrast, show mainly disseminated sulfide mineralization, fewer and variably transposed vein networks and only sub-economic gold grades. The association of disseminated and vein-type mineralization suggests that pervasive fluid flow was channelized within the lithologically heterogeneous packages that provided fracture permeabilities and hydraulic gradients for more focused fluid flow. Higher gold grades correspond to subtle (5-15°) deflections of bedding and the regional foliation that may relate to dilational jog geometries. On a prospect-scale, occurrence of economic-grade gold mineralization coincides with the inflection and change of the vergence of regional-scale first-order folds. The style of mineralization shares similarities with turbidite-hosted orogenic gold deposits. The differences in gold grades and styles of mineralization can be explained by syn-tectonic (D_2) fluid flow, the different metamorphic grade (amphibolite versus mid- to lower-greenschist) and ductility of wall rocks that prevented the formation of larger, brittle, high-permeability structures.

1. Introduction

Much of the world's gold production derives from quartz- and quartz-carbonate vein systems of orogenic lode-gold deposits from Archaean greenstone belts and younger supracrustal provinces (Groves et al., 1998; Goldfarb et al., 2005; Phillips and Powell, 2010; Goldfarb and Groves, 2015; Groves, Santosh and Zhang, 2020; Simmons et al., 2020). Mineralization is commonly structurally controlled. Fault systems and/or fold structures not only provided the necessary permeability structure for focused fluid flow, but also suitable physical and/or chemical traps resulting in relatively high gold grades (Colvine, 1989; Cox et al., 2001; Sibson, 2004; Goldfarb et al., 2005; Deng et al., 2015; Vearncombe and Zelic, 2015; Groves et al., 2018; Blenkinsop et al., 2020). As a result, the relationships between mineralization, alteration and controlling structures are commonly well preserved, which allows for the detailed reconstruction of fluid pathways and mineralizing processes (Kerrich, 1986; Groves et al., 2000, 2018; Goldfarb, Groves and Gardoll, 2001; Ashley and Craw, 2004; Hronsky and Groves, 2008; Hronsky, 2020).

Orogenic disseminated gold deposits, in contrast, refer to deposits where the host rock itself is mineralized (Bierlein and Maher, 2001; Christie and Brathwaite, 2003; Craw et al., 2006). These deposits are

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