Characteristics and origins of breccias in a volcanic-hosted alkalic epithermal gold deposit, Ladolam, Lihir Island, Papua New Guinea

By

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Abstract

The 46 Moz. Ladolam gold deposit is located on Lihir Island, Papua New Guinea and is the world's largest low sulfidation, alkalic epithermal gold deposit in terms of contained gold. Lihir Island is part of the 150-km-long, alkalic Tabar-Lihir-Tanga-Feni (TLTF) volcanic island chain that is located in the New Ireland basin. The Ladolam deposit occurs in the central portion of the dissected Plio-Pleistocene Luise volcano and is composed of four main ore zones: Minifie, Lienetz, Coastal and Kapit. This thesis focuses on the volcanic and subvolcanic facies that host the Minifie (predominantly mined out) and the Lienetz (the current focus of mining) ore zones. The Kapit and Coastal ore zones remain unmined at the time of this study.

The Luise volcano consists of volcano-sedimentary stratigraphy that has been cut by an intrusive complex and overprinted by various hydrothermal facies. The volcano-sedimentary stratigraphy is dominated by polymictic, matrix-supported breccias interbedded with lavas and shallow intrusions. The monzonitic intrusive complex is centred on the northern margin of a prominent 3.5 by 4 km elliptical depression or amphitheatre that is interpreted to be a relatively large volcanic-sector collapse scar. The sector collapse event is less than 190 ka based on ^{230}Th – ^{234}U age dating on the uplifted fringing limestone reef that was partly destroyed during the sector collapse event.

The Minifie ore zone occurs in a variably altered, southward-dipping volcano-sedimentary succession that was overprinted by at least three major hydrothermal brecciation and veining events, one in the porphyry environment and two in the epithermal environment. The volcano-sedimentary lithofacies record the transition from a subaerial environment close to an active vent to a subaqueous, quiet depositional environment into which a partly extrusive cryptodome was emplaced. The volcano-sedimentary stratigraphy was subsequently tilted ~ 30° to the south, which is consistent with the regional tilt indicated by limestone platforms throughout the TLTF island chain. The hydrothermal alteration and vein mineral assemblages reflect the evolution from porphyry (biotite-stable) to epithermal (adularia-stable) conditions in both the Minifie and Lienetz ore zones. Minifie epithermal gold mineralisation is hosted predominantly in hydraulic breccias and veins that are characterised by quartz-calcite-

adularia and adularia-quartz-pyrite assemblages.

The Lienetz ore zone is hosted within a magmatic-hydrothermal breccia that has cross cut polymictic breccias and sandstones (L1), pyroxene-phyric coherent and clastic basalt (L2) and a shallow-level microdiorite pluton (L3). The bulk of the gold mineralisation in the Lienetz ore zone is related to porphyry-style features, specifically an anhydrite-biotite-orthoclase-cemented breccia facies association (L4) that is associated with a feldspar-phyric syenite intrusion (L5). The L4 breccia and L5 syenite are interpreted to have been emplaced in a near-vertical orientation, but are now north-dipping as a result of regional tilting to the south. Lienetz epithermal facies are characterised by pyrite-cemented breccias that form a layer between an argillic and advanced argillic clay blanket and the underlying porphyry-style L4 lithofacies. Following the porphyry stage, volcanic-sector collapse, and the main epithermal stages, emplacement of breccia in a discordant, subvertical body (L7) destroyed the western margin of the ore zone and the argillic blanket. The L7 breccias were intruded by plagioclase-phyric andesite dykes (L8).

The volcano-sedimentary lithofacies of the Luise volcano demonstrate an evolution that includes volcanic cone growth, intrusions, subsidence, regional uplift and tilting, and volcanic sector-collapse. The hydrothermal facies record four gold depositional events related to an (a) early gold-rich (1 to 4 g/t gold with bonanza grade up to 180 g/t Au) porphyry environment that has been overprinted by low-sulfidation epithermal (>4 g/t Au) conditions in both the Minifie and Lienetz ore zones. Prior to and during regional uplift and tilting, gold was deposited by boiling hydrothermal fluids in the porphyry and (b) transitional epithermal environments. After dissection of the Luise volcano (<190 ka), a (c) homogeneous layer of refractory sulfide ore (4 to 6 g/t Au) gold was deposited, possibly by seawater-quenching of hydrothermal fluids, in the Minifie ore zone. In Lienetz, (d) epithermal gold (>4 g/t Au) was deposited in a zone of open space produced by acid leaching in the geothermal environment. The western margin of the Lienetz ore zone is cross cut by a discordant matrix-rich breccia body that may have formed during a phreatic explosive eruption. The breccia body was subsequently cut by andesite dykes. Geothermal activity continues today, locally remobilising and leaching gold in the near-surface clay alteration zone and driving steam explosions, both of which produce significant challenges to mining.

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