Unlocking the Giant Ladolam Gold Deposit: New Insights into Its Geology

William J. Clark, Fiona Karaut, Nicholas Fitzpatrick, Paul Napier, and Anthony C. Harris*

Newcrest Mining Limited, Melbourne, Victoria 3004, Australia

*E-mail, Anthony.Harris@newcrest.com.au

The Ladolam Au deposit in Papua New Guinea is one of the best examples of a telescoped epithermal-porphyry system. Ladolam's spectacular gold endowment, with its 59 Moz Au resource (www.newcrest.com.au), has been related to a catastrophic volcanic sector collapse event. Gold mineralization at Ladolam is complex and refractory, associated mainly with pyrite and marcasite occurring as veinlets, disseminations, replacements, and breccia fillings. Higher-grade alkalic epithermal mineralization formed in the brecciated core of a volcano and itself overprints multiple, early-formed porphyry systems. Texturally destructive hydrothermal alteration and mineralization obscures volcanic and volcaniclastic rocks that are cut by multiple diatremes and subvolcanic intrusions. This complexity has made basic observations and interpretations difficult. Despite this, integration of a long history (+30 years) of mineral observations with newly acquired automated drill core SWIR scanning across Ladolam has resulted in a new geological model.

The porphyry stage produced biotite-orthoclase-anhydrite ± magnetite alteration and minor disseminated and vein-hosted Cu-Au-Mo mineralization located in narrow domains that are near vertical. Pyritic epithermal mineralization is associated with low-temperature potassic alteration and later quartz-calcite-anhydrite veins and anhydrite-cemented breccia. Pyritic Au mineralization (3–5 g/t Au) is associated with pervasive adularia-pyrite-illite alteration in near-surface ores that grade down into barren anhydrite-adularia-pyrite alteration. Quartz-calcite-adularia-pyrite-marcasite ± electrum stockwork veins and breccias overprinted and replaced earlier anhydrite veins and locally have bonanza Au grades (up to 60 g/t Au).

Near-surface argillic and advanced argillic alteration overprinted epithermal mineralization (approximately 1.5–2.5 g/t Au) and formed a cap on the deposit occurring as subhorizontal tabular zones, locally diluting or concentrating ore. These clay assemblages are interpreted to have a complicated history of both steam-heated and supergene origins associated with relatively recent geothermal activity. Abrupt changes in the nature of the epithermal ore are suggestive of an abrupt change in fluid composition and/or depositional conditions during ore formation that have been attributed to the interaction between a hot, deeply derived magmatic fluid and cool surficial groundwater. Geothermal activity is expressed as fault-controlled hot mud pools, solfataras, hot springs and neutral chloride and acid sulfate waters, and low-temperature fumaroles.

Early exploration drilling used alteration as guides. The so-called "boiling zone" originates from Kennecott's 1980s understanding of "hot spring-style" epithermal deposits, where adularia is thought to be associated with boiling hydrothermal fluids. From the earliest drilling, this boiling zone was recognized as forming a broad sheet-like body, sandwiched between the "argillic" and "anhydrite seal." This early emphasis on mineralogy meant that subsequent drill core logging, involving multiple generations of geologists over 30 years, captured broad changes in alteration minerals. Once interpreted as alteration assemblages, it has meant that a new interpretation of porphyry- and epithermal-related alteration assemblages has been possible. We can now show that moderately dipping adularia-rich epithermal domains overprint multiple, upright, zoned porphyry centers.

High-resolution automated mineral logging has been applied to Ladolam. With a spatial resolution down to 0.5 mm, application of this automated scanning technology has made it possible to complete a deposit-scale petrographic study using VNIR + SWIR. This knowledge, gathered in the context of a well-established paragenetic framework (from multiple research projects in collaboration with university-based researchers), has challenged accepted thinking on the nature of the Lihir ore types. Over 20 km of scanning has helped inform a new detailed spatial model that further subdivides an adularia-pyrite (upper) epithermal and an anhydrite-dominant (lower) epithermal domain. Detailed subdivision of the advanced argillic domain has also been possible. High-resolution automated drill core scanning provides a greatly enhanced way of identifying important minerals and alteration boundaries compared to using conventional logging data.