EPITHERMAL GOLD-SILVER

and

PORPHYRY COPPER-GOLD

EXPLORATION

- Short Course Manual

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SUMMARY

This short course manual considers field aspects of epithermal and porphyry ore deposits as an aid to mineral exploration. The classification of ore systems used here allows ore and gangue mineralogy, hydrothermal alteration, structure, breccias and the paragenetic sequence of events, to be employed as exploration tools to identify hidden ore systems. Zoned hydrothermal **alteration** provides vectors to mineralisation and must be understood in order to correctly interpret geophysical data derived from: sulphide content (chargeability), silicification (resistivity) and magnetism, which is both created and destroyed. "Lithocaps" are divided into individual elements which vector to different deposit types. Major **structures** localise ore systems within second order dilatant fractures, and analyses of vein kinematics provide an indication of the tectonic conditions active during ore formation. A model is proposed that transient changes in the nature of convergence provide triggers for the emplacement of intrusions along with vein and breccia ores derived from deeper magmatic source rocks. **Breccias** which occur in most epithermal-porphyry deposits are considered using different classification methods for inclusion within geological models and as vectors to mineralisation.

Porphyry and most epithermal deposits are hosted within magmatic arcs related to compressional subduction settings, while only some epithermal deposit styles dominate in extensional back arc basins and intra-arc rifts. The late Terry Leach pointed out the importance of the Philippine arc geothermal systems as analogies to a wider variety of ore deposit and alteration types than the extensional New Zealand geothermal systems, and developed fluid mixing models to account for bonanza Au formation in low sulphidation epithermal Au deposits.

Two types of epithermal Au-Ag mineralisation, developed at shallow crustal levels, termed low and high sulphidation, are derived from dramatically different ore fluids to produce distinctive wall rock alteration as well as ore and gangue mineralogy. **Low sulphidation epithermal Au-Ag** deposits display two fluid flow trends and zoned deposit types, within either arcs or strongly extensional settings. The arc deposits tend to be sulphide-rich with a progression in styles, in time and from deep to shallower crustal levels, as quartz-sulphide Au $\pm$ Cu, to carbonate-base metal Au, and then epithermal quartz Au mineralisation at highest crustal levels, which may host bonanza Au grades. Banded epithermal Au-Ag veins which typically form in extensional back arcs may grade from deeper level polymetallic Ag-Au, as a Ag-rich end member of carbonate-base metal Au style, to chalcedony-ginguro Au-Ag mineralisation at higher crustal levels, with the inclusion of substantial quartz gangue deposited from circulating meteoric waters. **High sulphidation epithermal Au** deposits develop within arcs and feature characteristic zoned hydrothermal alteration derived from the reaction of hot acidic fluids with wall rocks, commonly overprinted by later Au $\pm$ Ag $\pm$ Cu sulphide mineralisation. Higher Au grades and better metallurgy are recognised where ore fluids evolve to lower sulphidation. The term carbonate-base metal Au is more correct for much of the mineralisation described in geological literature as intermediate sulphidation.

Ore shoots defined as wider and higher metal grade vein portions, which host the best ore in epithermal deposits, develop by the coincidence of several controls to mineralisation defined as: different styles of epithermal Au mineralisation (above), appropriate lithologies, dilatant fractures and efficient mechanisms of Au deposition.

Porphyry Cu-Au deposits develop within arcs as quartz-sulphide stockwork to sheeted veins and breccias hosted within polyphasal, commonly spine-like, porphyritic intrusions rising to within 1-2 km of the palaeo surface above deeper magmatic source bodies. The staged model for porphyry development helps to explain the overprinting relationships of zoned prograde and later retrograde hydrothermal alteration within intrusions and adjacent wall rocks, combined with overprinting near porphyry vein and breccia styles. Many of these features provide vectors towards blind exploration targets. **Skarns**, developed by the alteration of reactive rocks, represent both ore systems and vectors to buried porphyry source rocks. These are zoned in time and space from isochemical, to prograde and retrograde metasomatic skarns and later stage epithermal Au overprints.

The **exploration implications** of the geological models presented herein include the ability to target blind ore systems from an understanding of features expected to occur above or adjacent to mineralisation. Although geological models presented herein have been tested by application to many ore systems, in the exploration environment new data will prompt continued modification.

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