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Zircon Characterization as a Pathfinder for Porphyry Cu Deposits

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Porphyry Cu (± Au ± Mo) deposits are an important source of not only Cu but also Au, Mo, Ag, Re, and other metals. Porphyry Cu deposits are known to be associated with convergent plate margins, e.g., continental arcs, island arcs, and continental collision zones. These deposits are highly concentrated around the Circum-Pacific and Tethyan belts. The characteristics of porphyry Cu deposits are relatively well constrained and can be broadly summarized as follows: stockwork, disseminated and veinlet copper sulphide minerals commonly associated with porphyritic intrusions, subject to potassic, sericitic and in some cases even argillic alteration resulting from magmatic-hydrothermal activity due to the emplacement of intrusive complexes at relatively shallow depth (<6 km)[1]. Due to the significance of the porphyry Cu deposits, it is important to gain new insights into the processes that led to their emplacement.

Recent advances in analytical techniques, such as LA-ICP-MS, allow collecting large amounts of high-quality data at a relatively low cost and in a short period of time. Using this methodology, recent work has developed new Cu fertility indicators based on zircon trace element compositions[2]. The best Cu fertility indicators based on zircon compositions are zircon Eu/Eu* (>0.3) and 10,000*(Eu/Eu*)/Y (>1), while the zircon (Ce/Nd)/Y (>0.01) and Dy/Yb (<0.3) have proven to be moderately useful.

In addition to the previously mentioned zircon trace element data, we looked into the morphology, color, internal structure, and O-Hf isotopes of these zircons. These data provided insights into the source and petrogenetic processes associated with the formation of porphyry Cu systems. Because of the zircon resilience and its ability to survive different metamorphic and alteration processes, these zircons can be preserved in the detrital record, thus providing a new vector for the identification of porphyry Cu deposits.

To evaluate the viability of the previously described approach and provide further geodynamic constraints, two highly endowed and well-known deposits were studied. The Tampakan deposit (southern Mindanao, Philippines) and the Batu Hijau deposit (Sumbawa Island, Indonesia). Zircons from syn-ore intrusions were included as part of the initial zircon trace element Cu indicators[1]. The zircon characterization expands to pre- and post-ore samples.

Documentation of associated zircons using CL and BSE imaging techniques show that the samples, particularly syn-ore ones, are dominated by zircons with relatively unzoned cores surrounded by a thin oscillatory zoned rims. We interpret these zircon textural characteristics to reflect two stages of magma emplacement. Wide unzoned cores indicate crystallization from a long-lived, deep hot magma chamber, whereas thin zoned rims indicate a relatively short residence time in the shallow crust, which prevents the loss of Cu metals. In shallow epizonal environment, strongly zoned zircon will crystallize due to fast cooling. This zircon characterization can be expanded to areas such as Tibet, where they can be further tested.