How long does it take to make a giant porphyry copper deposit? Advances in high-precision geochronology and modelling of magmatic-hydrothermal processes

A. VON QUADT[1], S.J.E. LARGE[1,2], I. PEYTCHEVA [1,3], C.A.HEINRICH[1]

[1]ETH Zurich, Dept. Earth Sciences, Switzerland, vonquadt@erdw.ethz.ch
[2]Natural History Musuem, London
[3]BAS, Geological Institute, Sofia, Bulgaria

Porphyry copper deposits are characterized by multiple phases of magma emplacement alternating with hydrothermal veining, alteration and copper deposition. This geological complexity has contributed to the notion that the formation of the best deposits is a complex process drawn out over an extended time period. Combining the most precise geochronological constraints with microchemical evidence from zircon concur with physical models that the formation of even the biggest deposits is a rapid process lasting a few 10'000 years. A puzzle of field documentation, zircon petrography (SEM-CL), LA-ICPMS microchemistry including Hf isotopes, and final recovery of the same crystals for chemical-abrasion isotope-dilution thermal-ionization mass spectrometry (CA-ID-TIMS) provides time-calibrated information about the evolution of mineralizing magma chambers. Results are consistent with the interpretation that a single upper-crustal magma reservoir at 5-10 km depth acts as the source of fluid making one ore deposit. Antecrysts with geochemical signatures recording upper-crustal fractionation indicate life-times of large crystallizing magma chambers in the upper crust lasting several 100'000 years. High-precision zircon geochronology and physical modelling concur that this process extends over 10'000 to 100'000 years, for world-class to giant ore deposits.