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Magma Emplacement Rates and Porphyry Copper Deposits: Thermal Modelling of the Yerington Batholith, Nevada, USA

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Many porphyry copper deposits are associated with granitoid plutons. Their genesis is attributed to the degassing of pluton-forming intermediate to silicic magma chambers. These plutons are commonly envisioned as resulting from the slow cooling and crystallization of large magma chambers. Most of the models combine the formation of ore deposits and the cooling of a magma chamber. However, they do not consider neither how typically hundreds of cubic kilometres of magma were emplaced into the upper crust, nor the prolonged growth of plutons involving simultaneous cooling and crystallization together with the release of exsolved volatiles, which may contribute to ore formation.

We use numerical simulations of thermal evolution due to pluton growth to investigate the links between pluton construction, magma accumulation, solidification, volatile exsolution, volatile release and porphyry copper formation. The Jurassic Yerington batholith in western Nevada, USA, is used as a case study because it is associated with economic porphyry copper deposits, it shows an exceptional exposure revealing the geometry of the intrusion, and petrological and geochronological analysis have shed light on its emplacement style and duration. Our conductive heat flow model simulates the growth of the $\sim$1000 km^3 batholith emplaced at 2-8 km crustal depth by step-wise intrusions of vertically stacked sills. Different emplacement rates and repose times of no melt injection between the three main Yerington intrusions were tested.

Our numerical simulations show that to comply with the conceptual model linking porphyry copper deposits with the presence of large, highly molten magma chambers, magmas must be emplaced at a high rate of several cm/yr. In plutonic records, such high rates are uncommon. It follows that either the current conceptual model is incorrect or that porphyry copper deposits are only produced by the rare, rapidly emplaced plutons. The fact that many granitoid plutons are barren might be because they emplaced too slowly. Those slowly emplaced granitoids do not accumulate melts, release volatiles early during emplacement, and are unlikely to form cupolas that channel the volatiles. In the case of the Yerington batholith, the formation of a magma chamber requires a magma emplacement rate higher than 4 cm/yr and repose periods between the three intrusions exceeding 100 kyr. Since only the last emplaced intrusion is associated with copper deposits, we speculate that this fertile unit might have been emplaced more rapidly than the former units.