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An Abrupt Switch in Magmatic Plumbing Taps Porphyry Copper Deposit-forming Magmas

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Porphyry-type deposits are a vital source of green technology metals such as copper and molybdenum. They typically form in subduction-related settings from large, long-lived magmatic systems. The most widely accepted model for their formation requires that mantle-derived magmas undergo a ramp-up of volatiles and ore-forming constituents in mid- to lower crustal reservoirs over millions of years. However, these models are based on partial records of the shallow level rock record of porphyry deposits. To address this, we have evaluated the timeframe and geochemical signatures of magmatic rocks in a ~8 km palaeodepth cross-section through the classic Yerington magmatic system, Nevada, which is particularly well exposed in 3D and has provided constraints for most modern porphyry exploration models. Here we show that the magmas underwent a major and abrupt change in chemistry over a period of <200 kyrs that is coincident with the initiation of ore formation. This change in magma chemistry, which is documented across the plutonic to volcanic record, is attributed to a switch in the nature of the magmatic plumbing system. It is suggested that volatile-rich granitic melts were extracted from an estimated ~30 km depth and transported to shallow levels (~3-8 km) where they evolved to exsolve porphyry mineralising fluids. These were focused upwards through highly permeable crystal-mush dyke pathways. The rapid timescale of the switch suggests that the increase in a magma's ore-forming potential is not solely driven by a progressive ramp-up in ore-forming constituents, due to tectonic controls over multi-million year time scales, but through processes within the melt evolution zone, operating more than an order of magnitude faster than previously envisaged. This short timescale, in which geochemical signatures associated with mineralisation emerged, narrows the temporal-geochemical footprint of magmas associated with porphyry mineralisation, that can aid in exploring for new porphyry-type ore deposits.