Timescales for fluid storage and release in porphyry Cu-Mo systems – Timescales for felsic magma storage and volcanic eruptions

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In today's world, society demands scientific data to quantify geologic processes and predict geologic events that impact daily life. Primary among these are volcanic eruptions and all the surficial chaos associated with these colossal releases of energy. To investigate the timeframe and cyclicity for release of magmatic-hydrothermal fluids at sub-volcanic crustal levels, we use Re-Os dating of molybdenite from very young porphyry-style Cu-Mo deposits in Chile. Using a double Os spike to correct for isotopic fractionation and any common Os, we define the timing for successive bursts of ore-forming fluids carrying sufficient energy to rupture overlying rocks. The porphyry Cu-Mo environment is ideal for this exercise, as fluid bursts are instantaneously captured as veins filling fractured rock rather than released to the atmosphere as happens with eruptions. We obtained well-documented vein samples representative of distinct hydrothermal stages linked to the evolution of a porphyry Cu-Mo stockwork deposit. In some cases we dated molybdenite from two cross-cutting quartz veins in the same hand sample, obtaining the expected age relationship. For magmatic-hydrothermal systems whose age is less than 10 Ma, hydrothermal bursts can be delineated on a timeframe of 10,000 to 20,000 years. The collective magmatic-hydrothermal activity for a large porphyry-style Cu-Mo deposit may span several million years, but sets of B-stage (mainstage) planar stockwork veins form on the scale of thousands of years. The window for superposition of intense economic veining to build a giant porphyry-style deposit is 100,000 to 400,000 years.

We compare data for hydrothermal bursts to estimates for arrival and sequestering of felsic magma prior to its release through eruption. The development of a stockwork vein system and its alteration halo (with or without economic mineralization) provide episodic crack and seal events that repeatedly but only temporarily relieve upward pressure. As such, the development of a sub-volcanic Cu-Mo porphyry system may have the ability to forestall eruption in silicic magma chambers provided the periodic fluid release events and associated alteration strengthen (e.g. silicification) rather than weaken the overlying rocks. The relative rates of uplift and erosion also influence the ability of a porphyry system to breach the surface.