Duration of epithermal precious metal deposition based on ore grade, tonnage, fluid flow rate, and metal concentration of ore-forming fluids

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The duration of the mineralizing event is one of the least understood aspects of ore genesis. We have used ore tonnage (production + reserves) and grade information along with observed fluid flow rates in active geothermal systems to estimate the amount of time required to form an epithermal Au-Ag deposit. Total gold tonnage for 279 epithermal veins and deposits ranges from 0.0002 T (6 troy oz; Wharekirau-ponga, NZ) to 1,089 T (35 million troy oz; Pueblo Viejo, Dominican Republic), with an average of 7.10 T Au. Total silver tonnage for 252 epithermal deposits ranges from 0.0004 T (12 troy oz; Wharekirau- ponga, NZ) to 62,207 T (2.0 billion troy oz; Cerro Rico de Potosi, Bolivia), with an average of 60.3 T (1.94 million troy oz) Ag. The average gold grade, based on 241 deposits, is 4.7 g/T, and the average silver grade for 213 deposits is 89 g/T. The reported metal content and grade data suggest that about 10^{12} kg of fluid is required to form an average size deposit, but that 10^{16} kg of fluid is needed for the largest deposits. The average reported flow rate for 695 modern geothermal systems is about 10 kg/sec with the highest reported value near 3,000 kg/sec. Based on this average flow rate, the time required to form an average epithermal precious metal deposit is ~10,000 year. However, the very largest known deposit could have formed in 10,000 years at a fluid flow rate of 3000 kg/sec.

Results of this assessment indicate that the duration of active mineralization in epithermal systems need not be longer than ~10^4 yr, assuming continuous deposition. Field and laboratory data suggest, however, that mineralization is not continuous but, rather, is episodic and associated with discrete hydrothermal eruption events that lead to boiling and the quantitative precipitation of all metal in solution. As such, gold and/or silver deposition is likely occurring over only a small fraction of the total lifetime of the hydrothermal system. Results of this study also suggest that formation of giant deposits in a geologically reasonable amount of time requires hydrothermal systems that were active for longer periods of time and were characterized by higher fluid flow rates.