MODEL FOR THE ORIGIN AND DISTRIBUTION OF METALS IN PORPHYRY COPPER SYSTEMS, WITH APPLICATIONS TO EXPLORATION. R. J. Bodnar, Fluids Research Laboratory, Department of Geological Sciences, Virginia Tech, Blacksburg, VA 24061-0420 e-mail: bubbles@vt.edu

Over the past decade remarkable advances have been made in our ability to obtain quantitative analyses of individual fluid inclusions. Application of these techniques to study fluid inclusions from porphyry copper systems has provided abundant data related to the sources of metals and other ore-forming components in these economically important systems. These data, combined with an improved understanding of the chemical and physical processes associated with the emplacement and crystallization of epizonal silicic, hydrous plutons, have led to the development of an internally-consistent model for the evolution of magmatic systems associated with porphyry copper deposits. These models have a direct application in the exploration for hidden porphyry deposits, owing to the systematic variation in fluid inclusion characteristics in time and space relative to the major ore-depositing event(s).

Analyses of fluid inclusions from numerous porphyry copper deposits from the southwestern U.S. porphyry province show a clear distribution of metal contents of ore fluids with respect to location within the porphyry system and alteration and/or mineralization stage. Fluid inclusions representing the earliest magmatic fluids in all systems studied contain from a few thousand to tens of thousands of ppm copper. Similar concentrations of iron, manganese, zinc and lead have also been detected. A systematic decrease in metal contents is noted as the early fluids migrate further from the source and cool and are diluted by fluids of meteoric origin. Fluids that are clearly of wallrock origin contain no detectable metals. The results of these studies provide convincing evidence that metals in the porphyry copper deposits studied were sourced in the magma.

Fluid inclusion characteristics and the distribution of metals in fluid inclusions within the porphyry environment are consistent with the vapor-plume model proposed by Henley and McNabb (1978). The Bingham Canyon, Red Mountain (AZ), and Butte deposits all contain fluid inclusions that are thought to have trapped the "magmatic vapor", and analyses of these inclusions using synchrotron XRF techniques prove these fluids were responsible for transporting metals into the ore-forming environment. Moreover, results of theoretical and experimental studies of partitioning of metals between coexisting liquid and vapor at magmatic conditions are consistent with analytical results and provide a plausible mechanism for transporting metals such as gold, silver, copper, arsenic, antimony, mercury, etc. from the deeper porphyry environment to the near surface epithermal environment.