Role of oxidized, S-rich mafic magmas for giant Cu mineralization: Evidence from Pinatubo, Bingham Canyon and El Teniente

Hattori, K.H. and De Hoog, J.C.M., Earth Sciences, Univ. Ottawa, Ottawa, K1N 6N5, khattori@uottawa.ca, Keith, J.D., Geology, Brigham Young Univ., Provo, UT 84602, USA, Skewes, M.A. and Stern, C.R., Geological Sciences, Univ. Colorado, Boulder, CO 80309-399, USA

Giant porphyry and breccia Cu deposits contain large amounts of S. We have shown that much of S was supplied from mafic magmas based on $\delta^{34}S \sim 0$ ‰ of sulphides from large deposits and low solubilities of S in felsic magmas (Hattori & Keith, 2001). The occurrences of mafic rocks are recognized in increasing number of porphyry-type deposits (GSA Special Session T-10; 2002). Studies of these mafic rocks show that they are mantle-derived, intrinsically oxidized and S-rich.

The Bataan arc, Philippines, hosts young (Plio-Pleistocene) porphyry Cu and epithermal deposits, such as the ~1 Ma FSE-Lepanto deposit in northern Luzon island and the Dizon mine in Mt. Pinatubo. Mt. Pinatubo contains other Cu showings and numerous mineralized, acid sulphate hydrothermal systems above a magma reservoir at ~ 5 km. Melt inclusions and mineral compositions of mafic fragments in the 1991 eruption products show that mafic magma was oxidized (> NNO+1.4) and S-rich (>2,000 ppm). The S released from the mafic magma was incorporated into the melt and immiscible aqueous fluids in the overlying dacitic magma chamber (~ 800˚C), then acid-sulphate hydrothermal fluids. At Bingham Canyon, Utah, the largest Cu and Au deposit in N. America with 30 Mt Cu, is hosted by felsic intrusions at the centre of a 38 Ma stratovolcano. Mafic fragments in the volcanic rocks show that the mafic magmas were also S-rich and oxidized (~NNO+ 1.2) based on spinel-olivine oxybarometry, and the occurrence of barite in olivine (Fo ~90). Similar to Pinatubo, acid-sulphate hydrothermal activity was contemporaneous with the volcanic activity, forming alunite alteration. At El Teniente, Chile, an intrusion of gabbroic composition hosts igneous and hydrothermal breccias which contain the bulk of the Cu in the world-largest Cu deposit (>93 Mt Cu). The mantle-derived magmatic sources for these breccias were high in S and oxidizing, as shown by both the high Fe^{3+}/Fe^{2+} (> 1) of all igneous rocks related to the deposit and the occurrence of both magmatic and hydrothermal anhydrite in breccias (Skewes et al, 2002). These data indicate that oxidized, mafic magmas are important for large porphyry-type Cu mineralization by transferring large quantities of S and hydrophile metals from the mantle wedge to shallow felsic magma reservoir and overlying acid-sulphate hydrothermal systems. It is probably not coincidence that highly mineralized arcs are also known for volcanoes with excess S discharge.