High Oxygen Fugacities and Porphyry Deposits

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Most porphyry deposits are associated with oxidized magmas, but what is the optimum oxygen fugacity and how oxygen fugacity controls porphyry mineralization, remains controversial. Given that the oxygen fugacity of the hydrothermal fluids increases during mineralization, it is important to figure out when and how porphyry magma gain its high oxygen fugacity signature. Previous studies suggested that ΔFMQ+2 is the magic number for porphyry deposits, which may increase to ΔFMQ+4 during mineralization controlled by decreasing pH values of the hydrothermal fluids due to sulfate reduction. Calculated Ce^{4+}/Ce^{3+} of zirconssuggest that high oxygen fugacity is the primitive characteristics of the parental magmas. The magic number of porphyry deposits is refined to ΔFMQ+1.5, based on the estimation of oxygen fugacities using zircon Ce^{4+}/Ce^{3+} and the behaviours of sulfur. The behavior of chalcophile elements is controlled by sulfide, while the sulfur speciation is controlled by oxygen fugacity.Sulfate is the dominant species at $fO_2>$ ΔFMQ+1.5. High oxygen fugacity is not the only controlling factor for porphyry mineralization, e.g., normal arc rocks have no porphyry Cu deposits. This is because mantle peridotite has low Cu and S contents, high oxygen fugacity does not make much difference at 10-20% partial melting. Our modeling shows that partial melting of subducted oceanic crust, under oxygen fugacities higher than ΔFMQ +1.5, is favorable for producing primary magmas with Cu contents sufficiently high for porphyry mineralization. Porphyry Mo deposits require pre-enrichment of Mo during oxidation-reduction cycle on the Earth's surface, e.g.,Oceanic Anoxic Events. During plate subduction, large amount of the Mo-rich sediments in the Eastern Pacific have been taken down to the mantle wedge. Subsequently these sediments were metamorphosed and then Mo was transferred to porphyry deposits through partial melting.