

High magmatic oxidation state delays sulfide saturation and promotes metal fluxing in arcs

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Sulfide saturation during arc magma evolution depletes ascending magmas in chalcophile elements (e.g. Cu and Au) and promotes metal recycling into the mantle. Although magmatic sulfides have been extensively documented in deep arc cumulates, the timing of sulfide saturation relative to melt differentiation remains poorly constrained. Here, we track the behavior of sulfur in deep cumulates from the Sierra Valle Fértil–La Huerta (VFLH) arc section of the Famatinian arc (Argentina). We find that sulfide is rare in primitive cumulates and becomes more abundant with differentiation, indicating that sulfide saturation was delayed in contrast to observations in non-arc settings. Micro-X-ray absorption near edge spectroscopy at the S *K*-edge of apatite was performed to constrain sulfur speciation in magmas evolving in the deep crust. These measurements indicate that the melts had high S^{6+}/S^{2-} throughout differentiation, yielding a minimum oxygen fugacity (fO_2) of FMQ +1.2 to 2.0. This suggests that an elevated melt fO_2 acquired from the mantle source can explain late sulfide saturation in the system. We couple a thermodynamic model of magma differentiation with a sulfur speciation and sulfide saturation model, which indicates that magma differentiation at FMQ+1 to FMQ+2 would be sufficient to delay sulfide saturation in VFLH magmas. Our model indicates that the residual melts of oxidized arc magma differentiation can escape early sulfide saturation and associated loss of chalcophile elements. We suggest that oxidized, mafic-intermediate arc magmas play a key role in delivering metal fluxes to the atmosphere, which may contribute to ore deposit formation and the chalcophile depletion of modern continental crust.