High sulfur solubility in hydrous felsic magma at coexistence of sulfide and sulfate

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Porphyry deposits supply major proportion of the world's copper (Cu) and gold (Au). The role of magmatic sulfur (S) is important in the ore-forming processes. On one hand, the giant deposits require abundant S in addition to metals. On the other hand, when S^{2-} exceeds its solubility at variable oxygen fugacity (fO_2) conditions, sulfide saturated, scavenging Cu and Au and resulting in metal depletion in the magma. It is believed that high fO_2 depresses saturation of sulfide and favors the formation of porphry deposits. However, the relationship between oxidation state, S solubility and ore-forming process remains unclear. Here, we conducted experiments on a hydrous dacite at 1.0 GPa and 850 to 950 °C using piston-cylinder press. The oxygen fugacity ranges from FMQ-1.3 to FMQ+4.8. The results show that the maximum S solubility in deep hydrous silicic magma occur at the middle fO_2 (~FMQ+2), where sulfide (S^{2-}) and sulfate (S^{6+}) coexist, and the solubility is up to over 6000 ppm, higher than the solubility of S^{2-} plus S^{6+}. Based on the S and Au solubilities, we infer that an intermediate sulfur species, probably sulfite (S^{4+}), may be present in hydrous magma. As SO_2 is quite soluble in fluids, S^{4+} solubility in hydrous magmas increase with water content. Thus, the relatively high oxidation state and high H_2O content in hydrous magmas in arc regions favor the presence of S^{4+}. As water solubility increases with pressure, deep magmas can dissolve more water and S^{4+} than shallow magmas, which may explain why giant porphyry Cu-Au deposits occured at thickened continental arcs. Our results also have important implications for understanding S flux from subducting slabs to the mantle wedge.