



Contrasting effects of S and Cl on the gold enrichment of magmas

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Volatile-rich magmas are very important sources for highly siderophile elements (i.e. Pt group elements and Au), which they transport from depths of magma generation to subsurface Cu-Au-porphyry or Ni-Cu-PGE sulphide ore deposits. The behaviour of highly siderophile elements (HSE) is strongly controlled by the redox conditions in magmas and by the activity of volatiles, acting as mobilization and transport agents for HSE. Recently, it has been experimentally determined that Au solubility in silicate melts is significantly increased with increasing fO_2 in S- and Cl-bearing systems in comparison with S- and Cl-free magmas (e.g., Botcharnikov et al., 2010; Jégo et al., 2010). Here we present new experimental data illustrating that S and Cl have contrasting effects on the enrichment of Au in silicate melts as fO_2 increases from reducing to highly oxidizing conditions. The experiments at 200 MPa and at 1050 and 1200°C conducted in basaltic, andesitic and rhyodacitic systems show that in S-bearing magmas the highest gold solubility (by up to an order of magnitude) is observed within a narrow “window” of redox conditions characterized by sulfide-sulfate transition (i.e. Au concentration exposes a pronounced maximum, Botcharnikov et al., 2011). Within this redox range, Au is found to be particularly mobile and is dissolved in silicate melts as a sulphide-bearing component. With further increase in fO_2 , the solubility of Au drops dramatically to the level observed in S-free melts. On the contrary, the solubility of gold in S-free but Cl-bearing magmas increases almost linearly with the concentration of Cl at given fO_2 , and Cl-enriched magmas can dissolve exponentially increasing amounts of gold with increasing fO_2 . The highest solubility values (ca. 2 times higher than that in S-bearing systems) have been determined at $\log fO_2$ corresponding to FMQ+3 and it is expected that this dependence holds also at more oxidizing conditions.

The observed contrasting solubility of Au in S- and Cl-bearing magmas at different redox conditions implies that the presence of S would favour gold transport in a narrow range of fO_2 from $0.5 < FMQ < 1.5$, whereas Cl is expected to take control over the mobility of gold with progressive magma oxidation. At $FMQ < -0.5$, the change in volatile composition is not expected to affect Au mobility significantly. Thus, small variations in the activities of volatiles and redox conditions in natural magmas can lead to mobilization or fixation of gold during magmatic evolution. Hence, the relative changes in these parameters should be considered for the interpretation of natural magmatic processes leading to the formation of ore deposits.

References:

- Botcharnikov et al. (2011) *Nature Geoscience* (Advance online publication doi: 10.1038/NGEO1042)
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