Controls on the composition of magmatic volatiles in the crust: Implications for ore genesis and volcanic degassing

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Volatile elements dissolved in silicate melts not only serve as the driving force for explosive volcanic acitivity, but also facilitate the formation of magmatic-hydrothermal ore deposits and have a significant impact on the Earth's atmosphere and climate. Though water and CO_2 are the most abundant volatile components in most magmatic systems, the effect of sulfur and halogens on atmospheric chemistry and ore-forming systems is more pronounced.

We will discuss the most important parameters controlling the composition of exsolving magmatic volatiles in the middle to upper crust including numerous new experimental data on the effect of melt composition and P-T on the parition coefficients of S, Cl and some economically important metals such as Au, Cu and Mo.

Experimental data suggests that sulfur is the most easily degassed volatile element after carbon, in particular at relatively low fO_2 (<Ni-NiO) where FeS and H_2S are the dominant sulfur species in the silicate melt and the volatile phase, respectively. Similarly to CO_2, a large fraction of reduced S may be lost from the magma during moderate degree open system degassing induced by decompression. On the other hand, at subvolcanic depth, effective degassing of oxidized sulfur, and in particular Cl will require significant amount of crystallization. Crystallization will promote the transfer of these elements to the volatile phase by decreasing the melt volume, and increasing the volatile/melt partition coefficients by increasing the degree of melt polymerization. The maximum amount of S in the volatile phase is limited to a few mol% by the saturation of sulfide and/or sulfate minerals at P-T-fO_2 conditions typical of subvolcanic reservoirs in arc settings.

Considering metallic elements, Au can be effectively degassed by H_2S-bearing volatiles even from mafic magmas in the early stages of evolution. However, the extraction of Cu will become efficient only from felsic melts exsolving Cl-rich volatiles. The relative timing of saturation in sulfide and volatile phases may have a significant impact on metal extraction efficiencies if the sulfides are fractionated by entrapment in rock forming minerals or gravitational settling.

Biogeochemical poly-barrier qualities in plants

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In terms of the ability to accumulate chemical elements in relation to their concentration in the soils, two types of plant species are distinguished, barrier and barrier-free ones.

Our studies of moss and pine purple grass (Calamagrostis langsdorffii) show a more complicated correlation of the amounts of elements in the "soil-plant" system. Often the plants show biogeochemical poly-barrier qualities: as the concentration of the element in the soil increases, the barrier mechanism is repeatedly turned on and off.

The graph below shows the poly-barrier display in mosses with respect to Ni, the x axis being the logarithms of the average values for the selected content intervals for the element in soil (lnCs), the y axis being logarithms of average Ni content in mosses (lnCv), growing on these soils (fig. 1).

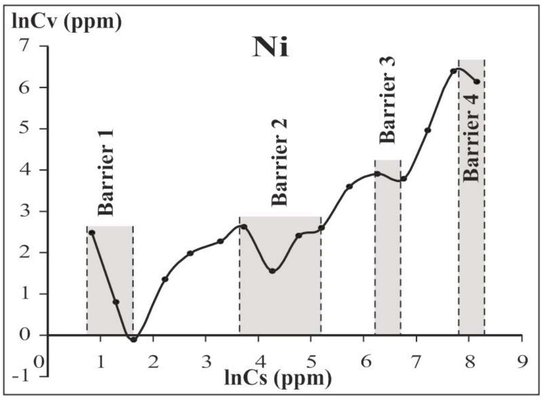

Figure 1: poly-barrier qualities of moss with respect to biological accumulation of Ni.

During the biogeochemical monitoring it is necessary to take into consideration that the cessation of the growth and the decline in the elements in plants are not always connected with the environmental conditions' improvement on the territory. It might as well be conditioned by activation of intermediate biogeochemical barrier. On the other hand, a sharp increase in contents of elements in the vegetation does not definitely mean the deteriorating environmental conditions, it can possibly be the consequence of the barrier being "broken". It is necessary to perform a full ecological-geochemical monitoring of the soils and vegetation to determine biogeochemical poly-barrier qualities in plants.

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