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Magmatic Sulfides in Quaternary Ecuadorian Arc Magmas

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New petrographic and geochemical data were obtained for a number of volcanic centers located from the frontal arc (Cotacachi, Cuicocha, Casitagua, Pululahua, Pichincha, Yanaurcu, Illiniza, and Pilongo) through the Inter-Andean Valley (Cusin, Cubilche, Mojanda-Fuya Fuya, and Imbabura) to the main arc (Cayambe and Chacana) and the back arc (El Reventador). This study investigates magmatic sulfide inclusions present in the volcanic rocks of the previously mentioned volcanic centers. Together with already sampled volcanoes from previous studies, microscopic observations were made on how sulfide melt and silicate melt inclusions occur, as well as comparison for any geochemical or textural difference. Sulfides occur as inclusions in silicate minerals (amphibole, clino- and orthopyroxene, and plagioclase) and Fe-Ti oxides (magnetite and/or magnetite-ilmenite pair). The sulfide inclusions have various sizes (1–30 μm) and shapes (ranging from spherical to ellipsoidal and, rarely, angular) and occur as different phases (mostly pyrrhotite and Cu-rich phases), depending on the host mineral and the host-rock composition. Semiquantitative estimation of the amount of sulfides present in each volcanic center has been realized with the optical microscope and has been crosschecked with scanning optical microscope. Sulfide abundances range from 0.00003 to 0.0007 area % in the host rock and from 0.0008 to 0.002 area % in the xenoliths.

Electron microprobe analysis of the host minerals (plagioclase and amphibole) indicates that no systematic change in the chemistry of the minerals coincides with the occurrence of the sulfide inclusions. Microprobe analyses of sulfides found in the host rock and in the xenoliths result in the following maximum metal contents, respectively: Cu = 65.7 wt %, Fe = 65.2 wt %, Ni = 10.1 wt %, and S = 52.9 wt %; and Cu = 57.7 wt %, Fe = 60.9 wt %, Ni = 5.1 wt %, and S = 47.1 wt %. Relations of the sulfide chemistry with the host whole-rock chemistry show that as the SiO_2 content increases, the Cu and Ni content of the sulfides decreases, whereas the Fe and the S content increases. The opposite behavior is observed with the increase of Cu in the whole rock. Laser ablation analysis of sulfide inclusions gave the following median values for PGEs and noble metals: Pd = 2.5 ppm, Rh = 1.2 ppm, Pt = 0.1 ppm, Ag = 4.1 ppm, and Au = 0.2 ppm. Platinum group element and noble metal contents presented higher concentration when sulfides were hosted by magnetite. Relations between the sulfide chemistry and the modal abundance of the inclusions in the sample indicate that Cu and Ni content of sulfides decreases with increasing abundance whereas the Fe iron increases. Sulfide inclusions are present in all volcanic centers, in all rocks (SiO_2 = 50–67 wt %), and are hosted by crystal zones with different chemistry, indicating that magmatic saturation happens independently of the location of the volcano with respect to the trench and at various stages of magmatic evolution.

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