Environmental geochemistry and mineralogy of heavy metals in contaminated soils from the Almalyk mining and smelting complex area, Uzbekistan

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Processing of numerous comparative analyses of soils, plants and waters of mining objects of Almalyk industrial region has shown that the heavy metals collected in surface layers of soils (1-20cm) revealed a high content of heavy metals toxicants (Pb, Cd, Cu, Zn, Hg) and As, which is tens of times higher than the threshold level value. The intensity of anomalies is sharply redused at the distance of 1-2 km from the sources of pollution. The forming aureoles spatially focused in the prevailling wind direction. The pollution of vegetation is correlated with the pollution of soil and also is connected with the receipt of heavy metals into bioweight through root system and to a lesser degree from atmospheric losses of polluting substances. The changes in specific composition and morphological indications of plants growing on metal-contaminated soils have been revealed, the selective ability of some kinds of plants to absorption of separate elements has been established. Studies of the heavy fractions of soil samples using modern analytical instruments have enabled to define the occurrence forms of heavy metals-toxicants. They contain various forms of primary and secondary hard-soluble ore minerals and technogenic new formation. The study of heavy fractions of soil samples by the electronic microanalyzer JEOL“Superprobe”JXR-8800R has allowed to determine the occurance forms of heavy metals. The analysis of technogenic new-formations using microanalyser gives the opportunity to present in which form of heavy metals-toxicants are contained in outbursts of metallurgical factories. They were found to have a diverse structure and internal - structure of ball-shaped isolations. The majority of these balls contains more metals than other components. In some grains, obvious spherical (ball) structures, similar to vulcanite structures were observed. In peripheral layers of the majority of these balls, there are layers with Pb- up to 61 %, Zn- up to 73,5 %, Cu- up to 56 %, S- up to 27 % and other. In the cores of these balls, dendrites were found, which are coalesced in silicate mass containing high amount of iron (up to 60 %), and in other grains the accretion of iron with copper is observed.

^{4}He/^{3}He Thermochronometry

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We demonstrate a technique that uses classical diffusion theory to determine ^{4}He concentration profiles within minerals. This approach should prove useful for constraining the low temperature cooling histories of individual samples and for correcting (U-Th)/He ages for partial diffusive loss. To validate the method, we investigated apatites with independently constrained cooling histories. The minerals of interest were irradiated with 220 MeV protons to induce an artificial distribution of spallation ^{3}He. Our results indicate that proton-induced ^{3}He is uniformly distributed and that radiation damage associated with a proton fluence of ~5×10^{14} protons/cm^2 does not cause noticeable changes in He diffusion behavior. Proton-induced ^{3}He can therefore be used to establish He diffusion coefficients in minerals with insufficient natural helium for analysis or those in which the natural ^{4}He distribution is inhomogeneous. In addition, step heating ^{4}He/^{3}He analysis of a mineral with a uniform synthetic ^{3}He concentration provides a means to constrain its natural ^{4}He distribution that arose during ingrowth and diffusion over geologic time.

The ^{4}He profile can be extracted from stepwise degassing experiments in which the ^{4}He/^{3}He ratio is measured. The evolution of the ^{4}He/^{3}He ratio as a function of cumulative ^{3}He released can be compared with forward models to constrain the shape of the profile. Profiles of radiogenic He are a sensitive function of the time-temperature (*t-T*) path that a cooling sample experienced. Thus, by step-heating a proton-irradiated sample it is possible to restrict the sample’s acceptable *t-T* paths. Results indicate that ^{4}He profiles provide rich information on *t-T* paths, especially when the profiles are coupled with (U-Th)/He cooling ages on the same sample.

Samples that experienced only moderate diffusive loss have ^{4}He concentration profiles that are rounded at the edge but uniform in the core of the diffusion domain. Such profiles can be identified by nearly invariant ^{4}He/^{3}He ratios after the first few to few tens of percent of ^{3}He have been extracted by step heating. We show how such data can be used to correct (U-Th)/He ages for partial diffusive loss.