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Alteration and arenization processes of granitic waste rock piles from former uranium Mines in Limousin, France.

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France counts approximately 200 former uranium mines, 50 of which are located in the Limousin region. Mining activities between 1945 and 2001 have generated close to 200 000 tons of waste rocks in the Limousin, with uranium levels corresponding essentially to the geological background. Waste rock piles from three former mining sites in this region, were selected according to their age, uranium content and petrological signature. These sites are part of the two-mica granitic complex of St Sylvestre massif, formed 324 million years ago. Granitic blocks that build up the waste rock piles have experienced different processes and intensities of alteration before their emplacement at the surface. These processes are responsible for the petrological heterogeneity throughout the waste rock pile at the time of construction.

It is important to make a distinction within waste rocks between natural-cut-off waste rocks and economic-cut-off waste rocks. The latter represents a minority and is linked to stock prices. Natural-cut-off waste rocks contain about 20 ppm of uranium; economic-cut-off waste rocks contain about 100 to 300 ppm of uranium.

The aims of this study are to 1) assess the neo-formation of U-bearing minerals hosted by these rocks, and 2) to characterize the weathering processes since the construction of the rock piles, including both mechanical and chemical processes.

The structure of the waste rocks piles, from metric blocks to boulders of tens centimeters, induces an enhanced weathering rate, compared to a granitic massif. Mechanical fracturing and chemical leaching by rainwater (arenization) of the waste rocks produce a sandy-silty alteration phase. Silty-clay weathering aureoles of submetric-granitic blocks evolving into technic soil are mainly located below growing birch trees. Sampling on the rock piles was restricted to surface rocks. Samples collected consist mainly of granites, and rare lamprophyres with a high radiometric signal, thereby especially concentrated in uranium compared to the 200 000 tons of waste rock piles in the Limousin.

The composition of clay minerals and the uranium content of the samples were investigated by XRD, ICP-MS, Optical microscopy, EDS and WDS punctual measurements or element mapping and SEM on both thin sections and on rock chips.

The initial granite paragenesis (quartz, albite, sanidine, microcline, biotite, muscovite, apatite, rutile, zircon and monazite) was identified. Chlorite, smectite, kaolinite and secondary phosphates and sulfates are the main secondary minerals of the different stage of hydrothermal alteration and weathering. In the clay fraction, smectites are the main mineral phases. U-bearing minerals are different according to the alteration state of mine tailings. The mean content in uranium for selected samples is about 800 ppm and rises up to 5000 ppm for the separated clay fraction of the same samples. Initially and mainly hosted by monazite, uranium is found in phosphates such as autunite, or associated with smectites.

Micromorphological studies reveal:
• The formation of protosoils from weathering processes.
• Different degrees of alteration in the rocks, smectite or kaolinite alteromorphose.
• U oxy-hydroxides, nanometric minerals or coatings associated with smectite.
• A complex paregenesis of submicrometric - nanometric U phosphates, suggesting uranium stabilization.