Uranium migration and stabilization during weathering of granitic waste rock piles

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Mining took place in France between 1945 and 2001 during which time ~ 210 different sites were exploited and/or explored. A total of 76 Kt of uranium was produced, 52 Mt of ore was extracted, but also 200 Mt of waste rocks were placed onto rock piles, the majority of which with uranium levels corresponding to the natural environment. So far, the processes of uranium migration in waste rock piles are not well understood but have important implications for understanding the environmental impact and long-term speciation of uranium in this setting. Understanding the processes behind uranium migration in waste rock piles is essential to determine their environmental impact and the effectiveness of possible remediation techniques. The main objectives of this work are to assess 1) the presence of neo-formed U-bearing phases and 2) the migration of uranium in waste rock piles that have been subjected to weathering since the time of mining.

The site that was chosen is the Vieilles Sagnes waste rock pile in Fanay (Massif Central France) that is representative of more or less hydrothermally altered samples that have been exposed to weathering since the construction of the waste rock pile approximately 50 years ago. This site serves as a key location for studying weathering processes of waste rock piles, as it has not been reworked after initial construction and has therefore preserves information on the original petrology and mineralogy of the waste rock pile enabling us to assess post emplacement processes related to weathering.

Weathering of the waste rock pile appears to be dominantly mechanical. The majority of U in the waste rock pile is immobile due to its incorporation into dominantly primary magmatic accessory minerals as zircon and monazite which are resistant to weathering. However, as disseminated uraninite (UIVO2) can occur as inclusions in the main rock-forming minerals, limited migration of U(VI) into the surrounding environment is coupled to major mineral alteration. The sandy technic paleosoil underneath the waste rock pile is enriched in uranium and seems to function as a natural liner. Retention of uranium occurs by sorption of U on Fe oxides and different clay minerals. In the arenized matrix of the rock pile we see these retention processes, as well as the neo-formation of different insoluble uranyl phosphates (e.g. torbernite, autunite) due to weathering. Therefore, despite oxidizing conditions prevailing in such environment, U migration is limited.