U-decay series studies of a redox front system in the Bangombé natural nuclear reactor zone (Gabon)

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As part of a major natural analogue study of relevance to radioactive waste disposal, studies of naturally occurring U-series radionuclides have been carried out on the natural nuclear reactor found in the Bangombé uranium deposit (Gabon). Due to its shallow location within the zone saturated by groundwaters, this reactor has undergone extensive weathering phenomena. Radiochemical analyses by α and γ spectrometry show significant disequilibria of the $^{234}U/^{238}U$, $^{230}Th/^{234}U$, $^{226}Ra/^{230}Th$ pairs. Therefore, the Bangombé system has not been a closed system at least during the last 1 Ma until recently. The shales overlying the mineralization show oxidation effects related to the percolation of oxygenated waters from the surface. This has produced downward migrating redox fronts which dissolve inherited mineral phases, mostly Fe(II)-bearing chlorite, producing secondary alteration phases such as goethite, kaolinite and halloysite. U has been remobilized, transported and accumulated as U(VI) at the boundary between reduced black shales and oxidized pelites. The estimated rate of downward redox front movement is 15 m/Ma which also corresponds to the erosion rate if we assume a major role of erosion over the redox front movement. Selective chemical extractions with NH4 acetate and NH4 oxalate were performed in order to determine the U-bearing phases. The results indicate that most of U is extracted into the NH4 acetate phase and, therefore, U is mainly adsorbed onto clays.