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The evolution of a weathering profile and the rates of soil and saprolite production

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How soil and saprolite form and evolve through time is one of the big issues in Earth surface sciences that has remained poorly understood. We have measured the uranium-series isotopic composition (^{238}U-^{234}U-^{230}Th) of soils and saprolite for four different pits on a hillslope from the Nunnock River catchment in temperate SE Australia. The U-series isotopic composition is used to model how much time elapsed since the bedrock was converted into saprolite, and the saprolite into soil, for different locations in the weathering profile. Using a simple model of continuous removal of radionuclides it is possible to show that soil residence time ranges from 390 kyr to 1.27 Myr and decreases with increasing distance from the ridge. Saprolite residence time ranges from 482 kyr to 1.37 Myr and increases with distance from the ridge. These results can then be used to establish the evolution of bedrock-saprolite and saprolite-soil boundaries through time for each pit}. Moreover, it is possible to calculate depth-averaged soil and saprolite production rate by using the residence time of a given sample and its current position above the underlying weathering front. The results indicate that soil production rates are very low, from 0.25 to 1.3 mm/kyr, whereas saprolite production rate ranges from 14 to 41 mm/kyr. Whether we take into account lateral transport of soil or not, the inferred soil production rates are of the same order of magnitude. Hence, slow soil production rates are not the result of an oversimplification of soil transport process. In comparison, denudation rates inferred from ^{10}Be range from about 10 to 35 mm/kyr. This implies that the soil cover has been produced 0.5 to 1 Ma ago and is currently being destroyed}. Interestingly, denudation rates and saprolite production rates are similar, indicating that {\it erosion is balanced by the conversion of bedrock into saprolite}, and that {\it the saprolite thickness is in steady-state}. This study shows that the combination of U-series and cosmogenic isotopes allows us to discuss the evolution of a weathering profile.