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Can calcretes be used to date pedogenic processes in soil profiles under semi arid climate ? An example from U-Th isochrons in calcretes from South India.

Nicolas Durand (1), Bruno Hamelin (1), Deschamps Deschamps (1), Yanni Gunnel (2), and Pierre Curmi (3)

(1) CEREGE, UMR Aix-Marseille University - CNRS - IRD - ; Technopole Arbois-Méditerranée, BP80, 13545 Aix en Provence, France, (2) CNRS-UMR 8591, Université Denis-Diderot Paris 7, France, (3) ENESAD, Agroécologie, Dijon, France

Pedogenic carbonates, such as calcretes, have often been questioned as possible markers of the pedogenetic evolution of soil profiles under semi-arid climate. However, providing precise chronological constraints on their formation is a perequisite to determine the climatic and paleo-environmental conditions prevailing during and after their formation, and to improve our understanding of the physical and chemical conditions that promoted their development and preservation. On the other hand, these authigenic calcium carbonate precipitates provide us with an interesting test of the U-Th radioactive disequilibrium dating method, the reliability of which has been demonstrated extensively in aragonitic marine formations, and calcitic continental speleothems, but remain much more questionable in highly porous and chemically complex media such as soil profiles. In this study, we combined U-Th systematics with detailed micromorphologic observations of calcretes from South India, investigated at different spatial scales, from the landscape to the soil profile, down to the micro-fabrics of the samples.
The U-Th analyses were performed by Thermo-Ionization Mass Spectrometry. Since calcretes are impure carbonates, mixed with various amounts of parent rock and weathered minerals, all ages had to be computed using the isochron technique to correct for the detrital component. This method involves the extraction of several coeval subsamples from a single soil horizon and their U-Th analyses after total dissolution (TDS method). The isochron age is derived from the slope of the mixing line between the pure authigenic carbonate and the detrital phase, and the precision established statistically using the probability of fit and weighted mean deviations (MSWD).
Our results show that each set of samples taken from decimetric blocks is characterized by a well defined isochron line, clearly distinct from each other in the 3D Osmond diagram (232Th/238U; 230Th/238U ; 234U/238U). The regression lines obtained for most of the samples show probabilities of fit around 1 and MSWD values ≤ 1 . Our data demonstrate also that the detrital component is different between samples, and is in all cases out of secular equilibrium, by contrast with the standard paradigm. The calculated U-Th ages vary between 304 ± 38 ka and 44 ± 2.9 Ka (2σ), that suggest a discontinuous precipitation of the different facies constituting the calcrete profile, in good agreement with micromorphologic observations.
Two puzzling cases of "vertical isochrons" (variable 232Th/238Th without variations of 230Th and 234U ratios) have been observed, that can be reconciled only with an open system interpretation.
Taken at face value, these results suggest that no direct correlation can be inferred between the age of formation of the calcrete veins and major climate variations recorded in other archives during the last glacial/interglacial cycles.