Evolution of Quaternary cave levels in low-relief karst regions: influence of fluvial incision and speleoinception of chalk caves in northern France

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In many lowland areas, fluvial incision is usually relatively slowly and another factors as the stratigraphical control would play a relevant role. In the lower Seine valley of Northern France, cave systems developed in the sub-horizontal Upper Cretaceous chalk of the Anglo-Paris Basin offer the potential to constrain the Quaternary evolution of the Seine valley and to test the role of speleo-inception theory of conduit development in the chalk aquifer. Six chalk caves, with a combined length of over 5.7 km were studied in detail. In each studied cave, data on the passage morphology, cave deposits (speleothem and sediments) and stratigraphical control were recorded. Cave levels were defined based on geomorphological evidence and altitudinal cave passage analyses. The chronology of cave development and abandonment was constrained by ten U-Th speleothem dates and 144 palaeomagnetic samples collected from laminated sediments within the caves. Four regional cave levels were identified at 10, 40, 75-80, and 85-90 m asl, showing 1% slope to the Seine estuary. Each cave level is formed by phreatic and epiphreatic conduits enlarged by paragenesis, showing branch work or maze patterns. Cave infill corresponds mainly to clayey to silty sediments that occupy the majority of the karst conduits. Locally, sands and pebbles occur, and speleothems are relatively scarce. Palaeomagnetic and U-Th data show that these cave levels developed sequentially from >1.06 ka to c. 300 ka, ca. 78% of them in relation to prominent Turonian, Coniacian and Santonian hardgrounds as well as sheet- and semi-tabular flint bands. Their age correlates with the estimated age of the lower river terraces from limited previously published OSL, palaeontological and U-Th dating, although new age data from the study cave improve the chronology of the higher-level river terraces. The combination of all this data suggests an initial slow rate of incision during the early Pleistocene, followed by a phase of more rapid river incision up to ~ 0.30 m·ka⁻¹ from ca. 1 to 0.7 Ma. Later, incision rates dropped to ~0.08 m·ka⁻¹ during Middle Pleistocene, and 0.05 m·ka⁻¹ since the beginning of the Upper Pleistocene. In conclusion, fluvial incision constitutes also a relevant speleogenetic factor in low-gradient areas as the Seine Basin, where conduit development was favoured at sites where suitable lithological inception horizons intercept the contemporary base level.