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Stages of weathering mantle formation from carbonate rocks in the light of rare earth elements (REE) and Sr-Nd-Pb isotopes

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Weathering mantles are widespread and include lateritic, sandy and kaolinite-rich saprolites and residuals of partially dissolved rocks. These old regolith systems have a complex history of formation and may present a polycyclic evolution due to successive geological and pedogenetic processes that affected the profile. Until now, only few studies highlighted the unusual high content of associated trace elements in weathering mantles originating from carbonate rocks, which have been poorly studied, compared to those developing on magmatic bedrocks. For instance, these enrichments can be up to five times the content of the underlying carbonate rocks. However, these studies also showed that the carbonate bedrock content only partially explains the soil enrichment for all the considered major and trace elements. Up to now, neither soil, nor saprolite formation has to our knowledge been geochemically elucidated. Therefore, the aim of this study was to examine more closely the soil forming dynamics and the relationship of the chemical soil composition to potential sources.

REE distribution patterns and Sr-Nd-Pb isotope ratios have been used because they are particularly well suited to identify trace element migration, to recognize origin and mixing processes and, in addition, to decipher possible anthropogenic and/or "natural" atmosphere-derived contributions to the soil. Moreover, leaching experiments have been applied to identify mobile phases in the soil system and to yield information on the stability of trace elements and especially on their behaviour in these Fe-enriched carbonate systems.

All these geochemical informations indicate that the cambisol developing on such a typical weathering mantle (“terra fusca”) has been formed through weathering of a condensed Bajocian limestone-marl facies. This facies shows compared to average world carbonates important trace element enrichments. Their trace element distribution patterns are similar to those of the soil suggesting their close genetic relationships. Sr-Nd-Pb isotope data allow to identify four principal components in the soil: a silicate-rich pool at close to the surface, a leachable REE enriched pool at the bottom of the soil profile, the limestone facies on which the weathering profile developed and an anthropogenic, atmosphere-derived component detected in the soil leachates of the uppermost soil horizon. The leachable phases are mainly secondary carbonate-bearing REE phases such as bastnaesite. The isotope data and trace element distribution patterns indicate that at least four geological and environmental events impacted the chemical and isotopical compositions of the soil system since the Cretaceous.