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First $^{40}Ar/^{39}Ar$ geochronology of lateritic manganiferous pisolites: Implications for the Palaeogene history of a West African landscape

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Abstract

A pisolitic superficial formation deriving from the geochemical degradation of a previous massive manganiferous crust has been investigated in West Africa using $^{40}Ar/^{39}Ar$ laser probe analysis on different generations of cryptomelane from Fe–Mn pisolites and their embedding lateritic matrices. Prior to the ^{40}Ar–^{39}Ar geochronological analysis, a detailed petrographical study has allowed the identification of successive assemblages from Mn-pisolites to (Fe,Mn)-pisolites embedded in Mn-rich and Fe-rich matrices, respectively. The age spectra obtained for pisolites, including cores, cortices and matrices enables the definition of three age clusters around 56–59, 44–47, and 24–27 Ma. The first two age clusters with the petrographical and geochemical results obtained on the different assemblages indicate that the development of the pisolitic crust first induced Mn-leaching and Fe-Al accumulations due to warmer and wetter climatic conditions in the age interval 56–47 Ma that characterizes the Tertiary greenhouse effect period propitious to bauxite formation in West Africa. The absence of $^{40}Ar/^{39}Ar$ ages between 44 and 27 Ma only means that geochemical conditions for cryptomelane crystallisation were not fulfilled, but could still be favourable to Fe- and/or Al-oxy-hydroxides formation, before drier climatic conditions became rather effective at the Oligocene period to sustain mechanical erosion rather than chemical weathering processes. The age cluster 24–27 Ma indicates however a reactivation of the manganiferous lateritic weathering late Oligocene. The $^{40}Ar/^{39}Ar$ dating results are discussed in terms of climatic condition changes during the Palaeogene that were favourable to the genesis of either Al- and Fe- or Mn-oxy-hydroxides in the course of development and evolution of the pisolitic formation. The $^{40}Ar/^{39}Ar$ dating also provides a new highlight to large-scale geomorphological patterns of West Africa.

Keywords: $^{40}Ar/^{39}Ar$-geochronology; Cryptomelane; Lateritic pisolites; Paleoclimate; Planation landsurface; Burkina Faso; West Africa

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1. Introduction

Since Cretaceous, rocks of tropical shields have been weathered under the effect of chemical and physical earth surface processes, into more or less dissected thick lateritic weathering mantles including at their top either aluminous, ferruginous, or manganiferous crusts [1,2]. These crusts often evolved under the influence of chemical and physical degradation processes into a pebbly layer essentially made up of nodules and/or pisolites embedded in a lateritic matrix [3–5]. In tropical areas, the lateritic weathering mantles capped with such crusts may constitute a long record of the past climatic conditions [6–9]. Age and dynamics of lateritic weathering systems and associated landforms are poorly known. Direct dating of weathering events remains thus a very tough issue for research devoted to the knowledge of long-term evolution of tropical landscapes. We propose to investigate a pisolitic superficial formation developed over a massive manganiferous crust, (*i*) by providing detailed petrographical observations and geochemical analyses of the different facies of that formation, and (*ii*) by performing $^{40}Ar/^{39}Ar$ laser probe and step heating analyses on different generations of cryptomelane identified in those facies. The main purpose of such investigations is first and foremost to constrain the age of weathering profiles and associated lateritic landsurfaces, in relation with specific paleoclimates. We will also discuss the spatial and temporal geomorphologic relations with the other lateritic formations capping stepped landsurfaces of the region, e.g., bauxites, and the Paleogene climatic changes suggested by our dating results.

Cryptomelane is a ubiquitous mineral of lateritic manganese weathering mantles and associated manganese crusts with concretionary or massive structures that can be sometimes pisolitic [10–13]. Absolute dating of cryptomelane of lateritic manganese ore deposits is an important scientific issue because it would allow constraining stages of past climatic changes from the knowledge of "weathering timescales" [8,14]. Pisolitic layers in tropical soil sequences are the product of the near-surface geochemical and structural degradation of massive lateritic crusts [3,4], which occurs under the effect of climatic condition changes. Detailed geochemical investigations on these superficial materials are as

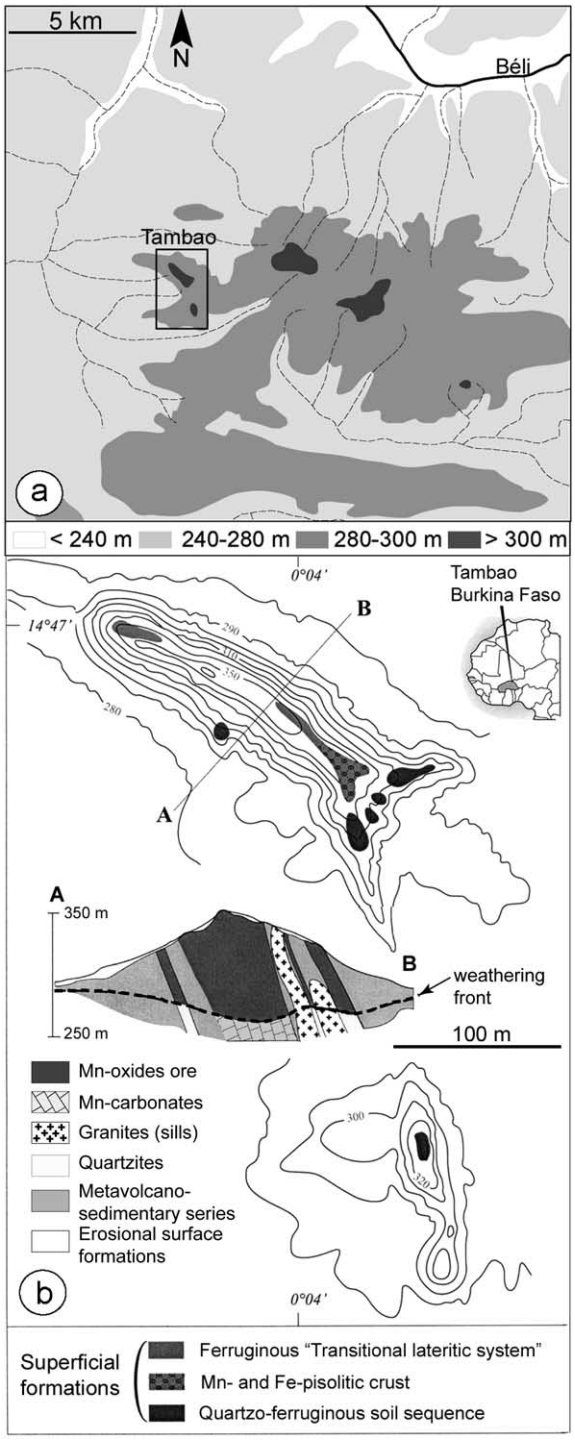

Fig. 1. *(a)* Location and geomorphologic patterns of the Mn-rich formations of the tambao Manganese ore deposit with *(b)* a section (A–B) across the main geological formations.