# $^{40}Ar/^{39}Ar$ dating of African manganese pisolites: implication for Cenozoic climatic changes

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Chemical and mechanical weathering-derived processes are among the most efficient factors in modifying the Earth surface. Weathering gradients are strongly dependent upon temperature, rainfall and tectonic stability over geological time. In this way, the upper part of tropical and sub-tropical cratonic lithosphere has been transformed into thick supergene lateritic mantles with frequent metal accumulations. In West Africa, the lateritic weathering episodes have developed from early Tertiary successive crusts that have controlled the local geomorphology. These indurated formations are evidence of the successive weathering and erosion cycles. In this way, laterites that constitutes the rain forest substratum, may trace the palaeoclimate evolution.

One of the best opportunities to date weathering events is to apply the $^{40}Ar/^{39}Ar$ method on isotopically closed supergene K-bearing minerals such as K-Mn oxides from the hollandite group ($A_xB_8O_{16}$, $nH_2O$ , where A represents $K^+$, $Ba^{2+}$, $Pb^{2+}$or $Na^+$ and B represents $Mn^{3+}$, $Mn^{4+}$, $Fe^{3+}$,). Initiated by Chukhrov *et al.* (1966), using the K-Ar dating method, direct dating of potassium-rich manganese oxides was widely facilitated by the recent development of the $^{40}Ar/^{39}Ar$ laser probe method as shown by the studies of Vasconcelos *et al.* (1992 and 1994) and Ruffet *et al.* (1996).

Cryptomelane is well represented in numerous lateritic manganese weathering profiles over the tropical belt. Then radiochronological study may help to understand the genesis of the Mn-lateritic systems and to correlate them to the development of Fe-laterites.

This work presents analytical performances of the $^{40}Ar/^{39}Ar$ argon-ion laser probe method in 'dating' K-rich samples of the pisolitic manganese formation and the underlying manganese crust of the Tambao deposit (northern Burkina Faso).

## Geological setting and development of the pisolitic formations

The Tambao manganese deposit consist of two 80 meters high hills mainly composed of manganese oxides produced by the weathering of a manganese-rich Birimian metavolcanic and volcano-sedimentary series. About 70% of the deposit derives from metacarbonates mainly composed of rhodochrosite,

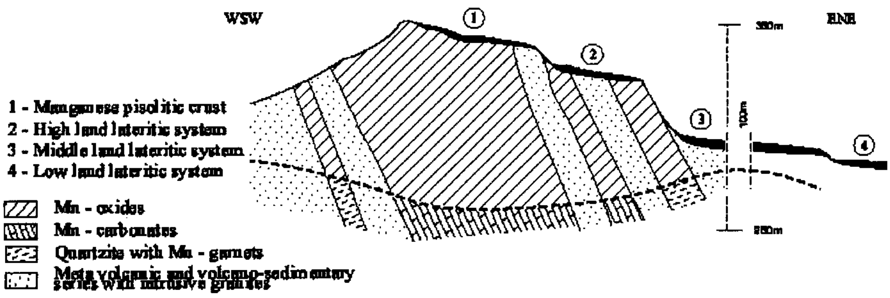


FIG. 1. Schematic section of the main hill of Tambao manganese deposit showing the different lateritic surfaces.

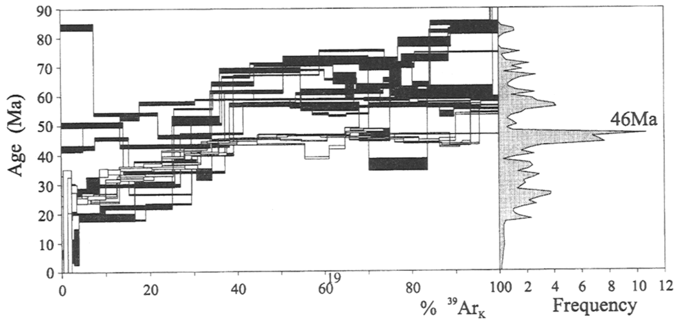


FIG. 2. $^{40}Ar/^{39}Ar$ age spectra and frequency diagram of the apparent ages.

associated to primary oxides (manganosite and hausmannite) and manganese silicates as rhodonite and tephroite. Four successive surfaces can be observed around and on the deposit (Fig. 1). The highest one is constituted by relics of a pisolitic layer and constitutes the oldest lateritic surface that can be observed on the deposit. Pisolites are formed at the expense of the manganese oxides crust and attest of successive dissolution-precipitation cycles. During dissolution cycles, the manganiferous matrix is probably entirely remobilized and pisolites partly conserved. The matrix is first affected by a leaching of manganese associated to an absolute accumulation of Al and Fe imported by the percolating solutions. The manganese oxides dominated by cryptomelane are then replaced in the matrix by gibbsite, hematite and goethite. Manganese is progressively removed from pisolites in which iron oxides are now well expressed. They gradually become relics only composed by goethite. These geochemical mechanisms, which constitute a special term of the soil evolution in lateritic environment, directly reflect the global climate evolution and the surface conditions.

## $^{40}Ar/^{39}Ar$ analysis

Several samples from the pisolitic formation were analysed by $^{40}Ar/^{39}Ar$ laser probe technique. Because of the absence of cryptomelane in the ferruginous matrices, the dated matrix samples only concern manganiferous matrices. All the age spectra have disturbed shapes (Fig. 2). Two groups can be defined : Pisolites and matrix. Matrix samples age spectra (white) are characterized by low ages (20–25 Ma) in the low temperature steps and by coherent and rather flat age segments, in the intermediate to high temperature steps, around 46 Ma. The age spectra displayed by the pisolites are much more complex and can be divided in two groups. The first one displays relatively coherent ages around 60–65 Ma (dark Grey). The second one (black) suggests ages around 70 Ma that are not well expressed by the frequency diagram of all the apparent ages (Fig. 2).

This frequency diagram highlights three age groups: 23, 46 and 60 Ma. The ages around 46 Ma displayed by matrix samples and some external rims of pisolites are sub-concordant with ages yielded by the underlying massive manganese oxide crust (Hénocque *et al.*, in press). Such concordance is in agreement with the petrographical observations. Matrix samples seem to characterize only one event which can be also observed in pisolite rims. Nevertheless, older ages seem memorized in pisolite cores, with possibly two ancient events at around 70 and 60 Ma. The absence of significant apparent age frequency peak between 46Ma and 23 Ma suggests that a forest regression could occurs during this period in the Tambao area. This interpretation is coherent with marine regression data between early and middle Eocene. The low temperature ages which define the age group at around 23 Ma indicate that the surface could have been partly reactivated at that time. Such age, also observed elsewhere in the deposit, could be connected to terrigenous kaolinite accumulations observed in sediments from the West African Coast.

## References


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