Alteration processes of the Paleoproterozoic manganese protores of North Téra: mineralogy and geochemistry (Niger Liptako Province, West Africa)

H. Garba Saley*, A. Soumaila, M. Konaté
Abdou Moumouni University of Niamey, Faculty of Sciences and Technology, Department of Geology, Groundwater and Georesources Laboratory, POB: 10662, Niamey, Niger
*E-mail: hamidougarbasaley@gmail.com

The manganese deposit of North Téra is located in the western side of the Diagorou-Darbani greenstone belt in the Niger Liptako Province (Northeastern part of Man Shield, West African Craton) (Fig. 1).
Manganese mineralization bearing rocks are mainly gondites (a kind of garnet-rich quartzite of the spessartine type) whose borders consist of a high concentration of Mn oxide concretions (Fig. 2A).
The methodological approach implemented consists of a field study followed by a polarizing microscopic analysis in transmitted and reflected light and a geochimical analysis.
North Téra gondites originate from Birimian manganese-rich sediments metamorphism in amphibolite facies (Soumaila, 2000; Soumaila and Garba, 2006).
The supergene alteration, more or less important, has developed on the gondite protores a saprolitic profile, whose setting up condition were recently described by Garba Saley et al. (2017).
The macroscopic analysis of the manganese deposits samples (Fig. 2B and C) combined with the metallographic microscopic and geochemical analysis confirms that manganese mineralization originated from weathering processes.
The first oxide that forms around the garnets is nsutite, while the mesostasis is invaded by pyrolusite (medallion of Fig. 2D) with lenses of lithiophorite destabilizing in favor of pyrolusite. In the botryoidal concretions, the latter forms an alternation with the psilomelane rich in Ba (8101 ppm) in the uppermost levels (Fig. 2D).
The abundance diagram shows that the normalize Rare Earths compared to PAAS derived from a plagioclase-rich quartzitic source. This observation is corroborated by a positive anomaly in Eu (Fig. 3A). Otherwise, the high levels of transition elements (Ni, V, Co and Cr) highlight the involvement of a basic source.
The contents of major elements show a significant leaching, with an increase in those of Mn and Al, during the increasing of the weathering. The CIA and PIA indices move in the same way towards high values leading to the Al_2O_3 pole on the Al_2O_3-CaO * + Na_2O-K_2O diagram. This indicates an increasing alteration along the profile, according to an alteration path from plagioclase-smectite to kaolinite on the one hand, and illite to kaolinite on the other hand (Fig. 3B).

Keywords: Gondite protore, Manganese, North Téra, supergene alteration, Birimian.

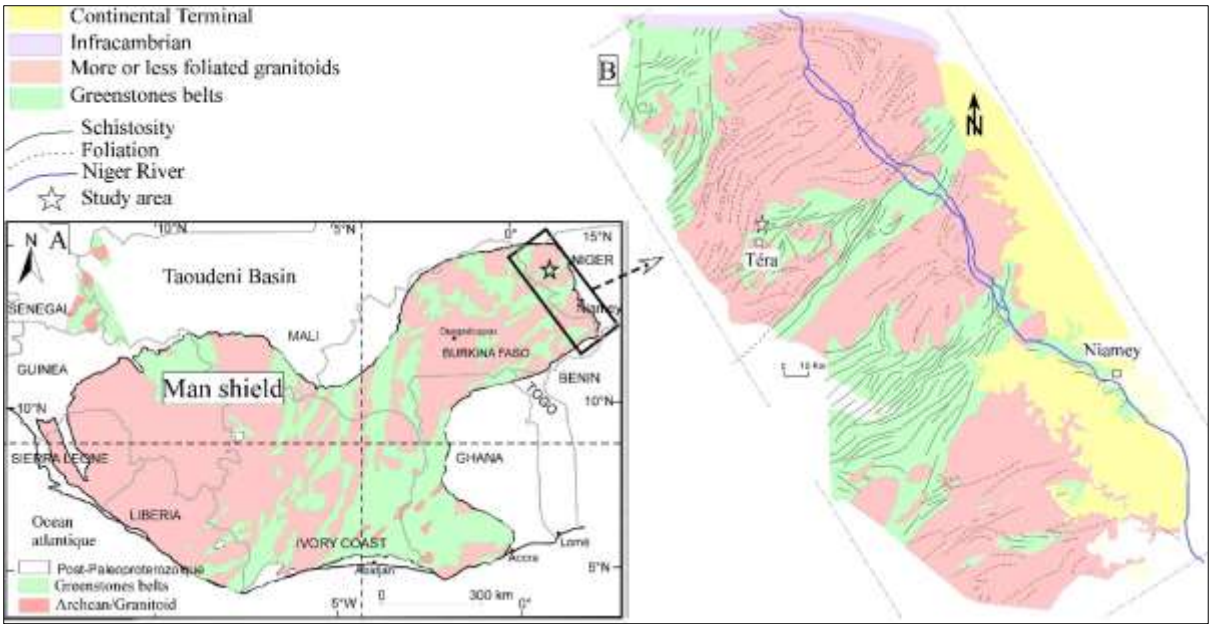

Fig. 1: (A) Simplified geological map of the Man's Shield (Milési et al., 1989) and (B) location of the study area in the Niger Liptako province (Machens, 1967, modified).

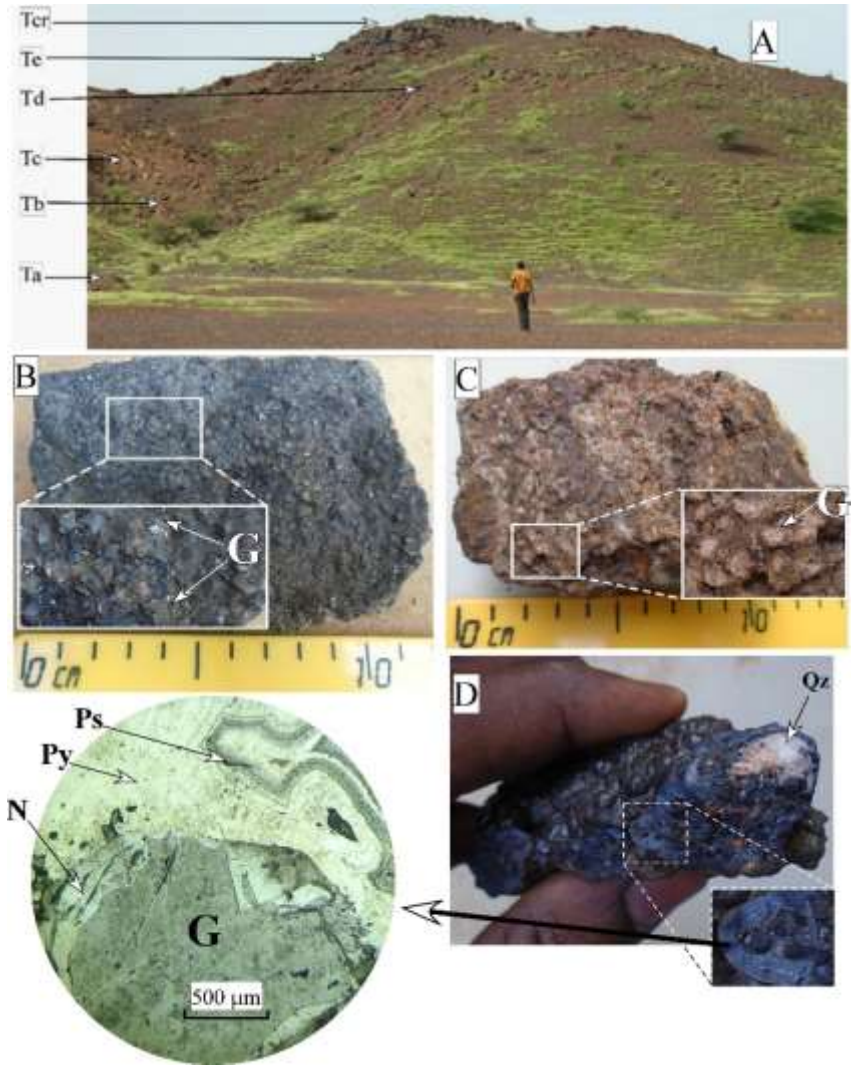

Fig. 2: Northern Téra manganese deposits: A- positioning of the sampling points (Ta, Tb, Tc, Td, Te and Tcr) on the main hill of manganese investigated; B- epigenization of garnet (G) in a dark brown to blackish gangue; C-

replacement of garnet (G) by brownish products of oxides and/or hydroxides of manganese; D- Concretion of manganese oxide with garnet constituting the heart of the visible concentric layers, and its microscopic correspondent (reflected light, Nic) showing a concretion of pyrolusite (Py) and psylomelane (Ps) which develop around an automorphic garnet (G) heart that transforms into Nsutite (N).
G: garnet, N: nsutite; Ps: psilomelane; Py: pyrolusite; Qz: quartz.

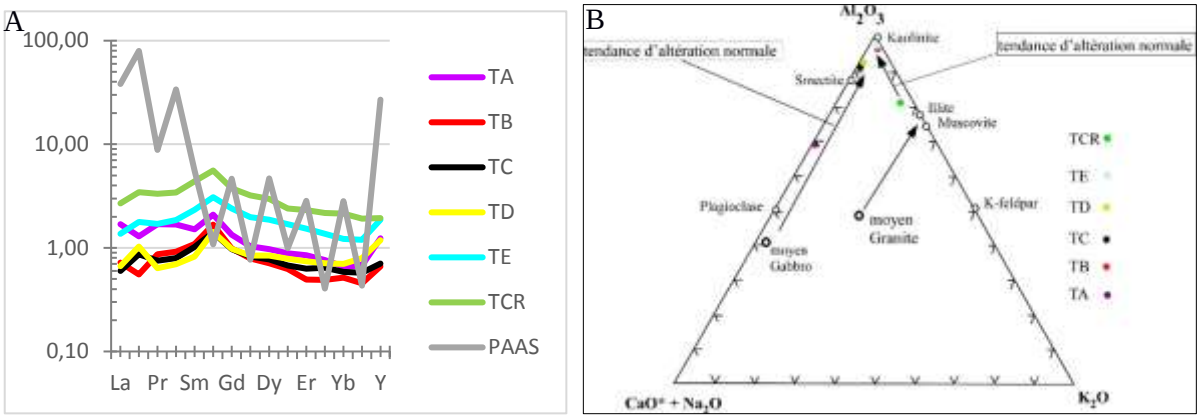

Fig. 3: the analytical points of the North Téra samples in the references diagrams : (A) Abundance diagram of standardized Rare Earth Elements relative to PAAS (Taylor and McLennan, 1985); (B) Alteration evolution in the ternary diagram Al_2O_3-K_2O-(CaO + Na_2O) (Nesbitt and Young, 1982).

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