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Organic matter in the archaeological agricultural soils of Gabon

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Abstract :
Raised fields are agrarian systems typical of humid areas in the intertropics. The principle is to raise "the land above the natural surface of the soil, in order to improve agricultural conditions" (Denevan and Turner, 1974). Massively used in the past, today this practice has fallen into disuse, creating vast archaeological sites. These archaeological raised fields have been studied mainly in South America since the 1960s (Denevan, 2002). In Central Africa, the presence of these remains was also observed at the same period (Sautter,1966; Denevan, 2002), but no study of these sites has been carried out until today. Furthermore, the majority of studies on these objects question the topographical extent they represent (Moore 1988, Blatrix et al., 2012; Lee and Walker, 2022), the way they were constructed and managed (Iriarté et al., 2012, Rodrigues et al, 2015), their interest in adapting to local environments (Erikson, 1992; Rodrigues et al., 2018, Lhomme and Vacher, 2002, Lombardo et al., 2011), and the quantity and quality of agricultural production they have enabled (Bruno, 2014, Whitney et al., 2014, Young et al., 2023). However, very few studies investigated the soil organic matter and carbon storage capacity of these systems, and these studies have only been carried out on presently used (i.e. still cultivated) raised fields (Rodrigues et al., 2020). In order to fill these gaps, this work focuses on the raised fields of Gabon, at the Matadi site, which is located in a flood zone of the Agouma, a tributary of the Ogouée. The archaeological site is represented by a totally transformed area ~2.5 km^2, made up of elongated fields approximately ~30 m long by ~8 m wide and around 0.8 m high. The aim of our work was to understand the nature of these structures in terms of organic matter and to determine whether they can store carbon. 9 fields and 4 interfields were auger sampled, as well as 4 field profiles sampled with apparent densities. The physico-chemical analyses, and in particular the Rock-Eval analysis, showed a strong similarity between the 9 fields. They all show a gradient over depth in texture, carbon content and the type of organic matter they contain. Furthermore, by comparing the OM of the fields and interfields, it was shown that the interfields are made up of two layers, with a layer of fresh organic matter on the surface and a layer of mature organic matter at depth. The fields have three layers, the first two common to the interfields, but also an intermediate layer, with organic matter that is weak in C-O and C-H bonds, and more thermoresistant. We hypothesise that the OM making up these structures is rich in charcoal. This result raises questions about past agriculture, which potentially includes management practices involving fire. By integrating these results with the cartography of the site, we were able to give an initial estimate of the carbon stocks that such systems may represent. The ultimate aim is to show that these archaeological sites need more attention, as they represent important and sustainable carbon sinks that need to be understood, studied and protected.

References

Blatrix, Rumsaïs, Jose Luis Aramayo, Anne Zangerlé, Bruno Roux, Mikaël Jouanne, Brice Anselme, Marie de Boisvilliers, Cédric Krasnopolski, Michel Assenbaum, et Doyle McKey. « Interpreting Landscapes of Pre-Columbian Raised-Field Agriculture Using High-Resolution LiDAR Topography ». *Journal of Archaeological Science: Reports* 42 (1 avril 2022): 103408. https://doi.org/10.1016/j.jasrep.2022.103408.

Bruno, Maria C. « Beyond Raised Fields: Exploring Farming Practices and Processes of Agricultural Change in the Ancient Lake Titicaca Basin of the Andes ». *American Anthropologist* 116, nº 1 (2014): 130-45. https://doi.org/10.1111/aman.12066.

Denevan, W M, et B L Turner. « FORMS, FUNCTIONS AND ASSOCIATIONS OF RAISED FIELDS IN THE OLD WORLD TROPICS » 39 (1974): 24-33.

Denevan, William M. *Cultivated Landscapes of Native Amazonia and the Andes*. Oxford University Press, 2002.

Erickson, Clark L. « Prehistoric Landscape Management in the Andean Highlands: Raised Field Agriculture and Its Environmental Impact ». *Population and Environment* 13, nº 4 (juin 1992): 285-300. https://doi.org/10.1007/BF01271028.

Iriarte, José, Mitchell J. Power, Stéphen Rostain, Francis E. Mayle, Huw Jones, Jennifer Watling, Bronwen S. Whitney, et Doyle B. McKey. « Fire-free land use in pre-1492 Amazonian savannas ». *Proceedings of the National Academy of Sciences* 109, nº 17 (24 avril 2012): 6473-78. https://doi.org/10.1073/pnas.1201461109.

Lee, Thomas W., et John H. Walker. « Forests and Farmers: GIS Analysis of Forest Islands and Large Raised Fields in the Bolivian Amazon ». *Land* 11, nº 5 (3 mai 2022): 678. https://doi.org/10.3390/land11050678.

Lhomme, J. -P., et J. -J. Vacher. « Modelling Nocturnal Heat Dynamics and Frost Mitigation in Andean Raised Field Systems ». *Agricultural and Forest Meteorology* 112, nº 3 (31 octobre 2002): 179-93. https://doi.org/10.1016/S0168-1923(02)00081-3.

Lombardo, Umberto, Elisa Canal-Beeby, Seraina Fehr, et Heinz Veit. « Raised Fields in the Bolivian Amazonia: A Prehistoric Green Revolution or a Flood Risk Mitigation Strategy? » *Journal of Archaeological Science* 38, nº 3 (1 mars 2011): 502-12. https://doi.org/10.1016/j.jas.2010.09.022.

Moore, Jerry D. « Prehistoric Raised Field Agriculture in the Casma Valley, Peru ». *Journal of Field Archaeology* 15, nº 3 (janvier 1988): 265-76. https://doi.org/10.1179/009346988791974402.

Rodrigues, Leonor, Umberto Lombardo, Seraina Fehr, Frank Preusser, et Heinz Veit. « Pre-Columbian Agriculture in the Bolivian Lowlands: Construction History and Management of Raised Fields in Bermeo ». *CATENA* 132 (1 septembre 2015): 126-38. https://doi.org/10.1016/j.catena.2014.08.021.

Rodrigues, Leonor, Umberto Lombardo, et Heinz Veit. « Design of Pre-Columbian Raised Fields in the Llanos de Moxos, Bolivian Amazon: Differential Adaptations to the Local Environment? » *Journal of Archaeological Science: Reports* 17 (1 février 2018): 366-78. https://doi.org/10.1016/j.jasrep.2017.11.023.

Rodrigues, Leonor, Tobias Sprafke, Carine Bokatola Moyikola, Bernard G. Barthès, Isabelle Bertrand, Marion Comptour, Stéphen Rostain, Joseph Yoka, et Doyle McKey. « A Congo Basin Ethnographic Analogue of Pre-Columbian Amazonian Raised Fields Shows the Ephemeral Legacy of Organic Matter Management ». *Scientific Reports* 10, nº 1 (2 juillet 2020): 10851. https://doi.org/10.1038/s41598-020-67467-8.

Sautter, Gilles. *De l'Atlantique au fleuve Congo, 2: Une géographie du sous-peuplement. République du Congo. République Gabonaise*. Walter de Gruyter GmbH & Co KG, 1966.

Whitney, Bronwen, Ruth Dickau, Francis Mayle, John Walker, Daniel Soto, et Jose Iriarte. « Pre-Columbian raised-field agriculture and land use in the Bolivian Amazon ». *The Holocene* 24 (20 janvier 2014): 231-41. https://doi.org/10.1177/0959683613517401.

Young, Danielle N., Neil A. Duncan, et John H. Walker. « Starch Grain Analysis of Ceramic Residue from Forest Islands Associated with Raised Fields in West Central Mojos, Bolivia ». *Journal of Archaeological Science: Reports* 47 (1 février 2023): 103761. https://doi.org/10.1016/j.jasrep.2022.103761.