

OLD ANTHROPIC SOIL HORIZONS IN THE TROPICS – AMAZONIAN DARK EARTHS (TERRA PRETA DO ÍNDIO), SHELL MOUNDS (SAMBAQUIS) AND EARTHWORKS (GEOGLIFOS): ITS CHARACTERIZATION AND LESSONS TO BE LEARNED FROM THE PAST

Wenceslau Gerales Teixeira¹

¹Embrapa Solos, Rio de Janeiro, RJ, Rua Jardim Botânico, 1024 - 22460-000, Brazil
E-mail: wenceslau@cnpq.embrapa.br

Old anthropic soil horizons in the tropics are only relatively recently being thoroughly investigated. To understand their formation and evolution is a rare opportunity not only to clarify cultural practices of prior civilizations but also to comprehend mechanisms to preserve carbon and nutrients in the constantly leached soils of the tropics. The characteristics of three distinct anthropic horizons found widespread in Brazil are presented. The Amazonian Dark Earths (*Terra Preta de Índio*), the anthropic shell mounds (*sambaquis*) and large ditches from human earthworks (called *geoglifos* in Brazil). *Terra Preta de Índio* (TPI) and *Terra Mulata* (TM) refers to expanses of anomalously dark, fertile soil horizons found mainly in the Amazon Basin. The TPI and TM sites are mainly surrounded in *terra firme* locations by Acrisols, Ferralsols, Plinthosols, and Spodosols and in the floodplains (*varzea*) by Fluvisols and Gleisols. TPI and TM anthropic horizons exhibit high densities of ceramic sherds and greatly increased levels of total and available phosphorus and other minerals (Ca, Mg, Zn, Mn, Ba and Sr) when compared with surrounding soils. TPI owes its name to the dark color originated from a large amount of aromatic forms of carbon (black carbon) that have a pyrogenic origin from incomplete combustion of organic materials, as well as increased amounts of organic matter. These soil horizons were created by pre-Columbian Indians largely during the period from 500 to 2500 years B.P. TM are believed to be intentionally improved to be agricultural fields of pre-Columbian Indians. Their browner color originates and often exhibit high levels of very stable recalcitrant carbon (pyrogenic), phosphorus, calcium, and cation exchange capacity in the topsoil horizons. In spite of a relatively intensive history of investigations concerning Amazonian Dark Earths (*Lehmann et al.*, 2003; Glaser and Woods, 2004; Teixeira *et al.*, 2009; Woods *et al.*, 2009) the studies carried out so far were interdisciplinary, but the research groups did not investigate the same site. Presently an Embrapa project is trying to model the creation and evolution of a specific TPI site located in the Research Station of Caldeirão in the Central Brazilian Amazon (Projeto Terra Preta).

The *sambaquis* (anthropogenic shell mounds) are found mainly along the Brazilian coast and are predominantly constituted of piled up mollusk shells and sediments in very complex stratigraphic configurations (Gaspar, 2008; Silveira and Schaan, 2005). Frequently they contain burial remains covered by dark soil and rare lithic artifacts. The *sambaquis* are believed to have been intentionally built by a population that inhabited the region for over 6000 years. The reasons why they piled up the mounds are not clear, and may have many explanations. Frequently the *sambaquis* show dark horizons not only in the top horizon, but also dispersed in a complex stratigraphic sequence. Some archeological and geological surveys are trying to understand the contributions from natural depositional processes and cultural deposition to their characteristics. Some results also indicated that those dark horizons have a large amount of phosphorus and carbon (Villagran *et al.*, 2010). The mechanism of stabilization of the carbon in the *sambaquis* is not clear, but probably is involved in the heating of organic material (pyrolysis) and large amounts of available calcium from the shells. Those horizon resembling, at least in some aspects, similar process involved in the formation of the A chernozems (from a geological parent material rich in carbonates).

The *geoglifos* are constructed earthworks of large and precise geometric forms (mainly circular or rectangular). They are characterized by excavated ditches and earthen banks, formed by deposition of the excavated soil frequently they are connected by roads believed to have built by a large and sophisticated pre-Columbian civilization in the Upper Amazon Basin. In Brazil they are found mainly in the Acre state (Pärsineen *et al.* 2009; Schaan *et al.*, 2008; Ballé and Erickson, 2006). Those earthworks spread out over a region larger than 12,000 km². Until now the investigations carried out have not found dark soil horizons related with the *geoglifos* or near them. What is intriguing in this case is the absence of dark horizons or clearly chemical

signatures typical of anthropic modifications. Why are these not there? To build ditches with a diameter larger than 300 meters with 10 meters wide and over four meters deep, surely a huge human work force was required and these people needed to be fed.

Few pedological and archaeological profiles have been thoroughly described and analyzed especially in sites with shell mounds and earthworks. Many facts and myths that have been created about those anthropic soil modifications since they were first reported in the 19th century. Therefore, it is still a large open field for multi-disciplinary research and many lessons are waiting to be learned about soil modification and mechanisms to preserve the carbon and hold the nutrients in the tropical soils. Understanding the management used to create those anthropic soil modifications could allow a model to be constructed to create new Anthrosols with desirable characteristics such as resilient carbon to mineralization and a high nutrient holding capacity. Those processes if understood have possibility to provide new soil management practices for soil reclamation, sustainable production, and to enhance soil carbon storage and nutrient holding capacity.

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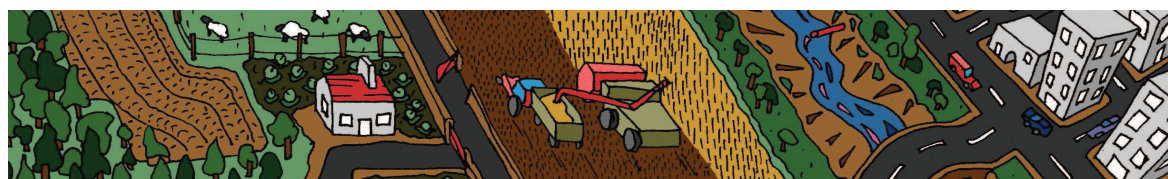
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