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SEM, EPR and ToF-SIMS analyses applied to unravel the technology employed for pottery-making by pre-colonial Indian tribes from Pantanal, Brazil

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ABSTRACT

The present work aims at elucidating the technology applied in the fabrication of ceramic objects by the ancient ceramists that inhabited the western border of Pantanal, Mato-Grosso do Sul, with the help of a multidisciplinary approach making use of chemical and physical methods of analysis. The potshards under study show the presence of different types of additives, as determined by scanning electron microscopy (SEM) and time of flight secondary ion mass spectrometry (ToF-SIMS). The dispersion of the additives within the ceramic matrix was also addressed by SEM, which shed light on the mounting technique used by the potters to assemble the ceramic vessels. Moreover, the tensile strength conferred to the pottery by the use of a specific type of additive was evaluated by applying a mechanical test. These results were correlated with the firing temperature of the potshards, determined by means of electron paramagnetic resonance (EPR).

1. Introduction

The most abundant material found at archaeological sites is ceramics, an outstanding source of information for the study of ancient civilizations in terms of their culture, technological knowledge and ancient trade patterns. A straightforward way to unravel some of the hidden secrets of an ancient population is to analyze in more detail their ceramic objects. In this context, archaeometric studies are known as a fundamental tool employed to shed light on aspects regarding the provenance of the raw materials used to fabricate ancient ceramics. These studies render precise determinations of the interconnections between different societies (Pio et al., 1996; Dran et al., 2000; Salamanca et al., 2000). The provenance of the potshards is addressed by the comparison of the chemical composition of the ancient ceramics with the composition of clay sources (Shingleton et al., 1994; Felicissimo et al., 2005). Moreover, important information regarding the techniques used to prepare the raw material and to assemble the vessel can be obtained by this methodology. In this case, interconnections between ancient societies can also be probed. For instance, if similar procedures are verified with different societies that inhabited nearby areas, the relation among them can be expected to be stronger than simply one of commercial trade. In this context, the use of chemical and physical methods of analysis is of great value for the investigation of the techniques used in the vessel and raw material preparation.

An essential step in the fabrication of pottery consists of drying and firing the ceramic piece. Electron paramagnetic resonance (EPR) and Mössbauer spectroscopy have proven to be excellent techniques for determining the firing practice applied by ancient potters (Bensimon et al., 1998; Wagner et al., 1999). An understanding of the exact procedure used by the ancient potters when preparing ceramic vessels can be estimated by combining archaeological evidence with knowledge of the firing temperature. EPR has been successfully applied in the determination of the firing temperature of ceramics burnt in kilns by tracing the changes of the Fe^{3+} signal within a temperature range (Wagner et al., 1999).

Since 1990, more than 200 mound sites located along flood plains and the Urucum Massif in the west border of Pantanal, Mato-Grosso do Sul – Brazil, triggered intense archaeological research (Rogge, 1996; Schmitz, 1997; Peixoto, 1998). Systematic archaeological studies enable the proposition of a new ceramic tradition, named

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'Pantanal', showing a cultural continuity with no influence from other ceramist groups in the pre-colonial period. The Pantanal Tradition encompasses four different phases, determined based on the technological characteristics of the ceramic findings, and named 'Pantanal', 'Jacadigo', 'Castelo' and 'Taimã' (Rogge, 1996; Schmitz, 1997; Migliacio, 2000; Peixoto, 2003). The area of influence of these phases is presented in Fig. 1. The archaeological evidence points to a pottery industry mainly devoted to vessels used in food preparation and cooking rather than storage. Radiocarbon dating shows that the Pantanal Tradition was established around 3000 years BP, and lasted until a few hundred years before the arrival of the first colonizers. This ceramic tradition includes carefully made pottery showing the use of different types of additives, some very characteristic of that region (Peixoto, 2003). The additives mixed with the clay in order to obtain a more fracture-resistant material are shells, quartz grains, sponge spicules and burnt bone.

The present work aims at elucidating the technology applied in the fabrication of ceramic objects by the ancient ceramists that inhabited the western border of Pantanal, Mato-Grosso do Sul, by means of an archaeometric approach making use of chemical and physical methods of analysis. To this purpose, we carried out a pilot study on representative potshards from the Castelo phase, belonging to the MS-CP-71 archaeological site. This mound site has been extensively studied and its occupation periods were determined as described in Table 1. The archeological classification of the ceramic material was performed based on the analysis of 1,939 fragments collected on the surface of the archaeological site, and 3,947 fragments collected at different depths, starting at the surface of the site until a maximum depth of 1.20 m within an area of 1 m^2. The shards are characterized as fragments of rims, walls and bases of vessels, as well as non-identified fragments. The potshards selected to be analyzed in the context of the present archaeometric study are

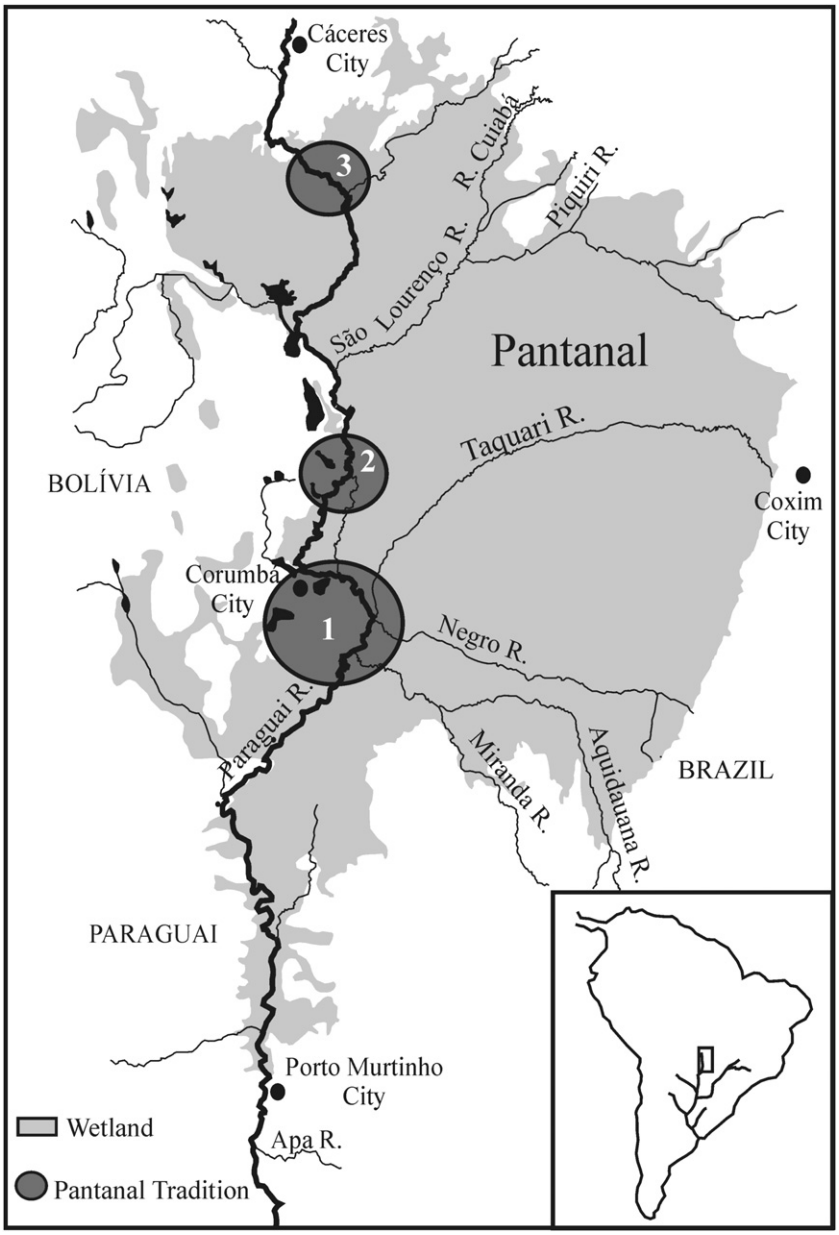

Fig. 1. Map of the wetlands of Pantanal with the indication of the areas corresponding to the four different phases of the Pantanal Tradition, identified as 'Pantanal' and 'Jacadigo' (1), 'Castelo' (2) and 'Taimã' (3).