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Palynofacies and organic geochemistry studies of organic matter from a wetland system of southern Brazil influenced by different hydrological regimes in the Quaternary

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ABSTRACT

The main goal of this study was to quantitatively and qualitatively characterize the sedimentary organic matter (OM) and demonstrate the usefulness of geochemistry and palynofacies analysis for obtaining paleoenvironmental data for the Holocene in southernmost Brazil. The results indicate that during the time interval from 10,586 cal yr BP to the present, the study area housed a wetland characterized by different hydrologic regimes. The basal peaty deposits correspond to a phase influenced mainly by the groundwater table, whereas the upper deposits composed of silty organic mud indicate fluvial influence related to river overflow events. In a similar manner, the TOC (total organic carbon) and TS (total sulfur) contents are higher in the basal portion of the profile, decreasing toward the top. These findings could be related to granulometry alterations that are linked to hydrologic regimes or anthropogenic interference in the landscape dynamics. Anomalous TS content observed in one of the samples might be due to an external source and perhaps related to the presence of thermal springs in the region. These types of areas have potential as a modern reference that can be applied in the reconstruction of past analogous environments such as coal deposits associated with fluvial paleoenvironments.

1. Introduction

Wetlands are important ecosystems that are favorable for organic matter preservation and peat accumulation (Clymo, 1983). The characterization of currently existing peaty areas is established according to the nature of the water resources, the origin and nature of sedimentary particles supply and the local ecological supply (Mesnage et al., 2002). Studies of Holocene peats have been improved because of their sensitivity to environmental changes caused by climate and human impacts (Sebag et al., 2006a). As wetlands, and particularly peaty sediments, are important areas for organic matter storage, studies based on organic geochemistry and palynofacies analyses of these types of Holocene deposits allow the identification of relationships between distinct organic patterns with their corresponding depositional environment. According to Tyson (1995), the advantage of applying the palynofacies technique lies in the fact that it provides direct information about the origin and characteristics of the particulate organic matter, allowing a more detailed analysis of subtle variations in the sedimentary environment.

Much of the interpretive models available in the scientific literature that concern organic geochemical and palynofacies analysis were designed for use in marine and epicontinental sections with the main objective being the exploration of hydrocarbon source rocks. Although relatively recently developed, palynofacies analyses have been applied to different depositional systems, resulting in a powerful research tool used to characterize the OM of present-day samples in continental deposits (Lorente, 1986, 1990a,b; Caratini, 1994; Gastaldo, 1994; Rull, 1995; Gastaldo et al., 1996; Di-Giovanni et al., 1999; Noël et al., 2001; Gastaldo and Huc, 1992; Cohen et al., 1999a,b; Sebag et al., 2006a,b), coastal environments (Marchand et al., 2003; Sparica et al., 2005; Prasad et al., 2007) and marine deposits (Lallier-Vergès et al., 1993; Van Waveren and Visscher, 1994; Lückge et al., 1996; Valdés et al., 2004; Lallier-Vergès and Albéric, 1990).

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In Brazil, studies based on palynofacies and organic geochemistry analyses of organic matter were widely applied in the investigation of deposits of marine and epicontinental origin from Paleozoic (Mendonça-Filho, 1999), Mesozoic (Carvalho et al., 2006a,b; Iemini et al., 2007) and Cenozoic deposits (Del Papa et al., 2002; Menezes and Mendonça-Filho, 2004; Menezes et al., 2005; Meyer et al., 2005, 2006, 2010; Medeanic and Silva, 2010; Chagas et al., 2009; Mendonça-Filho et al., 2010a; Silva et al., 2010). Nevertheless, only a few studies have improved the knowledge of environmental changes in continental areas through palynofacies analyses of peatlands (Medeanic and Silva, 2010) or inland lacustrine deposits (Meyer et al., 2010; Silva et al., 2010).

The present study is a pioneering research carried out in this region of southernmost Brazil (northwest plateau of the Rio Grande do Sul State) and was carried out using radiocarbon dating, organic geochemistry, palynofacies and sedimentary analyses of a strictly continental wetland. Considering that wetland deposits can be excellent archives of depositional past changes, the primary objectives of this study were as follows: (a) quantitatively and qualitatively characterize the organic matter in the T3-Iraí core, which covers 10,586 cal yr BP (median probability) of sedimentation in a wetland area under the influence of a fluvial system and (b) demonstrate the usefulness of the organic geochemistry and palynofacies analyses for this type of environment in obtaining paleoenvironmental data for the Quaternary in the southernmost region of Brazil.

2. Geological background and site description

The wetland study area of the present study area overlies a packet of igneous rocks of the Serra Geral Formation, the topmost lithological unit of the Paraná Basin (Fig. 1). The bedrocks are Upper Cretaceous basalts of the Alto Uruguai region, which are known for sheltering the amethyst deposits and hot springs containing mineral water. The thermal springs are resurgences located in fractures present in the basaltic rocks of the "fractured" aquifer of the Serra Geral Formation (Freitas et al., 2002). The Guarani Aquifer System, found in sedimentary rocks of the Botucatu Formation, underlies the volcanic rocks of the Serra Geral Formation. Large magnitude faults allow hydraulic interconnection of the two aquifers, which results in a mixture of waters with high chloride and sulfate content (Freitas et al., 2011). In the city of Iraí, beyond these mineral water springs, deposits of organic mud popularly known as "medicinal mud" (scientifically unproven) occur. This sediment, which is used for therapeutic purposes in the spas of Iraí is possibly derived from weathering of the basalts and deposited in low-lying areas. The organic mud is extracted in an open place, often saturated with water, due to the influence of the groundwater table, rainfall and the overflow of the Uruguay River (this river extends 2200 km^2 and delimits boundaries between countries such as Brazil, Argentina and Uruguay). The region surrounding the well open for commercial purposes displays the same silty organic mud composition, extending for an area of 1.0 ha within an owned property. The surface of the wetland is at an altitude of approximately 200 m above sea level.

3. Materials and methods

3.1. Sampling

For sampling the T3 core (27°10′822″ S × 53°14′980″ W), aluminum tubes that were 10 cm in diameter and 2.0 m long were used. Once collected, the core samples were labeled and packaged in plastic bags. Thereafter, the core samples were split into subsamples in the laboratory for sedimentary, geochemical and palynofacies analyses.

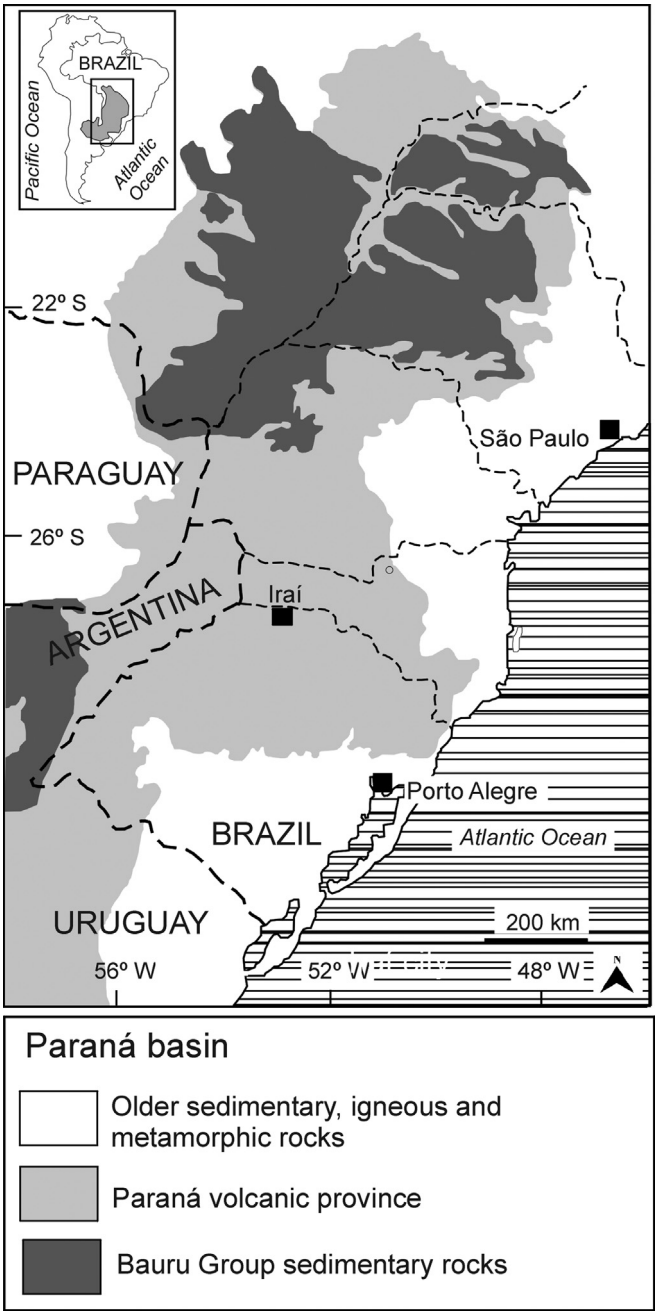

Fig. 1. A) Location map of Iraí.
(adapted from Hartmann et al., 2010)

3.2. Granulometric analyses

Granulometric analysis was performed in the "Laboratório de Sedimentologia, Centro de Estudos Costeiros e Oceânicos (CECO), Instituto de Geociências, Universidade Federal do Rio Grande do Sul (UFRGS)" and applied a sieving and pipetting method, with class intervals of 1 e ¼ of *phi*, according to the method proposed by Folk and Ward (1957).

3.3. Dating

The analyses were performed by Beta Analytic, Inc. Only two samples were analyzed, Base (115 cm) and Top (15 cm). The unconsolidated surface sediment (0–10 cm) was not sampled because