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New Sakmarian ages for the Rio Bonito formation (Paraná Basin, southern Brazil) based on LA-ICP-MS U–Pb radiometric dating of zircons crystals

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ABSTRACT

Two ash fall beds (tonstein) sampled from the post-glacial Permian deposits of the Paraná Basin have provided new U–Pb radiometric age constraints for this stratigraphic interval. The zircon grains were recovered from tonstein layers interbedded with fine-grained and carbonaceous lithologies in the middle portion of the Rio Bonito Formation. In both samples, the dominant population is interpreted as generated by explosive volcanism, as having formed immediately before the eruption. Based on $^{238}U/^{206}Pb$, the selected zircon grains from the dominant population have weighted mean ages of 290.6 ± 2.8 Ma and 281.7 ± 3.2 Ma, corresponding to the Sakmarian and Kungurian ages in the Cisuralian epoch, respectively. These ages constrain the time of the deposition of the tonstein horizons and have important stratigraphic implications for the Late Paleozoic evolution of both the Paraná Basin and the southwestern region of Gondwana. The results presented here and the radiometric data already published suggest that deposition of the post-glacial coal-bearing deposits of the Rio Bonito Formation was probably initiated before the Early Permian. Thus, we infer that the climate had already ameliorated by this period in order to allow for the formation and accumulation of peat in this region of Gondwana.

1. Introduction

The Carboniferous–Permian deposits of southern Gondwana record an important shift from glacial to arid climatic conditions, passing through intermediate moist and seasonal stages (Gulbranson et al., 2010). Although Gondwana glaciations were initiated from multiple ice centers and lasted short discrete intervals (Frank et al., 2008), a global compilation of climatic data suggests that the onset of widespread glaciations seems to have occurred in South America and eastern Australia during the Late Mississippian (Serpukhovian, Fielding et al., 2008). In Antarctica, Carboniferous glaciation would have been less extensive than previous reconstructions show according Isbell et al. (2003a).

Various lines of evidence suggest that the earth's climate warmed during the Late Pennsylvanian although ice centers persisted in Gondwana (Fielding et al., 2008). Paleosols and coal-bearing intervals of Middle to Late Moscovian in the Paganzo Group (Argentina) record a shift in precipitation, suggesting a sub-humid to humid climate (Gulbranson et al., 2010). Coal-bearing intervals are also recorded in the Guatá Group, Paraná Basin (Lavina and Lopes, 1987; Holz et al., 2000, 2008), and are interpreted to be Permian in age based on palynomorphs (Daemon and Quadros, 1970; Souza and Marques-Toigo, 2005; Souza, 2006) and absolute dating (Rocha-Campos et al., 2006; Guerra-Sommer et al., 2006, 2008a,b,c; Mori et al., 2012; Simas et al., 2012). The change from humid to arid climatic conditions is recorded in the latest Moscovian and earliest Kasimovian deposits in the Paganzo Group (northwest Argentina, Gulbranson et al., 2010). In the Paraná Basin, continental deposits predominate from the Guadalupian (Rio do Rasto Formation) and evidence of dry climatic conditions is present in the Corumbataí Formation deposits in São Paulo, which are equivalent to the Serra Alta and Teresina formations in the southern part of the basin (Tavares and Rohn, 2009).

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Fielding et al. (2008) suggested that the major glacial events occurred synchronously across Gondwana while minor events may have been diachronous. The lack of index fossils in southern hemisphere Carboniferous–Permian successions has resulted in endemic plant and palynomorph fossils being used as the main tools for stratigraphic correlation between many south Gondwana sedimentary basins. Furthermore, the scarcity of radiometric age data from the Paraná Basin Supersequence Gondwana I (Milani et al., 2007) makes correlation with other basins difficult.

U–Pb analysis of volcanic zircons grains contained within ash fall beds in the Early Permian sedimentary succession of the Paraná Basin has constrained the timing of their deposition (Matos et al., 2001; Rocha-Campos et al., 2006; Santos et al., 2006; Guerra-Sommer et al., 2008a,b,c; Mori et al., 2012; Simas et al., 2012). In addition, ages have been obtained from ash fall beds of the Karoo Basin in South Africa (Bangert et al., 1999; Stollhofen et al., 2000, 2008) and the Paganzo Basin in northwest Argentina (Gulbranson et al., 2010), with these volcanic deposits providing Carboniferous–Permian ages for the rocks in which they are interbedded.

In this paper we present new radiometric ages based on U–Pb analyses of zircon crystals from two tonstein layers from the southeastern edge of the Paraná Basin. The stratigraphic significance of these ages is analyzed with reference to the evolution of the Paraná Basin, and we discuss the implications of these data on the correlation of Carboniferous–Permian deposits across the southwestern region of Gondwana.

2. Geological setting

The Paraná Basin is an intracratonic basin covering approximately 1,500,000 km^2 of central-southern Brazil, Paraguay, Uruguay, and northern Argentina (Zálan et al., 1990; Milani et al.,

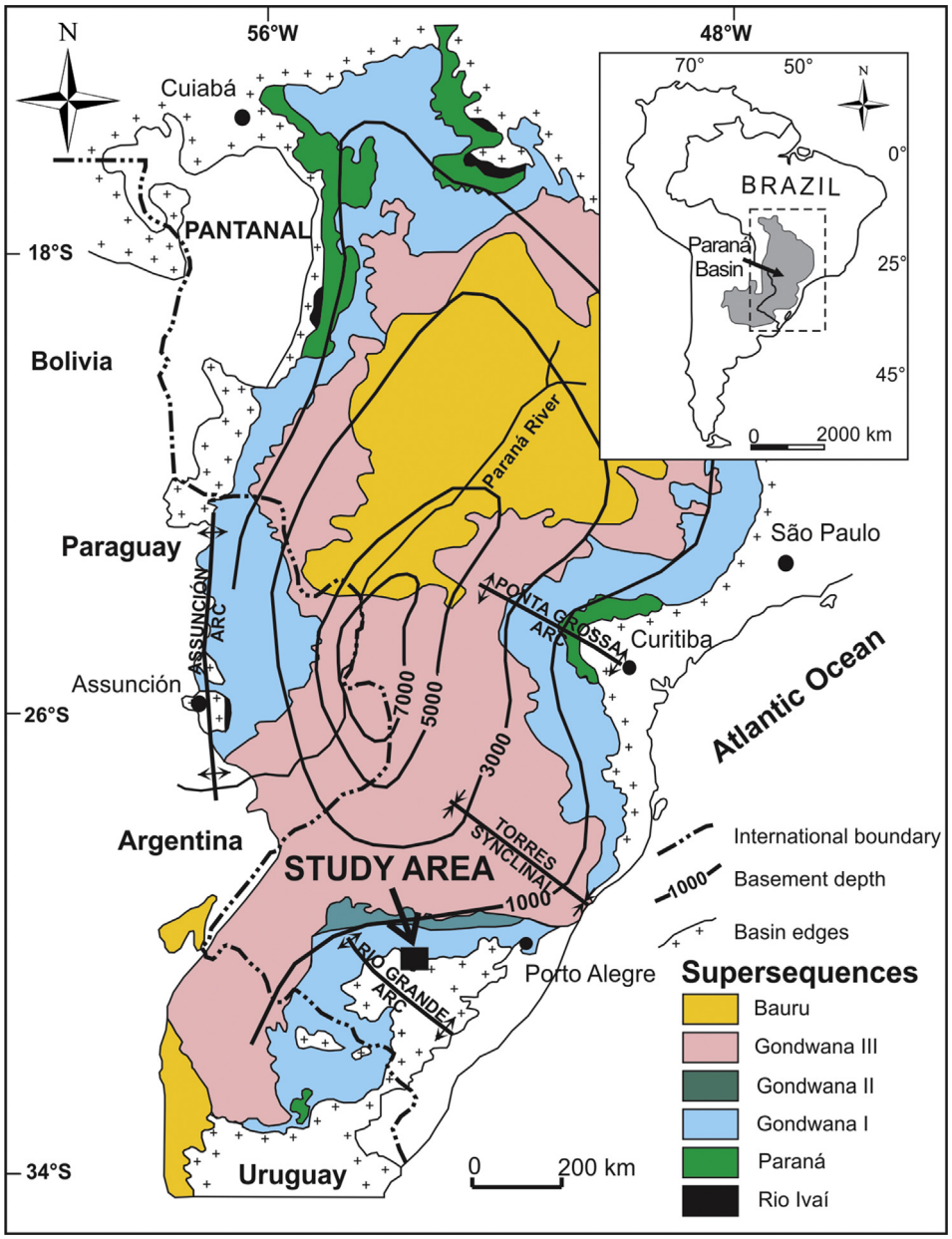

Fig. 1. Simplified geologic map of the Paraná Basin showing structural contours for basement units and the distributions of the Supersequences described in the text (after Milani, 2004). The black rectangle south of the Paraná Basin marks the location of the study area.