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Geomorphology and genesis of the remarkable Araras Ridge tufa deposit, Western Brazil

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ABSTRACT

The Araras Ridge tufa extends for over 30 km along a c. 100 m high fault scarp, probably representing one of the most extensive tufa deposits in South America. The deposit comprises massive crystalline calcite occurring both as in situ tufa deposited along the vertical face of the scarp or as extensive debris deposits resulting from erosional disaggregation of the scarp. Although minor active tufa precipitation can be observed in streams, the deposit is not active at present, except for volumetrically limited reprecipitation of calcite as subaerial stalactites or surface flowstone. ^{230}Th dating confirms that the bulk of the deposit is considerably old, basal ages being beyond the dating limit of the method (>600 ka B.P.) and most ages being older than 250 ka B.P. Field and remote sensing observations demonstrate that the upper limit of the deposit parallels the fault scarp, being associated with the contact between the upper dolomitic and the lower limestone members of the Araras Formation. Carbonate beds are arranged in a regional scale synclinal structure that allows water infiltration and storage at the top of the more impure limestone, favouring discharge at the ascending limb of the syncline, close to the scarp. Genesis of the deposit thus probably involved a series of palaeo perched springs aligned along the top of the scarp. Current climatic and geomorphic conditions are not conductive to major tufa development, suggesting a distinct palaeoenvironment during former depositional phases.

1. Introduction

Tufa deposits have provided important palaeoenvironmental information due to their geomorphic and palaeohydrological significance (Martin-Algarra et al., 2003; Carthew et al., 2006), palaeobotanic/palaeofaunistic remains (Ali et al., 2003; Pentecost, 2005) and isotopic signature (Lojen et al., 2004; Andrews and Brazier, 2005). Many deposits can be chronologically constrained by various methods (Mallick and Frank, 2002; Garnett et al., 2004; Meyrick and Karrow, 2007; Prescott and Habermehl, 2008; Ortiz et al., 2009) allowing bracketing of phases of precipitation and related environmental changes. In Brazil tufa deposits are known to occur in several geomorphic and climatic settings, having been studied mostly in now semi-arid northeastern Brazil, making possible the determination of past periods of rainfall (Auler and Smart, 2001; Wang et al., 2004) and former environmental conditions (Auler et al., 2004; Cristalli, 2006).

There is an extensive tufa deposit along the Araras Ridge between the towns of Cuiabá and Cáceres, in Brazil's western state of Mato Grosso (Fig. 1). Due to its proximity to the ancient colonial trading route between the Atlantic coast and Brazilian westernmost provinces, the Araras tufas have been noticed since the 19th Century by early travellers (Waehneldt, 1864). The tufa develops mostly along a c. 100 m high vertical scarp associated with a major reverse fault. Except for some erosional or non-depositional hiatus, the tufa deposit extends for about 30 km along the Serra Azul (Blue Ridge), a local denomination of the longer Araras Ridge. Such a vast and areally extensive deposit represents an exception to the usually more localised tufa deposits described elsewhere, normally associated with waterfalls and springs (Pentecost, 1995; Ford and Pedley, 1996). Although the area also contains minor active tufa precipitation along streams, this study will emphasise the characterisation, geochronology and genesis of the massive Araras Ridge tufa deposit.

2. Regional setting

The study area (Fig. 1) is located in the southwestern portion of the state of Mato Grosso, between coordinates 15°45′–16°05′S and 57°00′–57°20′W. Geology comprises Cambrian carbonates of the Araras Formation, divided into a lower member characterised by dark

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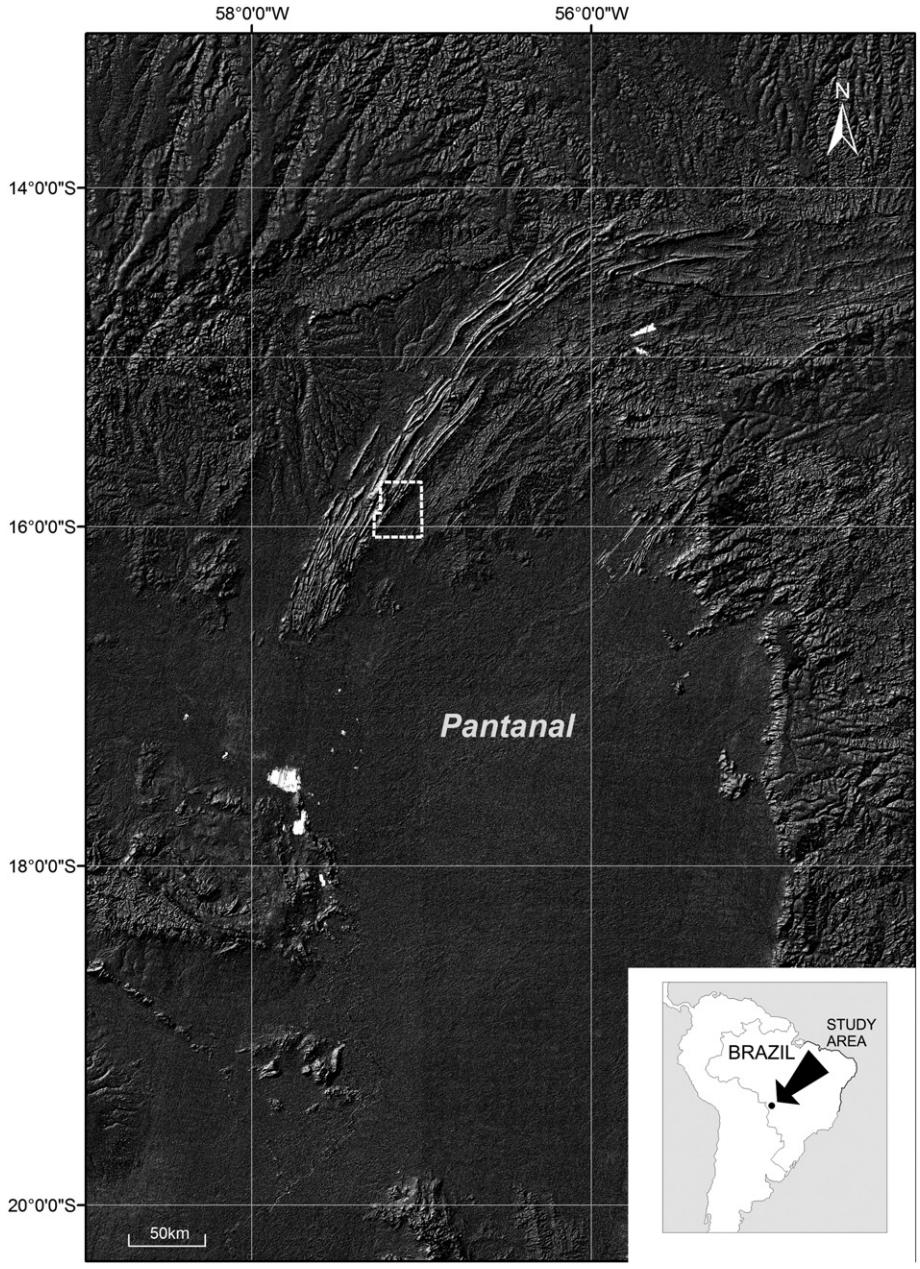

Fig. 1. Location of the studied area with SRTM image of the Araras Ridge and the Pantanal swamplands subsidence basin. The white rectangle depicts the tufa site illustrated in Fig. 2.

grey laminated limestone and dolomitic limestone overlaid by light grey dolomites with intercalations of sandstone and siltites of the upper member (Luz et al., 1978). The carbonates were deposited over paraconglomerates of the Puga Formation and Precambrian metapelites, quartzites, phyllites and schists of the Cuiabá Group (Luz et al., 1978). Overlying Cambrian sandstones of the Raizama Formation form the highest portions of the Araras Ridge, the southwestern exposures of carbonates being mantled by the comparatively thin tufa deposits (Fig. 2). Shales, siltites and arkoses of the Diamantino Formation occur to the northwest. More recent carbonate rocks, mostly as unconsolidated tufaceous sediments or both active and inactive tufas (including the Araras Ridge deposit) have been included by Almeida (1945, 1964) under the umbrella designation of Xaraiés Formation of suggested Quaternary age. The generic Pantanal Formation comprises young unconsolidated deposits in the flood prone area of the Pantanal swamplands.

The area is characterised by a series of linear ridges displaying strong structural control. The Araras Ridge comprises a SW/NE trending 60 km long narrow synclinal ridge truncated by reverse faults, representing a sharp transition between the hilly area to the NW and the remarkably flat lowlands (altitudes around 200 m asl) of the Pantanal subsidence basin (Fig. 2). The major structural feature in the area is the Araras fault, a 250 km long N40–45°E trending fault mostly covered by more recent sediment (Barros, 1982). Although originally related to the 550 Ma Brasiliano tectonic event, later reactivation due to the Andean orogeny has been proposed (Luz et al., 1978). Climate is markedly seasonal with precipitation mostly concentrated in the austral summer, with average annual rainfall around 1270 mm as recorded in the Cáceres meteorological station, about 40 km to the southwest.

3. Methods

Due to the absence of a detailed geological map of the study area, reconnaissance geological work over a region of around 900 km^2 was performed at the tufa deposits and immediate surroundings. The tufa site was studied in more detail, involving six 3 km long transects