



The Serra da Cangalha impact structure, Brazil: Geological, stratigraphic and petrographic aspects of a recently confirmed impact structure

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ABSTRACT

Serra da Cangalha is a complex impact structure with an apparent diameter of 13.7 km located in essentially undisturbed sedimentary rocks of the Parnaíba basin in northeastern Brazil. The stratigraphy of the crater region includes, from bottom to top, the Longá, Poti, Piauí and Pedra de Fogo formations of Devonian to Late Permian age. The age of the impact event is constrained to <250 Ma by stratigraphy – the youngest formation affected by the event is the ~250 Ma Pedra de Fogo Formation. The structure comprises a ~5.8 km wide central uplift involving the Piauí, Poti and Longá formations and a prominent ~3 km wide collar of Poti Formation rocks. We divided Serra da Cangalha into four distinctive structural domains (i–iv), from the innermost zone outward. (i) The central domain, with an inner collar ~1.5 km radius from the center, yielded all the samples with microscopic shock features identified so far. These include planar deformation features (PDF), feather features (FF), and planar fractures (PF) in quartz grains found in polymict breccias and shatter cones from the central depression. Furthermore, significant cementation with iron oxide is observed in the rocks of Serra da Cangalha, especially in the Poti Formation and in the polymict breccias, conferring to them a peculiar red color. Macroscopic deformation involves faulted, folded and subvertical strata within a ~2.9 km radius from the center. (ii) The annular basin domain has limited outcrops; its most prominent features are two concentric annular ridges formed by chert breccias and fossilized wood-bearing folded strata of the Pedra de Fogo Formation. (iii) The crater rim and (iv) external domains comprise undisturbed strata of the Pedra de Fogo and Piauí formations with well-preserved sedimentary structures. Whilst the existing literature on Serra da Cangalha has focused on the structure morphology, general geology and some shock features, we present here a detailed description of the stratigraphy and the geology of each formation in the interior and around Serra da Cangalha, as well as further detailed microscopic shock feature analysis. This provides significant evidence that the rocks of the central uplift have undergone shock pressures of, at maximum, 10 GPa.

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1. Introduction

The Serra da Cangalha (SdC) structure (first referred by Dietz and French, 1973; McHone, 1986) is located in Tocantins state, northern Brazil, centered at 8°05'S/46°52'W, ~40 km south of the

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Riachão Ring (another impact structure – Maziviero et al., 2012) (Fig. 1). SdC is a complex impact structure with an apparent diameter of about 13.7 km, with a central uplift of 5.8 km width (Kenkmann et al., 2011a). This impact structure was formed in undeformed Paleozoic sedimentary rocks of the Parnaíba Basin (Fig. 2), an intracratonic sedimentary basin containing strata of Late Silurian to Triassic age (Góes, 1995). The presumed age of the structure (<250 Ma) is not well constrained: it is based merely on the regional stratigraphy (Fig. 2) and on the age of the Pedra de Fogo Formation, the youngest strata that were affected by the formation of the crater (Góes and Feijó, 1994).

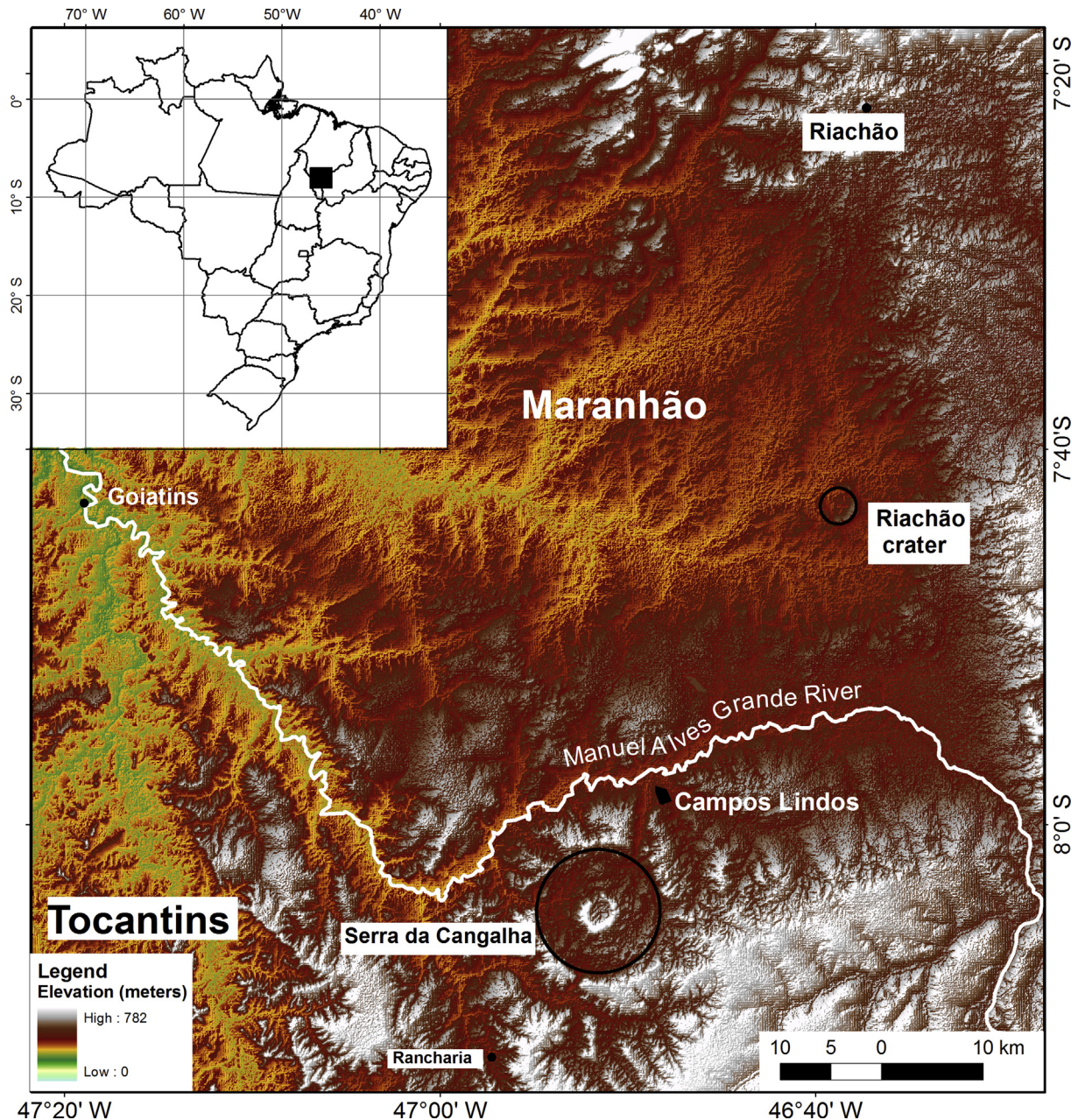


Fig. 1. Digital elevation model based on Shuttle Radar Topography Mission (SRTM) data showing the location of Serra da Cangalha. Inset shows a map of Brazil with the location of the SRTM image. Further to the NE is the Riachão Ring, a second smaller impact structure ($D = 4.5$ km).

The circular structure of SdC has been known since the late 1960s, when it was described by Ojeda and Bembon (1966) within the scope of a regional geological survey for oil exploration purposes carried out by Petrobras (the Brazilian oil company). The first reference to SdC as an impact structure was made by Dietz and French (1973), who proposed its impact origin based on its morphology, as seen on early Landsat satellite images. They pointed out – as indications of the impact nature of SdC – its nearly circular shape and the presence of a conspicuous central uplift. McHone (1979) and Santos and McHone (1979) reinforced the impact origin hypothesis of SdC, after finding breccias and possible shock deformation features in sandstone. Further geological studies, including reconnaissance fieldwork, were done by McHone (1986), which resulted in a preliminary map of SdC and the disclosure of possible shock features. A first published review of the meteoritic

impact structures in Brazil by Crósta (1987) referred to SdC as an impact structure, based on the bona fide shock evidence reported by the previous authors.

In the early 1970s the Brazilian Department of Mineral Production (DNPM) drilled three boreholes into the central depression of SdC, as part of a regional campaign for diamond exploration. At that time, DNPM geologists interpreted the structure as being related to a buried kimberlite intrusion, as a number of these are known in the Parnaíba Basin (DNPM, 1972). Each borehole reached ~200 m depth, whereby only intensely deformed strata attributed to the Devonian Longá Formation were found.

In recent years, geological, geophysical and remote sensing studies have been conducted at SdC, aiming at the characterization of this complex structure. Almeida-Filho et al. (2005) employed ASTER (Advanced Spaceborne Thermal Emission and Reflection

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