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Mousso structure: A deeply eroded, medium-sized, complex impact crater in northern Chad?

Elmar Buchner *, Martin Schmieder

Institut für Geologie und Paläontologie, Universität Stuttgart, Herdweg 51, D-70174 Stuttgart, Germany

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Abstract

The Mousso structure, a complex, ~3.8 km circular structure centred on 17°58′ N/19°53′ E and located near the Mousso oasis, Borkou–Ennedi–Tibesti, northern Chad, displays structural features typical for complex impact structures: a circular rim with concentric faults, an annular basin, and a central peak. Remote sensing investigations based on Landsat-7 Enhanced Thematic Mapper Plus (ETM+) and Shuttle Radar Topographic Mission (SRTM) data reveal a specific morphological–structural resemblance of the complex central peak of the Mousso structure to the central uplift of the Spider impact structure, Western Australia, and, to some degree, to the central uplifts of the Upheaval Dome, Sierra Madera, and Gosses Bluff impact structures. This is consistent with the layered sedimentary rocks associated with all of these structures. No endogenic geological processes such as magmatism, diapirism, karst dissolution, and glacial or fluvial erosion can conclusively explain the formation of the Mousso structure within a large area of flat-lying early Paleozoic sandstones. Thus, this paper proposes that the Mousso structure might represent a deeply eroded, medium-sized, complex impact structure. As field investigations are currently impossible due to the civil war in Chad, the search for shock-metamorphic effects in rocks of the Mousso structure remains outstanding.

Keywords: Possible impact structure; Chad; Africa; Remote sensing; Landsat; SRTM

1. Introduction

The discovery and confirmation of the two large eroded impact structures of Aorounga (~16 km in diameter) and Gweni Fada (~22–23 km in diameter) has drawn special attention to Chad in the field of Impact Geology (Becq-Giraudon et al., 1992; Koeberl, 1994; Koeberl et al., 1994; Vincent and Beauvilain, 1996; Koeberl et al., 2005a). Beside the two confirmed impact structures in northern Chad, several authors have hypothesised on the possible impact origin of additional circular structures (e.g., Aorounga North, Central, and East; Ocampo and Pope, 1996; Master and Reimold, 2001; the circular structures of Oun and Uri; Gonzalez and Alonso, 2006). However, to date, none of these has been confirmed as having an impact origin. Large areas of flat-lying Paleozoic sedimentary rocks in a desert region provide a preferential terrain for searching for possible impact structures, which is subject to a remote sensing investigation based on Landsat-7 Enhanced Thematic Mapper Plus (ETM+) satellite images and Shuttle Radar Topographic Mission (SRTM) data. Recently, the Faya basin in northern Chad has been proposed by Schmieder and Buchner (2007) as being a potential impact crater. In this work, another conspicuous circular structure of complex geometry, the Mousso structure, which is located in the same region of the Borkou–Ennedi–Tibesti, is discussed. A morphological–structural comparison to some confirmed terrestrial impact structures contributes to the discussion of whether the Mousso structure might be of endogenic or exogenic geological origin.

* Corresponding author. Tel.: +49 711 685 81340; fax: +49 711 685 81341.
E-mail address: elmar.buchner@geologie.uni-stuttgart.de (E. Buchner).

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2. Remote sensing: methods and data sets

Remote sensing is based on Landsat-7 satellite images and Shuttle Radar Topographic Mission (SRTM) radar data. Landsat-7 images were acquired by an Enhanced Thematic Mapper Plus (ETM+) instrument on path 182 and row 47 on January 08, 2001. In general, Landsat-7 ETM+ ground resolution is 30 m. The ETM+ instrument provides a maximum ground resolution of 15 m on band 8 (panchromatic) and a resolution of 60 m on band 6 (thermal infrared). All ETM+ bands were investigated during this work. SRTM radar data provide a spatial resolution of ~90 m near the equator and a vertical resolution of 10–16 m; therefore, terrain height data represent approximate values. Vertical exaggeration of the SRTM ground information emphasises the topographic conditions of the area observed. 3D terrain models were computed combining SRTM data with Landsat-7 satellite image overlays. Image and terrain model processing was carried out using the PC programmes Microdem 10.0 and 3DEM 19.0.

3. The Mousso structure – structural and geological setting

The Mousso structure is a circular structure centred on 17°58′ N and 19°53′ E, about 80 km east of Faya (Largeau) and ~5 km east of the Mousso oasis (also named Musu or Moussou in maps by Tilho, 1920a and Thesiger, 1939; respectively; Fig. 1). As with the Aorounga impact structure and the Faya basin of suggested impact origin, the entire region is characterised by numerous large NE-SW trending Quaternary yardangs, barchan-type sand dunes, and evaporitic salt deposits (see also Tilho, 1920b; Grove, 1960; Grove and Warren, 1968; McHone et al., 1996; McHone et al., 2002; Schmieder and Buchner, 2007). The Mousso structure is of complex geometry, displaying a circular rim, an annular basin, and a central peak (Figs. 2 and 3). The observable diameter of the Mousso structure is ~3.8 km (the diameters of the annular basin and the central peak area are ~3.2 km and ~1.8 km, respectively). The rim of the Mousso structure, in parts superimposed onto the edge of a sedimentary plateau, is visible as a semicircular escarpment in the eastern domain, and as a dark annular trace in the sand- and salt-covered western domain of the Mousso structure. Concentric semicircular faults along the eastern rim could indicate westward normal wall failure (slumping) towards the annular basin. A conspicuous structural feature of the Mousso structure is a complex central peak about 1.5 km in diameter, made up of radiating arcuate ridges and somewhat similar in shape to large-scaled star dunes (see Figs. 2 and 3). Based on the study of SRTM data and vertical cross sections, the topographically highest point of the Mousso structure is marked by the complex central peak, which is elevated 30–40 m above the surrounding basin and ~10 m above the present level of the eastern rim and the adjacent plateau of Early Paleozoic sandstones (Fig. 4). A second escarpment is linked to the south-western slope of the central peak.

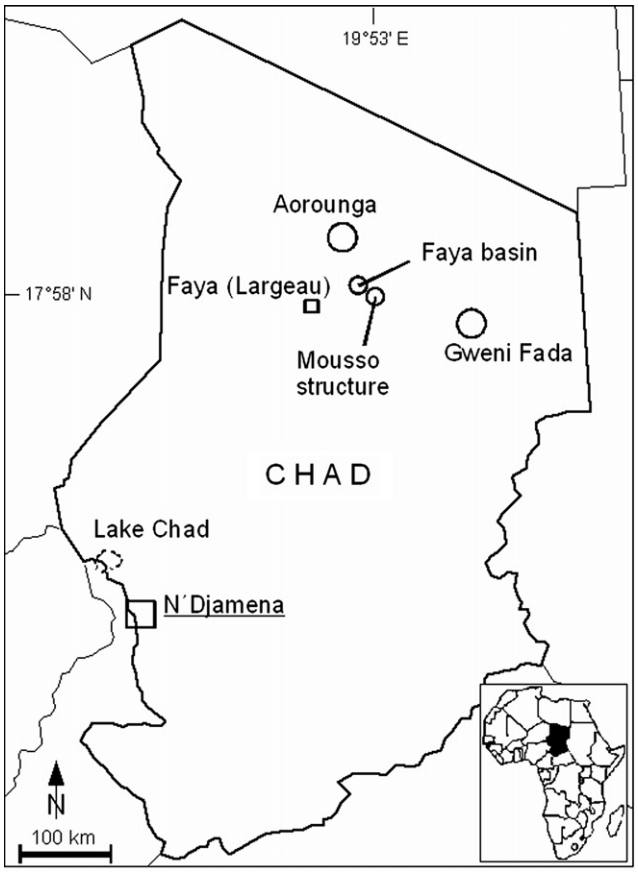

Fig. 1. Map of Chad (inset showing the position of this country on the African continent) and location of the Mousso structure, the confirmed impact structures of Aorounga and Gweni Fada, as well as the proposed impact structure of the Faya basin in northern Chad.

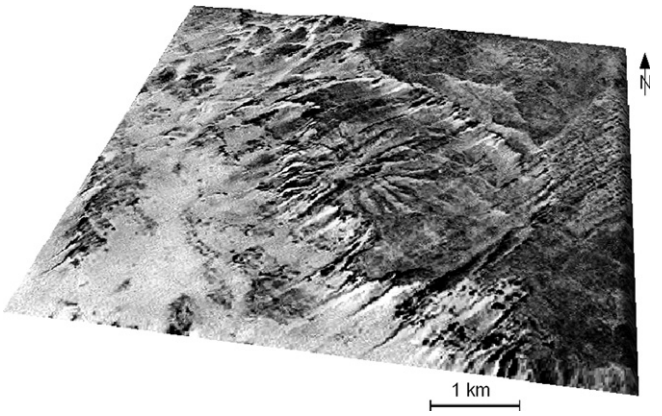

Fig. 2. Three-dimensional oblique view of the Mousso structure in northern Chad. The circular rim cutting into the sedimentary plateau of early Paleozoic rocks, semicircular concentric faults, an annular basin, and a structurally complex central peak are visible. Parts of the basin are covered by sands and salts. One diameter of the circular structure is ~3.8 km. View is from South; 5-fold vertical exaggeration. Scene modelled from Landsat-7 ETM+ satellite image (scene path 182, row 47; RGB visible light bands 3–2–1 merged with panchromatic band 8) draped over Shuttle Radar Topographic Mission (SRTM) data by Microdem 10.0 and 3DEM 19.0.