A SRTM INVESTIGATION OF SERRA DA CANGALHO IMPACT STRUCTURE, Brazil. W.U. Reimold[1], G.R.J. Cooper[1], R. Romano[2], D. Cowan[3], and C. Koeberl[4] [1]ICRG, School of Geosciences, Univ. Witwatersrand, P/Bag 3, P.O. Wits 2050, Johannesburg, RSA (reimoldw@geosciences.wits.ac.za); [2]Univ. of Ouro Preto, Dept. of Geology, Ouro Preto, Brazil; [3]Cowan Geodata Serv., 12 Edna Road, Dalkeith, West. Australia; [4]Geol. Sci., Univ. of Vienna, Althanstr. 14, A-1090 Vienna, Austria.

Summary: We review the current knowledge about the Serra da Cangalha (SdC) impact structure in Brazil and compare observations from MSS Landsat and STRM.

Introduction: The Serra da Cangalha crater structure (8°05'S/46°52'W) in the extreme northeast of Tocantins state of Brazil, is a confirmed impact structure [1-4] of 12 or 13 km diameter. It comprises several ring features, most prominent a 3 km (5 km according to [5]) circular ring of 250-300 m high mountains that lends this structure an appearance very similar to that of the Gosses Bluff structure, Australia, which has a 4.5 km inner ring and a subdued outer ring feature at 24 km diameter; 6]. This inner ring is, as for Gosses Bluff and the Oasis structure in Libya, interpreted as the result of differential erosion of a lithologically diverse central uplift. The SdC structure was formed in the intracratonic Parnaíba basin (formerly known as Maranhão basin) that comprises a stratigraphy of Upper Silurian to Cretaceous sedimentary rocks. Target rocks include upper Permian Pedra do Fogo sandstones, Permian/Carboniferous sandstones, carbonaceous shales of the 323-290 Ma Piauí Formation and the 354-323 Ma Poti Formation, and dark shales of the Longá Formation. In the center, these strata have vertical dip and are intensely deformed [7]. The base to these supracrustals in the region is estimated at 100-1300 m. A strong NE-SE depositional direction was obtained for the sedimentary rocks in the crater region [8].

SdC was first proposed as a possible impact structure by [2] based on a circular shape recognized in Landsat imagery, absence of volcanic rocks in drill core from the center of the structure, and because diapirism did not seem a viable option (no carbonate or salt layers in the sedimentary country rock stratigraphy). Later, [2,3] described shatter cones on quartzite boulders of a conglomerate at the base of the Poti Formation in the central ring. These authors also described intricate fracturing of quartz, as well as microspherules in microfractures (possibly related to the occasional melting described by [9] on so-called MSJ fractures from Vredefort?). The age of SdC is estimated, purely based on regional stratigraphy, at <250 Ma. The local stratigraphy involves 1200 m Devonian-Carboniferous, locally covering the impact structure. Contrary to repeatedly published allegations, Crósta (1987) [1] did not show the presence of shock metamorphic features ("shock lamellae", "breccia"). Interpretation of aeromagnetic data indicates a diameter of 12.7 km for the structure [10] and magnetotellurics [11] suggest that impact-induced structural deformation is limited to 2 km depth.

Data: For this work, we used Shuttle Radar Topography Mission (SRTM) data for the SdC region (ca. 55 x 55 km). Global SRTM single-pass radar interferometry data [12] were obtained by the STS-99 mission between 11 and 22 February 2000. SRTM digital elevation model data have a horizontal resolution of 1 arc second (equivalent to 30 m at the equator) and a vertical resolution of 10 m (C-band radar). The USGS is the responsible data archiving agency, and so far data for North and South America, and Eurasia have been released. Initial comparison between 3 arc second SRTM and older GTOPO DEM (Global Topography 30 arc second DEM) of the USGS [13] showed that the resolution of SRTM DEM is a significant improvement and will be especially useful in areas where limited topographic data are available.

The MSS Landsat data available for the SdC structure provide some comparison with the new SRTM data. In addition, we have applied several enhancement packages, especially sun-shading techniques, including fractional order sunshading and a technique that enhances circular anomalies [14]. Several DEM were generated.

Observations: Based on MSS Landsat imagery, the structure was shown to comprise a 3 km wide, near-circular central ring around a central depression. Adepelumi et al. [11] find the structure open to the northwest. An intermediate ring feature, with a diameter of ca. 5 km, is also indicated. This is surrounded by a broad and apparently flattish annulus of ca. 3-4 km width, terminated by the outer rim at 6-6.5 km from the center.

A strong radial and, in some sectors, concentric drainage pattern runs outward from the outer rim. Only a handful of radial drainage lines originate in the annular trough presumably exploiting radial faults that breach the outer rim.

The wider drainage pattern is distinct – and must be impact related – to a maximum distance from the center of 0.75-1 crater diameter. A NW-SE structural trend is obvious in the rather straight geometry of the NE and SW sectors of the inner ring, and in fracturing cutting across the SE sector of the outer rim.

The SRTM raw data provide a most detailed image of the drainage pattern, much clearer than the Landsat imagery. The regional pattern is distinct from that of the crater area – strongly NW-SE and ENE-WSW compared to radial and annular around the crater structure. This trend does certainly not extend further than deduced from the Landsat imagery. Sunshading provides a most detailed image of the regional structure, where strong NW-SE and ENE-WSW fault trends are prominent again. The crater region is extremely deformed, in contrast to larger areas (plateaus) to the SE, NW and NE of the impact area. Circular sunshading [14] enhances annular features of the crater area and immediate environs – essentially mirroring the region of impact-related drainage structure. This confirms the utility of this method to emphasize local annular features. A regional DEM shows the presence of several extensive plateaus in the wider environs of the crater structure. We observe the following structural elements: central topographic low to 1.1 km radius; prominent inner ring from 1.1 to 1.6 km radius, intermediate ring at ca. 3 km radius, weak incomplete ring at 5.5 km radius, outer rim at 6.7 km radius. Very intricate structural detail in the form of multiple faults of radial to oblique orientation with respect to the center of the impact structure is imaged, but this deformed zone does not extend into the plateaus outside of the crater – thus, delimiting the strongly impact-deformed zone to a radial distance of 10-11 km from the center, with several individual radial faults extending further to a maximum of 16-18 km from the center – about 1.5 as far as the drainage pattern alone would indicate.

Conclusion: The SRTM data provide a powerful tool for the detailed structural related deformation can be imaged and interpreted in investigation of geological features. In comparison to the Landsat MSS data, impact-much greater detail by the SRTM data. Table 1 compares the structural features identified for SdC with those for Gosses Bluff, and the BP and Oasis structures (Libya; [15]):

Clearly, these data do not indicate (yet?) adequate trends, but they represent a first basis for comparison with further structural data that should become available in due course. It must, however, be cautioned that variation in relative levels of erosion should be important in such comparisons of impact structures of very diverse age.

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Table 1 Apparent diameters of structural features of several eroded impact structures.

Crater:	**BP**	**SdC**	**Oasis****	**G. Bluff**	**Bosumtwi**	**Ries**	**Chixc.**
Central Ring	**0.5**	**2.2-3.2**	**5-6**	**4.5**	**1.5 (uplift)**	**4**	**80**
1st Intermediate R.	**-**	**6**	**[11.5]**	**7****	**10.5 (crat. rim)**	**10**	**180 (rim)**
2nd Intermediate R.	**-**	**10.5**	**-**	**-**	**-**	**-**	**-**
Apparent outer rim	**2***	**13.4**	**11.5 [18]*****	**24**	**18-20**	**23**	**240**

*There is a further feature outside of the crater rim, which [15] interpret as a detachment fault. ** Our interpretation of Fig. 2 of [6]. ***Two alternatives: either 11.5 [or 18] km apparent diameter: see [16], for discussion; the feature at 18 km. Is not annular – rather "an arcuate feature".