THE NEW LUIZI IMPACT STRUCTURE (DEMOCRATIC REPUBLIC OF CONGO) AND IMPLICATIONS FOR CENTRAL PEAK AND PEAK RING FORMATION. L. Ferrière[1] and G. R. Osinski[1,2], [1]Department of Earth Sciences, University of Western Ontario, 1151 Richmond Street, London, ON, N6A 5B7, Canada (ludovic.ferriere@univie.ac.at), [2]Department of Physics and Astronomy, University of Western Ontario, 1151 Richmond Street, London, ON, N6A 5B7, Canada (gosinski@uwo.ca).

Introduction: Rocks exposed within the uplifted central part of meteorite impact structures come from depths up to several kilometers and thus provide a unique opportunity to study subsurface crustal and, in some cases, potentially upper mantle material of planetary bodies. However, the crater-forming process that results in the formation of central peak and peak ring(s) is poorly understood. Much of our knowledge is based on extraterrestrial observations, as on Earth these types of impact structures with intricate structural features are very rarely exposed and preserved. Based on these planetary observations, it is widely accepted that central uplifts typically show a progression from central peak to peak ring basin morphology with increasing crater size.

Here we report on the ~17 kilometer diameter Luizi structure (Democratic Republic of Congo), a pristine and moderately sized complex crater, with an intermediate ring (~5.2 km in diameter), and a ~2 km wide circular central ring around a central depression [1].

Previous work: The Luizi structure was first mentioned in a field geological report published in 1919 [2] in which it is described as a semi-circular basin. The general aspect of the structure, as visible using satellite data, was briefly discussed in [3,4]. The hypervelocity impact origin of the Luizi structure have been confirmed only very recently by Ferrière et al. [1] with the documentation of shatter cones, multiple sets of PDFs in quartz grains, and shocked feldspar grains.

Results and discussion: We conducted a remote sensing study using available imagery and topographic data (Fig. 1), which revealed the dominant morphological features of the structure. Luizi exhibits, from the periphery to the center of the structure, a rim elevated up to ~300–350 m above the crater interior, an annular depression, an intermediate ring with a diameter of ~5.2 km, and a ~2 km wide circular central ring around a central depression (Figs. 1,2). All these features are well defined and can be easily recognized because of their sharp local topographic gradients. Using a digital elevation model (DEM) and derived cross-sections, we estimate the rim diameter of the structure to be ~17 km (Figs. 1,2 and [1]). A large fault zone oriented NNW-SSE, unrelated to the impact event, is also apparent on the right part of the Figure 1.

Of great interest to the community is the fact that the overall morphology of the Luizi structure appears to be relatively well preserved based on comparisons with other similarly-sized impact craters (e.g., Haughton impact structure, Canada [5]). The absence of crater-filling impact breccias within the structure [1] suggests that at least 200–300 m of material were removed by erosion.

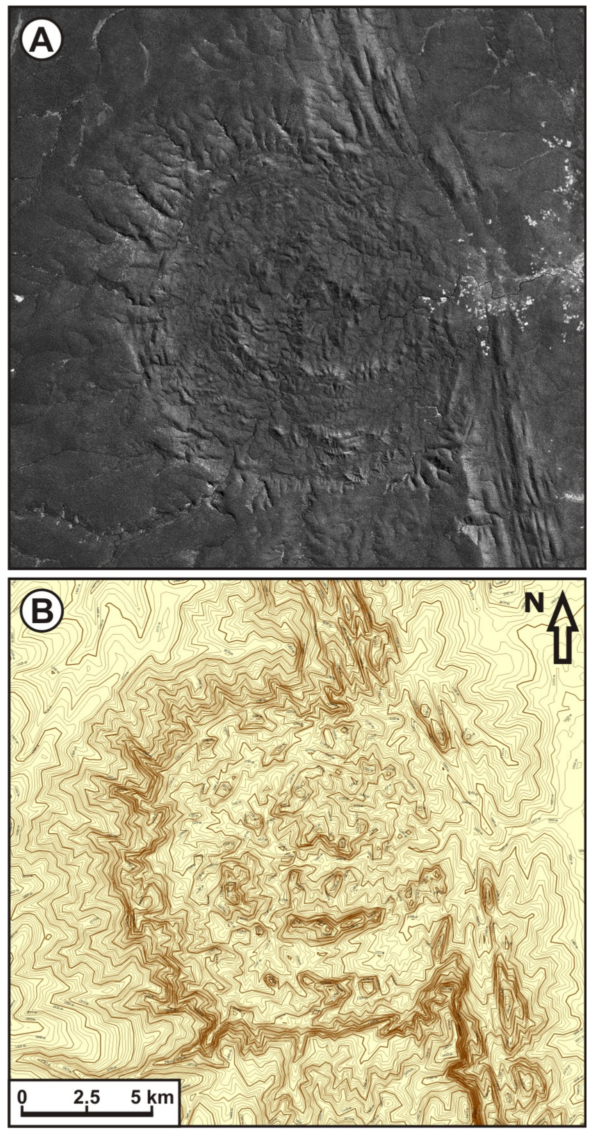

Fig. 1: Landsat image (a) and SRTM (Shuttle Radar Topography Mission) 5m topographical contour lines (b) of the Luizi structure. SRTM data were available online (http://www2.jpl.nasa.gov/srtm/, accessed 14 July 2010).

The Luizi structure displays characteristic of complex impact craters on other planetary surfaces, with an elevated structural rim, an annular depression, and a central uplifted zone (Fig. 2). As noted above, on the Moon, central uplifts typically show a progression from central peak to peak ring basin morphology with increasing crater size. It should be noted that this represents the pristine crater morphology, such that the peak or peak ring protrudes through the coherent impact melt/breccia sheets that typically line these large complex craters.

Luizi lacks a central topographic "peak" and, instead, displays intricate structural features, namely, an intermediate ring and a ~2 km wide circular central ring around a central depression. The occurrence of such types of intermediate "inner" rings is particularly rare on Earth and generally interpreted, as in the case of the Haughton (Canada) and Serra da Cangalha (Brazil) structures, to represent the differentially eroded remnants of central uplifts formed in layered sequences of target rocks [5,6]. The lack of a topographic central peak could, at first glance, be explained by erosion. However, as noted by Grieve and Therriault [7], other prominent terrestrial impact structures also lack central peaks: Haughton, Ries (Germany), and Zhamanshin (Kazakhstan). These structures are all relatively young and well preserved and share the same feature as being formed in mixed targets with thick sedimentary sections. Grieve and Therriault [7] close their discussion by stating "the lack of a central topographic peak is a more complex (but yet unknown) function of target and impact characteristics."

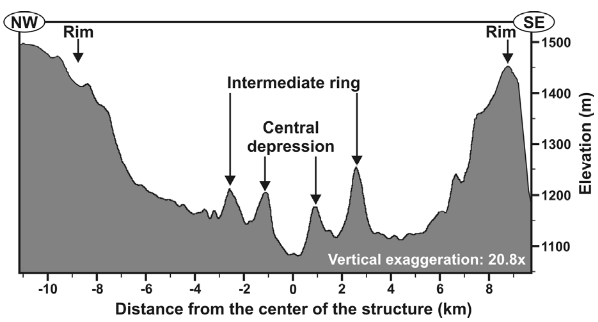

Fig. 2: Cross-section (profile from northwest to southeast) of the Luizi impact crater, based on SRTM data.

A comparison with the well-exposed and well-documented Haughton structure is particularly interesting, as Haughton possesses a rim diameter of 16 km [5]. Most notably, both Luizi and Haughton lack a central topographic peak characteristic of craters of this size developed in crystalline rocks on Earth and other planetary bodies (e.g., [8]). Instead, both structures comprise a central ~2 km diameter depression surrounded by a series of structural rings, which are also manifest topographically, likely due to differential erosion. Based on detailed structural mapping of Haughton, these observations were explained as being due to the partial collapse of an unstable central peak due to the sedimentary target lithologies [5]. Our findings at Luizi suggest that this may be a typical feature for mid-size craters developed in layered target rocks. We thus propose that the interaction of two flow regimes, namely, the inwardly collapsing crater rim and the outwardly collapsing central peak – which is potentially involved in peak ring basin formation, as modeled numerically [9] – is enhanced in the case of layered sedimentary rocks as they are much less resistant to horizontal movement than crystalline rocks.

The formation of these *structural* rings should not be confused with the peak ring basin morphology of pristine impact craters; although, the formation processes may actually be similar. Luizi thus provides a new source of information for furthering our understanding on how central peaks form and collapse within sedimentary target lithologies.

Conclusion: Our findings at Luizi provide insights into the formation of mid-sized impact craters on Earth, adding to the evidence that, in the case of sedimentary target lithologies, structural ring structures within the central uplift may form by collapse of an unstable central peak.

Acknowledgments: This work was supported by the National Geographic Society/Waitt Grants Program (grant #69-09). L.F was supported by the DFAIT, Government of Canada. G.R.O.'s research is supported by an Industrial Research Chair sponsored by the Natural Sciences and Engineering Council of Canada, MDA Space Missions, and the Canadian Space Agency, plus the Ontario Ministry of Innovation Early Researcher Award fund.

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