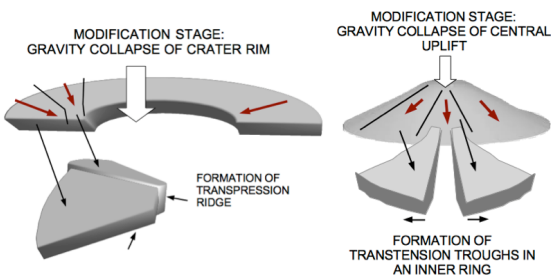


# TRANSPRESSION AND TRANSTENSION IMPACT CRATERING FEATURES: THE STEINHEIM, SAARLOUIS (BOTH GERMANY) AND SINGRA-JILOCA (SPAIN) CASES. K. Ernstson<sup>1</sup> and F. Claudin<sup>2</sup>

<sup>1</sup>University of Würzburg, 97074 Würzburg (Germany), kernstson@ernstson.de, <sup>2</sup>Associate Geological Museum Barcelona (Spain); fclaudin@xtec.cat.

**Introduction:** Strike-slip transtensional and transpressional tectonics including oblique slip tectonics is a well known process in structural geology. Apparently for the first time, such processes were also proposed for complex terrestrial impact structures [1] and were further explained and specified using the Siljan and Decatureville impact structures, but also added observations on the Carlswell, Upheaval Dome and Araguinha impact structures. The transpression, preferably treated in [1], but also the transtension in complex impact structures are easily understood in the context of impact cratering, when in the modification stage gravitationally conditioned the primary crater collapses and blocks of the outer ring converge more or less radially inward, or divide outward during the collapse of a central uplift. In a highly simplified form, Fig. 1 shows the two basic forms of these two processes for a complex impact structure.

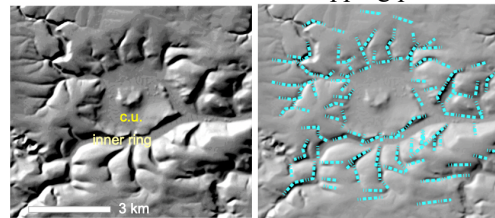


**Fig. 1.** Simple models of transpression and transtension strike-slip structures in complex impact craters.

Here we revisit the idea of transpression and transtension for three selected impact structures and highlight that, in particular, high-resolution digital terrain model data have become an important tool not only in structural geology but also in impact research in general.

**Steinheim Basin:** In the scientific literature the Steinheim crater has been named since time immemorial with a diameter of 3.7-3.8 km. This essentially refers to the morphology visible to the eye and to the contour lines of the topographic map. However, almost 40 years ago an extensive gravimetry and a very precise morphological analysis of the basin proved that the crater is about twice as large, i.e. has a diameter of 7-8 km [2]. The publication of 1984, although published in a renowned journal, was ignored and swept under the table in the "impact community" until today [3], and even in more recent papers with modeling of the Steinheim impact process [4, 5] the

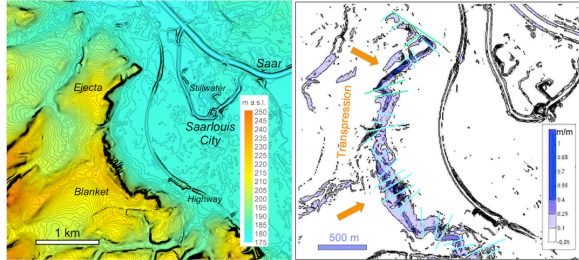
small crater with 3.8 km diameter is taken as a measure, which makes the modeling rather suspect. With the analysis of the DTM presented here (Fig. 2) it becomes again clear how far obviously the postulated small crater is beside reality. The fact that a crater rim with structurally displaced tectonic blocks (transpression ridges, which are quite clearly visible in the DTM) will remain hidden from geology in the future is due to the monotonous litho-stratigraphy of the Jurassic limestones without significant reference horizons, where hardly any movements can be determined, but also due to the continuous forest areas without mapping possibilities.



**Fig. 2.** Steinheim Basin – twice as big as commonly referred to [2]. Lineation pattern in the Digital Terrain Model (shaded relief) are enhancing transpression and transtension strike-slip faulting (right). c.u. = central uplift. Map source: TOP 25 Baden-Württemberg.

**The Saarlouis semi-crater:** The Saarland impact has been an established event for several years with the existence of two craters with diameters of about 200 m (Nalbach) and Saarlouis (2.3 km) [6, 7]. Finds of rocks and glasses in a strewn field with typical impact features (e.g. suevites) strengthened the impact hypothesis and initiated comprehensive mineralogical SEM-EDS and thin section analyses establishing strong shock metamorphism [7]. The 2.3 km-diameter Saarlouis crater, in which the city of Saarlouis lies in the middle, has never attracted attention as a special morphological and certainly not as a geological structure, despite its relative size. Only in connection with the general establishment of the Nalbach impact with the extended impact findings and the 250 m-diameter Nalbach crater did a local resident with knowledge of natural science and local history notice the unusually sharply cut, exactly semicircular steeply rising rim of the valley level of the Saar river, provided with a pronounced rampart. What seemed to him as geologically particularly strange, almost inexplicable, but not noticed at all by geologists, was the ring wall immediately adjoining the steep rim, which slowly flattened outwards. Findings of typical impactites with shock effects (e.g. suevite and melt glasses) [7, 8] left no doubt

about the impact genesis of the now so called Saarlouis crater as belonging to the Pleistocene/Holocene Saarland impact event. Recent ground penetrating radar (GPR) measurements over the impact ring wall [9] confirmed a structure that could not be reconciled with the known Buntsandstein stratigraphy of the region.

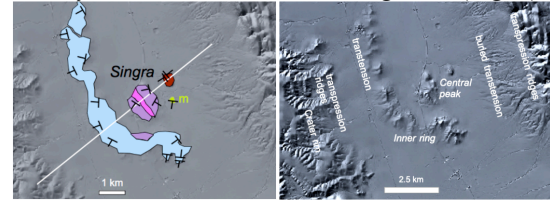


**Fig. 3.** Saarlouis semi crater: Digital Terrain Model (left), contour interval 1 m. Right: formation of transpression ridges in the impact modification stage. DTM; computed terrain gradient.

In Fig. 3 in the topographic map of the DTM it can already be seen well that the sharply cut crater rim, despite the almost perfect semicircular morphology, is composed of more or less small-scale structural units. With the data processing capabilities of the DTM and a gradient computation (1st horizontal derivative, Fig. 3, right), it is possible to convey a higher resolution of what undoubtedly fits the model of structural transpression in an impact crater rim. This is equivalent to the statement that all possibly from the traditional geology put forward counterarguments like sedimentation or erosion morphology in the valley of the Saar river cannot have any validity.

**The Jiloca-Singra impact structure:** The Iberian System in NE Spain is characterized by a distinctive graben/basin system (Calatayud, Jiloca, Alfambra-Teruel) which has received much attention and discussion in earlier and very recent geological literature. A completely different approach to the formation of this graben/basin system is provided by the impact crater chain of the Rubielos de la Cérda impact basin as part of the important Middle Tertiary Azuara impact event, which has been published for about 20 years [10-12]. Although the Rubielos de la Cérda impact basin is characterized by all the geological, mineralogical and petrographical impact findings recognized in international impact research, it has completely been hushed up in the Spanish geological literature to this day. A lengthy and comprehensive article [13] used the example of the Jiloca graben to show the absolute incompatibility of the previous geological concepts with the impact structures that can be observed in the Jiloca graben without much effort. Digital terrain modeling and aerial photography together with structural and stratigraphic alien geology define a new lateral Singra-Jiloca complex impact structure with

central uplift and an inner ring, which is positioned exactly in the middle of the Jiloca graben (Fig. 4).



**Fig. 4.** Simplified geological map of the Singra-Jiloca complex impact structure; Jurassic inner ring, Triassic central peak. Right: DTM of the transpression and transtension structures related to outer rim and inner ring.

While in the case of Saarlouis crater the structurally excellent feature is limited to strike-slip transpression of the outer crater rim, the 10 km diameter Singra-Jiloca crater has all the features of the combination of outer transpression and inner transtension, as Fig. 4 so significantly shows in the DTM, fine illustrative material for Spanish geologist who until recently steadfastly adhere to their ideas about different graben models (see e.g. [13]).

**Conclusions:** The structural peculiarities in the formation process of complex impact structures in the modification phase, which were recognized by Kenkmann and von Dalwigk [1], add up to the realization that, in addition to mineralogical-petrographical findings, purely geological observations can increasingly be proving criteria in the detection and establishment of impact structures. This is of importance not to be underestimated, as we want to point out with our examples here, that the excellent possibilities of the DTM have opened up possibilities to see and analyze impact structures in inaccessible and not visible areas morphologically in all details.

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