

NEW INSIGHTS INTO THE STEINHEIM CENTRAL UPLIFT – PART III: SHATTER CONES AND THE ‘CONE-IN-CONE’ PROBLEM RELOADED

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Background: Specific conical features in terrestrial rocks may originate from various geologic processes, such as (1) shatter cones generated during (and diagnostic for) meteorite impact events [1], or (2) ‘cone-in-cone’ structures (‘Tutenmergel’ or ‘Nagelkalke’ in German) that may sometimes appear similar to shatter cones but which are thought to represent sedimentary-diagenetic phenomena [2;3]. A thorough systematic comparison and distinction between shatter cones and cone-in-cone structures is given by [4].



Fig. 1: Shatter cones and cone-in-cone structures from the Steinheim central uplift (Middle Jurassic ‘Opalinuston’); **A:** well-defined shatter cones in claystone nodule; fingers for scale; **B:** cone-in-cone structure marking the top of a marly limestone bed; **C:** cone-in-cone aggregate with distinct corrugations.

New Observations and Discussion: Water catchment works have recently made an outcrop and freshly excavated material of the Middle Jurassic ‘Opalinuston’ claystone accessible on top of the Steinheim central uplift. Surprisingly, both well-defined shatter cones in shocked concretionary claystone nodules (Fig. 1A) [5] and (deformed) cone-in-cone structures in a marly limestone layer (Fig. 1 B-C) were recovered from the outcrop. In contrast to the shatter cones that are commonly slightly curved and show variable orientations [6], cone-in-cone structures are straight, nested features, sometimes intersected by corrugations, and run perpendicular to the bedding plane of the host bed [4]. Shattering of the pre-impact cone-in-cone structures is obviously due to the Steinheim impact. Comparative field studies at the nearby Essingen ‘Opalinuston’ quarry revealed similar cone-in-cone features in intercalated limestone layers but, expectedly, neither shatter cones in the claystone nodules, nor ‘shattered’ cone-in-cone structures. To our knowledge, this is the first report of coexisting shatter cones and cone-in-cone structures in the same outcrop.

References: [1] Dietz R. S. 1960. *Science* 131:1781-1784. [2] Usdowski H.-E. 1963. *Beiträge zur Mineralogie und Petrographie* 9:95-110. [3] Selles-Martinez J. 1994. *Carbonates and Evaporites* 9:172-186. [4] Lugli S. et al. 2005. In Koeberl C. and Henkel H. (eds.) *Impact Tectonics*, Springer, p. 82-110. [5] Buchner E. and Schmieder M. 2010. This volume. [6] Schmieder M. and Buchner E. 2010. This volume.