HOW 'DRY' WAS THE RIES-STEINHEIM IMPACT EVENT? M. Schmieder[1] and E. Buchner[2,1] [1]Institut für Planetologie, Universität Stuttgart, Herdweg 51, D-70174 Stuttgart, martin.schmieder@geologie.uni-stuttgart.de. [2]HNU Neu-Ulm University, Wileystrasse 1, D-89231 Neu-Ulm, Germany.

Background: The ~24 km Ries crater and the ~3.8 km Steinheim Basin, S Germany, likely struck by a binary asteroid ~14.5 Ma ago in the Miocene, count among the best-preserved impact structures on Earth [1;2]. Both impact structures are hosted by a thick sequence of Mesozoic to Cenozoic sedimentary rocks (Ries: ~620 m of Lower Triassic to Miocene rocks; Steinheim: ~1180 m of Lower Triassic to Upper Jurassic rocks [1]) that overlie the Variscan crystalline basement and build up the karstified plateau (~200-300 m of Upper Jurassic limestones and marls) of the Swabian-Franconian Alb (SFA). In addition to the proximal Ries ejecta blanket (lithic Bunte Breccia, impact melt rocks, and suevites), distal ejecta define the Central European tektite strewn field ~200-450 km to the NE [1] and the more proximal 'Brockhorizont' [3]. The Ries and Steinheim impact structures thus provide unique insights into cratering mechanics, ejecta emplacement, and impactite petrogenesis under continental conditions. Despite the continental (i.e., presumably rather 'dry') environment at the time of impact, lines of evidence are presented that suggest a comparatively 'wet' Ries-Steinheim scenario [4].

Discussion of Paleoenvironmental Conditions: Miocene shales and black pebble-bearing pisolithic-onkolithic limestones (e.g., Stubersheim) that once covered larger parts of the SFA before and after the time of impact indicate limnic-palustrine surface conditions in a wide area surrounding the Ries and Steinheim impact sites. These sediments are to variable degrees incorporated into Bunte Breccia (e.g., Harburg or Demmingen) and post-impact (e.g., the 'Rezat-Altmühl paleolake' deposits), which further suggests that the pre-, syn-, and post-impact landscape was surficially water-saturated. Host to the Brockhorizont (e.g., Biberach or Ziemetshausen), fluvial to limnic siliciclastics including paleosoils suggestive of water-logging make up large parts of the Upper Freshwater Molasse in the North Alpine Foreland Basin [5].

Slight SE-ward inclination of the South German terrane in response to the Alpine orogeny caused the Jurassic limestones and deeper parts of the SFA to progressively emerge. Karstification of the SFA might have commenced in the Cretaceous but has been penetrative since the Paleogene [6]. A high karst groundwater level within the SFA is in accord with a high global sea level and a subtropical-humid regional paleoclimate in the Miocene. The high supply of groundwater in the Ries-Steinheim area is, moreover, substantiated by the spontaneous inflow of water and the formation of the Ries and Steinheim crater lakes, pronounced degassing [7] and fluvial reworking [8] of Ries ejecta, and the precipitation of freshwater limestone deposits [9] at both craters soon upon impact (e.g., Wallerstein at the Ries; Steinhirt at Steinheim).

Ries and Steinheim impact ejecta petrology is, furthermore, compatible with elevated water contents in the target. Strong dispersion of impact melt, as well as the formation of accretionary lapilli in the Ries suevite [10], might suggest water-saturated target rock conditions. Ries impact glasses are known to contain comparatively high amounts of water [11], and surficial suevites are intensely altered to clay minerals [12]. Likewise, impact melt particles in the largely carbonatic Steinheim impact breccia have been transformed into hydrous phyllosilicates [13].

As a nearby volcanic event 'analog', the roughly contemporaneous (~13-17 Ma) volcanism at the Urach volcanic field, a ~1,500 km³ olivine melilititic volcanic province comprising more than 350 tuff breccia-bearing maar-diatremes set in the sedimentary succession of the central Swabian Alb and its foreland, demonstrates the strong impact of groundwater in contact to magmatic heat [14]. Explosive phreatomagmatism characterized by (multiple) eruptions at variable levels of the host rock and the subsequent formation of maar lakes (e.g., the Randecker Maar) indicate deep groundwater saturation of the SFA in Miocene time.

Conclusions: The Ries-Steinheim impacts occurred in a water-saturated paleoenvironment, maybe best described as a landscape of rivers, wide swamplands, and lakes. In addition to surficial waters [4], the deeply karstified plateau of the SFA provided substantial amounts of subsurface water that probably influenced the formation and emplacement of Ries and Steinheim impact ejecta.

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