RIES CRATER AND SUEVITE REVISITED: PART I OBSERVATIONS. D. Stöffler[1], C. Meyer[1], W. U. Reimold[1], N. A. Artemieva[2], and K. Wünnemann[1], [1]Museum für Naturkunde – Leibniz Institute at the Humboldt University Berlin, Germany, [2] Institute for the Dynamics of Geospheres, Russian Academy of Sciences, Moscow, Russia; dieter.stoeffler@museum.hu-berlin.de

Introduction: The Ries of Nördlingen (diameter: 26 km, age: 14.35 Ma) is the type locality of suevite which is the most characteristic rock type formed in impact craters. Though studied since 1834 [1], the formation and emplacement of suevite in the Ries and in impact craters in general is still enigmatic. As information from suevite can contribute significantly with regard to understanding the cratering process in general and the ejecta plume in particular, we have reevaluated suevite genesis in the context of modern modelling capabilities in conjunction with new petrographic studies [2]

Geology of the Ries crater: The crater is formed in a 500 to 700 m thick layer of Mesozoic sediments underlain by crystalline basement [3]. It has 5 major structural elements (Fig. 1): (1) a central, ~ 700 m deep cavity (radius r = 6 km), (2) an uplifted inner ring and (3) a megablock zone from r = 6 to 13 km, (4) a "tectonic" rim at r = 13-15 km, and (5) an outer ejecta blanket from r = 13 to ca. 45 km.

Types of suevite and their geological setting: At the Ries suevite occurs in three different geological settings [4, 5]: (1) a thick continuous layer in the central crater cavity inside the inner ring ("crater suevite" = CS), (2) thin isolated patches on top of the continuous ejecta blanket (previously called "fallout suevite" [5]; we propose to call it "outer suevite" = OS), and (3) dikes in the crater basement and in displaced megablocks.

Crater suevite CS. The CS is exposed in several industrial and research drillings. Only the drill core Nördlingen 1973 (Fig. 1; [6]) provides a complete section. There, we distinguish severals subunits based on texture and modal composition: An upper unit A comprising ~ 60 m of "reworked" suevite underlain by ~ 17 m of "sorted" suevite (probably more than one cycle), a middle unit B of ~ 194 m of "high temperature", i.e., melt-rich suevite, and a lower unit C of ~ 77 m of "low temperature" suevite characterized by a low melt content that decreases with depth. Units A and C display no or only extremely low reversed remanent magnetization, whereas unit B is strongly magnetized [7]. Except for unit A the crater suevite is not stratified and has a very low degree of sorting (grain size < ~ 20 cm). Near the inner ring (drill core Enkingen [8]) the suevite grades into a clast-rich impact melt rock with depth.

Outer suevite OS. Field observations and evaluation of the erosion history of the Ries indicate that the patchy distribution of this type of suevite is a primary feature and not due to erosion [9, 10]. The maximum radial extent of the suevite is 22 km (1.8 crater radii). A distinct feature of the melt inclusions is their "aerodynamic" shape, which is lacking in the crater suevite. The outer suevite displays a sharp contact to the underlying continuous ejecta ("Bunte Breccia" = BB). In addition, this boundary represents a distinct change in lithology and grain size: The OS has > 95 – 99 % crystalline basement rocks in its lithic clast population and a grain size < 30-50 cm, whereas BB contains > 90-95 % sedimentary rock clasts, with block sizes up to tens of meters in BB.

Volume of suevite. Estimates of the volumes of the respective suevite types (recalculated to zero porosity) range up to 7 km^3 for CS and 0.25 km^3 for OS, respectively, corresponding to ~ 4.7 % and 0.17 %, respectively, of the total volume of displaced rocks, for which we assume an average value of 150 km^3 [4, 5]. For the OS some 80% loss by erosion is taken into account [4].

Results of recent petrographic studies: Our petrographic analysis of the various suevite types is based on samples of OS from outcrops in the entire ejecta blanket (outside of the inner ring) and from two drill cores, and on samples of CS from several drill cores (Fig. 1) including the most recent Enkingen drill core close to the inner ring [8].

General textural properties. REM studies confirmed the view that suevite is an assemblage of clastic and molten material with a primarily particulate matrix [11] and is not similar to an impact melt breccia (defined in [11]) as suggested by [12]. Typically, a finely crystallized interstitial matrix composed mainly of phyllosilicates (locally also of secondary carbonate) is present between lithic and mineral clasts and melt particles on a size scale of 5 – 10 µm. Similar to [12], we interpret this matrix tentatively as a hydrothermal alteration product originating from a very fine-grained fraction of melt particles and/or from secondary post-depositional solutions.

Grain size. The OS outside of the "tectonic" rim (e.g., at Otting) has a distinctly smaller mean grain size compared to the OS of the megablock zone (drill core Wörnitzostheim) and the CS. The grain size is rather constant with depth at Otting, whereas at Wörnitzostheim and in the CS it increases with depth. Sorting is very poor in all suevites and constant with depth in the OS of Otting, whereas it becomes somewhat poorer with depth in the CS and in the OS of Wörnitzostheim. Sorting appears to be less poor in the OS of Otting.

Modal composition. The component population in all types of suevite is dominated by melt particles (10 – 40 vol.%; up to 80 % at Enkingen) for sizes > 1 mm [2, 3, 4, 13]. The lithic clasts are almost exclusively derived from the crystalline basement (sedimentary rock clasts mostly < 1 vol.%). The CS typically lacks sediments from the Malmian, i.e. from the upper 300 m of the pre-impact sedimentary rock strata.

Conclusions: Laboratory and field data indicate clearly that different processes are responsible for the genesis of the different types of suevites in the Ries. The details of these processes can only be solved by numerical modeling using the observational data as boundary conditions. Previous genetic concepts [4, 6, 12, 13, 14, 15] can obviously not explain the data as too many open questions remain. Particularly enigmatic is the genesis of the OS and the upper section (units A and B) of the CS. It seems that (1) the role of the ejecta plume has been overestimated in the past and (2) a pure flow of impact melt [15] to explain the OS is in conflict with observations. A new genetic concept for these suevites is presented in Part II of this contribution [16].

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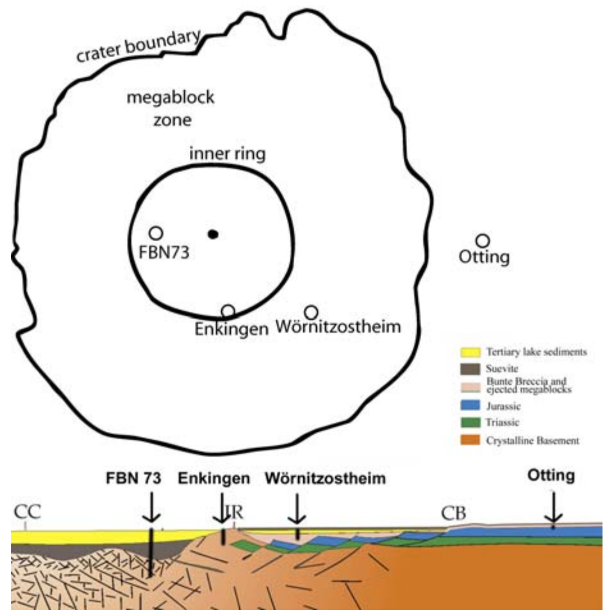

Fig. 1: Location of drill cores with respect to inner ring (IR) and “tectonic” rim (CB) of the Ries crater; CC = center of crater; FBN73 = research drilling of Nördlingen 1973.