MEGABLOCKS IN THE RIES IMPACT CRATER, GERMANY: NEW DISCOVERIES AND STATISTICAL ANALYSIS OF DISTRIBUTION AND LITHOLOGIES. S. Sturm[1], M. Willmes[1], H. Hiesinger[1], T. Kenkmann[2] and G. Pösges[3], [1]Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Germany (s.sturm@uni-muenster.de), [2] Institut für Geowissenschaften, Universität Freiburg, Germany, [3]Rieskrater-Museum Nördlingen, Germany.

Introduction: The Ries crater is a well-preserved complex crater, 25 km in diameter, located in Bavaria, southern Germany [1 and references therein]. The impact occurred in a heterogeneous target that consisted of ~600 m sedimentary cover (Triassic to Jurassic) resting over a crystalline basement [2]. It consists of (i) a 10-12 km diameter inner crater basin filled with suevite and post-impact lake deposits, (ii) a collar zone of upturned and overturned highly faulted and shock metamorphosed material called the "inner ring" and (iii) a zone of large blocks ("megablock zone") that were displaced during the crater formation process [e.g., 3]. The Ries has been intensively studied, however the megablock zone still poses questions regarding crater formation mechanics. Here we present new data of the megablock zone using a combined approach of remote sensing analysis and shallow drillings.

Formation of megablocks is caused by two processes: (i) They were either thrown outwards during the crater excavation stage and were deposited simultaneously with the continuous ejecta blanket (Bunte breccia) and/or (ii) slumped inwards during the modification stage, leading to a complex juxtaposition of allochthonous crystalline and allochthonous and parautochthonous sedimentary megablocks. Their abundance and distribution is a tribute to the pre-impact geology, the impact process and post-impact erosion. The megablock zone exhibits a hummocky morphology that is dominated by large Malmian and crystalline megablocks easily detectable at the surface [2, 4]. Megablocks are also present in the subsurface as they have been buried by Suevite, Bunte Breccia or post-impact sediment deposition [5]. These subsurface megablocks have only rarely been detected so far and are not shown in the present geological map of the Ries [6].

Detection of subsurface megablocks: Google Earth and HRSC-AX airborne images with average resolutions of 1m/pxl were used to search the megablock zone for possible subsurface megablock structures. Shallow drilling devices (Pürckhauer and Percussion Piston Corer) were used to verify and classify observed structures in the near subsurface. Figure 1 gives an example how megablocks were detected by their higher albedo characteristics in comparison to the darker surrounding field material [7, 8].

Fig. 1: *Google Earth image of a crystalline megablock structure near Alerheim. Points indicate the location of the corresponding drilling sites. D032 and D033 yielded weathered crystalline material at a depth of ~30 cm. D030 and D034 did not reveal evidence for crystalline material in the borehole profiles down to ~3 m depth. The arrow in the megablock sketch indicates the direction of the crater center.*

Statistical analysis: For a statistical analysis of the distribution and size of megablocks the known megablocks from the current geological map [6] were combined with the newly identified megablock structures from this study. The statistical analysis include position, orientation, size and volume estimations of all megablock structures with regard to the crater center and crater rim in the megablock zone of the Ries impact crater.

Results and Discussion: The systematic survey resulted in a new coherent distribution map of all megablock structures (*Fig. 2*) and 81 newly identified megablocks, increasing the total number of megablocks known in the Ries to 1777. For many other megablocks, their shape and size were better constrained and their lithologies verified. As most of the newly found megablocks are relatively small, they added ~1.7 km² to the total area of megablocks, which is now ~113.60 km². Volume calculations based on the size measurements of the megablocks indicate ~52.62 km³ of megablock material. This number is in good agreement with the findings of Stöffler [1], who estimated the amount of megablock material to be in the range of ~30-50 km³. The volume derived in this study most likely underestimates the total volume of megablock material since not all megablocks can be detected and our knowledge about the actual extent of the megablocks in the subsurface is limited.

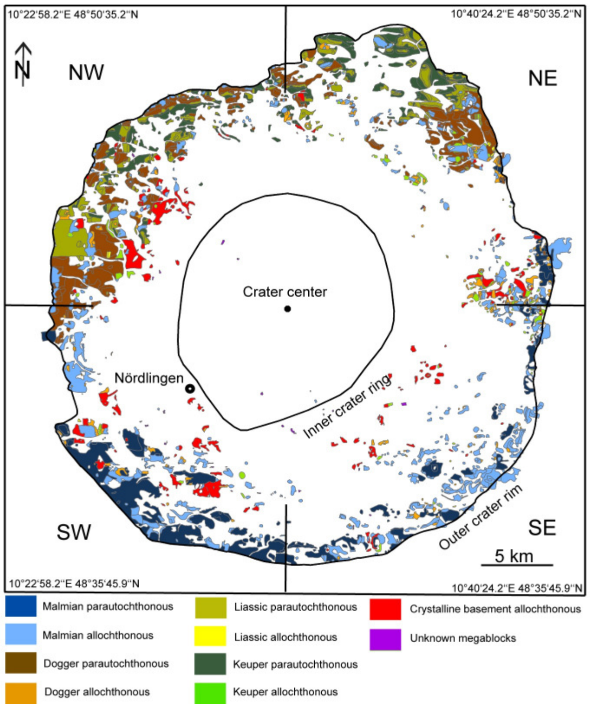

Fig. 2: *Distribution map of all megablock lithologies in the Ries crater, Germany. The megablock zone is located between the inner crater ring and the outer crater rim.*

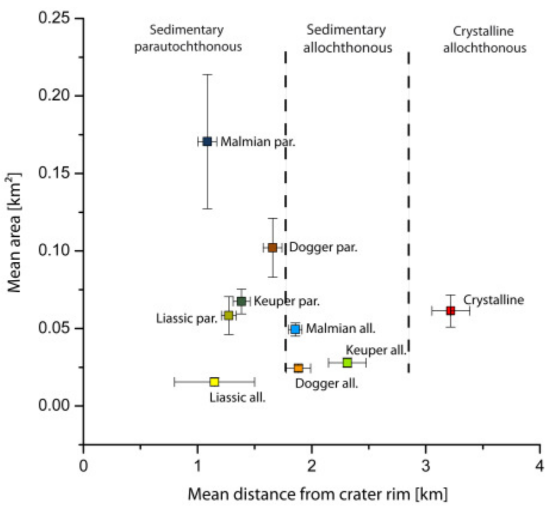

Fig. 3: *Plot of the mean distance of megablocks from the crater rim [km] versus their mean area [km²].*

The distribution of parautochthonous megablocks in the Ries crater shows a strong correlation to the pre-impact geology. As previously observed [1, 2, 4], they predominantly occur very close to the outer crater rim in areas where their lithology is also found outside of the crater (*Fig. 3*). Malmian parautochthonous units are found in the S of the Ries while Dogger, Liassic and Keuper are found in the N. Parautochthonous megablocks are less deformed and lack a shock metamorphic overprint. Neighboring megablocks are bounded by faults rather than extensive breccia occurrences. They are fewer in number but larger in extent than their allochthonous counterparts, an indication of their shorter transport and formation later in the cratering process. The largest known parautochthonous units, that represent coherent megablocks near the crater rim, show an almost concentric strike in relation to the crater center which is consistent with oberservation of the crater rim zone of Hüttner and Schmidt-Kaler [4]. In contrast, allochthonous megablocks show intensive brittle fracturing and often a shock metamorphic overprint. They are mostly embedded in Bunte breccias ejecta deposits, are more randomly distributed, and also occur closer to the inner crater ring (*Fig. 3*). Crystalline megablocks are unique in that they are definitely formed during the excavation stage since no crystalline material was present at the surface before the impact. Within the megablock zone they form the majority of blocks near the inner ring (Fig. 3).

Conclusion: The distribution of the megablocks is related to the heterogeneous, layered target, the exposure of different lithologies on the surface before the impact and the complex interplay between different processes during the crater formation. From the inner crater ring to the outer crater rim, the whole megablock zone can be divided into three zones dominated by different megablock units and transportation processes: (1) Excavated highly-deformed allochthonous crystalline megablocks near the inner crystalline ring that are part of the overturned flap , (2) allochthonous sedimentary units, and (3) parautochthonous less-deformed sedimentary material that was collapsed inwardly and downwardly into the crater near the outer crater rim.

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