THE STRUCTURE OF RIES CRATER MEGABLOCK ZONE AND SOUTHERN RIM AREA ACCORDING TO SEISMIC REFLECTION PROFILES. K. Sarv¹, A. Jõeleht¹, N. McCall², S. Gulick², J. Wilk³, G. Pösges⁴ ¹University of Tartu, Department of Geology, Ravila 14a, 50411, Tartu, Estonia (kai-di.sarv@ut.ee), ²University of Texas at Austin, Jackson School of Geosciences, Institute for Geophysics, 10100 Burnett Rd Bldg ROC, Austin, Texas 78758, USA ³University of Freiburg, Institute of Earth and Environmental Sciences, Freiburg, Germany, ⁴Rieskrater Museum, Eugene-Shoemaker-Platz 1, D-86720 Nördlingen, Germany

Introduction: Ries crater in Germany is a well preserved 26 km wide complex impact crater that is characterized by a crystalline inner ring of about 12 km in diameter [1]. The annular area between the inner ring and outer rim is called the megablock zone, which comprises of allochthonous megablocks of variable size and composition covering the parautochthonous blocks of sedimentary rocks. Allochthonous blocks originate from the target rocks that were initially ejected or transported outside of the transient cavity as a result of the impact event; these include both sedimentary and crystalline lithologies and are embedded in the Bunte breccia, covering the megablock zone within the crater and as a continuous layer over a large area outside the crater [1].

The parautochthonous blocks are formed as the larger blocks outside the transient crater have slumped inward during the crater collapse. These blocks occur only in the megablock zone [1]. Several boreholes have penetrated the area, and numerical models have been created to simulate the event and final crater structure [2,3]. While the understanding of the location and composition of the allochthonous breccia has developed over time, the nature of the parautochthonous blocks has remained speculative, yet this information is important for understanding the cratering processes.

Methods: Four seismic profiles were acquired in summer 2017, two of which are discussed here. One of the profiles (profile 3) covers most of the area of the megablock zone, whereas the other profile (profile 4) shows the area just outside the crater (line locations in figure 1). Both profiles were acquired using a recording array 710 m long with geophone groups of 5 located every 10 m along the line. An earth-tamper was used for hit timings. Further processing of initial records included correlation-based shot time adjustment and rejection of shots to maintain source randomness. Selected shots (typically 200-400) were stacked together to overcome traffic and other random seismic noise. Seismic data with 1 ms sampling interval were prepared with two second record length although 1 second was enough to see the deepest prominent reflections. Seismic data have a wide range of frequencies with peaks at 30–80 Hz.

The profiles followed roads and paths which were not straight. The source to channel offsets were altered to compensate for the wave arrival time anomalies due to the curved paths of the profiles.

Figure 1. Locations of the seismic profiles. In the background is 1:50 000 geological map [4].
Manually picked first breaks were used for velocity tomography for near-surface layers combined with calculation of residual statics account for weathering layer and incorrect shot timings. The following processing was performed using Seismic Unix software. The processing flow followed the traditional path with the Kirchhoff prestack depth-migration used to create depth-sections.

**Results and discussion:** In profile 3 the contact between the Bunte breccia containing allochthonous blocks and deep-lying parautochthonous blocks can be distinguished. The outline is seen as several peaks and valleys of prominent reflections. The size of parautochthonous blocks does not follow any general rule regarding the distance from the current crater rim, but seem to be roughly equal in size through most of the profile. The distance between the adjacent crests of the listric faults vary between 500–700 m and the slopes have little or no asymmetry.

The strong reflection between the Bunte breccia and parautochthonous blocks allows for estimating the thickness of the breccia at various locations. The thickness of the breccia reaches its maximum (up to 150 m) in the troughs overlying the footwalls of this fault system. Above the crests, or where the tilted blocks represent hanging walls, the thickness varies between 60–80 m. Bunte breccia and potential suevite patches are not separable from each other, and therefore, the estimated thickness of the breccia might also incorporate suevite.

Apparently topography of parautochthonous blocks and ground surface are not linked suggesting that hilly topography in mega block zone is likely due to variations in resistance to erosion of Bunte breccia and suevite.

While the top of the parautochthonous blocks could be easily seen, the internal structure of the parautochthonous zone remains ambiguous. A strong reflector seen in profile 4 also continues in profile 3 but is soon distorted and largely lost for the rest of the profile. Occasional groups of strong reflectors occur approximately at the same depth but at larger distances.

Profile 4 proves to be a good source of information of the geological setting outside the crater that has been only minimally affected by the cratering process. Here the boundary between the Bunte breccia (ejecta) and sedimentary bedrock is not observed. This is probably due to the small thickness of the breccia cover, that could not be visualized in the near-surface area. However, several prominent reflections occur at deeper levels. These reflections can be interpreted as boundaries of Malm-Dogger and Lias-Keuper lithostratigraphic units, and the top of the crystalline basement. The contact of Lias and Keuper units is likely to be the origin of the strong reflection seen also in profile 3.

It is also seen that the geological units dip southwards (away from the crater) [1], but not as much as previously thought. The tilting is around 130 m per 5 km. Instead of a gradual increase of depth, the reflections make a steeper descent in the southern half of the profile 4. The abrupt change of dip gives a reason to suggest that there might be a larger fault in this area. The thicknesses of the rock sequences are constant throughout the profile and seem to follow the topography of the crystalline basement.

Besides the aforementioned prominent reflections in profile 4, no other clear reflections could be seen. The lack of good reflectors, even in the undisturbed area might be the reason why the megablock zone in profile 3 has only a few reflections from within the parautochthonous blocks. As the contact between the crystalline basement and overlying sediment cover showed only a faint reflection in profile 4, it is even more unlikely that it could be noticed in profile 3.

**Conclusions:** These seismic profiles provide a rare glimpse into the underground structure of the megablock zone of the well preserved Ries impact crater. The outlines of the parautochthonous blocks are well seen at the contact of Bunte breccia. This allows to estimate the thickness of impact sediments that cover the parautochthonous megablocks, ranging from 60–150 m depending on the location of these blocks. For most of the profile these blocks have nearly symmetrical slopes and are of similar size. The ejecta layer is not distinguishable outside the crater due to its small thickness, but the profile gives a good understanding the overall geological setting outside the crater.