SHOCK DISTRIBUTION WITHIN THE CRYSTALLINE EJECTA BLANKET OF THE LOCKNE IMPACT STRUCTURE, SWEDEN. U. Raschke[1,2], [1]Museum für Naturkunde Berlin - Leibniz Institute for Evolution and Biodiversity Science, Invalidenstraße 43, 10115 Berlin, Germany; [2]Freie Universität Berlin, Institut für Geologische Wissenschaften, Malteser Str. 74-100, 12249 Berlin, Email: ulli.raschke@outlook.com.

Introduction: The shock distribution within the crater basement and in impact ejecta is a vital part to understand the impact cratering processes. During the last years impact cratering experiments (MEMIN-Multidisciplinary Experimental and Modeling Impact Research Network) opened a new insight into these processes, on a small scale [1]. The Lockne crater in Jämtland (Sweden) (Fig. 1) provides an almost complete crystalline ejecta blanket that was sampled for shock distribution analysis.

Geological Background: The Lockne crater is situated in Central Sweden (14°40´E, 63°00´N). The target lithologies are middle Ordovician limestones (455 Ma) and crystalline basement at the western continental shelf of Baltica [2]. During the Caledonian orogeny, the crater was preserved by overlying nappes and then exhumed after their erosion.

Fig. 1: Topographic map of the Scandinavian peninsula. The location of the Lockne crater is indicated by a red star.

The central crater depression is 7 km in diameter and is surrounded by an elevated crater rim composed of brecciated and fractured crystalline rock that is interpreted as an overturned ejecta flap [3]. The inner crater is still partly covered by a nappe outlier of the Caledonides. Resurge deposits are preserved inside and outside of the crater. Their presence and numerical models suggest a pre-impact water depth of 500–800 m [4, 5].

Samples and Analytical Work: For the study of shock distribution only samples from the "Tandsbyn-Breccia", outside of the inner crater, were selected. The Tandsbyn Breccia is a monomict impact breccia exclusively comprising fragments of local Revsund granite. The samples were collected during two field campaigns in 2005 and 2013. Polished thin sections were prepared from 21 samples and analyzed by polarizing microscopy. To determine the peak shock pressure of shock metamorphic effects, the crystallographic orientations of c-axes, PF and PDF were measured in 6 quartz grains in 2 thin sections. These thin sections exhibit the highest abundance of shock features (LO-3 and LO-UR-1.6, Fig. 2). With the Leitz universal stage microscope the crystallographic orientations of the PDF were measured and indexed within a reference system after [6].

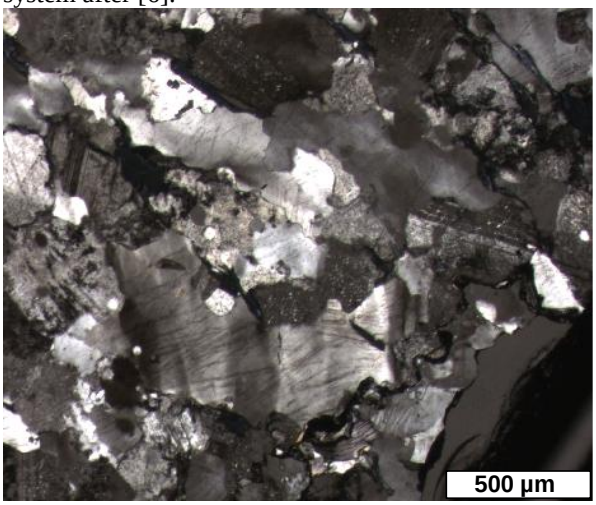

Fig. 2:Shocked quartz grains of the Tandsbyn breccia, sample LO-UR-1.6.

Results: In general, the samples of the crystalline ejecta of the Lockne crater are unshocked to moderately shocked. In 11 thin sections shock metamorphic effects were recorded. A maximum of 3 sets of PDF within a single quartz grain were found. In 10 samples no shock evidence was observed. Most PDF show a crystallographic orientation of (0001), $\{10\bar{1}3\}$ and $\{10\bar{1}2\}$, which indicates a peak shock pressure of approximately 2 to > 10 GPa [7]. In one case a second set

of PDF was oriented {1$\bar{1}$22}. PF occur mainly as 1 set with a (0001) orientation.

The samples that contain shocked quartz show a (local) trend regarding their spatial distribution. The three samples showing the highest shock metamorphism are located in the NW part – in the down range – of the ejecta blanket. The samples containing low shock effects are adjacent to the northeast and southwest from down range. Samples without shock metamorphic effects were found close to the cross range direction of the ejecta curtain (Fig. 3).

Discussion: These are preliminary results and the data base should be extended by a larger number of samples.This work is an important supplement for the ejecta studies of impact craters in general and especially for the shock recovery experiments (MEMIN). Due to experimental conditions and limits it is only possible to produced hypervelocity crater with an impact angle of 90°. One of the aspects of the MEMIN research group is the particle size distribution of ejected material produced by vertical shot experiments into sandstone targets [8]. The asymmetric ejecta distribution of the Lockne crater supports the hypothesis that the projectile hit the Earth with an angle of around 45 degrees from southeastern direction [5].

This study reveals that the highest shocked rocks of the ejecta were deposited in the downrange direction of the projectile path.

Outlook: The results of this work could initiate a new reseach aspect for the investigation of impact craters formed by oblique impacts. The shock recovery experiments and the numerical modelling undertaken by the MEMIN group focus on vertical impact angles. In nature, most impact craters were formed by a projectile with an oblique impact angle.

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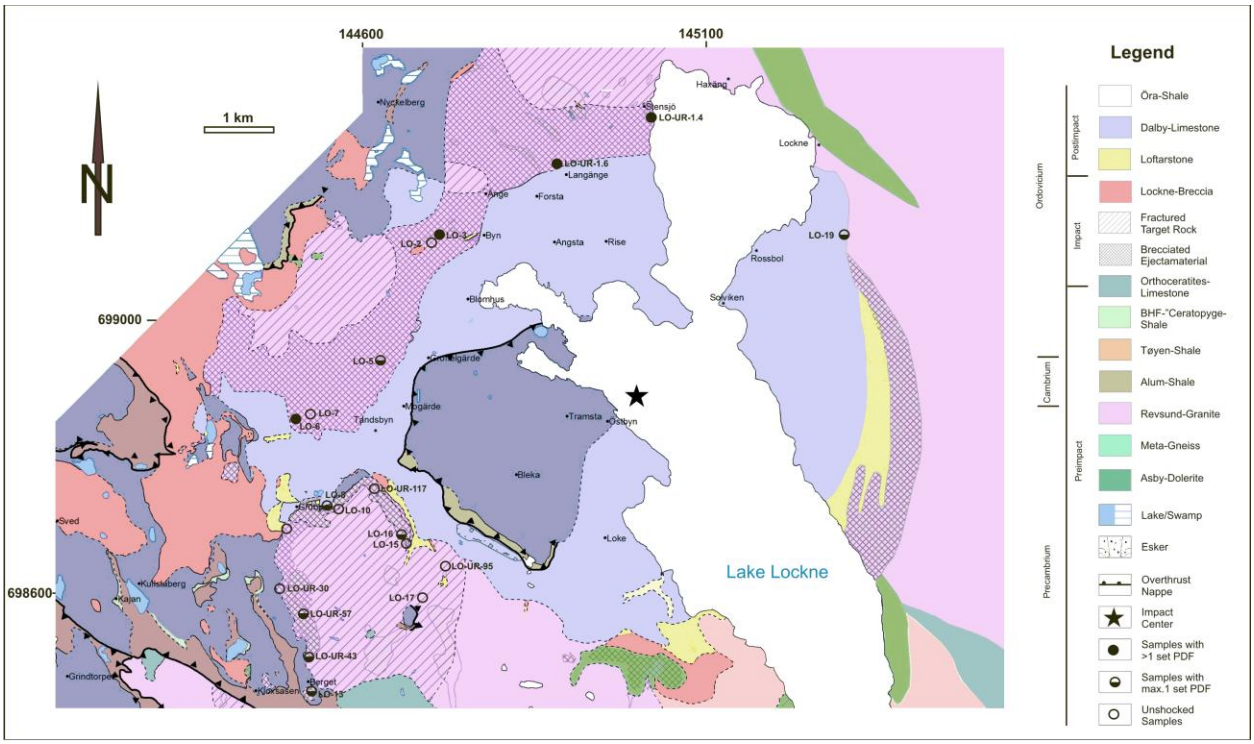

Fig. 3: Geological map of the Lockne impact structure (Sweden) with sample locations of Tandsbyn Breccia (modified after [2, 9]).