EPSC Abstracts
Vol. 8, EPSC2013-1028, 2013
European Planetary Science Congress 2013

Shocked quartz in samples from the Målingen structure – Evidence of an impact

C. Alwmark (1), S. Holm (1), J. Ormö (2) and E. Sturkell (3). (1) Dept. of Geology, Lund University, Sölvegatan 12, 22362 Lund, Sweden (carl.alwmark@geol.lu.se), (2) Centro de Astrobiología (CSIC/INTA), Instituto Nacional de Técnica Aeroespacial, Ctra de Torrejón a Ajalvir, km 4, 28850 Torrejón de Ardoz, Madrid, Spain, (3) University of Gothenburg, Department of Earth Sciences, PO Box 460, SE-405 30 Göteborg, Sweden.

Abstract

Here we present the findings of shocked quartz in drill core samples from the Målingen structure in Sweden, thus proving that the structure is impact derived. Furthermore, the ages of the deposits that fill the depression at Målingen are identical to features at the nearby Lockne impact structure. Thus, Målingen is most likely a small twin crater to Lockne.

1. Introduction

The 700 meter in diameter circular Målingen structure, located in the Jämtland province of central Sweden, has for long been considered a geological anomaly [1–3]. The occurrence of sedimentary breccias in combination with its circular shape and similar age as the nearby ~7.5 km diameter early Late Ordovician Lockne impact structure (N 63°00', E 14°49'; Fig. 1) evoked the suggestion that it is an impact crater formed in conjunction with Lockne [2–4]. However, in the absence of any subsurface information of the structure the hitherto consensus has been that it is a tectonic feature caused by the Caledonian orogeny [5].

In this study, thin sections from samples of the 148.80 meter long Målingen-1 A&B drill core from within the Målingen structure have been investigated and searched for microscopic shock metamorphic features, in an attempt to verify whether the structure is indeed impact derived.

2. Material and Methods

At this point we have studied four intervals of the Målingen-1 A&B drill core; 108 meters, 111 meters, 114 meters and 115 meters. The sampled intervals are all within a polymict breccia that is located at the

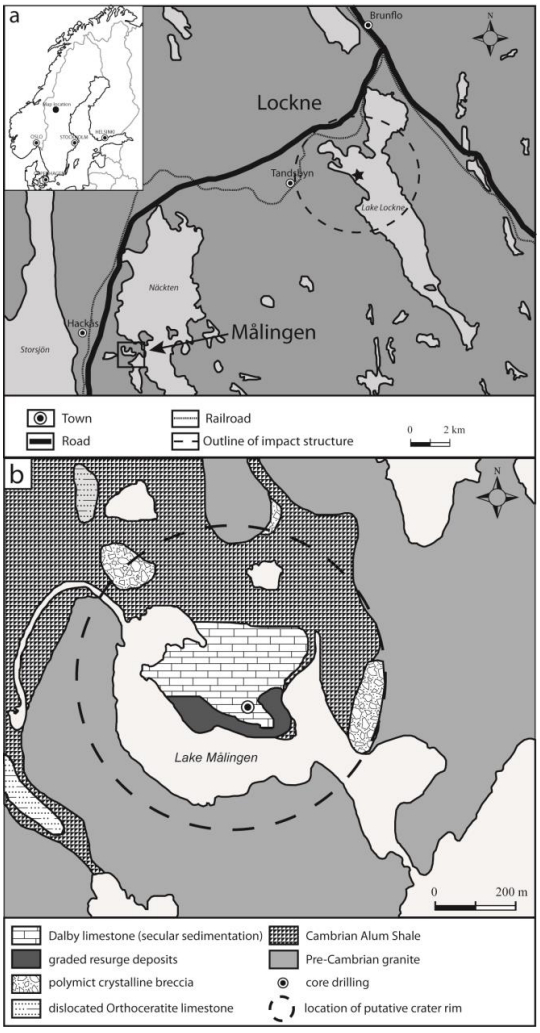

Fig. 1. a) Orientation map of the Lockne and Målingen area. The circle outlines the 7.5 km diameter Lockne impact structure. b) Simplified geological map of the Målingen structure (close-up of the rectangular area in a). Modified from [5].

estimated depth of the true crater floor, below the slump deposits that make up the main part of the infill.

Two thin sections were prepared from each sample and searched for shock metamorphic features in quartz grains under optical microscope. Quartz grains displaying planar deformation features (PDFs) were further studied using a Leitz 5-axes universal stage [6] and the crystallographic orientations of identified PDFs were determined according to techniques described in [7, 8].

3. Results

Shock metamorphic features in the form of decorated PDFs where found in four grains from the 114 meter interval and in two grains from the 111 meter interval. No PDFs could be identified in the 108 and 115 meter intervals. The quartz grains with PDFs are between 100-400 µm in size, angular and commonly display undulose extinction (Fig. 2). Of the six shocked grains, three display a single set of PDFs, two with PDFs oriented parallel to the basal plane *c* (0001) and one with a set parallel to crystallographic plane ω $\{10\bar{1}3\}$. Two grains contain two sets; one set oriented along (0001) and one parallel to crystallographic plane ω $\{10\bar{1}3\}$. One grain displays three sets of PDFs, with one set oriented along (0001) and two parallel to crystallographic plane ω $\{10\bar{1}3\}$.

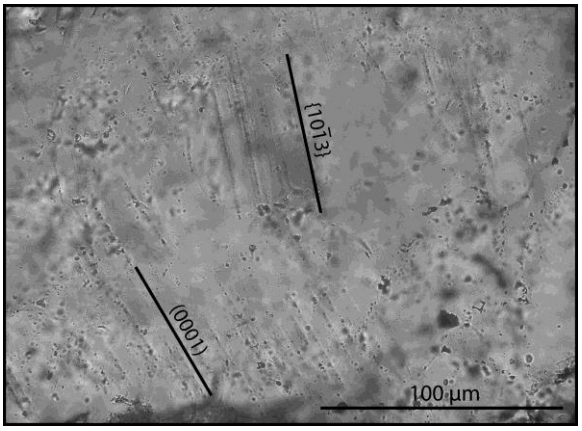

Figure 2. Thin section photomicrograph of shocked quartz grain displaying two decorated PDF sets (uncrossed polars).

4. Discussion and Conclusion

Quartz grains displaying PDFs oriented along crystallographic planes typical for shock metamorphism are present in the Målingen structure. The shocked quartz grains are found in the lower parts of structure below the sediment fill, proving that the shocked material is not transported from e.g., Lockne. Thus, the Målingen structure is indeed impact derived.

The ages of the deposits that fill the depression at Målingen are identical to those of the Lockne impact structure, implying that Målingen is most likely a small twin crater to Lockne. Whether the bolide responsible for the formation of the Målingen structure was a separate object or part of a binary asteroid, is at this stage not known.

References

[1] Thorslund, P.: On the Chasmops series of Jemtland and Södermanland (Tväre n), SGU, Vol. C436, pp. 1–191, 1940.

[2] Sturkell, E., Lindström, M., and Sundblad, K.: Excursion Guide to the Lockne Impact Crater. The identification and characterization of impacts, Second international workshop, Lockne, Sweden, 1994.

[3] Grahn, Y.: Chitinozoan biostratigraphy of the early Caradocian Lockne impact structure, Jämtland, Sweden, MAPS, Vol. 32, pp. 745–751, 1997.

[4] Lindström, M., Sturkell, E., Törnberg, R., and Ormö, J.: The marine impact crater at Lockne, central Sweden, GFF, Vol. 118, pp. 193–206, 1996.

[5] Ormö, J., Sturkell, E., Melero Asensio, I., Frisk, Å., Lepinette, A., and Moro Martin, A.: The Målingen Structure: a Probable Doublet to the Lockne Marine-Target Impact Crater, Central Sweden, LPSC XLII, 7-11 March, 2011, Houston, USA, 2011.

[6] Emmons, R. C.: The universal stage (with five axes of rotation), Geological Society of America Memoir, Vol. 8, pp. 1-205, 1943.

[7] Engelhardt, W. v., and Bertsch, W.: Shock induced planar deformation structures in quartz from the Ries crater, Germany, Contributions to Mineralogy and Petrology, Vol. 20, pp. 203–234, 1969.

[8] Ferrière, L., Morrow, J. R., Amgaa, T., and Koeberl, C.: Systematic study of universal-stage measurements of planar deformation features in shocked quartz, MAPS, Vol. 44, pp. 925–940, 2009.