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Summanen, the twelfth meteorite impact structure in Finland

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Abstract

The Summanen structure (62°39’00’’N, 25°22’30’’E) is located within the Paleoproterozoic Central Finland Granite Belt, Fennoscandian Shield. The structure is hidden under the Lake Summanen and is not directly observable. It owes its discovery to low altitude airborne geophysical data, which revealed a circular ~2.6 km wide electromagnetic anomaly. Two field campaigns were conducted in 2017 to search for rocks with impact signatures. The field-work concentrated on the south-eastern side of the lake following the ice flow direction by the latest (Weichselian) glaciation. A few tens of erratic boulders with shatter cones and striated features along with brecciated rocks were discovered. The microscopic shock metamorphic features out of two shatter cone-bearing samples include up to two sets of planar deformation features (PDFs) in quartz and kink bands in biotite. Based on geological, and petrographic results we conclude that Lake Summanen hides a relatively small, meteorite impact structure, so far of unknown age.

1. Introduction

The Summanen geophysical feature was first identified in the early 2000’s by Jouko Vanne [2]. The observation was based on low altitude aeroelectromagnetic data which revealed circular electromagnetic anomalies. The meteorite impact origin of the Summanen structure has been now proven by [3]. Lake Summanen is located 275 km north from Helsinki (Fig. 1). It is elliptical (8 × 4 km) in shape where the longest axis is in the NW-SE direction due to erosional influence of the Weichselian glaciation. The area deglaciated about 10,700 years ago [4]. Presently, the water level of Lake Summanen is located at 108.5 m a.s.l. and the lake is connected to several other surrounding lakes.

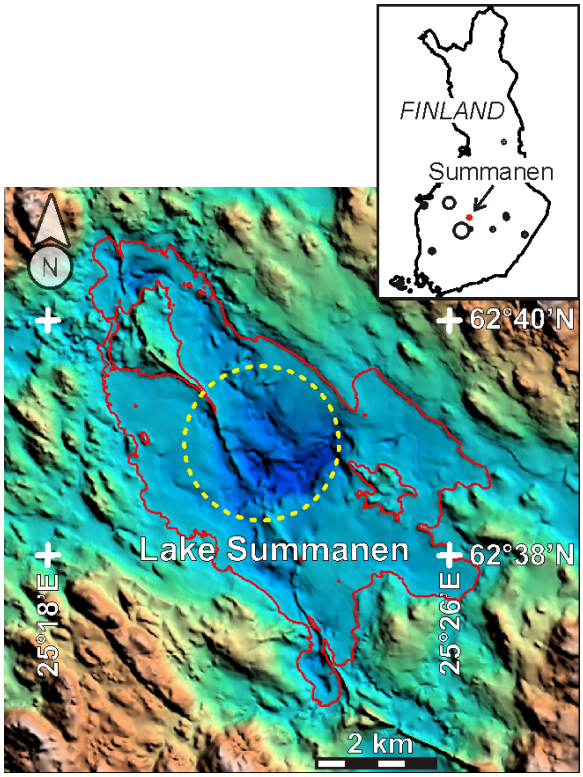

Figure 1: Topographic and bathymetric shaded relief map of the Lake Summanen area. The red line outlines Lake Summanen at the average water level of 108.5 m a.s.l. Max. and min. elevation levels are 231 and 67 m a.s.l., respectively. The maximum depth of the lake is 41 m. The dashed ring with a diameter of ~2.6 km indicates the outline of the proposed crater structure as derived from aeroelectromagnetic data. Inset shows location of the Summanen structure in respect to other Finnish meteorite impact structures.

2. Methods

In 2017, we carried out field campaigns to collect geological data [3], aiming to clarify the origin of the geophysical anomalies. We searched mainly for impact rocks occurring as erratic boulders. Boulder findings were GPS-referenced, lithology was described, photographs were taken and hand samples collected. Seventeen thin sections were prepared. Measurements of PDF orientations were done with the LOMO FS universal-stage (U-stage) mounted on a polarizing microscope. A standard technique described by [1] was followed in measuring the orientation of the c-axis, and poles to PDFs relative to the orientation of the thin section.

3. Results

In two shatter-cone-bearing samples PDFs were identified (Fig. 2). Altogether sixty four measurements of the angle between host quartz c-axes and poles to PDFs were made in 60 quartz grains. In most cases, there was one set of PDFs per grain, usually penetrating the entire grain. Four grains with two sets were found. Eighty three percent of the measured angles between c-axis and poles to PDF are between 20-35°, which with 5° error would correspond to $\{10\bar{1}3\}$ (22.95°) or $\{10\bar{1}2\}$ (32.42°) in most cases. No PDFs with basal (0001) orientation were identified. All PDFs are decorated. Spacings between neighboring lamellae are between 5 and 8 µm. In addition to PDFs, planar features are common, and in rare cases, feather features occur.

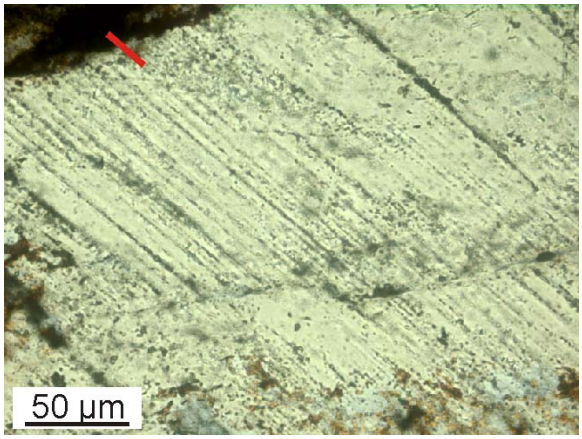

Figure 2: Example of thin section microphotograph of one set of decorated PDFs, taken in cross polarized light.

4. Conclusions

The Summanen impact structure in central Finland, located in a Paleoproterozoic granitic terrain of the Fennoscandian Shield, was discovered due to pronounced aeroelectromagnetic anomalies. The anomalies coincide with the central part of Lake Summanen and are circular, unlike the lake's shoreline that was sculptured by the Weichselian glaciation. The identification of shatter cones in glacially derived erratic boulders, and multiple sets of planar deformation features in quartz prove that the structure is of impact origin. The Summanen structure is the twelfth confirmed impact structure in Finland.

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