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Impact melt boulder from northern Sweden from an unknown source

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Abstract

We report an impact melt rock finding from northern Sweden, near the village of Kitkiöjärvi. There is no confirmed meteorite impact structure nearby, thus, the source is currently undiscovered. The impact origin of the finding was confirmed by the presence of planar deformation features (PDFs) in quartz.

1. Introduction

Impact cratering is a common and frequent process that affects the planetary surfaces across the solar system throughout geologic time. On Earth, there are 191 confirmed impact structures which are distributed unevenly around the globe. The Fennoscandian Shield houses around 10% of them. Here, we report an impact melt rock finding that originates from an unknown structure in northern Sweden. The semi-rounded impactite boulder, sized 10 × 7 cm, was found by Tapio Soukka in 2017 from a gravel pit at the western side of village Kitkiöjärvi (67°46'16"N 23°03'06"E; Fig. 1).

2. Methods

Mineralogical composition of the whole rock sample was studied by X-ray diffractometry (XRD) and modelled using the Rietveld algorithm-based program Siroquant in the University of Tartu. Two thin sections were prepared and characterized using a standard polarizing microscope with universal-stage (LOMO FS) mounted on it. In addition, thin sections were studied using a ZEISS EVO MA15 scanning electron microscope (SEM) with Oxford AZTEC-MAX energy-dispersive detector (EDS) attached to the SEM.

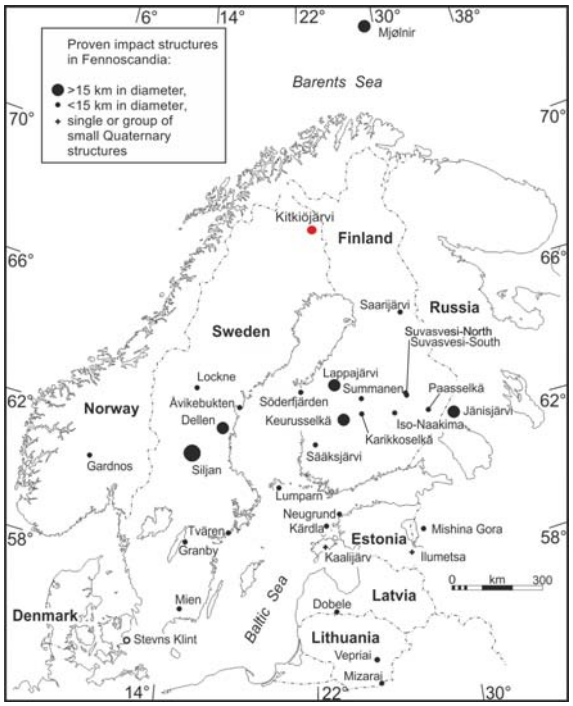

Figure 1: Proven impact structures in Fennoscandia. Location of Kitkiöjärvi impactite is marked by red circle (modified after [1]).

3. Results and discussion

XRD shows that the sample is composed of K-feldspar (66.3 wt%), plagioclase (12.3 wt%), quartz (11.7 wt%), and clay minerals (9.8 wt%). Mineral grains and lithoclasts are rounded to angular (Fig. 2A), mostly composed of feldspar and quartz. Rare biotite is chloritized and shows kink banding. Planar deformation features (PDFs) are common in quartz (Fig. 2B). PDFs are decorated and appear mostly as one or two sets. Quartz also exhibits

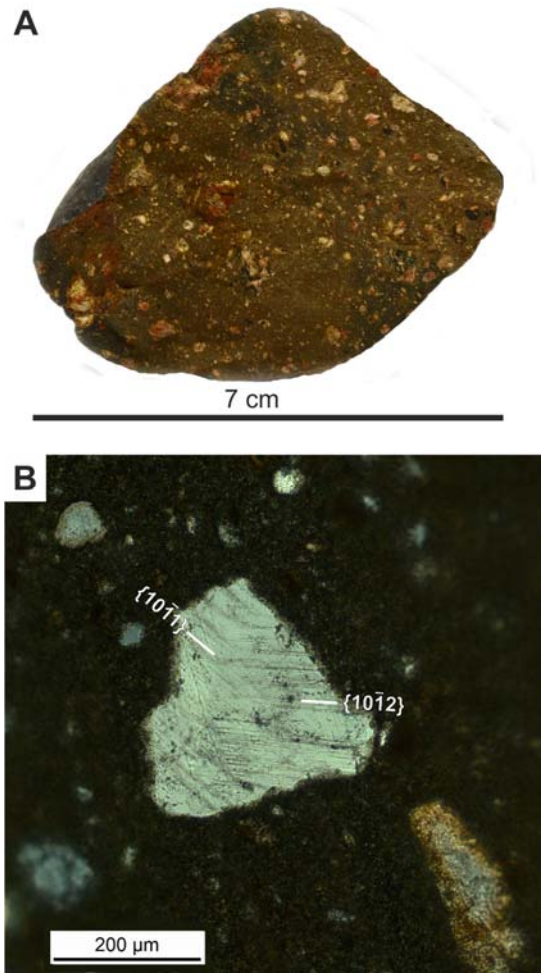

Figure 2: (A) clast-poor impact melt boulder. (B) two sets of PDFs in anhedral quartz grain, XPL.

structure similar to chert-like ballen quartz. Groundmass is aphanitic (recrystallized) and consists of cryptocrystalline K-feldspar.

3.1 Origin of the Kitkiöjärvi impactite

With the identification of PDFs in the Kitkiöjärvi sample, we have proven its impact origin since the PDFs in quartz are the most commonly used indicator to prove an impact origin of the rock sample/structure. The PDFs are formed in pressure range from 5 to 35 GPa [2], which are experienced only in the impact cratering process. There are, however, no known meteorite impact craters nearby that could serve as source structures for the present finding.

We note that Kitkiöjärvi is just a few kilometres apart from the Muonionalusta octahedrite field [3] but the meteorites from the latter and the Kitkiöjärvi impactite unlikely result from the same event. First, impact glass in Kitkiöjärvi impactite has recrystallized to cryptocrystalline K-feldspar hinting for the significantly greater age than the terrestrial age of Muonionalusta is >0.8 Ma [4]. Second, formation of the PDFs in Kitkiöjärvi impactite required pressures >5 GPa, which hints for a cratering process. On the contrary, large size (25 × 15 km) of the present Mounionalusta strewn field and the undisturbed nature of the saprolite of the area [5] suggest that the Mounionalusta meteoroid was not a cratering one.

4. Conclusions

We report an impactite (melt) finding from northern Sweden. Impact origin of the melt rock sample was confirmed by the identification of planar deformation features in quartz. The source of this boulder has to be a currently unknown meteorite impact structure, as the nearest known impact structure (Saarijärvi) is 350 km away. Hence, further geological studies of the area are required to find a source of this impactite.

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