MICROSTRUCTURAL CHARACTERIZATION OF SHOCKED ZIRCON AND MONAZITE FROM THE SÄÄKSJÄRVI IMPACT STRUCTURE, FINLAND – TOWARDS PRECISE U-Pb DATING OF SMALL IMPACT STRUCTURES. Gavin G. Kenny[1]*, Irmeli Mänttäri[2], Martin Schmieder[3,4] and Martin J. Whitehouse[1] [1]Department of Geosciences, Swedish Museum of Natural History, SE-104 05 Stockholm, Sweden, [2]Radiation and Nuclear Safety Authority, Laippatie 4, Box 14, FI-00811 Helsinki, Finland, [3]Lunar and Planetary Institute – USRA, Houston TX 77058, USA, [4]HNU – Neu-Ulm University of Applied Sciences, D-89231 Neu-Ulm, Germany. *gkennyeire@gmail.com

Introduction: Small impact structures in crystalline basement have a unique ability to shed light on the temporal and spatial extent of paleobasins. Accurate and precise age dating of such structures indicates that basement was not deeply covered by sediments at a given time and can therefore be used to test and place boundaries on the size and lifetime of sedimentary basins which might otherwise be difficult to constrain.

The Sääksjärvi impact structure, southwestern Finland, is an approximately 6 km diameter impact structure which formed in crystalline rocks of the Precambrian Fennoscandian (or Baltic) Shield. Sääksjärvi has historically represented a complication for modelled sedimentary cover of the Caledonian foreland basin. Ar–Ar age dating of the Sääksjärvi structure has been interpreted to indicate an impact age of 330 Ma or younger [1] or an age of approximately 560 Ma [2]. If an age of *ca.* 330 Ma had been accurate this would have made Sääksjärvi the only impact structure in crystalline basement in Sweden or Finland between ~500 and ~200 Ma [3] and would have questioned models for the Caledonian foreland basin in the region [e.g., 4-6]. However, U–Pb results for shocked zircon grains in melt rock and suevitic impact breccia from Sääksjärvi indicate an age of *ca.* 600 Ma [7], consistent with the Caledonian foreland basin model.

The U–Pb age of 602 ± 17 Ma (2.8 %; MSWD = 2.6; n = 31) reported for Sääksjärvi by [7] is a lower intercept age calculated from an array of data points plotting between the *ca.* 1850 Ma age of the target rocks and the *ca.* 600 Ma impact age. The location of U–Pb spot analyses of [7] were decided on the basis of scanning electron microscope (SEM) images of shocked zircon grains and the spot size was approximately 30 µm, making it difficult to isolate purely impact-aged domains within complex grains. In recent years, two analytical developments have improved our approach to dating shocked grains: U–Pb analysis is generally preceded by microstructural characterization

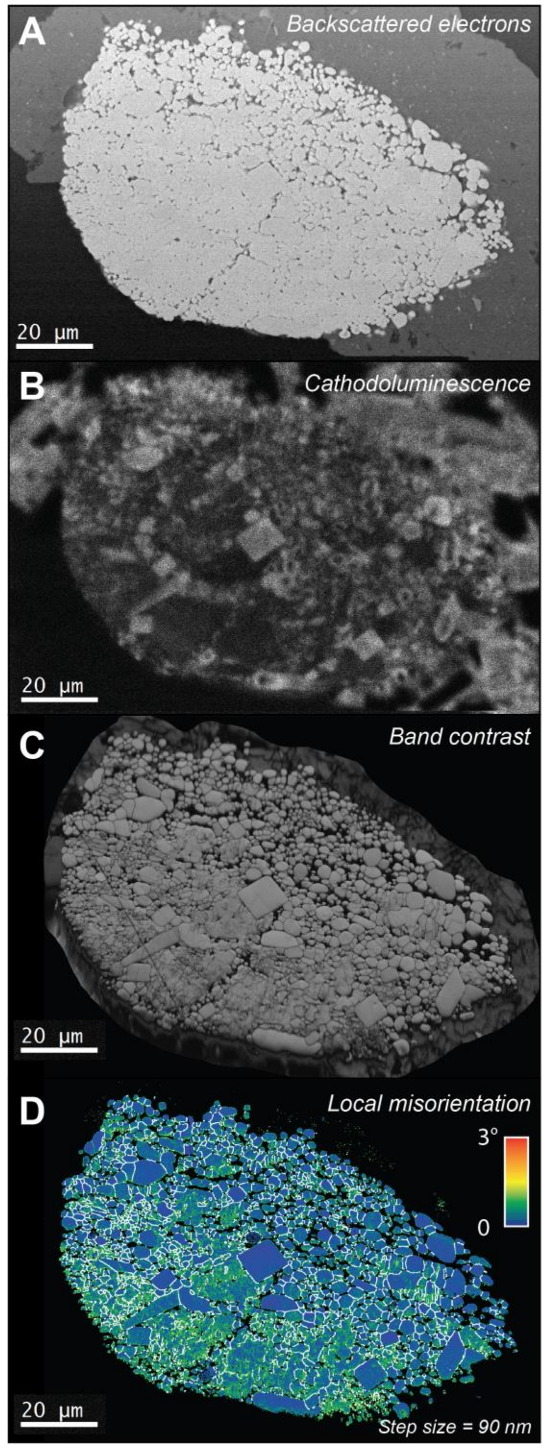

Fig. 1. Imaging and microstructural characterization of a recrystallized zircon grain from the Sääksjärvi impact structure, Finland. In D, misorientation is calculated as the average misorientation between a pixel and its nearest neighbors in a 3x3 grid. Grain boundaries (white) defined by neighboring pixels with >2° misorientation.

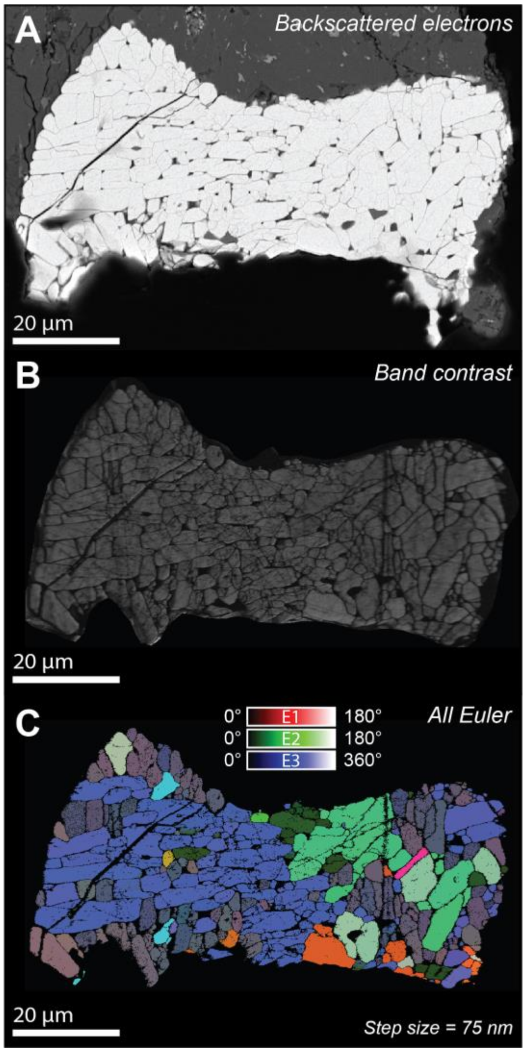

Fig. 2. Imaging and microstructural characterization of a recrystallized monazite grain from the Sääksjärvi impact structure, Finland.

of shocked minerals by electron backscatter diffraction (EBSD) mapping (e.g., [8, 9]) and U–Pb spot sizes of 10 µm or less are now routine, meaning that recrystallized domains can be isolated and concordia ages with uncertainties of just ±1 % achieved [9].

Here we apply state-of-the-art methods of microstructural characterization to zircon and monazite from a new sample of impact melt rock from Sääksjärvi as well as the zircon grains previously studied by [7] to develop new targets for high spatial resolution secondary ion mass spectrometry (SIMS) U–Pb analysis.

Methods: Zircon and monazite grains were separated from whole-rock samples by crushing and milling and concentrated by magnetic and heavy liquid separation. The grains were mounted in epoxy and polished with a diamond suspension to expose their interiors before undergoing a final polish with colloidal silica. Imaging of the grains in backscattered electron (BSE) and cathodoluminescence (CL) mode, as well as microstructural characterization by EBSD analysis, was undertaken on an FEI Quanta FEG 650 SEM at the Swedish Museum of Natural History, Stockholm.

Results: Microstructural characterization by EBSD analysis reveals recrystallization textures in zircon and monazite from the Sääksjärvi impact structure.

In zircon, newly grown, low-strain microcrystallites, or neoblasts, occur in a variety of styles: some display euhedral morphologies and reach approximately 20 µm in length (e.g., Fig. 1) whereas others display smaller, rounded morphologies and form clusters with crystallographic orientations indicative of formation after the high-pressure $ZrSiO_4$ polymorph reidite (not shown; [10]). Reidite itself was not directly observed and only minor occurrences of ZrO_2 were documented.

Low-strain recrystallized domains in monazite also reach 20 µm in length with some monazite grains apparently entirely composed of neoblasts (e.g., Fig. 2).

No microtwins were encountered in either zircon or monazite.

Conclusions: Microstructural characterization of zircon and monazite from the Sääksjärvi impact structure, Finland, reveals discrete recrystallized domains that are difficult to discern with traditional SEM imaging alone. These constitute new targets for high spatial resolution SIMS U–Pb analysis with the aim to place a precise age on the Sääksjärvi impact event. Refined protocols in characterization and U–Pb analysis of shocked minerals has great potential for the relative quick and efficient absolute age dating of terrestrial impact craters. Application to small craters (both those which are currently known and those yet to be discovered) is likely to help constrain the lifetime and spatial extent of sedimentary basins in deep time.

Acknowledgments: This project received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie Individual Fellowship Grant Agreement No. 792030, supporting Kenny. We thank Kerstin Lindén for tireless support with sample preparation.

References: [1] Bottomley R. J. et al. (1990) *Proc. Lunar Planet. Sci. Conf., 20,* 421–431. [2] Müller N. et al. (1990) *Meteoritics & Planet. Sci., 25,* 1–10. [3] Schmieder M. and Kring D. A. (2020) *Astrobiology, 20, doi: 10.1089/ast.2019.2085*. [4] Larson S. Å. And Tullborg, E.-L. (1998) *Geology, 26,* 919–922. [5] Larson S. Å. et al. (1999) *Terra Nova, 11,* 210–215. [6] Cederbom C. (2000) *Tectonophysics, 316,* 153–167. [7] Mänttäri I. et al. (2004) 32nd IGC, Abstract #1434. [8] Erickson T. M. et al. (2017) *Contrib. Mineral. Petrol., 172:* 11. [9] Kenny G. G. et al. (2019) *Geochim. Cosmochim. Acta, 245,* 479–494. [10] Cavosie A. J. et al. (2016) *Geology, 44,* 703–706.