A HIGH-PRECISION LATE MESOPROTEROZOIC ^{40}Ar/^{39}Ar AGE FOR THE KEURUSSELKÄ IMPACT STRUCTURE (FINLAND). M. Schmieder[1], F. Jourdan[2], S. Hietala[3], J. Moilanen[4], T. Öhman[5] and E. Buchner[1], [1]Institut für Planetologie, Universität Stuttgart, Herdweg 51, D-70174 Stuttgart, Germany, martin.schmieder@geologie.uni-stuttgart.de, [2]Western Australian Argon isotope facility, Applied Geology & JdL-CMS, Curtin University of Technology, GPO Box U1987, Perth WA 6845, Australia, [3]Kiveläntie 2 B 13, FI-42700 Keuruu, Finland; [4]Pinkelikatu 6 B 48, FI-90520 Oulu, Finland, [5]Department of Geosciences, P.O. Box 3000, FI-90014 University of Oulu, Finland.

Introduction and background: In a list of eleven impact structures detected to date in Finland, Keurusselkä is the latest addition [1-2]. The impact structure, with an estimated original diameter of up to ~30 km [3-4], is hosted by ~1880 Ma Paleoproterozoic crystalline rocks of the Svecofennian Domain, mainly granites, granodiorites, quartz diorites, mica schists, as well as subordinate gabbroids and volcanics of the Central Finland Granitoid Complex [1-2]. Due to deep erosion of the Keurusselkä impact structure down to the subcrater basement, only shatter cones and one boulder of granite-derived lithic impact breccia have previously been reported [1;4]. Shatter cones occur in a ~14 km wide circular area thought to represent the eroded remnants of the central uplift [2]. The general lack of impact melt lithologies precluded isotopic dating of the Keurusselkä impact structure, and only the age of the Paleoproterozoic host rocks constrained a maximum impact age of ~1880 Ma; the minimum impact age was tentatively estimated at ~600 Ma based on the erosion level of the target rocks [2]. Other estimates for the age of the impact are 1.25-1.8 Ga [5] and <1.0 Ga [6].

New findings: The recent detection of a ~2-cm-wide dark pseudotachylitic breccia dike near Kirkkoranta in the central part of the impact structure by two of the authors (S.H. and J.M. in fall 2006; the dike outcrop is usually below the Lake Keurusselkä water level) provides, for the first time, impact-related friction melt rocks (e.g., [7-8]) suitable for radioisotopic dating. As the pseudotachylitic breccia dike crosscuts *in situ* shatter cones in granite (Fig. 1a), the dike plays a key role in the local (syn- to post-impact) geochronological evolution. In thin section, the pseudotachylitic breccia is composed of variable amounts of crystalline lithic and mineral clasts (mainly K-feldspar, quartz, plagioclase, mica, and amphibole) together with irregularly shaped partially to completely molten and recrystallized feldspar within a glassy to cryptocrystalline matrix that locally exhibits a fluidal fabric; clast-poor domains also occur (Fig. 1b). Shock metamorphic features in both the pseudotachylitic breccia and the shatter-coned granitic wallrock comprise planar fractures in quartz (Fig. 1c) indicative of shock pressures in the range of ~2-8 GPa [8]. Geochemical measurements yielded an intermediate (~55-62 wt% SiO_2) and potassic (~8-13 wt% K_2O) composition of the melt matrix, thus, potentially being an ideal candidate material for ^{40}Ar/^{39}Ar dating.

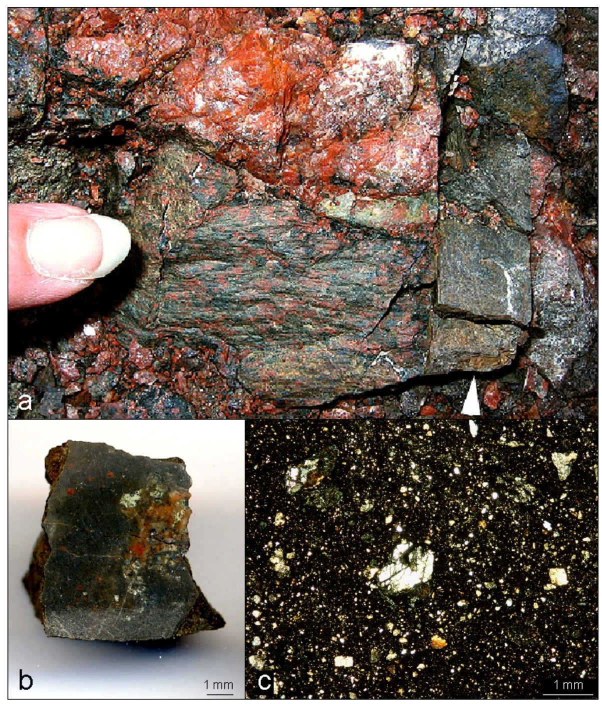

Fig. 1: The Kirkkoranta pseudotachylitic breccia; a) field photograph of the breccia dike (white arrow) crosscutting *in situ* shatter cones in granite; finger for scale (photograph by Satu Hietala); b) polished endcut with clast-poor melt domains (dark) and granitic target rock clasts; c) thin section photomicrograph of clast-rich breccia domain showing quartz with planar fractures (centre) within an optically isotropic matrix (crossed polarizers).

^{40}Ar/^{39}Ar dating results and interpretation: Step-heating analysis of the least altered and largely clast-free parts of the Kirkkoranta pseudotachylitic breccia (for sample treating and preparation procedures see [9]) was carried out at the Western Australian Argon isotope facility, Curtin University of Technology. Four of five aliquots (samples KEU-1 to KEU-5) yielded one plateau and three mini-plateaus comprising 90% and between 51-56% of total ^{39}Ar released, respectively, and with age ranging from 1152 ± 5 Ma to 1140 ± 6 Ma. Heating of sample KEU-3 resulted in an irregular release spectrum. All samples showed some indication of argon loss in the low temperature extraction steps (younger apparent ages), probably due to alteration or argon recoil redistribution [9-10]. The more robust age is given by sample KEU-4 that yielded a plateau over 90% of the total ^{39}Ar released, indicating a weighted plateau age of 1140 ± 6 Ma (2σ) with a MSWD of 0.11 and a probability *P* of 0.98 (Fig. 2a). No meaningful age and ^{40}Ar/^{36}Ar intercept value could be derived from the inverse isochron due to a clustering of the data near the radiogenic axis. In contrast, sample KEU-1 with a mini-plateau age of 1150 ± 6 Ma (2σ), MSWD=0.79, and *P*=0.54; sample KEU-2 with a mini-plateau age of 1152 ± 5 Ma (2σ), MSWD=1.9, and *P*=0.098 (Fig. 2b); as well as sample KEU-5 with a mini-plateau age of 1145 ± 5 Ma (2σ), MSWD=1.3, and *P*=0.25 exhibited slightly hump-shaped plateaus, which suggests the presence of a combination of inherited ^{40}Ar from undegassed K-rich phases (apparently older ages) and recoil-induced redistribution of ^{39}Ar within the samples [9-12]; thus, these mini-plateau ages are less robust compared to KEU-4. A lower K/Ca ratio (3.125 ± 1.343) indicates that sample KEU-4 is probably not disturbed by inherited argon and that, therefore, this age reflects the formation age of the pseudotachylitic breccia within uncertainty. Importantly, the ~1140-1150 Ma Mesoproterozoic ages are not compatible with the Paleoproterozoic deformational history of this part of the Svecofennian Domain (i.e., no other rocks of Mesoproterozoic age are known from this region) but in good agreement with the Keurusselkä impact as a temporally and spatially singular resetting event.

Discussion and conclusions: The recently detected Kirkkoranta pseudotachylitic breccia dike is the first finding of impact-related melt lithologies known from the deeply eroded Keurusselkä impact structure, Finland. Based on our ^{40}Ar/^{39}Ar dating results, considering the high precision of the KEU-4 data yields, we interpret the undisturbed late Mesoproterozoic (Stenian [13]) 1140 ± 6 Ma (2σ) plateau age of the pseudotachylitic breccia as the age for the Keurusselkä impact event and concomitant formation of friction melts within the central uplift. The slightly older ~1150 Ma ages probably reflect the incomplete degassing of Paleoproterozoic target rock material incorporated in the melt. Maybe together with the poorly dated (Meso- to Neoproterozoic?) Iso-Naakkima impact structure, Finland [14] and the remnants of a Mesoproterozoic impact structure in Scotland (proximal ejecta blanket deposits of the Stac Fada Member) [15], this places Keurusselkä amongst the oldest known impact structures in Europe and, moreover, within the short list of the oldest terrestrial impact structures that were precisely dated by isotopic methods. Additional measurements and further refining of the Keurusselkä impact age, together with detailed petrographical-geochemical studies, are currently ongoing.

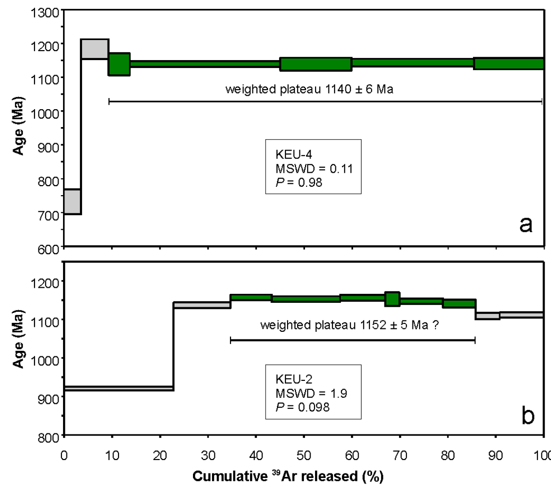

Fig. 2: Age spectra for the Kirkkoranta pseudotachylitic breccia; a) sample KEU-4; b) sample KEU-2.

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