DETERMINATION OF PRODUCTION RATES OF COSMOGENIC HE AND NE IN METEORITIC CHROMITE GRAINS. Ph. R. Heck[1], B. Schmitz[2], H. Baur[1] and R. Wieler[1], [1]Isotope Geology, NO C61, ETH, CH-8092 Zürich, Switzerland, heck@erdw.ethz.ch, [2]University of Lund, Department of Geology, Sölvegatan 12, SE-22362 Lund, Sweden.

Introduction: Chromite grains from fossil meteorites are very resistant to alteration and retain cosmogenic noble gases even after complete pseudomorphosis of most other minerals in the meteorite and diagenesis of the target sediments [1, 2]. Unusually short cosmic ray exposure ages of ~10^5 to ~10^6 years have been determined from chromites in fossil meteorites found in marine limestone in southern Sweden [3]. These meteorites are thought to be fragments of a major asteroid disruption event about 480 Myr ago (L chondrite parent body break-up). Their exposure ages increase with higher position in the stratigraphic column and the difference between the lowest and highest exposure age matches the total sediment deposition time. This shows that relict chromite grains allow a reliable determination of cosmic-ray exposure ages of fossil meteorites. [3]

So far, production rates for cosmogenic ^{3}He and ^{21}Ne in chromites had to be based on physical model calculations [4], because no measured data was available. A particular problem is the lack of cross section data for Cr, which is a major target element for cosmogenic nuclide production in chromite ($FeCr_2O_4$). ^{21}Ne production in chromite might also be enhanced due to recoiled nuclei from formerly adjacent silicates, if the outermost few μm of the original chromite grain would have survived up to analysis. Therefore, production rates in [3] were assigned a large uncertainty of ~40% (incl. uncertainty due to unknown shielding). Besides oxygen, chromium is the most important target element for the production of cosmogenic ^{3}He and contributes on the order of 15% to the total ^{21}Ne production.

The goal of this study is a direct determination of ^{3}He and ^{21}Ne production rates in chromite by comparing measured ^{3}He and ^{21}Ne concentrations in chromite separates from several meteorites with the published cosmic ray exposure ages of these meteorites. At the conference, we will complement the literature bulk sample data with own measurements from samples adjacent to those used to prepare the chromite grains.

Samples and Experimental: Five ordinary chondrites, Mt. Tazerzait (L5), St. Séverin (LL6), Eva (H5), Hessle (H5) and Harleton (L6), with relatively high exposure ages of ~15 – 60 Myr were selected for this study. We choose meteorites whose ^{22}Ne/^{21}Ne ratios were in a range around 1.11, indicating "average" shielding and hence allowing a relatively reliable determination of shielding-corrected exposure ages. Chromite grains in a size range of roughly 80-100 μm were extracted, selected and analyzed as described in [3], except that HF was used instead of HCl. Each sample comprised several grains and total sample masses ranged between 4 - 23 μg. He and Ne isotopes were measured using an ultra-high-sensitivity mass spectrometer equipped with a compressor source [5]. Exposure ages of bulk meteorites were calculated according to [6] using published ^{3}He and ^{21}Ne data [7] with shielding corrections based on ^{22}Ne/^{21}Ne ratios. In all cases these ages are in good agreement with values predicted by the model of [4] for shielding conditions indicated by the ^{22}Ne/^{21}Ne parameter.

Results: We have analyzed 9 batches of chromite grains from the five meteorites. Cosmogenic ^{3}He as well as ^{21}Ne concentrations in different samples from the same meteorite always agree within 2σ. Fig. 1 shows that both ^{3}He and ^{21}Ne concentrations correlate linearly with the adopted exposure ages. The slopes of the best linear fits give the following production rates: P(^{3}He) = $(1.86 \pm 0.10)\cdot10^{-8}$ cm^3 STP g^{-1} Myr^{-1}; P(^{21}Ne) = $(6.57 \pm 0.43)\cdot10^{-10}$ cm^3 STP g^{-1} Myr^{-1}. The new ^{3}He value is about 50% higher than the modeled value of $(1.23 \pm 0.49)\cdot10^{-8}$ cm^3 STP g^{-1} Myr^{-1} used in [3], whereas the new ^{21}Ne production rate falls in the range of the previous values of (4.7-7.2)$\cdot10^{-10}$ cm^3 STP g^{-1} Myr^{-1}. The variable ^{21}Ne production rates used in [3] were mainly the result of somewhat variable Mg concentrations in the fossil chromites.

Discussion and Conclusions: We have shown that the ^{3}He and ^{21}Ne production rates in meteoritic chromites used by [3] were basically correct. The somewhat large difference between the previous and new ^{3}He value is of no practical concern, as concentrations of cosmogenic ^{3}He in the fossil chromites were compromised by diffusive losses [3]. The good agreement of old and new ^{21}Ne values, on the other hand, is very satisfying. It further confirms the conclusion [3] of very low exposure ages of the fossil meteorites. Relict extraterrestrial chromite grains are thus very valuable, e.g., to test dynamical models of the delivery of extraterrestrial material to Earth.

Acknowledgements: ETH Zürich partially funded this project.

References:

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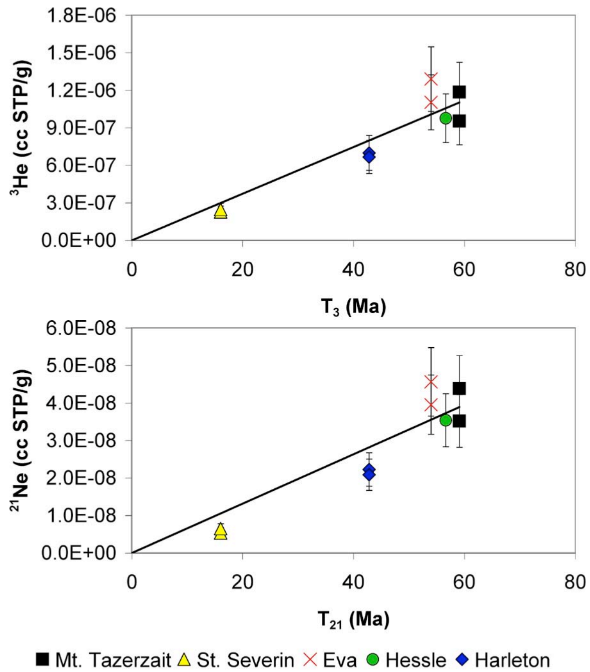

Fig. 1. Measured cosmogenic ^{3}He- and ^{21}Ne-concentrations in meteoritic chromite separates plotted against average exposure ages (T_3, T_{21}) calculated from published ^{3}He and ^{21}Ne data for bulk meteorites [7]. The slopes of the best linear fits give the production rates listed in the text. Error bars are 2σ.