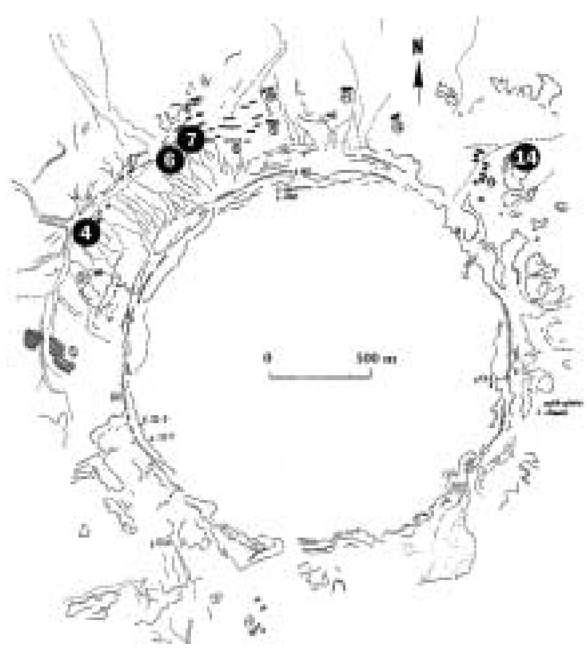
THE AGE OF TENOUMER CRATER, MAURITANIA, REVISITED. Storzer D., Sélo M., Latouche L., and Fabre J., Muséum National Histoire Naturelle, Dept. Histoire de la Terre, 61 rue Buffon, 75005 Paris, France (storzer@cimrs1.mnhn.fr).

Introduction : On occasion of two field trips through the Mauritanian Western Sahara, one of us (J.F.) crossed twice the Tenoumer area and extensively collected target- and impact melt-rocks. The Tenoumer crater [1] is a moderately large (diameter about 1.9 km) almost perfectly circular explosion crater located at 22°55'N/10°24'W. The crater is filled with unconsolidated fresh-water sediments. The structure is developed in the Precambrian basement of the up to 3.5 Ga [2] old gneisses and granites of the Reguibat rise which in turn is overlain by a thin veneer of silcretes and calcretes, the post Pleistocene "hamada". The crater was first described by [3] and interpreted as the result of an explosion of post "hamada" age. Due to the rare occurrence of fused igneous materials outside the crater, "basalt" [1,3], "rhyodacite" [4], a volcanic origin was favored. Together with Temimichat-Ghallaman and Aouelloul, two other Mauritanian craters, Tenoumer is almost perfectly aligned along an about N 40° E trending line. For this reason it was speculated that all three structures might have resulted from a triplet impact cratering event [5]. Although a possible origin by meteorite impact was already proposed by [6], clear and diagnostic evidence for the origin of Tenoumer crater by meteorite impact was first given by [7]. Up to eight different sets of planar features were described in quartz grains from strongly shocked granitic basement rock inclusions trapped by the melt samples. K-Ar age determinations [7] on melt rocks established an average value of 2.5 ± 0.5 Ma for the most reasonable age of the Tenoumer crater, whereas specimens of unshocked basement granites and gneisses, yielded K-Ar ages of about 2 Ga. K-Ar dating has been successfully applied to tektites and impact glasses in the past [e.g.8]. However, it was also realized at that time that the presence of undetectable inherited radiogenic Ar might considerably increase K-Ar ages. On example of impact glasses from the craters: Aouelloul, Darwin, and Wabar, which were aliquots of the same samples used by [8] for the K-Ar analyses, it was demonstrated by fission track dating [9] that this age increase was especially marked in the case of young craters on old country rocks. This effect is the more pronounced the younger the events and the older the targets are. Since the K-Ar age of the Tenoumer crater has never been reconsidered during the last 33 years, and as new and precisely documented material was available for fission track dating, we felt motivated to reinvestigate the timing of this impact event. As impact-glass in a quality required for fission track dating is not available, apatite represents the only datable phase among the impact melt-rocks of Tenoumer. Although the apatites were part of the Precambrian country rocks, the residual temperature of the melt rocks after the impact was sufficiently high in order to reset completely the apatite fission track clock (e.g. 380 °C prevailing for 1 hour). Former age results for the Rochechouart crater (France) and the Ries crater (Germany) [10,11], demonstrated clearly the applicability of apatites, trapped in impact melts, to the dating of impact structures. In the following, we present a detailed account of the age obtained from fission track analysis of apatites trapped in Tenoumer impact-melt rocks.

Experimental : For the measurements four, about one kg, samples of impact-melt rocks were selected among the different rock collection sites. These four sites are shown in the figure.



Tenoumer crater, Mauritania. The sites of melt- and crystalline- rocks used in this study are in bold type.

For comparison with apatites thermally unaffected by the specific impact event and only affected by the regional geologic thermal history, a further one kg reference sample of only slightly shocked granite was selected from site n° 14. These five bulk samples were crushed and apatites were extracted from three melt rocks and the granite. In impact rock n° 14 no trace of apatite was observed. Apatites in the size-range between 100 µm and 150 µm were separated by conventional heavy liquid and magnetic separation techniques followed by a purification of the apatite concentrates through hand-picking under a binocular microscope.

Fission track analyses were performed on apatites applying the "external detector" technique. Individual apatite crystals from the three melt rocks and from the one granite respectively, were mounted in clear epoxy, polished, and the fossil fission tracks revealed in a solution of 5% HNO_3, at 23 °C for 45 sec. Covered with KAPTON as an external fission track detector, the four apatite mounts were afterwards irradiated with a time - integrated thermal neutron flux of 1.42 x 10^{15} n/cm^2, together with a 14.87 ± 0.36 Ma old Moldavite age standard [12] and NBS reference glass : SRM 613. The irradiation was performed in the most thermalized position, canal 8, of the swimming pool reactor Thetys at Gent (Belgium). The induced fission tracks, recorded on the external track detector KAPTON were revealed in an aqueous solution of 14 % NaClO + 12 % NaCl, at 100°C, for 8 min.. Fossil and induced fission tracks were counted with an optical microscope under the high magnification of 1600 x. The constants used for calculating the fission track ages are given in [12]. It should be noted, that the fossil fission tracks in the apatite crystals were recorded and developed by etching in a 4π-geometry. The induced fission tracks on the KAPTON external detector, however, only in 2π-geometry. Therefore, this difference in registration geometry has to be corrected by the factor of 1.651 [13]. For details on the technique and analytical data treatment, see [13,14].

Results and Discussion : The apparent mean fission track age of the unshocked reference granite, averaged over 20 apatite crystals, converge to 87.3 ± 3.9 Ma. This age is interpreted as a cooling age (uplift above the 120 °C isotherme), and is assumed to be representative for the thermal history of the local crystalline basement, just prior to the impact event. The apparent mean fission track age of the three melt rocks, averaged over 140 apatite crystals, and based on five fossil fission tracks, converge to only 21.4 ± 9.7 Ka. Hence, without any ambiguity, the fission track record of the melt rock apatites was thermally erased by the impact event and the fission track clock reset. The individual age results of the fission track age determinations for the three apatite separates are : n°4 : t = 36.7 ± 18.7 Ka ; n°6 : t ≤31 Ka ; n°7 : t = 20 ± 20 Ka. The five fossil fission tracks were counted over a total area of 3.17 mm^2 and the high magnification (1600 x) makes it unlikely that any tracks were missed. On the other hand, lowering of the fission track ages due to track fading is also unlikely because of the relatively high retention temperature of fission tracks in apatite (380 °C for 1 hour) and because of the good correlation among the ages of the three sites. All three individual standard deviations overlap the mean age and its standard deviation, which emphasizes the reliability of the mean age of about 21 Ka. In consequence, the apatite fission track age of 21.4 ± 9.7 Ka is interpreted to determine the time of the Tenoumer impact event. This age value, together with an earlier impact glass fission track age of 3.3 ± 0.5 Ma [9] for Aouelloul precludes the possibility that both craters are genetically related and are part of one multiple impact event. In addition, the fission track age of 21 Ka is not concordant with the K-Ar age estimate of 2.5 ± 0.5 Ma [7] for the Tenoumer impact, but about hundred times smaller. The most plausible interpretation for this age difference might be the possible presence of undetectable inherited radiogenic Ar which had increased the K-Ar age considerably. For specimens of unshocked basement granites and gneisses K-Ar ages of about 2 Ga were determined [7]. If only one per thousand of the radiogenic Argon which had accumulated over these 2 Ga would have survived the high temperature pulse of the impact in the melt-rocks, this tiny quantity of Ar could entirely account for the measured K-Ar age. Apparently, the residual temperature after the impact melt-rock formation was not high enough in order to reset completely the K-Ar clock. This finding, together with earlier K-Ar- [8] and fission track- work [9], suggests that, in fact, radiogenic Ar which had accumulated within the country rocks might never be quantitatively removed during the shock heating process of a meteorite impact. If this is a general feature, the effect of age increase would be occulted for impact craters of high age in the order of hundreds of million years and / or cases where crater and target are not very different in age. However, for impact craters younger than one million years and situated on Precambrian or even Paleozoic targets the effect of inherited Ar might become crucial and the corresponding K-Ar ages might require major revisions.

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