AGE OF THE LONAR IMPACT CRATER, INDIA: FIRST RESULTS FROM FISSION TRACK DATING.

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Summary. The Lonar crater (1.8 km diameter) is a well-preserved simple impact crater in basaltic target rocks (Deccan Traps). Its age is not well defined, with previous age determinations ranging from ca 10 to 50 ka, the latter one being a thermoluminescence age that is commonly quoted as the age of the structure. In an attempt to refine the crater age, we began a fission track investigation of impact glass from Lonar. The first results from this study indicate an age of about 15 ka, but with a fairly high error. Further fission track work to refine this age is in progress.

Introduction. The Lonar crater [1-3] is a relatively small (rim to rim diameter 1830 m), almost perfectly circular simple (bowl-shaped) impact crater centered at 19°58'N and 76°31'E. The depression is excavated from the basalt flows of the Deccan Traps in the Buldana District of Maharashtra, India. Whereas the age of the target area is sufficiently well known (the Deccan Traps erupted around 65 million years ago, around the time of the Cretaceous-Tertiary boundary), the age of the impact event itself is – so far – not well constrained, despite of the fact that the impact feature was already known to Gilbert [4] in 1896. Several dates have been reported in the literature, but they are either not well documented, or do not agree well with each other. For example, Fredriksson et al. [3] noted that preliminary fission track results indicate an age of less than 50,000 years. Radiocarbon ages of post-impact lake sediments gave (unpublished, see [13-15]) radiocarbon ages of ca. 15 – 30 ka, which were thought to be lower age limits due to contamination with young carbon. Sengupta and Bhandari [16] quoted a thermoluminescence age of 62 ka, and Sengupta et al. [15], based on more or less the same dataset, arrived at an age of 52 ± 8 ka.

Fission Track Dating for Impact Craters. Fission track dating has been successfully applied during the last thirty years to tektites and impact glasses (e.g. 5-8), mid-ocean ridge.- [9-10], and lunar- (11) glasses of basaltic composition. Due to our experience with the handling of basaltic glasses in fission track dating we attempt here a fission track reconnaissance in order to find out if Lonar crater glass is datable at all with the fission track method.

Methodology. Fission track analyses were performed on three impact glasses (LO-1, LO-2, LO-3) collected in 1990 from the Lonar crater. The three discs (saw cuts about 0.8 mm thick) of these glasses were mounted in epoxy, in one section and polished. In order to determine the optimal etching characteristics for the basaltic Lonar crater glasses, the polished section was irradiated with Cf-252 fission fragments. Fission track development was found optimal by etching the polished section for 45 seconds in an aqueous acid solution (2 vol. 40% HF + 1 vol. 96% H_2SO_4 + 1 vol. 65% HNO_3 + 6 vol. H_2O)at 23°C. After repolishing and reetching the mounted sample, the glass sections were scanned for fossil fission tracks in reflected light under an optical microscope (eyepiece: 10x; objective: 50x). This procedure was repeated two times. For details on the technique and analytical data treatment, see [11, 12].

Table 1: Fission track analytical results.

	fossil tracks	induced tracks (b)
Number of tracks	2	
Scanned surface area (mm^2)	218.09	
Track density (N/ cm^2))	0.92 ± 0.64	0.30 ± 0.15 pi / 10^{11} n
Age (ka) (a)	15.3 ± 13.3	

(a) constants used : σ_f = 580.2 x 10^{-24} cm^2 ; I = 7.253 x 10^{-3} ; σ_f = 8.46 x 10^{-17} a^{-1}

(b) the density of induced fission tracks is normalized to an integrated thermal neutron fluence of 10^{11} n/ cm^2. Following the empirical relationship: pi / 10^{11} n = 0.6 x U ppm for oceanic basalt glasses (9,10), this density stands for a uranium content of 0.50 ± 0.25 ppm. The fission track etching efficiency is assumed to be within ± 10% to the efficiency of oceanic basalt glass.

Results. The results of our first fission track analysis are reported in Table 1. The apparent fission track age of the Lonar impact crater glass is 15 ± 13 ka. The analytical uncertainty of the age value is the standard deviation as calculated from the quantities of fission tracks counted and the uncertainties of the uranium content and the fission track etching efficiency in Lonar

crater glass. This age may correspond to the age of the impact event or, more plausibly, to a reset fission track age, which was thermally lowered to an unknown extent. It is unlikely that any tracks were missed. On the other hand, lowering of the fission track age due to track fading cannot be excluded (see Table 2).

Table 2: Fission track retention temperatures for basaltic glasses (data are compiled from [12])

degree of track loss	Range of retention temperatures (°C) for different annealing times			
	1hr	1a	10^2 a	10^4 a
beginning	110-130	<0-13	<0	<0
half	170-235	72-124	37-84	8-51
complete	230-345	175-246	144-207	116-173

Latent fission tracks are, like any radiation damage, very sensitive to elevated temperatures. Thermal energy reactivates the radiation damage accumulated along latent tracks, so that a latent track heals up gradually and becomes shorter with increasing annealing temperature. At the same time, the etching velocity along this latent track is reduced. The consequence of these two effects is that increasingly fewer and smaller fission tracks cross an etched reference surface. The extent of partial fading of fossil fission tracks at a given ambient temperature and, hence, the degree of thermal age lowering, depends on the track retention properties of the specific material to be dated.

Conclusions. The age obtained in our study is a fairly low age, based on few fission tracks. The relatively high uncertainty of the age results from the low number of tracks and the uncertainty of the U content. Both parameters can be refined, the first one by counting more samples/areas, and the second one by determination of the U content of the analyzed samples. Both points are being considered during further studies. The main result at this time is the confirmation of a low age for the Lonar impact crater.

In order to resume our work, we need to make sure that Lonar crater glasses are well datable by means of the fission track method. The analytical uncertainty of a future fission track age can be sensibly lowered by increasing the glass surfaces scanned for fossil tracks as well as by the irradiation of the glasses with thermal neutrons in order to produce induced fission tracks. By doing so, not only the proper uranium content of a given sample can be determined precisely, but also any thermal lowering of a fission track age can be quantified and corrected for [6,12], unless the record of fossil fission tracks was repeatedly completely erased by thermal annealing due to intense human farming activity for very long times in the Lonar village area (e.g., burning of agricultural waste). Given the very low thermal retentivity of fission tracks in basaltic glasses, it is emphasized that - for fission track dating - the sampling of glass directly from the surface should be avoided. Therefore, the major challenge for a future fission track dating program will be the search for glasses that were exposed neither to too much sunshine nor to human thermal manipulation.

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