SIMULATED COSMIC-RAY INDUCED U-FISSION TRACKS IN ARTIFICIAL LUNAR SOIL AND IMPLICATIONS FOR THE U-238 FISSION TRACK DATING OF LUNAR SURFACE SAMPLES, K.Thiel, G.Damm, W.Herr, K.Baer, Institut für Kernchemie der Universität zu Köln.

Cosmic ray-bombardment of the lunar surface was simulated by a 600 MeV-proton-irradiation of ~170 kg artificial lunar soil(1). The proton flux within this thick target was controlled by means of the spallation reactions Al-27(p,3p 3n)Na-22 and Al-27(p,3pn)Na-24 induced in high purity Al-monitor foils. Using U-glasses containing 0.1 % UO_2 as fission track detectors, p- and secondary n-induced U-fission tracks were recorded as a function of depth within the target and the distance from proton beam center respectively. The proton flux and fission track data obtained at normal p-incidence during the experiment were transformed under simple assumptions to an isotropic 2π-influx of 600 MeV -protons on the lunar surface. The production rate of p- and n-induced U-fission tracks turned out to be strongly depth dependent. At depths < 50 g/cm^2 the production rate $\dot{\varrho}_i$ of induced U-fission tracks in the glass was $> 10^{-10}$ tracks cm^{-2} sec^{-1}/(proton cm^{-2}·sec^{-1} ppm U). For comparison the production rate $\dot{\varrho}_s$ of U-238 spontaneous fission tracks was calculated from the known data of our monitor glass to be $\sim 1.1 \cdot 10^{-11}$ tracks cm^{-2}·sec^{-1} · (ppm U)$^{-1}$. Using this figure and the fission track results from the simulation experiment the fraction $\varrho_i/(\varrho_i + \varrho_s)$ of induced U-fission tracks was calculated as a function of depth (fig.1). This fraction does not depend on the specific properties of the track registering material. In fig.1 the fraction $\varrho_i/(\varrho_i + \varrho_s)$ is given for three different p-fluxes at the lunar surface corresponding to the maximum, minimum and time average solar activity. Adopting the energy spectrum of cosmic ray protons having a maximum around 600 MeV (2-3) these experimental results represent a good approximation to the irradiation conditions on the actual lunar surface. The portion of cosmic-ray induced U-fission tracks in any U-containing track recording material at the lunar surface varies between 40 % and > 95 % of the total of the U-fission tracks. The contribution of induced tracks to spontaneous U-fission tracks only becomes negligible at depths $\gtrsim 200$ g/cm^2. A high fraction of cosmic-ray induced tracks can explain unrealistic high ages of glass spherules from soil samples of Apollo 14-17 and Luna 16 and 20 (4-6) which went up to $6 \cdot 10^9$a (5).

The importance of a clear distinction between p- and n-induced U-fission tracks in extraterrestrial track detectors and spontaneous fission tracks as proved by our experiment demands a careful revision of all U-fission track ages of lunar surface samples so far published.

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In the same experiment the depth dependence of radiation induced thermoluminescence (TL)-intensity was measured in plagioclases. The data which were corrected for an isotropic 2π p-influx, too, give the thermally "undisturbed" TL-depth profile for artificial lunar soil. Using temperature gradients which were known from two Apollo landing sites (7), it was possible to calculate two temperature disturbed TL-depth profiles from the simulation experiment (fig.2).

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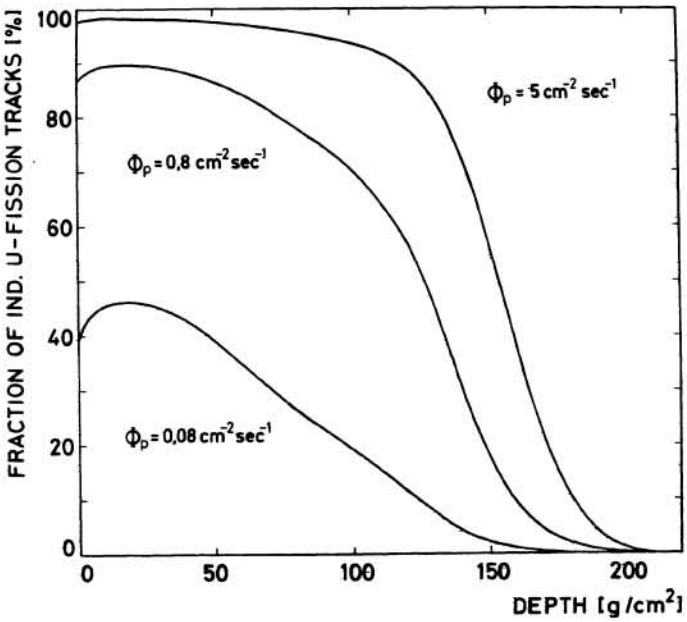

Fig.1

Fraction $\rho_i/(\rho_i+\rho_s)$ of induced U-fission tracks in U-containing minerals and glasses in artificial lunar soil as a function of depth. The function is given for 3 different isotropic p-fluxes at the lunar surface.(Incident proton energy Ep~600 MeV.)

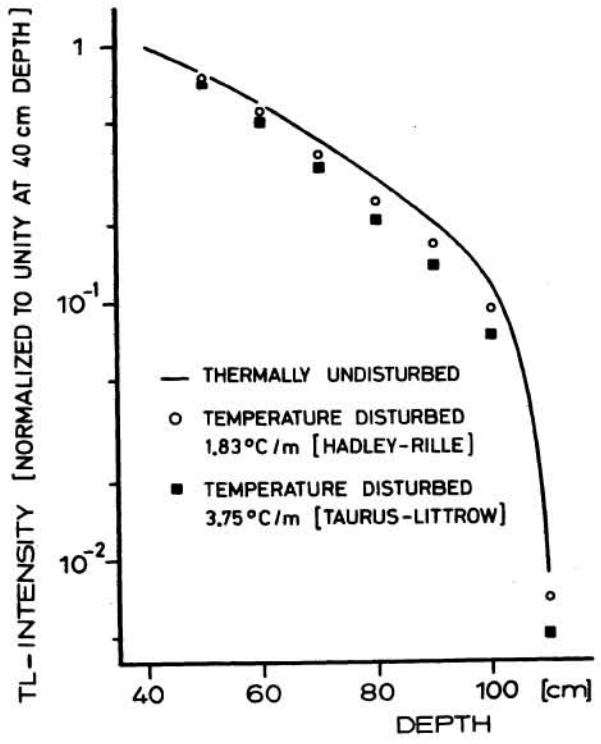

Fig.2

TL-intensity versus depth for an isotropic 600 MeV p-irradiation of artificial lunar soil. (The abszissa gives the depth considering the increase of lunar soil density with depth(8).)