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Final Report

For the period 1 February 1971 to 31 May 1983

Grant NGR 09-015-145

Ptn Dr Dietrich 11-17-83

Principal Investigator

Edward L. Fireman

September 1983

Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts 02138

The Smithsonian Astrophysical Observatory
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The NASA Technical Officer for this grant is Dr. John Dietrich, Code SN2, Lyndon B. Johnson Space Center, Houston, TX 77058

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Final Report of NASA Grant NGL 09-015-145

Studies of Carbon-14 and Tritium in Lunar Soil and Meteorites

(February 1, 1971 to May 31, 1983)

Edward L. Fireman

The cosmic-ray, solar-flare, and solar-wind bombardments of lunar rocks and soils and of meteorites were studied by measurements of tritium (^{3}H), carbon-14 (^{14}C) and argor radioactivities (^{37}Ar and ^{39}Ar). The radioactivity integrates the bombardment for a time period equal to several half-lives: (^{3}H, 12.3 year), (^{37}Ar, 35 day), (^{39}Ar, 270 year), and (^{14}C, 5730 year). For the interior samples of lunar rocks and for deep lunar soil samples ($\geq$10 g/cm^2), the amounts of the radioactivities were equal to those calculated for galactic cosmic-ray interactions. The top near-surface samples of lunar rocks and the shallow lunar soil samples (<10 g/cm^2 depth) showed excess amounts of the radioactivities attributable to solar flares. The excess ^{37}Ar was particularly large for Apollo 17 near-surface samples due to the large solar flare of August 4 - 9, 1972. The solar flare proton flux obtained from the ^{37}Ar excess was consistent with satellite measurements. Studies of the ^{39}Ar excess at shallow depth (<10 g/cm^2) indicated that the solar flare proton flux averaged over the past 1,000 years was slightly higher than averaged over the past 30 years.

Lunar soil fines contain a large amount of hydrogen ($\sim$1 cm^3/g) due to implanted solar wind. There was no excess ^{3}H in this hydrogen. In fact, studies of the ^{3}H in lunar soils and in recovered Surveyor-3 materials gave an upper limit for the $^{3}H/^{1}H$ ratio in the solar wind of 10^{-11}. Solar wind carbon is also implanted on lunar soil fines. Lunar soils collected on the surface contained a ^{14}C component attributable to implanted solar wind ^{14}C. The $^{14}C/^{1}H$ ratio attributed to the solar wind from this ^{14}C excess is approximately 4×10^{-11}. This concentration of ^{14}C in the solar wind has not been theoretically explained and it is important to verify this result by more precise ^{14}C measurements. Along these lines, an accelerator ^{14}C program was started in collaboration with accelerator groups at Chalk River, Zurich-Bern, and the University of Arizona. This program is continuing.

Our ^{14}C program on lunar samples was expanded to include the dating of Antarctic meteorites shortly after the discovery of a large number of Antarctic meteorites. We measured ^{14}C terrestrial ages for approximately thirty meteorites from the Allan Hills site and four meteorites from the Yamato site. Only one of the Allan Hills meteorites had a terrestrial age as young as 11 x 10^3 years; the others were older than 20 x 10^3 years. On the other hand, two of the Yamato meteorites had very young terrestrial ages. Y-7502 was (4.3 ± 1.0) x 10^3 years old and Y-7304 was (7.2 ± 0.6) x 10^3 years old.

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