^{210}Pb as a tracer for volatile transport on the lunar surface

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Radon-222 ($t_{1/2}$=3.82 days), produced in the decay chain of natural ^{238}U, is expected to emanate from the upper layers of the hot sunlit-side of the lunar surface by thermal diffusion and be trapped on the cooler night-side surface grains. Through its shortlived radioactive daughters (^{218}Po, ^{214}Pb, ^{214}Bi and ^{214}Po), it decays to 22.26 year ^{210}Pb (and further to ^{210} Po) and therefore a thin paint of ^{210}Pb and ^{210}Po is expected on the lunar surface. Here we explore the possibility of using ^{210}Pb (^{222}Rn) as a proxy tracer for understanding transport of volatiles like water, mercury and other gases on the Moon.

The surface concentration of ^{210}Pb can be measured by its decay X- rays (10.8 keV, 9.52%; 13.0 keV, 10.2%; 15.4 keV, 2.29% and 46.5 keV, 4.05%), using a suitable detector on board a lunar orbiter. Measurements of ^{222}Rn and ^{210}Po by alpha spectrometers on Surveyor landers and Apollo orbiters on lunar surface and study of ^{222}Rn and ^{210}Pb in lunar rocks and soils suggest that their concentrations are spatially and temporally variable [1-3]. Turkevich et al. [4] found ^{210}Po in excess over ^{222}Rn at Surveyor 5 site and Gorenstein et al. [5] found that the edges of several lunar maria, as also the crater Aristarchus, showed higher concentration of radon over its surroundings. Its excess in Maria edges, the most dramatic being Mare Fecunditatis, is attributed to radon emanation from dark haloed craters. On the other hand, Lindstrom et al.[6] did not find any excess of ^{210}Pb in the topmost lunar soil core layer and concluded that the diffusion coefficient of radon in lunar soil is $<3 \times 10^{-8}$ cm^2/s.

Several models have been proposed for transport of radon from the lunar interior to the lunar surface and then across the terminator to the colder regions. Heymann and Yaniv [2] predict that peak concentration of radon (and hence also of ^{210}Pb) may be expected at sunrise and sunset terminators. Other than by diffusion, radon may also occasionally escape from the Moon by rare transient phenomena like seismic activity, volcanism and other geological processes. Thus there are three components of ^{210}Pb on the lunar surface (i) produced *in situ* due to decay of ^{238}U. Flux of its decay radiations, transmitting through the lunar surface layers has been estimated [7] to be small (ii) produced by decay of degassed radon from the upper few meters of the lunar regolith by thermal diffusion and deposited as a paint on the lunar surface. This component is orders of magnitude larger than (i) and, (iii) transient component due to geological activity resulting in degassing of radon from the lunar interior. If there are pockets of high concentration of radon (and ^{210}Pb), large area detectors, such as CZT arrays operating in 10 to 200 keV, with suitable anticoincidence systems, and high spatial resolution should be able to determine its distribution on the lunar surface and help us understand the transport and deposition of volatiles.

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