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LIFE IN MARTIAN SNOWS – MEASUREMENTS OF UV PROTECTION UNDER NATURAL ANTARCTIC SNOWS IN THE UVC (254 nm)

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Introduction: Ultraviolet radiation down to 195 nm penetrates to the surface of the Martian north polar ice cap during the polar summer on account of the lack of an ozone column, in contrast to the Earth where only radiation above ~290 nm penetrates to the surface (except under ozone depletion, when radiation down to ~280 nm may penetrate). During the winter, spring and fall some ozone production does occur over the Martian poles, but the column abundance is about two orders of magnitude lower than terrestrial stratospheric ozone values. Although this ozone will provide some protection from UVC (200-280 nm) radiation, it is transient. The DNA-damage experienced on the surface of the Martian poles is approximately (under clear, dust-free skies at vernal equinox) three orders of magnitude higher than that experienced by terrestrial polar organisms (under an undepleted ozone column at the same orbital position).

UV in Antarctic and Martian Snows: To investigate the potential of Martian snow to act as a protection mechanism for contaminant microorganisms or organics, the penetration of 254 nm radiation (produced from a field-portable mercury vapor source) into natural snows was measured at Mars Oasis, Antarctica (72°S) during the 2001 austral summer.

Sections of icy snow-pack of approximate dimensions 10 x 10 cm were placed between the cosine-corrected collector of a calibrated Ocean Optics S-2000 spectrometer and the radiation source. A control measurment was taken before each snow-pack measurement and the ratio of the value under the snow-pack to the control was calculated as the attenuation coefficient. The thickness of each snow-pack sample was measured.

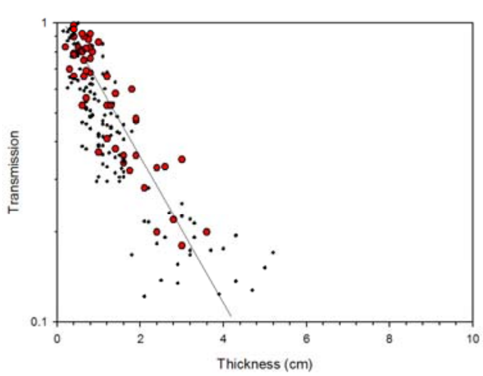

Figure 1. Attenuation of 254 nm radiation (large circles) through snow-pack of different thicknesses. Small dots show attenuation of solar radiation at 310 nm.

The measurements at 254 nm were used as an approximation of the UV-attenuating properties of Martian snows across the whole UVC range. The attenuation of the snow was linearly interpolated between 254 and 310 nm and then linearly extended to 200 nm to make a crude attenuation throughout the Martian UVC range.

For measurements of natural solar radiation between 310 and 400 nm, values were acquired at 1 nm intervals and the collector was held in a clamp directly pointing towards the sun for the control and snow-pack measurement. The penetration of solar radiation from 310 to 400 nm was used for transmission values for the UV ranage common to Earth and Mars [1].

Convolved with a simple Mars radiative transfer model, the data suggests that under ~6 cm of Martian snow, DNA-damage would be reduced by an order of magnitude [2]. Under approximately 30 cm of snow, DNA damage would be no worse than that experienced at the surface of the Earth. Although we do not know the exact characteristics of Martian snows, these first-order data suggest that burial in even modest coverings of Martian snows could allow for the long-term survival (and if water if present, even growth) of contaminant microorgannisms at the Martian polar caps even under the extreme UV fluxes of clear Martian skies. These coverings of snow will also allow for enhanced preservation of organics against UV-degradation.

Intriguingly, at the depth at which DNA damage is reduced to similar levels as those found on the surface of present-day Earth, light levels in the photosynthetically active region (400 to 700 nm) are still two orders of magnitude higher than the minimum required for photosynthesis, showing that within snow-pack on planets lacking an ozone shield, including Mars, UV damage can be mitigated, but light levels are still high enough for organisms that have a requirement for exposure to light for their energy needs. Photosynthetic life is not expected at the Martian poles, but the data reveal the apparently favourable radiation environment for life within the polar caps.

References: [1] Cockell, C.S. and Cordoba-Jabonero, C. Photochem. Photobiol. (in review). [2] Cockell C.S. Abstracts of the 2nd European Exo/Astrobiology Conference, 2002.