UV ATTENUATION IN ROCKS AND MINERALS: IMPLICATIONS FOR HABITABILITY AND BIOSIGNATURE PRESERVATION ON MARS. B. L. Carrier*, L. W. Beegle, R. Bhartia, W. J. Abbey, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA (*bcarrier@jpl.nasa.gov).

Introduction: Subsurface penetration of UV photons has implications for habitability and for preservation and detection of organic biosignatures. UV radiation is known to photodissociate amino acids, DNA and other common biological molecules [1 and references therein]. It is therefore important to identify to what extent rocks and minerals can provide effective shielding against UV radiation as a necessary step towards constraining what constitutes suitable habitats for life as well as promising locations for organic molecule biosignature preservation.

The attenuation of UV radiation in natural mineral and rock samples has not been well characterized. Here we have used a mechanical press to form pellets of varying thickness from powdered samples of a natural gypsum, kaolinite, basalt and a welded tuff. The transmittance of these pellets to the full spectrum UV (200-400 nm) radiation, as well as to the UVC (200-280 nm), UVB (280-315 nm) and UVA (315-400 nm) wavelength ranges, has been determined. We have used these transmittance values to determine the potential lifetimes of several organic molecules and biosignatures at different depths in the subsurface of these rocks and minerals.

Methods: *Sample Preparation*: Samples used in these experiments were: the Mojave Mars Simulant (MMS) [2], kaolinite, gypsum and Bishop Tuff. Samples were cleaned prior to pressing to remove potential UV-absorbing contaminants. Rock or mineral dust was then pressed into pellets of 13 mm diameter with varying thicknesses. The thickness of the resulting pellets was then measured using a Mitutoyo digital thickness indicator with an accuracy of ±3 μm.

UV source and detector: A UV-Enhanced Oriel-Newport 1000 W Xe-Arc lamp was used to generate UV photons. UV transmittance through each pellet was determined by placing the pellet between the UV source and a NIST-calibrated spectroradiometer.

Results and Discussion: Transmittance data was collected as a function of layer thickness in each substrate for various UV wavelength ranges. MMS had the lowest UV transmittance overall of the 4 sample types analyzed followed by Bishop Tuff, kaolinite and gypsum. For each rock and mineral analyzed the transmittance was found to be highest for the UVC wavelength range. This is significant because continuous exposure to UVC radiation is more damaging to potential organic biosignatures and microbial life than longer wavelength UVA/UVB radiation.

Although transmittance falls off quickly with depth, all four substrates showed detectable UV penetration at depths greater than 500 μm. Thus over geological time scales it is unlikely that organic biosignatures would persist in the top mm of the martian subsurface.

We have used calculated UVC transmittance values for each substrate in order to extrapolate potential lifetimes of various organics buried in the subsurfaces of these rocks and mineral types. Table 1, for example, shows the possible half-life values for glycine under a 500 μm layer of each material. These values have been extrapolated from the half-life of ~231-250 hrs for glycine on the surface found in the literature [3,4]. These lifetimes are based on continuous noontime peak illumination and neglect other factors contributing to surface organic degradation such as exposure to atmospheric oxidants and can thus be regarded as possible lower limits. This further emphasizes that the search for organic molecules, especially those that could be considered biosignatures, has to occur at depths below 1 mm in order to be successful.

Extrapolated $t_{1/2}$ (Mars yrs) for Glycine in the Subsurface	
Gypsum 500 μm	~0.39 Mars years
Kaolinite 500 μm	~19 Mars years
MMS 500 μm	~154 Mars years
Bishop Tuff 500 μm	~473 Mars years

Table 1. Extrapolated half-lives for glycine in the subsurface.

Conclusions: The transmittance of UV radiation varies depending on rock and mineral type, with detectable levels of UV radiation penetrating >500 μm in all sample types investigated. The higher transmittance of UVC radiation highlights the importance of exploring deeper below the surface to look for preserved organics or extant life.

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References:

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