PROSPECTS FOR *IN-SITU* DATING OF MARTIAN SEDIMENTS USING OPTICAL TECHNIQUES.

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Introduction: NASA's current strategy for the exploration of Mars focuses on the idea of "following the water", including ancient surface and subsurface water, and present subsurface water [1]. Mars Global Surveyor (MGS) images show structures suggestive of "recent" surface water activity [2], while the extensive northern polar caps are believed to be mainly composed of water ice. The layered terrain observed in MGS images surrounding the poles point to a rich record of data pertaining to the past history and climate of the planet. Understanding this topography and geomorphology in terms of composition, depositional processes and history is of foremost importance in understanding the martian climate and hydrology and, thus, the search for life, either fossil or extant [3].

In this context the development of age dating techniques for the martian surface is especially important. Determining when the evidently young, pristine, fluvial-like features observed from MGS were laid down is of special relevance to the search for evidence of life. Time scales for these events may place constraints on models for prebiotic chemistry and protobiology.

We suggest an *in-situ* dating system based on a commonly used terrestrial technique [4], which may be readily adaptable to a robotic spacecraft on Mars. The technique is based on a radiation dosimetry method using optically stimulated luminescence from silicate grains trapped within sedimentary layers. The system would be relatively simple, small, robust and would use low power solid state devices. The method – called Luminescence Dating (or Optical Dating) - is the only one that has been discussed in the literature for dating sedimentary layers on Mars [5,6].

Luminescence Dating:

The event to be dated using luminescence is the last exposure of the sediment grains to solar radiation. Eolian sediments provide an excellent example and are suitable materials because they are well-dispersed during transport and are therefore well exposed to solar radiation during this period. This exposure removes ("bleaches") their existing luminescence. To calculate the age, the method uses the natural, radiation-induced luminescence from silicate grains to determine the natural dose of absorbed radiation *since the sediment was deposited*. By establishing the natural environmental radiation dose rate, the age may then be calculated from:

$$Age = Natural\ Dose/Dose\ Rate. \quad (1)$$

The efficiency of solar bleaching is dependent upon wavelength, shorter wavelengths being most efficient. On Mars one can expect enhancement of the shorter wavelengths relative to Earth because of less atmospheric attenuation which more than compensates for increased distance from the Sun. The range of ages that is accessible to luminescence dating of terrestrial materials varies with mineralogy and local ionizing radiation dose rate but is generally considered to be from ~0.1 ka to ~250 ka.

An *in-situ* luminescence dating module (ODIN - Optical Dating INstrument) compatible with a wide variety of platforms is proposed for Mars in order to provide absolute ages for various sediments. Multiple samples would be analyzed at each site and the luminescence from each sample would be used to calculate the natural dose of radiation absorbed by that sample. Furthermore, the distribution of the determined natural dose, from sample to sample at a given site, can be used to distinguish between eolian (wind-blown) deposits and fluvial (water-lain) deposits [7]. Extraction of dose-rate information at each site using sensitive luminescence dosimeters will produce depositional dates for the sediments using Eq. (1) The instrument would be equipped with a sample handling and sorting subsystem, a sample illumination (stimulation) and luminescence detection subsystem, a sample irradiation (for calibration) subsystem, and a sample heating subsystem. Radiation dosimetry of the surrounding soils will be carried out through a combination of measurement (using synthetic luminescence dosimeters) and radiation transport calculations. This paper will examine the prospects for the development of such an *in-situ* optical dating instrument.

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