

**AKAGANEITE ABSORBS LESS UV THAN OTHER IRON OXIDES – IMPLICATIONS FOR THE PRESERVATION OF ORGANIC MATTER ON MARS AND APPLICATIONS OF REGOLITH SIMULANT JSC MARS-1A.** A. M. Priestley<sup>1</sup>, G. Pearce<sup>2</sup>, and C. Schröder<sup>1</sup>, <sup>1</sup>Biological and Environmental Sciences, University of Stirling, Stirling FK9 4LA, UK, christian.schroeder@stir.ac.uk, <sup>2</sup>School of Engineering and Applied Sciences, Aston University, Birmingham B4 7ET, UK.

**Introduction:** The surface of Mars today is exposed to ultraviolet (UV) radiation, which is destructive for organic compounds and potentially biologically damaging. This has provoked questions concerning what on Mars could mitigate against such harmful UV radiation. Dust on Mars covers much of the planet's surface and contributes significantly to Martian climatology e.g. aeolian processes including wind erosion, aeolian sediment transport, and deposition. The composition of dust on Mars has been described as being mainly basaltic and contains igneous primary minerals e.g. olivine, pyroxene, magnetite, and nanophase iron oxides (npOx) [1-5]. Components of the latter may include several phases of iron oxide minerals such as hematite, goethite, magnetite, lepidocrocite, ferrihydrite and akaganeite [3,4]. Iron oxides have a varying capacity to attenuate UV radiation. Hematite and magnetite have been detected extensively spread within the dust and regolith of Mars [1-4], whilst akaganeite [6-8] and goethite [9] have been detected on more localized scales. Lepidocrocite and 6-line ferrihydrite have been hypothesised as precursors to iron oxides such as hematite and as components of npOx [3,4]. We measured the UV absorption of these iron oxides as powders in suspension and compared them the UV absorption of a Martian regolith simulant to reflect a regolith composition with a high iron oxide component, and a lunar regolith simulant to reflect a basaltic regolith composition with less iron oxides.

**Materials and Methods:** Mineral powders of hematite ( $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>), magnetite (Fe<sub>3</sub>O<sub>4</sub>), goethite ( $\alpha$ -FeOOH), akaganeite ( $\beta$ -FeOOH), lepidocrocite ( $\gamma$ -FeO(OH)) and ferrihydrite (Fe<sup>3+</sup><sub>10</sub>O<sub>14</sub>(OH)<sub>2</sub>) had been synthesized according to [10]. The Martian regolith simulant JSC MARS-1 is a spectral analogue of the bright regions on Mars. It is comprised of weathered volcanic ash (palagonite tephra) and was collected from Pu'u Nene cinder cone on Hawaii [11,12]. JSC MARS-1A is an additional amount of material made available after JSC MARS-1 ran out, presumably from the same location. The EAC-1 lunar regolith simulant was developed by the European Astronaut Centre in Cologne, Germany. It consists of Na and K rich basalt and was sourced from a quarry in the Eiffel region near Cologne [13]. Small samples of both JSC MARS-1A and EAC-1 had been acquired for and were provided by a separate ISRU project [13]. To establish their iron

oxide content, Mössbauer spectra of JSC MARS-1A and EAC-1 were obtained using a miniaturized Mössbauer spectrometer MIMOS II [14].

During the Viking landing missions, optical depth and vertical distribution of dust loading across the two global storms on Mars in 1977 were measured [15,16]. Over a 100 sol period, building up to the first global dust storm, total mass loading increased by  $4 \times 10^{-3}$  g/cm<sup>2</sup> whilst during the peak of the second global storm, total dust mass rose to  $4.3 \times 10^{-4}$  g/cm<sup>2</sup>. The global dust loading across the period of both storms reached  $1 \times 10^{-3}$  g/cm<sup>2</sup>; these values were used as references and converted to mg/cm<sup>2</sup>. Each sample of iron oxide and both regolith simulants were divided into weight groups of 5 mg, 10 mg and 15 mg (+/- 3mg) and added into cuvettes with a cross section of ~2 cm<sup>2</sup> and an optical path length of 1 cm. One milliliter of deionized water was added to each sample cuvette to allow suspension of particles. Transmission was recorded with a Hitachi U-1100 UV/Vis spectrophotometer in 10 nm wavelength steps over a range of 290-400 nm in polystyrene cuvettes and 200-400 nm in quartz glass cuvettes. Prior to insertion into the spectrophotometer, each sample cuvette was shaken vigorously to suspend particles. Transmission recordings were repeated three times for each sample and an average value was obtained.

**Results and Discussion:** Our results show that the transmittance spectrum across the different weight groups for akaganeite ranged between 54% and 74%. In contrast, other individual iron oxides do not reach above 20% transmission across any weight group (Fig. 1). This shows that akaganeite is a significantly weaker UV absorber compared to other iron oxides on Mars (e.g. hematite, magnetite, and goethite).

JSC MARS-1A presents a transmission range of 41% to 76% across all weight groups. The transmittance of EAC-1 does not exceed 20% (Fig. 1). This goes against our initial expectation because JSC MARS-1A contains more iron oxide (91% of total iron) than EAC-1 (49%). However, Mössbauer spectra reveal that the majority of iron oxide in JSC MARS-1A is in fact akaganeite (72%) (Fig.2, Table 1), which explains the high transmission. The iron oxide content of EAC-1 is surprisingly high at 49% of which 30% are goethite and the remaining 19% are npOx, which explains the low transmission of this material.

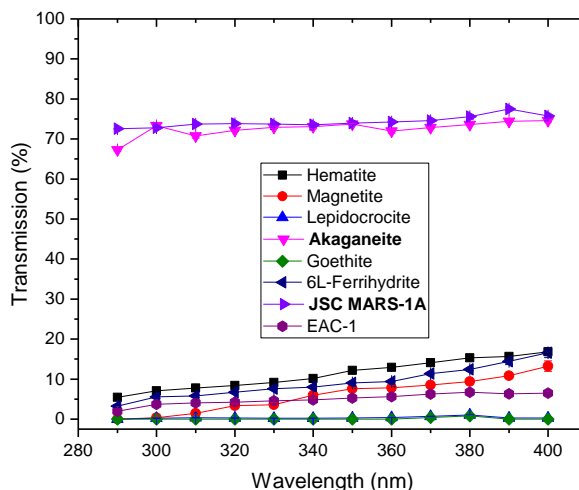
Akaganeite occurs relatively rarely on Earth in chlorine-rich locations, for example hot brines, salt lakes or rust in marine environments [10,17]. It had not been identified in JSC MARS-1 previously. Instead, iron oxides had been identified as palagonite [11,12]. If JSC MARS-1A is the same material, this palagonite would then in fact be akaganeite. Or JSC MARS-1A is different material sourced from a nearby location. Where JSC MARS-1A was used as a spectral or engineering analogue, results should - where relevant - be evaluated with respect to akaganeite mineral properties, such as the low UV absorbance reported here. The formation of akaganeite in the basaltic volcanic environment of Mauna Loa on Hawaii provides a useful analogue for formation pathways of akaganeite on Mars.

Currently, akaganeite has been identified at around 10 locations but may occur in other locations on Mars [6-8]. With respect to the search for life on Mars, akaganeite indicates the presence of water on the one hand. Salt-rich environments and resulting low water activity, on the other hand, provide their own challenges for life [18,19]. Akaganeite transforms into hematite at temperatures above 245°C [20]. Its presence therefore indicates long-term low-temperature conditions beneficial to the preservation of potential biomarkers. It does not protect organic biomarkers against destruction by UV radiation as efficiently as other iron oxides would, though. Akaganeite is not a significant component of Martian atmospheric dust, which contains the more efficient UV absorbers hematite and magnetite instead [1-5].

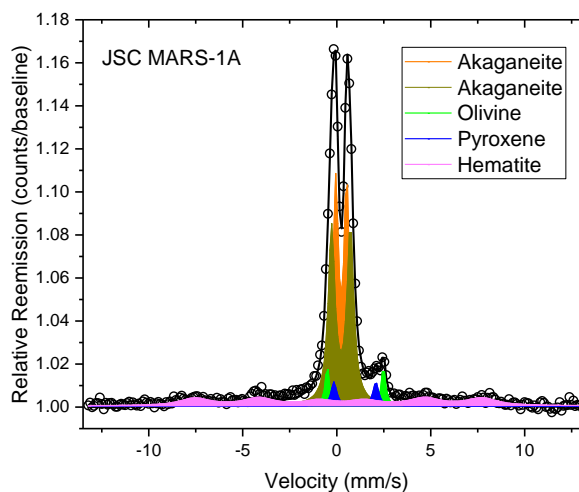
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**Fig. 1.** UV transmission of 5mg suspended mineral and regolith simulant powders (error bars smaller than symbols).



**Fig. 2.** Room temperature Mössbauer spectrum of JSC MARS-1A.

**Table 1.** Mössbauer parameters for room temperature spectrum of JSC MARS-1A.

Mineral	$\delta$ (mm/s)	$\Delta E_Q$ (mm/s)	$B_{hf}$ (T)	Area (%)
Akaganeite	0.35	0.59		36
Akaganeite	0.34	1.00		36
Olivine	1.10	2.99		5
Pyroxene	1.08	2.23		4
Hematite	0.29	-0.18	47.4	19