ORGANIC PIGMENTS ON MARS SURFACE? S. Pershin, Space Research Institute, Russian Academy of Sciences, P.O. Box 117810, GSP-7, Moscow, Russia, spershin@mx.iki.rssi.ru

"Extraordinary claims demand extraordinary evidence"
Carl Sagan 1996

A two-band, red/green radiance ratio indicates a region containing traces of relic organic pigment on the surface of Mars. The Hubble's Mars images from 10/03/97 at 08:(20-26):14 UT were analyzed. Anomal, more 10^x, 763/554 color index was observed in the strange "dark spot", 177W37N, dark "line", (155-160)W38N and North basin (170-180)W(over 55)N. The method of analysis is based on the observation of a strong red component in the fluorescence spectra of Earth relic (about 250 million years) plant fragments excited by a 355 nm laser pulse. The response differs from the blue-green fluorescence spectra of the typical mineral chalk and kaolin, granite and quartz sand responses at the same excitation frequency. This identifying feature of organic matter was observed on Mars under solar radiation.

NASA's Space Science Program states that the main goal of future Mars missions is to find traces of life. This objective was greatly stimulated by the announcements that fossils of ancient microorganisms may be in Martian meteorites, and of detection of current-era liquid water on the surface of Mars. Early an exiting results after Viking color images processing to observe of the biological activity on Mars surface were published by Levin *et al.*, 1978. Analysis of three component color pictures taken by the Viking lander camera on Mars has established color differences for the background material, the rocks and spots on the rocks. However, the observed patches, patterns and changes could also be attributable to biological activity. Analysis of six component color data on the same scene confirms the observations including the greenish color of the rock patches. It should be mentioned, the observed phenomenon brings to mind moss, lichen, algae and other organisms on Earth which live in extreme environments creating visible pattern and color changes as they extend their growth or die. Algae, fungi and lichen, as well as bacteria, have given positive responses in laboratory experiments. Recently high-resolution altimetric data define the detailed topography of the northern lowlands of Mars was published with conclusion about large standing body of water present in middle Mars history (Head III *et al.*, 1999). This report concerns of the recent efforts to detect of a relict organic pigment on the Martian's surface without landing. Earlier such possibilities was discussed by Pershin, (1998) on the base of the preliminary analysis of organic pigment in soil using of the fluorescence Lidar remote sensing technique (Bunkin *et al.*, 1997).

Hoge *et al.* (1987) observed that radiance-ratio bands exited by solar radiation yield chlorophyll estimates that are highly correlated with laser-induced chlorophyll fluorescence. This paper describes results obtained from investigations of the UV laser and solar radiation-induced fluorescence spectra of different samples, including a paleontological one containing imprints of leaves from relic plants (presented by Gumenkov). The observation of a strong red component in the fluorescence spectra of relic plant fragments stimulated our efforts to analyze the image of Mars using the two-band radiance ratio to see whether there were traces of relic organic pigments on the surface of that planet. We observed that Lidar-induced fluorescence spectra of the leaf fragment (sample N266) of ancient plant *Tatarina conspicua from peltaspermaceae* (ages about 255 mln y.) and samples N4734 and N3981 of relic plant from Devonsky epoch (about 380 mln y.) are red shifted and have strong red components. In contrary the Lidar-induced fluorescence spectra of wide spreading mineral: red kaolin, volcanic stones, quartz sand, chalk, midia-shell coral, and granite has emission in blue-green-yellow spectral range. It should be noted that the samples from the Moon surface (Geak *et al.*, 1972) has no fluorescence under the UV but only under the proton beam excitation. Other sample of leaf from relic plant (sample N4552/18) is located on the paleontology stone (mineral *alevrolit*) surface and modern leaf were studied under Sun light excitation. Solar exited spectra have the difference in the red (600-800 nm) region. The modern leaf has stronger differences in 700-830 nm (Chl a pigment) than the relic one. Nevertheless the last one is detectable too. This difference directs us to make an attempt to detect of relic organic matter on Mars surface by solar induced fluorescence radiance-ratio (or normalized) technique. It is clear that this method avoids of the surface albedo features if its does not change strong over the wavelength. Hubble's images of Mars (presented by D.Crisp, JPL) were processed on the base of this approach. The last one on 554 and 763 nm is presented by Fig. 1a, 1b. Here the Noth Cap is located in the left upper corner on the Fig.1 and the white spot close to the center of image is the Olimpus (133^0W18^0N). Dark area over the 55^0 N is the North Polar basin and the dark spot look like of the inverting coma 177^0W37^0N and dark "line" (155-160)W38N keeps dark color for long time.

The image changes dramatically after ratio "763nm" to "554nm" processing (Fig.1(c)). For instance, many details of surface structure such as mountain Olimpus or albedo details disappeared and smoothed as Polar Cap. On the other hand the intensity both dark area strongly changed. Note the ratio value over the bottom of the "inverted coma" increased to 13. It exceeds a normal color index of the black body at 6000 ^{0}K more than 10^x. This enhancement can be interpreted as contribution both the increasing of the red components by fluorescence and strong absorption in the green range. It is may be caused by relic organic pigments from ancient lichen or lichen-bearing rocks (Levin *et al.* 1978) and plant leaves or algae. It would be frozen inside the water ice and conservation. Fortunately, the area of North Polar basin was interpreted by Head (1999) as ancient ocean basin with groundwater. Remarkable we can detect dark spot after ratio processing (did not observe before) in the East-South part of the "inverted coma" (see zoom image in Fig.2). As is shown by modern Mars Global Surveyor image of Mars surface (http://ida.wr.usgs.gov/html/areas/c_45n165.htm) the "inverted coma" has a specific detail, for instance, the small white spot shifted to the East-South from the center. This correlation indicates that some detail inside of this spot has no the anomaly color index.

So, these regions and other (proposed by B. DiGregorio) is more prospective to find of the organic pigment during a landing mission on Mars surface in future. It should be noted that we can improve of this color index value by selected of optimal spectral band parameters based on the lidar and Solar excitation study of different paleontology samples. For instance, the typical fluorescence spectra under the Solar excitation of the modern green leaf of soya, demonstrated by Fig.3, has characteristic features: the peak around 750 nm, indicates a high fluorescence efficiency of chlorophyll pigment and minimum – its absorption band in 650-700 nm. It is clear that we can increase the value of ratio by selected the maxi mum intensity in the red band (750-800 nm) and

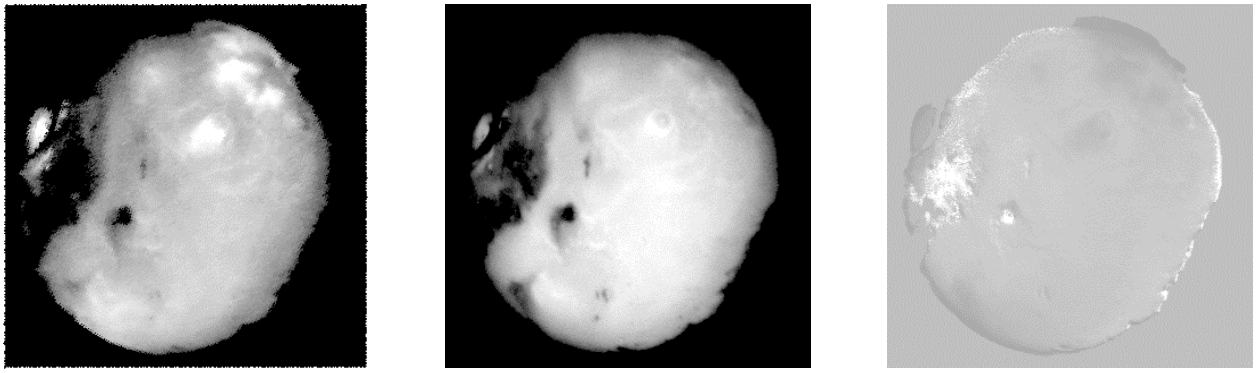

Fig.1. The Mars image with central wavelength: 554nm, FWHM ~5.5nm, exposure time: 2 seconds, observing date and time: 10/03/97 08:20:14 UT (a) and central wavelength: 763nm, FWHM ~7.6nm, exposure time 0.6 seconds, observing date and time: 10/03/97 08:26:14 (b) and image ratio 763/554 (c).

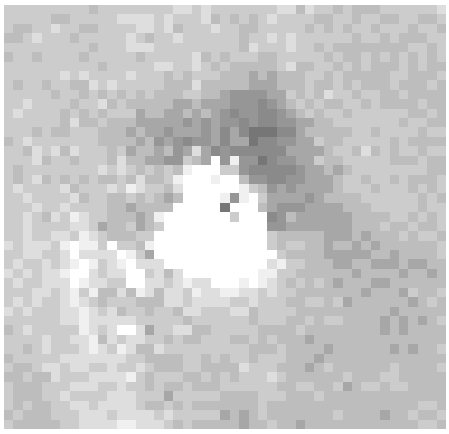

Fig.2. Zoom of Utopia basin from Fig.3(c) with dark fragment on the bottom

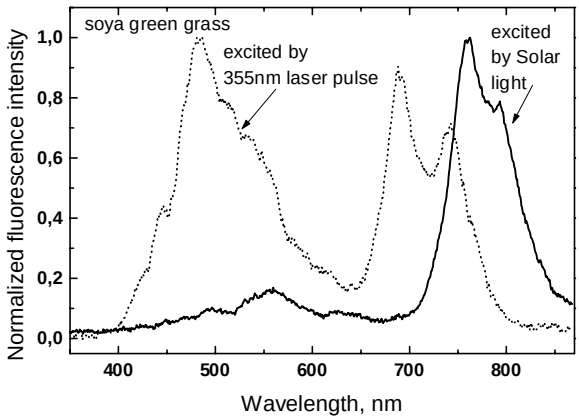

Fig.3 Green soya fluorescence spectra excited by UV laser pulse and Sun radiation (dark)

mum intensity in the red band (750-800 nm) and minimum one near the 650-700 nm instead of to 500-550 nm as we did here. On the other hand the organic pigment phycoeritrin has a strong absorption band centered about of 550nm (Lehninger *et al.*, 1993) in the middle of Solar radiation band. So we can suppose that the dark color in the visible range of the "inverted coma" may be caused by strong absorption of Solar light if it contains some organic pigment such as phycoeritrin. Note, the fluorescence spectra are changed under the UV excitation (see Fig.3). May be it more convenient to Mars surface. We sure that this approach can be applied for satisfactory relict organic pigments detection and 2-D mapping from the Earth or Mars Orbiter without landing using Mars image with high spectral resolution in blue-red range. From an engineering and/or economic standpoint, the two-band sensor requires minimum data transmission, storage, reduction, and algorithm application to obtain organic pigment mapping. This can lead to significant economic benefits for spaceborne sensor design and instrumentation. Of two-band possibilities, the radiance ratio (as opposed to radiance difference or radiance slope) does not demand exceptional measurement precision. The two-band radiance ratio serves to reduce the influence of the surface albedo variation and its correction. It is clear that such normalized image maps could represent relic organic pigments spread over a field or ancient ocean basin and canyon.

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