REFLECTANCE SPECTRA OF CM2 CHONDRITE MIGHEI IRRADIATED WITH PULSED LASER AND IMPLICATIONS FOR LOW-ALBEDO ASTEROIDS AND MARTIAN MOONS. L.V. Moroz[1], T. Hiroi[2], T.V. Shingareva[3], A.T. Basilevsky[3], A.V. Fisenko[3], L.F. Semjonova[3] and C. M. Pieters[2], [1]German Aerospace Center (DLR), Rutherfordstr. 2, D-12489, Berlin, Germany (Ljuba.Moroz@dlr.de), [2]Dept. of Geological Sci., Brown Univ., Providence, RI 02912, USA; [3]Vernadsky Institute, RAS, Moscow, 119991, Russia.

Introduction: Micrometeoritic bombardment is an important space weathering process modifying surface optical properties of airless solar system bodies. We have used irradiation with a microsecond pulsed laser as an experimental method to simulate such a process on various targets [1-4]. The experiment discussed here was performed on a powdered sample of CM2 carbonaceous chondrite Mighei. Shingareva *et al.* [5] report the details of experimental procedure as well as the results of mineralogical and chemical studies of the irradiated material. Here we present reflectance spectra of irradiated Mighei samples and discuss their spectral properties compared to those of non-irradiated meteorite and low-albedo small solar system bodies.

Experimental procedure: The irradiated sample was sieved to several partice size fractions (<40; 40-75; 75-125; 125-200 and >200 µm) for spectral studies. The pulsed laser irradiation produces large droplets and aggregates of the quenched melt [5], so that amount of the altered material progressively drops in the fine separates. The coarsest separates are not contaminated. Therefore, we produced an additional non-contaminated <40 µm separate by grinding the >125 µm irradiated separate.

Visbile-near-infrared (Vis-NIR) reflectance spectra were acquired using NASA-Keck RELAB bidirectional spectrometer in the range of 0.3-2.6 µm at i=30° and e=0°. FTIR reflectance spectra were measured in the range of 2-25 µm at biconical geometry using Nicolet 740 spectrometer. The FTIR spectra were mearged with RELABbds spectra at ~2.5 µm to obtain the composite 0.3-25 µm spectra.

Results and Discussion: Mighei is a typical CM2 chondrite. It consists largely of a black matrix, olivine-rich chondrules, olivine aggregates and individual grains, carbonates, sulfides. The matrix is composed mostly of Fe-rich serpentine-tochilinite intergrowth intimately mixed with carbonaceous material [e.g., 6].

Spectral reflectance properties of the Mighei meteorite have been studied, e.g., by [7, 8, 9]. Although Mighei and other CM2 chondrites contain minerals with pronounced absorption bands, Vis-NIR spectra of these meteorites are essentially featureless (Fig.1). Most of the bands are supressed by fine-grained spectrally featureless phases (tochilinite, troilite, pentlandite, carbonaceous material). Tochilinite [10, 11] is the most abundant darkening phase in CM chondrites. Few

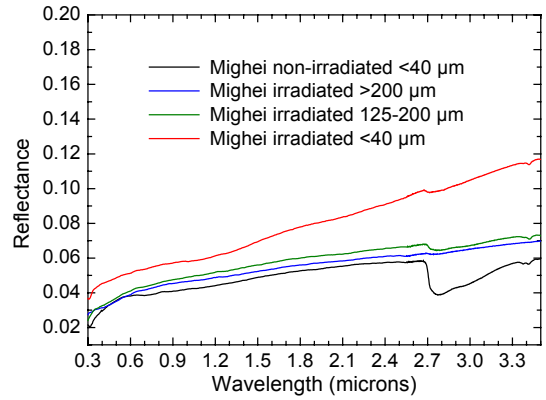

Fig. 1. Reflectance spectra of non-irradiated and irradiated powdered samples of Mighei. Particle size is indicated on the plot. Irradiated fraction of <40µm is produced by grinding the >125 µm fraction

absorption bands are detectable in the Vis-NIR region. These include: a complex absorption feature near 2.7-3 µm mostly due to structural OH in matrix phyllosilicates and tochilinite; absorption features due to charge transfer in Fe^{3+}-bearing phyllosilicates (UV-falloff below 0.5 µm and a weaker feature near 0.75 µm). Similar absorption bands have been detected in otherwise featureless C-type asteroids [e.g., 12, 13]. A weak 3.4 µm feature due to C-H stretch in hydrocarbons is seen in the Mighei spectrum. Although Mighei contains up to 2.5 wt.% organic material [14], this feature may be due to terrestrial contamination. The spectrum of the Mighei fine fraction shown on Fig. 1 has positive (reddish) slope in the NIR region. The reddening degree of Mighei and other CM2 chondrites increases with decreasing grain size [7, 8] most probably due to spectral contribution of olivine [8]. Spectra of matrix material [8] and coarser bulk Mighei separates are less red or even flat/bluish [7, 8].

The absorption features related to hydrated minerals (the 2.7-3 µm band; the UV-falloff, and the 0.75 µm band) in the spectra of irradiated Mighei significantly weaken due to dehydration of the material. In the spectrum of the finest fraction a weak broad band near 1 µm is due to crystal field electronic transitions in Fe^{2+} in olivine and Fe-rich glass. Although the irradiated material is dominated by olivine of Fo_{74} crystallized from the melt [5], olivine-related absorptions near 1 µm and below 0.6 µm are essentially sup-

pressed and the material remains dark most probably due to abundant submicron inclusions of Fe-rich phase finally dispersed in the glassy mesostasis [5]. Additional factor may be carbonization of organic matter. Comparison of the spectral curves scaled to 1 at 0.55 µm (Fig. 2) shows that the spectra of irradiated Mighei separates do not significantly redden in the Vis-NIR region compared to the non-altered meteorite.

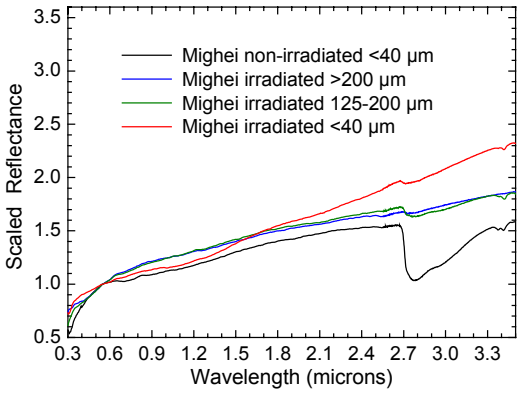

Fig. 2. Scaled reflectance spectra of non-irradiated and irradiated powdered samples of Mighei. Spectra are scaled to 1 at 0.55 µm. Particle size is indicated on the plot.

Mid-IR spectra (Fig. 3) of the irradiated Mighei demonstrate spectral dominance of olivine crystallized from the quenched melt. The 6 µm feature due to H-O-H bending present in the non-altered Mighei spectrum is now substituted by the complex olivine absorption feature near 5-6.5 µm possibly caused by overtones of Si-O fundamentals and their combinations with lattice modes [15]. Strong characteristic Reststrahlen bands of olivine (Si-O fundamentals) become evident between 10 and 16 µm, as well as the features at ~20 µm due to O-Si-O bending vibrations in olivine.

Our experimental products [5] show many mineralogical similarities to the samples produced by melting and quenching the CM2 chondrites in experiments by Clark et al. [16]. However, our altered samples are darker and their Vis-NIR spectra are more featureless.

Major spectral effects in our space-weathering simulation experiments on Mighei meteorite are dehydration and overall smoothing of the spectral curve. The irradiated samples are not much redder than the finest fraction of non-altered Mighei. However the non-altered finest fraction is redder than typical C-type asteroids [17]. Preliminary comparison of the irradiated Mighei´ spectra with those of low-albedo asteroids shows that the spectra of our experimental products (even the coarsest fractions) are redder than C-types and are comparable to P-, D-, and T-types. Most of asteroids of the latter types show no 3 µm feature related to hydrated phases. At least some of them might have featureless reddish spectra due to micrometeoritic bombardment of their surfaces. Preliminary comparison with Phobos´ spectra [18, 19] shows that irradiated Mighei samples are redder than Phobos "Blue Unit" but are not as red as Phobos' "Red Unit".

Thus, micrometeoritic bombardment may cause surface dehydration on dark asteroids/planetary satellites of CM composition covered with mature regoliths. In addition, this process may improve the spectral match between CM2 chondrites and, e.g., Martian moons in terms of spectral shape.

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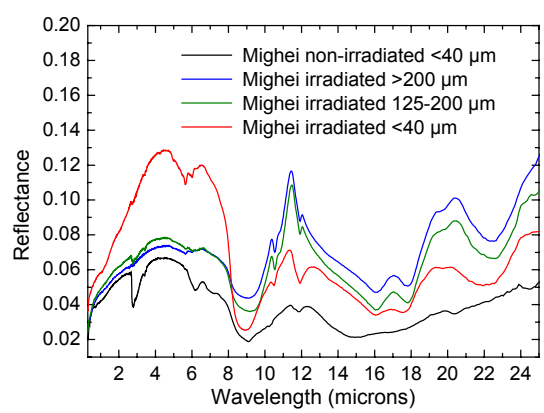

Fig. 3. Infrared reflectance spectra of non-irradiated and irradiated powdered samples of Mighei. Spectra are scaled to 1 at 0.55 µm. I Particle sizes are indicated on the plot.