
Reflectance spectra of heated Ivuna CI meteorite and some CM2 meteorite powders have been measured for the first time. Heated Ivuna samples show the same correlation between the UV and 3-μm absorption strengths as the CI/CM/CR meteorites and heated Murchison samples previously studied. In addition to the previously known five unusual CI/CM meteorites, thermal metamorphism has been detected for Y-82098 and EET87522 from their round 3-μm band. These heated CI/CMs fall into a consistent range on the UV-3 μm absorption plot.

Introduction: It was shown that the UV absorption strength is an indicator of thermal metamorphism of the C, G, B, and F asteroids to some extent [1] based on reflectance spectra of thermally metamorphosed CI/CM meteorites and artificially heated samples of Murchison CM2 meteorite [2]. Because the 3-μm band strength should be a more direct measure of hydration/dehydration [3], the correlation between the UV and 3-μm absorption strengths should be evaluated [4, 5] to apply the method to low-albedo asteroids. Both the UV and 3-μm spectra can be easily measured for carbonaceous chondrites to detect thermal metamorphism and to study any correlation among the UV absorption strength, the 3-μm absorption strength, and thermal metamorphism.

Experimental: Ivuna CI meteorite chips were heated in a vacuum cell with a carbon rod to keep the evolved atmosphere reducing at temperatures 300, 400, 500, 600, and 700 °C for one week. These procedures are slightly different from those used in the Murchison heating experiments [2]. Chips of the Ivuna samples and 13 CM2 meteorites (ALH84033, ALH84044, ALHA77306, EET87522, GRO85202, LEW87022, LEW87148, Y-74662, Y-791198, Y-793321, Y-82042, Y-82098, and Y-86789) were ground into powders of grain size <125 μm. Reflectance spectra of the powders were measured using the RELAB [6] bidirectional spectrometer and Nicolet FT-IR biconical spectrometer. These two spectral sets were connected to cover a wavelength range from 0.3 to 3.6 μm. Reflectance spectra of some other meteorites were taken from our previous study [7].

Method of Analysis: The shape of the 3-μm band was used to detect thermal metamorphism of CM meteorites because the heated ones tend to have a rounded 3-μm band instead of the usual triangular one. The UV and 3-μm band strengths are defined by ln[R(0.337)-lnR(0.55)] and ln[R(2.9-3.0)-lnR(2.3-2.5)], respectively, where R(x) and R(y-z) indicate reflectance at wavelength x μm and average reflectance in the wavelength range from y to z μm, respectively. R(0.337) and R(0.55) were calculated by simulating the ECAS filters [8] for asteroidal applications.

Results: Reflectance spectra of unusual CI/CMs and Ivuna samples are shown in Fig. 1. Previously proposed thermal metamorphism of Y-86789 [9] has been reconfirmed by its spectrum which has a round 3-μm band shape and weaker UV absorption strength than usual CMs. In the same way, EET87522 and Y-82098 have been found to be slightly and highly dehydrated, respectively. Y-74662, Y-791198, and ALH84033 also show unusual spectral shapes and similar 3-μm band strengths to those of heated CI/CMs. Reflectance spectra of naturally-heated CI/CMs are shown in order of decreasing 3-μm band strength in Fig. 1. Two separate portions of heated Ivuna show somewhat different spectral slopes and the UV and 3-μm absorption strengths. The Ivuna sample lost a large part of its 3-μm band strength by 300°C and almost completely lost it by 700°C, showing complicated changes of the 3-μm band in between. The UV absorption also weakened significantly by 300°C and the shape was changed at higher temperatures, ending up with a completely different shape at 700°C. The UV and 3-μm absorption strengths of meteorite samples are plotted in Fig. 2 together with the previously studied samples [7]. All the samples plot in a positively correlated zone (between two broken lines), where heated CI/CMs plot in the region with the 3-μm and UV absorption strengths weaker than -0.31 and -0.50, respectively. Both of two samples of heated Ivuna plot in the same region with other CI/CMs in Fig. 2.

Discussion: With the newly identified Y-82098, thermally metamorphosed CI/CMs compose 68 wt% of all CI/CM/CRs of Japanese Antarctic meteorite collection studied to date, whereas there are only two candidates (EET87522 and ALH84033) among the American Antarctic collection and none among non-Antarctic collections. Whether this bias reflects a real difference due to the arrival time of the meteorites or not is an important issue because these heated CI/CMs show the closest reflectance spectra to the C, G, B, and F asteroids [1, 10].
UV-3μm SPECTRA OF HEATED CI AND CM CHONDRITES: Hiroi T. et al.

Fig. 1. Reflectance spectra of naturally-heated CI/CMs and artificially-heated Ivuna (CI) meteorite.

Fig. 2. Plot of the 3-μm and UV absorption strengths of CI, CM, CR, and heated CI and CM meteorites. Heating temperatures (°C) are written next to the markers for heated Ivuna and Murchison meteorites.

Acknowledgments: We thank the American Museum of Natural History for the Ivuna samples and the National Institute of Polar Research and the Meteorite Working Group for the Antarctic meteorite samples. We also thank Loan Le and Gary Lofgren for assistance with the heating experiments. RELAB is a multiuser facility operated under NASA grant NAGW-748.