Applications of infrared nano-spectroscopy for carbonaceous chondrites: To understand organic-mineral interactions during aqueous alteration

*癸生川 陽子[1]、浦山 憲雄[2]、小林 華栄[2]、馬殿 直樹[2]、Bechtel Hans [3]、近藤 正志[4]、小林 憲正[1]
*Yoko Kebukawa[1], Norio Urayama[2], Hanae Kobayashi[2], Naoki Baden[2], Hans A. Bechtel[3], Masashi Kondo[4], Kensei Kobayashi[1]

1. 横浜国立大学 大学院工学研究院、2. 日本サーマル・コンサルティング、3. Advanced Light Source Division, Lawrence Berkeley National Laboratory、4. 横浜国立大学　機器分析評価センター
1. Faculty of Engineering, Yokohama National University, 2. Nihon Thermal Consulting, 3. Advanced Light Source Division, Lawrence Berkeley National Laboratory, 4. Instrumental Analysis Center, Yokohama National University

Organic matter in carbonaceous chondrites is distributed in fine grained matrix. Although 100 nm to <1 μm "nanoglobules" are often found in chondritic meteorites, these are ~10% of OM in chondrites [1], and the rest is smaller than nanoglobules. In order to understand pre- and post-accretion history of organic matter and its association with surrounding minerals, microscopic techniques are mandatory. Scanning transmission X-ray microscopy (STXM) combined with X-ray absorption near-edge structure (XANES) spectroscopy is so far the most suitable method in this purpose, that allows molecular structure information in ~40-nm spatial resolution. Infrared (IR) spectroscopy could be a complementary to XANES. However, the spatial resolution of IR is limited to a few micrometer, due to diffraction limit. Use of near-field light is one possibility to overcome the limitation of the spatial resolution. We have applied near-field IR spectroscopy to carbonaceous chondrites [2, 3]. However, the near-field signals are very low thus the intensity of IR light from a typical ceramic IR light source in a bench-top FTIR seems not large enough. Here, we applied two methods of high spatial resolution IR to carbonaceous chondrites, one is synchrotron infrared nanospectroscopy (SINS) using near-field IR with atomic force microscope (AFM) that is installed at Advances Light Source (ALS) beamline 5.4 [4, 5], other is AFM with its tip detecting thermal expansion of a sample resulting from absorption of infrared radiation (NanoIR2, Anasys Instruments) [e.g., 6].

We prepared ultramicrotomed thin sections of Murchison and Bells meteorites, as well as antigorite that was baked at 500 °C for 4 hours as a contamination control, since the IR absorption spectroscopy is susceptible to contamination from volatile organic matter [7]. We confirmed that both methods have at least 50-nm special resolutions. In the IR imaging, we observed that overlapping of regions that absorb 3400 cm^{-1} corresponding to OH and 2920 cm^{-1} corresponding to aliphatic CH, indicating association of organic matter with phyllosilicates. Such association is well known previously but in ~1 μm spatial resolutions [2, 3, 8]. We will further discuss parent body processes inferred from nano-scale IR imaging of Murchison and Bells meteorites.

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