学位論文要旨

Geochemical study of organic matter in terrestrial/extraterrestrial samples using multi-probe microscopic observation based on scanning transmission X-ray microscopy
（走査型透過Ｘ線顕微分光を主軸とした複合顕微分析に基づく
地球内外有機物試料の地球化学的研究）

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In this PhD thesis, we investigated several natural organic matter (NOM) included in terrestrial and extraterrestrial samples using our own multi-probe microscopic technique (X-ray, electron, and ion-probe analyses are combined). Our goal is (i) the establishment of a methodology for NOM analysis (including sample preparation, data extraction, and analysis), (ii) the clarification of organic-inorganic interactions occurring in the terrestrial and extraterrestrial samples, and (iii) the preparation for astrobiological samples that will be returned to the Earth in the future.

This PhD thesis consists of six chapters. Chapter 1 is for a methodology. The author developed Japanese original compact scanning transmission X-ray microscopy (cSTXM) device at BL-13, Photon Factory in High-Energy Accelerator Research Organization (KEK-PF) for terrestrial and extraterrestrial organic-inorganic samples. The author describes here i) why microscopic observation is important for NOM analysis, ii) general background about STXM, and iii) the characteristics of cSTXM from the viewpoint of hardware and software including its performance. Subsequently, the author explains our unique multi-prove analysis flow, cSTXM combined with TEM (transmission electron microscope)-NanoSIMS (secondary ion mass spectroscopy) analysis technique. The author developed sample preparation methods for samples with varied forms (e.g., powder, redox sensitive, and less amount samples), and also optimized the conditions for the systematic STXM-TEM-NanoSIMS measurements.

From chapter 2 to 5, the author applied own sample preparation techniques and optimized measurement flow described in chapter 1 for terrestrial and extraterrestrial samples. The author

attempted to clarify the organic-inorganic interactions occurring in various terrestrial and extraterrestrial samples; in chapter 2, the behavior of radioactive cesium adsorbed in clay minerals with organic mattes contained in river water, in chapter 3, the characterization of iron species around the microbe collected from a pond, in chapter 4, the observation of the building-brocks of early Solar System in carbonaceous chondrite, and in chapter 5, the characterization of of Martian subsurface water and related organic matter included in Martian breccia. The last Chapter 6 summarizes individual conclusion from chapter 1 to 5, and addressed unresolved issues. Several future prospects including ongoing sample return projects such as Hayabusa 2 were also mentioned in chapter 6.