Structural analysis of the carbonaceous materials in the Allende meteorite: Raman spectroscopy and TEM observation

Kazuhiko Morishita[1]; Masayuki Nara[2]; Sachiko Amari[3]; Jun-ichi Matsuda[1]

[1] Earth and Space Sci., Osaka Univ.; [2] Coll. Lib. Arts Sci., Tokyo Med. Dent. Univ.; [3] Washington University

[Introduction]

Phase Q has higher abundances of heavier noble gases (Ar, Kr, Xe) compared to those of the solar component. Although the isotopic and elemental abundances in phase Q are well known, no investigator has ever succeeded to identify this phase Q itself. It is only known that phase Q is a kind of purely carbonaceous material. We carried out the Raman spectroscopy and transmission electron microscope (TEM) observation to investigate how phase Q retain the noble gases and what structural feature it has.

[Sample and Experiments]

We investigated the HF/HCl residue (original residue) and its further treated sample with an oxidant (etched residue) of the Allende (CV3) meteorite. Lewis et al. (1975) reported that noble gases were in the HF/HCl residue that was obtained by dissolving the bulk Allende meteorite with HF/HCl. When the HF/HCl residue was further treated with an oxidant, most of the heavy noble gases were lost. The dissolved fraction is phase 'Q' that is only 4 to 8 percent of the bulk Allende and contains most of heavy noble gases in the bulk meteorite. We compared the structural features of the original residue and the etched residue to investigate phase Q.

[Results and Discussions]

The typical Raman spectrum of graphite shows G band (1580cm^{-1}) and D band (1350cm^{-1}). G means the graphite and D means the defect. D band derives the lattice defect of graphite. We compared the spectra parameters (peak positions, FWHMs and the intensity ratio of G and D band) between the original residue and the etched residue. The G band positions of the etched residue downshifted from those of the original residue. This result indicates that the oxidation changes the structure of graphite in the original residue and expands the bond distance of carbon. This was in agreement with our earlier studies of the Saratov meteorite (Morishita et al., 2008). However, the changes of FWHMs of D band and the intensity ratio were different from earlier studies.

In high-resolution TEM images the largest lattice spacing observed was 0.34 nm. Both the original residue and the etched residue contained many curved carbon layers, some enclosing voids and amorphous carbon. The orders of curved carbon layers are 20- 30 nm and those of the enclosed voids are 2-10 nm in size. Harris et al. (2000) and Harris et al. (2003) proposed that the enclosed voids were the very carrier of Q-gas because they simply observed a lot of voids in the original residue of the Allende meteorite. Our study shows that there is not much difference in enclosed voids between the original (Q-rich) and the etched (Q-deficient) residues, indicating that the enclosed voids are not phase Q.