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Fractal distribution of mercury inclusions in quartz by in situ X-ray computed tomography (CT) system

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Large amounts of data are obtained by contemporary analytical instruments and observation systems. Mathematical and statistical analysis of the obtained data serves for the states or origin of objective matter. As X-ray computed tomography (CT) analysis has been developed in medical imaging method, the CT analysis for terrestrial materials yields a new approach in resolving their internal structure and origin (e.g., Tsuchiyama et al, 2009). We here investigate in situ X-ray CT analysis of mercury inclusions in quartz, and discuss relationship between the inclusions and the quartz using mathematical and statistical analysis.

We used quartz crystal (2 cm x 5 cm x 5 cm) from San Benito, California. This crystal contains visible mercury inclusions of their size, 1-2 mm, and this crystal is a suitable sample for the CT analysis because great density difference between the inclusions and the crystal. We used a microfocus X-ray CT system (Shimazu Corp., SMX-225CT), and obtained 260 CT images of 2-D slices over rotating a sample. The obtained images were processed using an image processing software.

These 2-D binary images were utilized for fractal and multifractal analysis using box-counting method. Obtained fractal dimension (D) is 1.76, suggesting that the distribution of mercury inclusions in quartz indicate planate form (D=1, linear form; D=2, planate form). Based on multifractal analysis, fractal structure could not be uniform because its singularity is widely. As the fractal structure of mercury inclusion are formed by random walk of mercury particles in Euclid spatial, the mercury inclusion would coincide with quartz growth or flow without constrained situation. Preliminary results from in situ X-ray computed tomography (CT) analysis also yield to recognize quantitative and spatial information of the inclusions in the quartz using fractal and multifractal analysis.

Reference

Tsuchiyama et al., Meteoritics and Planetary Science, 44, 1203-1224, 2009.

Keywords: fractal, random walk, mathematical and statistical analysis, X-ray computed tomography system, mercury inclusions, in situ observation