Superresolution of X-ray CT images of core samples for understanding the multi-scale structures of water-rock interaction

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X-ray computed tomography (CT) has become a common tool of earth sciences for the 3D imaging of various structures (layering, fractures, pores etc) of rocks. Recently, several scientific drilling projects has been carried out, and the X-ray CT of such cores provide us the 100 to 1000 m scale continuous data. However, the resolution of such X-ray CT for the cores (for example, ~0.17 mm by the X-ray CT of Drilling Chikyu) is slightly low compare to reveal the shape and geometry of mineral grains and thin fractures. In contrast, the resolution of X-ray CT in usual laboratories is high (~0.01 mm). Therefore, if we can link the high resolution X-ray CT in the lab of the limited samples to the low resolution drilling core CT data, we can obtain the valuable big data for the analyses of multi-scale structures.

For this purpose, we have tried to apply sparse superresolution techniques to the sample of serpentinezed dunite in the Moho transition zone taken by the Oman Drilling project (CM1A). We took the X-ray CT images of the samples with the voxel size of 10, 20, 40 and 80 micrometers. The X-ray CT image reveals that distribution of magnetite and spinel grains and fractures filled with serpentine. In sparse image representation framework, an image is expressed as a sparse linear combination of basis images. In learning phase, basis images are learned from multiple X-ray CT images. In superresolution phase, high resolution X-ray CT image is estimated from low resolution one through common sparse representation of basis images between high and low resolution images. By applying the sparse superresolution technique to the sample of serpentinezed dunite, we obtained results that 2x and 4x sparse superresolutions provide fine structure from low resolution X-ray image.

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