Multifractal analysis of X-ray CT images of liquefied boring cores with seismically-induced deformation structures

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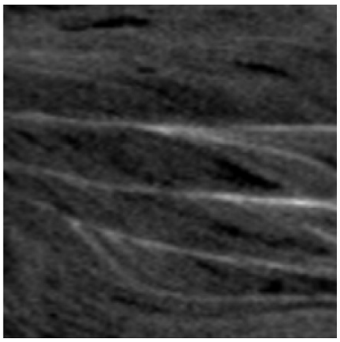
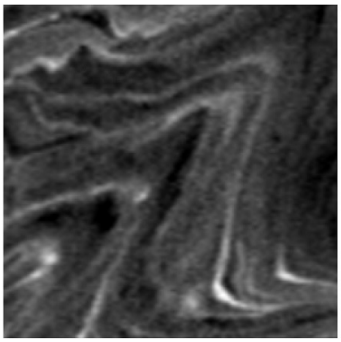
Unconsolidated soft sediments deform and mix complexly like Sumi-Nagashi marbling patterns [1] by seismically induced fluidization. Such geological soft-sediment deformation structures (SSDSs) recorded in boring cores were imaged by X-ray computed tomography (CT), which enables visualization of the inhomogeneous spatial distribution of iron-bearing mineral grains as strong X-ray absorbers in the deformed strata. Multifractal analysis was applied to the two-dimensional CT images with various degrees of deformation and mixing (Fig. 1). The results show that the distribution of the iron-bearing mineral grains is multifractal for less deformed/mixed strata and almost monofractal for fully mixed (i.e., almost homogenized) strata. Computer simulations of the deformation of real and synthetic digital images were performed using the egg-beater flow model. The simulations successfully reproduced the transformation from the multifractal spectra into almost monofractal spectra with an increase in the degree of deformation/mixing. The present study demonstrates that multifractal analysis coupled with X-ray CT and the mixing flow model is useful to quantify the complexity of seismically induced SSDSs, and is thus a novel method for the evaluation of cores for seismic risk assessment.

References:
[1] Terada,Torahiko et al., (1934) Experimental studies on colloid nature of Chinese black ink. Part I, Sci. Pap. Inst. Phys. Chem. Res. 23(482) 173-184.
[2] Nakashima, Yoshito and Komatsubara, Junko (2018) MULTIFRACTAL ANALYSIS OF SEISMICALLY INDUCED SOFT-SEDIMENT DEFORMATION STRUCTURES IMAGED BY X-RAY COMPUTED TOMOGRAPHY. Fractals, vol. 26, article ID 1850018 (open access at https://doi.org/10.1142/S0218348X18500184).

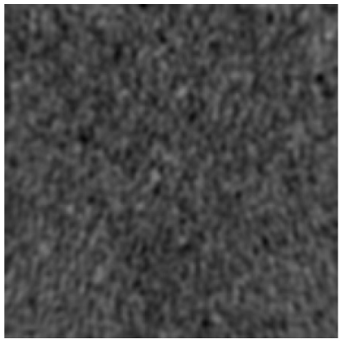
Keywords: liquefaction, multifractal, soft-sediment deformation, X-ray CT



undeformed



deformed



heavily deformed (manually homogenized)

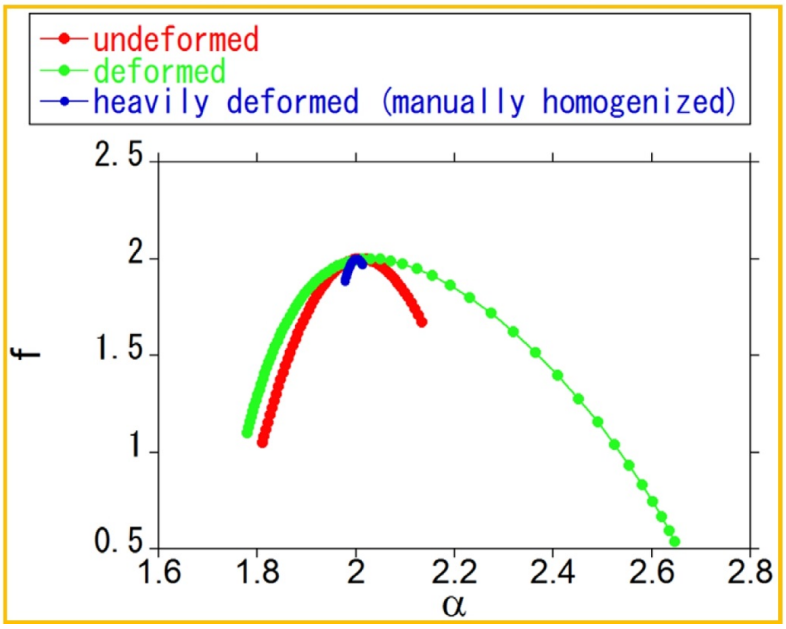


Fig. 1
Two-dimensional X-ray CT images of sediments with various degrees of deformation. The edge length of each image is about 5cm. The corresponding f(α) spectra are also shown (Nakashima & Komatsubara, 2018).