Environment and Energy Engineering

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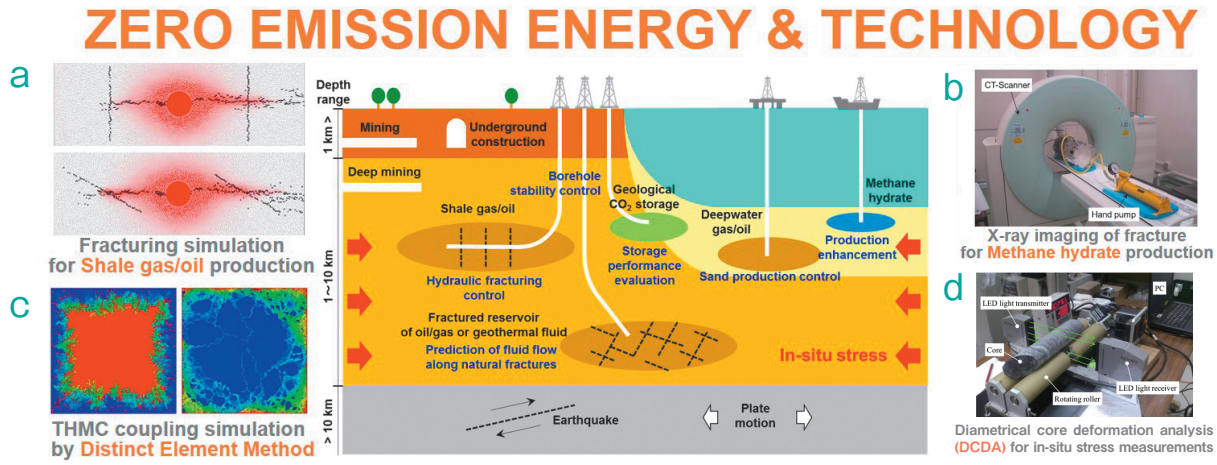

Development of Zero Emission Energy & Technology by "Geomechanics = Geo + Mechanics"

With the recent growth of the development for unconventional resources, we have realized that the knowledge of geomechanics is quite crucial for the understanding of failure phenomena in subsurface and resource development. In our lab., we have been conducting researches based on geomechanics for various applications such as CO2 geological storage, methane hydrate from deep seafloor, unconventional resources (shale gas & oil), easy and reliable in-situ stress measurement, and supercritical geothermal resource development. We develop the technology to highly utilize the subsurface environment (temperature, stress, closedness) to solve many challenges related to energy and to realize a sustainable society.

a. Highly utilization of hydraulic fracturing in unconventional resources development

Unconventional resources such as shale gas & oil generally exist in impermeable formations. Hydraulic fracturing is an essential method to extract those resources economically by nucleating or reactivating fractures. Those failure phenomena still have many aspects of being investigated since we cannot directly observe the failure phenomena in the subsurface. So, we have to develop the technology to control the fracture nucleation and reactivation for efficient resource development. In our lab., we are working for the understanding of fracturing behavior and the process of permeability enhancement to establish new theories for the engineering application of these phenomena.

b. Understanding of fracturing mechanism on unconsolidated formation and application to the methane hydrate production

Methane hydrate often locates in the unconsolidated formation such as a soft sand rock in the seafloor. Methane hydrate has been found in the seafloor of Japan and expected for our next energy resources. The fracturing method will be used for the effective production of Methane hydrate. However, the theory of fracturing for hard rock cannot be simply applied for such soft formation. We research to understand the mechanism of fracturing to the soft formation by using our special apparatus and computer simulation methods.

c. Investigation on Hydro-Thermal-Mechanical-Chemical (THMC) coupled phenomena of a subsurface environment using the discrete element method (DEM)

DEM method is a relatively new computer simulation method that can analyze larger deformation associated with failure phenomena of the rock mass. We originally develop the DEM code and realize THMC coupled phenomena in the subsurface environment to understand the mechanism of failure of ground material such as sand, mud, and rock.

d. In-situ stress measurement by diametrical core deformation analysis (DCDA)

Measurement of in-situ rock stress is a critical parameter for the effective production of geothermal or unconventional hydrocarbon resources as well as the evaluation of seismic hazard risk. We propose a new method of diametrical core deformation analysis (DCDA) for evaluating the in-situ stress of rocks from an elliptical deformation of boring cores. DCDA is game-changing method since we can directly estimate the magnitude of in-situ stress from simple core diameter measurement.