流体科学研究所 特別講演会のお知らせ

2019/1/10 THU 10:00-12:00 @流体科学研究所２号館大講義室

USGS より Justin Rubinstein 博士と UC Berkeley より Jack Norbeck 博士の特別講演会を開催いたします。両者ともに米国の地下流体エネルギー開発時に発生する誘発地震分野のトップクラスの研究者です。Norbeck 博士は平成 30 年度一般公募共同研究の一環で来所されます。どうぞ，奮ってご参加ください。

A Review of Induced Seismicity in the United States Since 2001

Justin Rubinstein (US Geological Survey, Menlo Park, CA)

The central United States is experiencing an unprecedented surge in earthquakes that began in 2009, rising from an average of 21 magnitude 3 and larger quakes to over 1000 M3 earthquakes in 2015 alone. The primary cause of these earthquakes is the deep underground injection of waste fluids that are a byproduct of the oil production process. Oklahoma has experienced the largest increase in seismicity, such that its earthquake rate has exceeded that in California for the past 5 years. The earthquakes are primarily induced by an increase in fluid pressures due to the fluid injection, but there is mounting evidence that poro-elastic stresses are also an important factor in inducing seismicity.

Here we will explore both case studies and synthesis studies as a foundation for our knowledge of induced seismicity. These studies have demonstrated that geologic conditions and operational parameters strongly affect the likelihood that injection will cause earthquakes. Based upon these studies, the USGS has developed statistical and hydro-mechanical methods to forecast induced earthquake rates and their hazard. USGS hazard forecasts have been used by state and federal regulators in their development of rules to mitigate seismicity. As a result of regulatory actions in concert with the decrease in the price of oil, earthquake rates in the central US have dropped by nearly 75 percent since their high in 2015.

Mixed-mechanism stimulation at Fenton Hill

Jack Norbeck (US Geological Survey, Menlo Park, CA/UC Berkeley)

The Fenton Hill enhanced geothermal system (EGS) test site was the first of its kind, and interpretations of field observations from the project have influenced the past four decades of EGS development. In this study, we hypothesized that stimulation (i.e., permeability enhancement) in the Fenton Hill reservoir occurred through a mixed-mechanism process that involved propagation of hydraulic splay fractures encouraged by the stress changes induced as natural fractures opened and failed in shear. We used a hydromechanical fractured reservoir numerical model to validate the efficacy of the mixed-mechanism stimulation conceptual model. Our modeling results were consistent with the observations recorded during the Fenton Hill field

experiments in three distinct ways: (1) a marked increase in injectivity occurred at a threshold injection pressure, (2) the near wellbore injectivity enhancement following each stimulation treatment was reversible, and (3) seismicity propagated in a direction that was inconsistent with the orientation of the maximum principal stress, despite injection having occurred at pressures significantly above the fracturing pressure. The modeling results demonstrate that several independent hydromechanical observations could be replicated by the mixed-mechanism stimulation conceptual model. In contrast, the observations could not be explained by a pure mode-I hydraulic fracture propagation nor by pure shear stimulation. Distinct fracture sets are activated through the mixed-mechanism stimulation process; the natural fractures provide most of the heat transfer surface area, and the tensile splay fractures form the bulk of the fluid storage volume. Future EGS projects could take advantage of mixed-mechanism stimulation to design wellbore completion and reservoir engineering and strategies to increase effective transmissivity, improve heat mining efficiency, and extend useful reservoir lifetime.

Info.

東北大学 流体科学研究所 地殻環境エネルギー分野
椋平　祐輔 Yusuke Mukuhira
Email: mukuhira*tohoku.ac.jp(*→@)