Anisotropic Elastic-Waveform Inversion and Least-Square Reverse-Time Migration for Geothermal Reservoir Characterization

Dr. Lianjie Huang
Senior Scientist
Los Alamos National Laboratory
Los Alamos, NM 87545, USA

Abstract: Geothermal fields often consist of complex fault/fracture systems and complex geologic structures altered by heat and hot water, which result in significant seismic-wave scattering in incoherent seismic reflections. Some geothermal fields such as the Soda Lake geothermal field in Nevada, USA, also contain a basalt body in addition to a complex fault system. We develop a suite of novel elastic-waveform inversion and least-squares reverse-time migration methods in anisotropic media for geothermal reservoir imaging and characterization. In addition, we develop a novel structure-oriented, fault preserving, nonlinear anisotropic diffusion filtering method to unravel faults on seismic migration images. We present geothermal imaging results of 3D surface seismic data from the Soda Lake geothermal field, walkaway VSP data from the Raft River geothermal field, and continuous active seismic source monitoring data from the EGS Collab project. The ongoing EGS Collab project is supported by the U.S. Department of Energy's Geothermal Technologies Office. Under this project, U.S. national laboratories, universities and industrial collaborators are conducting intermediate-scale (on the order of 10 m) field experiments at the Sanford Underground Research Facility (SURF) site to study the fracture creation using hydraulic and shear stimulations. Our imaging results at various scales demonstrate anisotropic elastic-waveform inversion, elastic reverse-time migration, and nonlinear anisotropic diffusion filtering are powerful tools for imaging faults and geothermal reservoirs in hydrogeothermal fields and enhanced geothermal systems. This work was supported by the U.S. Department of Energy's Geothermal Technologies Office.

Biography: Lianjie Huang is a Senior Scientist 5 at Los Alamos National Laboratory. He obtained his PhD in Geophysics (1994) from the University of Paris 7/Institut de Physique du Globe de Paris, under supervision of Peter Mora and Albert Tarantola, after receiving his B.Sc. in Physics (1985) and M.Sc. in Mathematics (1989) from Peking University. His research encompasses high-resolution seismic imaging and inversion for subsurface resource/fracture characterization, and medical ultrasound imaging for early detection and characterization of breast cancer and prostate cancer. His research in seismic imaging includes acoustic- and elastic-wave modeling, least-squares reverse-time migration, and full-waveform inversion in isotropic and anisotropic media with applications to subsalt imaging, geothermal energy, and geologic carbon storage. He has served as PI for numerous projects on seismic imaging and medical imaging for more than $45M of funding supported by U.S. DOE and DoD. He has mentored 21 summer students and 22 postdocs. He has published more than 200 peer-reviewed journal papers and proceedings papers.