King Abdullah University of Science and Technology
Thuwal, 23955-6900, Saudi Arabia
Mobile: +966-544700581
E-mail: kai.lu@kaust.edu.sa

KAI LU

RESEARCH INTERESTS

- Seismic interferometry
- Seismic modeling, migration and inversion
- Seismic land data acquisition and processing
- Machine learning in seismic data processing

EDUCATION

- **B.S.**, Geophysics, University of Science and Technology of China, 2008 – 2012.
- **M.S.**, Geophysics, King Abdullah University of Science and Technology, 2012 – 2014.
- **PhD. Candidate**, Geophysics, King Abdullah University of Science and Technology, 2014 – expected at the end of 2018.

INTERNSHIP

- **Saudi Aramco (Dhahran),** July – Sep, 2017
- **Topic: Code optimization and parallelization for the pQC module:** I optimized the code of the pQC module by algorithm optimization, language conversion (from Python/Matlab to C/C++) and parallelization. It leads to a 10X - 30X speed boost when running the code with a single node, and further improvement depending on the number of nodes.

FIELD EXPERIENCES

- **Olduvai Gorge Seismic Project,** June. 2015 – Feb. 2017

  I took charge of this project, collecting seismic land data in Olduvai Gorge, Tanzania, with the purpose of imaging the subsurface of the Olduvai Basin, as a part of hominid research in this area. I trained a team of 15 local people on how to use the seismic equipment and led them recording 2D seismic land data with a total length of more than 12 km in four trips. I also organized the logistics including the equipment transportation, the food supply, and the daily service from the locals.

RESEARCH EXPERIENCES

- **Auto-windowed Super-virtual Interferometry via Machine Learning,** Feb. 2018 – current

  Super-virtual Interferometry (SVI) is a tool to significantly improve the signal-to-noise ratio (SNR) of the far-offset first arrivals. However, a time window must be specified that contains the first-arrivals, and such windows are usually manually picked. I propose an approach to automatically pick windows for SVI via two machine learning methods: convolutional neural network (CNN) and density-based spatial clustering of applications with noise (DBSCAN). This approach provides a strategy to auto-pick the first breaks for severely noisy data: automatic SVI data enhancer + FB auto-picker on SVI enhanced data.

- **Super-virtual Interferometry for Reflections**, July. 2017 – Feb. 2018
  The Super-virtual Interferometry (SVI) theory is successfully applied to far-offset reflections with the property of semi-stationary phases, which is defined as that the traces in the common pair gather are nearly aligned and the largest phase shift among the traces is less than quarter period. This work enables SVI to become a powerful tool to improve the seismic data throughout the whole workflow from first arrivals to reflections.

- **Hominid Seismology – Seismic Imaging of Olduvai Basin**, July. 2015 – Feb. 2018
  We use seismic methods to image the subsurface structure of Olduvai basin in Tanzania, providing references for geologists and paleoanthropologists to better understand the environments hominids lived million years ago. I am in charge of this project from data acquisition to processing. We recorded three active seismic 2D lines, with the length of 6km, 4.2km and 4.6km, respectively. Both refraction and reflection data are processed. The depth of the bedrock revealed by the seismic result is around 400 m, which is beyond previous expectation, suggesting a longer hominid history in this area.

- **Theory of Skeletonized Inversion**, Apr. 2015 – Dec. 2016
  I theoretically derived the general theory of skeletonized inversion. Instead of the full wavefield, a skeletonized feature is used to match the predicted and observed data, in order to simplify the objective function and mitigate the cycle skipping problem. A connective function with an implicit form is defined to connect the waveform and a certain feature, which is sensitive to the change of the inverted parameter. The theory is general, and can be applied to cases with any skeletonized feature and inverted parameters. I introduced several successful examples such as WT, WQ, WD and Plane-wave MVA.

- **3D Super-virtual Refraction Interferometry**, Sep. 2013 – Feb. 2017
  I extended super-virtual refraction interferometry from 2D to 3D, to improve the signal-to-noise ratio of far-offset head waves. The stationary phase integration is applied along the source or receiver line, avoiding the necessity of knowing the location of stationary sources or receivers. In the field marine data example, the pickable offset is increased from 10 km to at most 18 km.

- **Iterative Multiple Elimination**, Sep. 2014 – Apr. 2015
  We separate primary from multiples by iterative method. The predicted demultipled data is least-square migrated to model domain, then the image is demigrated with a multiple forward modeling operator. By minimizing the difference between calculated primary + multiple data and original data, the predicted primary data is updated iteratively with gradient based method.

- **Visco-acoustic Least-squares Migration of Cross-well Data**, Nov. 2012 – Feb. 2013
  The visco-acoustic wave equation is applied into least-squares reverse time migration algorithm, to compensate the energy attenuation and modify the phase shift caused by the anelastic property of the media. The image is much focus and balanced in low Q area compared to the standard LSRTM.

SELECTED PUBLICATIONS

- ***K. Lu**, S. Hanafy, I. Stanistreet, H.Stollhofen, K. Schick, N. Toth, J. Njau and G. Schuster*, Seismic imaging of the Olduvai basin: Palaeo3 (accepted with minor revision).
- *J. Njau, I. Stanistreet, H.Stollhofen, K. Schick, N. Toth, A. Deino, L. McHenry, **K. Lu**, S. Hanafy and G. Schuster*, Coring and seismic surveys shed new light on hominin evolutionary framework at Olduvai Basin, Tanzania: Science (submitted).
- **K. Lu**, A. Atheyab and G. Schuster, 2018, 3D super-virtual refraction interferometry: Geophysics (submitted).
- ***K. Lu**, J. Li, B. Guo, L. Fu, and G. Schuster*, 2017, Tutorial for inversion of skeletonized data: Interpretation, 5(3), SO1-SO10.
- ***K. Lu**, A. AlTheyab, G. Schuster*, 2014, 3D super-virtual refraction interferometry: SEG Technical Program Expanded Abstracts, pp. 4203-4207.
- *J. Li, **K. Lu**, and G. Schuster*, 2018, Two robust imaging methodologies for challenging environments wave equation dispersion inversion of surface waves and guided waves an supervirtual interferometry+ tomography for far-offset refractions: Interpretation, (accepted).
- *G. Schuster, J. Li, **K. Lu**, A. Metwally, A. AlTheyab, and S. Hanafy, 2017,* Opportunities and pitfalls in surface-wave interpretation: Interpretation, 5(1), T131-T141.
- **K. Lu** and Z. Liu, 2018, Super-virtual interferometry for reflections (to be submitted soon).

COMPUTER SKILLS

- Programming: MATLAB, Python, Fortran 90/95, C/C++, MPI, OpenMP
- Seismic Softwares: Seismic Unix, Madagascar

AWARDS

- Best Presentation Award in 2018 SEG Maximizing Asset Value through Artificial Intelligence and Machine Learning Workshop

REFEREES

- Supervisor: **Gerard Schuster**
  Professor, King Abdullah University of Science and Technology
  gerard.schuster@kaust.edu.sa
- **Ian Stanistreet**
  Professor, University of Liverpool
  istanistreet@btconnect.com
- **Daniele Colombo**
  Team Leader, Saudi Aramco
  daniele.colombo@aramco.com