



# 2019 GSH-SEG Spring Symposium and Exhibition The Resurgence of Seismic Inversion



*By Maitri Erwin (GSH First Vice President and Symposium General Chair)*



The Geophysical Society of Houston and Society of Exploration Geophysicists once again co-hosted the annual Spring Symposium, which was held on April 16<sup>th</sup> and 17<sup>th</sup> 2019 at Norris Conference Centers in Houston's Energy Corridor. This year, the GSH took the opportunity to celebrate seismic inversion and the contributions of Dan Hampson and Brian Russell. The event was attended and enjoyed by more than 200 Houston-area and Canadian geoscientists, underpinning the continued importance and value of the GSH and relevant events to the profession.

Seismic inversion takes us back to the rocks. It transforms seismic reflection data into the closest possible description of the invisible earth – what is the rock and what is in it? In a time for our profession when geoscientific integration and scientist collaboration are increasingly emphasized and rewarded, the seismic inversion expert has

been doing this for decades. There is no doubt our profession will continue to rely on seismic inversion for all aspects from exploration and enhanced resource recovery to aquifer detection and novel applications of geophysics.

Therefore, the chosen theme of the 2019 symposium was "The Resurgence of Seismic Inversion" with theory and case studies which highlighting advances in seismic inversion that impact drilling decisions. And who better to honor in the field of seismic inversion than Dan Hampson and Brian Russell? Dan and Brian are well known for the development of industry leading geophysical analysis software. Many in the industry developed their quantitative interpretation and reservoir characterization skills using Hampson & Russell theory and tools.

Expertly curated by Technical Chair Jim Schuelke and Technical Subcommittee Chair Simon Voisey, the talks devoted to inversion featured industry experts from operators, service companies and academia, as well as students up and coming in the field. The extended presentation and discussion time after each talk offered a lot of time for Q&A and lively discussion among audience members. The following is a summary of the days' talks and events.

## **Session 1: The Basics**

After a short welcome and introduction by Symposium General Chair Maitri Erwin and Technical Chair Jim Schuelke, the very first talk



*Web Symposium continued on page 19.*



# 2019 GSH-SEG Spring Symposium and Exhibition



was given by Brian Russell himself on the history of seismic inversion. In this talk, Brian reviewed the key mathematical concepts of inversion and early innovations, including the integration of seismic amplitude values to approximate the acoustic impedance and the incorporation of the low frequency component from picked seismic velocities to recover the missing frequency content. Also discussed was how these ideas paved the way for the further development of seismic inversion techniques in the almost half century since the original work. Brian ended the talk with an overview of current inversion methods and future innovations, including stochastic approaches, the FWI method and the incorporation of machine learning techniques. A very lively discussion with audience members, including legends such as Fred Hilterman, Heloise Lynn and Leon Thomsen, followed this presentation.

Next, Tad Smith gave a primer on seismic petrophysics and the need for proper conditioning and analysis of log data for seismic inversion. The talk included many key takeaways – careful log editing, taking the time to understand log responses, and increasing awareness of reservoir complexity beyond quartz and clay. Colin Sayers closed out the morning with a talk on advanced seismic inversion for engineering applications in unconventional plays. Sayers emphasized the need for in-situ stress and natural fractures to model hydraulic fracture propagation, and the use of AVOAz inversion to characterize in-situ stresses and pore pressures. He underlined how this helps optimize well placement, trajectory and spacing before spud.

The SEG Gulf Coast Challenge Bowl sponsored by Hess and ExxonMobil was held during lunch, emceed by the energetic Peter Duncan. Five university teams of two students each (University of Texas at Austin, University of Tulsa, Oklahoma University, and two teams from University of Houston) competed against each other in this fun geoscience trivia game show. It was a close and heated battle between University of Houston's Team Cryogenian and Oklahoma University until UH Team Cryogenian took the lead towards the end to win a trip to the 2019 SEG Annual Meeting in San Antonio. Good job, students!

## **Session 2: Student Papers and Case Study**

The afternoon session was presided over by Rob Stewart (University of Houston). As mentioned above, one novelty this year was the inclusion of papers given by graduate students. Four area students gave lightning talks that highlighted the uses of emerging computational and physical technology



Web Symposium continued on page 20.





# 2019 GSH-SEG Spring Symposium and Exhibition



– deep learning workflows, neural networks, high-performance computing, and distributed sensors – in seismic inversion. The presenters were Wenyan Zhang (University of Houston), Son Phan (University of Texas at Austin), Ao Cai (Rice University), and Ezzedein Alfataiarge (University of Houston).

After the student presentations, attendees enjoyed a Vendor Hour in which they interacted with a record ten exhibitors to learn about their technologies and services. The attendees included CGG, Dawson3D, Earth Signal Processing, FracGeo, Gustavson Associates, GSH, IKON Science, Lumina Technologies, Schlumberger, and SeisWare International. Thank you to all vendors for their support of the Symposium.

The final talk of the day was a case study given by Arcangelo Sena (ConocoPhillips) on the use of quantitative seismic reservoir characterization in unconventional plays using the ConocoPhillips' acreage in the Permian Basin of Texas as an example. Arcangelo emphasized the value of 3D integrated reservoir models based on geologist input.

The day closed out with a reception in which the speakers, vendors, and colleagues all continued to mingle.

## **Session 3: Advances**

Robert Stewart (University of Houston) kicked off Day 2 with a talk on "enriching the harvest", i.e. using as much of the recorded wavefield as possible to image the subsurface for property estimation. He gave a nice overview of the growing scope and scale of data collection, and the emerging tools and techniques to get the most out of the data as well as applications to onshore data sets.

The morning continued with Jon Downton (CGG) discussing machine learning; more specifically, deep neural networks (DNN) and its uses in predicting, from seismic data, density, P- and S-wave impedances and other rock properties. Jon described the two-component theory-guided data science model (TGDS) in which the outputs of the theory-based component are used as inputs in the data science component. Jon compared the results of a DNN inversion with those of a deterministic inversion.



Web Symposium continued on page 21.



# 2019 GSH-SEG Spring Symposium and Exhibition



The morning concluded with a talk by David Johnston (Differential Seismic) on time-lapse inversion and the move to quantitative 4D interpretation. Johnston examined several 4D inversion methodologies and how to address their limitations. He highlighted the value of the 4D FWI for the improvement of imaging, relaxing repeatability requirements, increasing automation, faster cycle time and meaningful quantitative results with uncertainty estimates.

This was followed by the Toast and Roast of Dan Hampson and Brian Russell during lunch, sponsored by CGG and emceed once again by Peter Duncan. Dan and Brian and their spouses were equal parts amused and touched by the photographs and memories offered by Peter Duncan, Jon Downton, Jim Schuelke, Tad Smith, Simon Voisey, John Castagna and many others. Maitri Erwin presented each honoree with a polished ammonite, aptly two halves of the same fossilized whole. We hope that the Toast and Roast event is a cherished memory for years to come for both Dan and Brian and all attendees alike.

## **Session 4: Case Studies**

Day 2's afternoon session began with a talk by John Castagna (University of Houston) that highlighted the limitations of the conventional sparse-spike approach in closely-spaced, large-reflection events due to side-lobe interference. Castagna described reflectivity decomposition – a type of waveform decomposition, as well as phase decomposition, which was suggested as being valuable and currently underutilized.

The afternoon continued with a talk by Klaas Koster on the comparison and contrast of conventional and unconventional reservoir characterization. Koster proposed that, while they are invaluable in the exploration and volumetric assessment of conventional reservoirs, data- and technology-intensive geophysical solutions are not applicable to onshore resource plays, and that the current focus of multi-disciplinary onshore characterization projects is on the geomechanical aspects of the zone of interest.

The day and Symposium concluded with an overview of inversion techniques, culminating in facies-



*Web Symposium continued on page 22.*





## 2019 GSH-SEG Spring Symposium and Exhibition



and multi-realization-based inversion, by Gabriela D'Aubeterre (Ikon Science)

Much gratitude goes to the Symposium Committee members, volunteers and GSH staff for their advice, support, hard work and dedication. This year, the committee consisted of Maitri Erwin (General Chair), Peter Wang (Vice-Chair and Challenge Bowl support), Jim Schuelke (Technical Program Chair), Simon Voisey (Technical Program Sub-Committee), Peter Duncan (Challenge Bowl), Lee Lawyer (Toast and Roast), Haynie Stringer (Sponsorship and Advertising), Karen Blakeman (Exhibitors), Denise Dorsey (Venue), Frank Dumanoir (Technical Support and Speaker Gifts), Kathy Sanvido (Website and Registration), Nicola Maitland and David Moral (Volunteers), and Zohreh Souri (Program Book). The organizing committee and chairs are open to feedback and suggestions for future meetings.

A big thank you to the GSH Board, Dennis Yanchak (GSH President) and to our annual sponsors for

their commitment to supporting our Society! And a special thank you to the Spring Symposium sponsors - CGG, Anadarko, ExxonMobil, Chevron, Apache, FracGeo, MicroSeismic, effdee consulting, and ZTerra.

Finally, we thank our members. Your participation has allowed us to continue offering educational, networking and social events that allow us to maintain a vibrant geoscience community. But, how do we sustain and grow into the future? How do we evolve and diversify revenue? How do we promote diversity, inclusion and outreach even more? Each one of us has a responsibility to this Society, so we ask you to become more involved in our conversation and strategies. Please encourage your colleagues - especially early career professionals - to become members of the GSH and, if you are in the position to do so, help secure sponsorship dollars at any level. We look forward to seeing you at the next GSH-SEG Spring Symposium. □

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