Virgil Kauffman Gold Medal

Xianhuai Zhu

Xianhuai Zhu has significantly advanced the concepts, developments, and application of solutions to seismic imaging below complex near-surface environments. He previously received the SEG Life Membership (2018) and Reginald Fessenden (2012) awards. He is awarded the Virgil Kauffman Gold Medal for his pioneering research and applications of joint tomography using both turning-ray and reflections, which provide a viable tool for the industry to construct near-surface velocity models that are essential for accurate onshore depth imaging in complex geologic settings. Zhu founded Forland Geophysical, which has developed and applied a technique for integrated tomography for velocity model building under complex near-surface conditions such as foothills areas and gas-obscured zones. This work has been applied to multiple projects with great success on several continents and in challenging geologic environments, including onshore basins in China, the United States overthrust, the Andes of South America, Southeast Asia, and the Middle East. SEG is proud to award the Virgil Kauffman Gold Medal to Zhu for his significant advancement in applied geophysics.

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by Allen Bertagne, Samuel Gray, and Alfred Liaw

Xianhuai Zhu is being honored with SEG’s Virgil Kauffman Gold Medal Award for his decades-long technical accomplishments in processing and imaging of seismic data from challenging land environments. These advances have resulted in recent seismic images from foothills and other areas that are far superior to the best images that were possible even a decade ago. In 2012, he received the SEG Reginald Fessenden Award for fundamental contributions to near-surface seismic imaging, in particular his development of turning-ray tomography. He has also volunteered much of his time over the past decades to serving SEG. For those activities he was recognized in 2018 with SEG’s Life Membership Award.

Xianhuai's work on land seismic data began in the 1990s and over time evolved into a systematic approach that combines advanced processing techniques with realities of land data acquisition. The challenges faced in terrestrial settings include sparse surface sampling, rugged topography, and poor sensor coupling caused by ground conditions. To this day, these factors limit our ability to estimate velocity and image land seismic data successfully. Another of Xianhuai's contributions has been to describe some of the associated imaging and velocity uncertainties.

In a 1992 paper in *The Leading Edge*, Xianhuai and coauthors introduced the concept of tomostatics (turning-ray tomography plus static corrections). A follow-up in GEOPHYSICS in 1998 showed striking early examples of applying the method to synthetic and field data, and as a result the method was quickly adopted by the industry. By 2001, he shared his vision for the "road ahead" for land imaging in an SEG presentation, consisting of a combination of near-surface velocity estimation (refraction tomography) and deeper velocity estimation (reflection tomography) in a joint inversion. Sparse surface sampling of land seismic data delayed a full realization of this vision until more recent developments such as 5D seismic interpolation. In many cases, 5D interpolation (or simply acquiring denser data) has allowed a downward shifting of the refraction tomography maximum depth and an upward shift of the reflection tomography minimum depth, resulting in an overlap region with sufficient statistics to permit a joint inversion. This joint tomography approach has been used to create improved velocity models in areas with rugose topography and complicated near surface in such diverse regions as Tarim Basin, China; shallow low-velocity gas clouds in southeast Asia; high-velocity basaltic outcrops in the Middle East; and areas of low-velocity sand dunes. A good summary of Xianhuai's approach appears in his coauthored 2018 paper in *Interpretation*. Continued refinements in both technology (e.g., machine-learning-based first-break picking) and workflow have resulted in a comprehensive approach to imaging seismic data in foothills areas, as described in his 2020 coauthored *Interpretation* paper.

Three decades ago, Xianhuai chose to tackle a particularly challenging problem — imaging land data. Land-data processors are well aware of unique problems that originate in the near surface: significant elastic-wave scattered noise, low P- and S-wave velocities, extreme anisotropic effects, and more. These problems are often exacerbated by sparse data sampling, which usually results in aliased elastic-wave noise and poor statistics for velocity estimation.

Limitations of seismic acquisition, including weak coupling, nonrepeatable source signatures, and sparse surface sampling, have prevented the complete solutions of all these problems. This situation persists even now. As a result, seismic images on land have not been able to match the levels possible in the case of deepwater P-wave imaging. The techniques pioneered by Xianhuai may not initially appear as "glamorous" as, say, full-waveform inversion and least-squares reverse time migration, which are now routine for marine processing, but given the realities of land seismic data, they are equally significant and they represent the most-advanced currently available technology. There can be no doubt that the images resulting from application of these pioneering approaches are a distinct improvement over depth-migrated images from a decade ago and a spectacular improvement over the state of the art (refraction statics, residual statics, time-velocity analysis, time migration) from two decades ago!

In summary, Xianhuai's dedication to land seismic acquisition, processing, and velocity estimation, in areas with a complex near-surface geology, has greatly advanced seismic imaging technology in challenging areas widely encountered on all continents. Modern land imaging owes much to his efforts, and the sum of those technical efforts make him clearly worthy of one of the SEG's very highest honors, the Virgil Kauffman Gold Medal.