The history of MASW

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Editor's note: The Back Page is a new feature in TLE that has been added to allow publication of short articles which may not easily fit into other sections of the journal. The first year of articles in this section will be primarily devoted to brief reviews of what are believed to be the most cited and/or influential articles published in TLE's first 25 years. However, it is expected and hoped that the content of this feature will become increasingly diverse in the future. Contributions from SEG members are welcome. This article discusses "Multichannel analysis of surface waves to map bedrock" by Rick Miller, Jianghai Xia, Choon B. Park, and Julian M. Ivanov, published in December 1999.

The story of "Multichannel analysis of surface waves to map bedrock" was based on a project of opportunity. Surface waves have always been the bane of near-surface reflection seismologists, even more so than petroleum exploration seismologists because of the close offsets and small two-way traveltimes we routinely deal with. With the development of MASW at the Kansas Geological Survey in the mid-1990s, surface waves have proven their utility as signal rather than noise on multichannel seismograms used for many near-surface applications. Extending the original 1D velocity estimation method to a 2D imaging and mapping technique was first demonstrated in this article.

Prior to this paper, the utility, accuracy, and precision of the newly developed MASW method to estimate 1D shear-wave velocity functions had been demonstrated in several studies and publications. One of the most significant of these studies was a field test in the Vancouver, Canada area, orchestrated by Jim Hunter of the Geological Survey of Canada (which included the first blind test of the method with ground truth). This test turned out to be both the blue-ribbon success this method needed to enhance its credibility and a credit to Hunter's insight and vision. The success of that test spurred the team that authored this paper to extend the potential of this 1D method of estimating shear-wave velocities into a large-scale 2D imaging technique specifically designed for near-surface problems.

A great deal of credit must go to Carlene Merey and Eric Williams of Harding Lawson Associates (now MACTEC), who realized the utility of the method and put a great deal of faith in the science and potential of technique. As with any method, without a critical mass of supporting case studies, potential clients were skeptical about paying for "proof of concept" work (in this case it was more proof of application). In spite of lacking a bona-fide track record of successes, Merey was convinced this approach would be optimal for their site and project objectives. So, collectively, Carlene and Eric pushed management until the decision was made to take more risk than they were comfortable with and spend the money.

The follow-on explosion in research and use of this method since this paper was published has been overwhelming and beyond what we had ever imagined. There are now several software packages commercially available for processing MASW or very similar methodologies. As well, we are aware of several hundred users (individuals, companies, governments, and universities) with whom MASW capabilities are a standard part of their repertoire of tools available for various near-surface mapping and material characterization applications.

In the early developmental stages of this technique, Rob Huggins of Geometrics brought to our attention the need to address commonly encountered construction problems. In 1995, he mentioned the many challenges of Chinese engineers as they began to address a substantial upgrade of the national railroad system. Since that time, we have worked with Geometrics and brought our results to the geoscience community through several conferences and workshops. We have discussed the need for reducing the ambiguity associated with inversion of Rayleigh waves, as well as possible wider application of the technology. Improved resolution and S/N would permit continuous profiling.

—Jianghai Xia

I am not sure if we all were clearly aware of the effectiveness of the MASW method to map bedrock at the time. But this case study actually came ahead of subsequent studies and research outcomes that indeed proved the approach is quite well suited for bedrock mapping, perhaps in a more efficient manner (in field and data-processing costs) than other seismic methods. It gives the stiffness distribution information as well. This method can be fully automated in acquisition and data processing, and I hope this will happen in the near future.

—Choon Park

From the very onset, based on theoretical estimations of resolution, the level of accuracy of the MASW method has significantly exceeded our expectations. This study was one of our first attempts at using this inversion-based approach to produce a continuous 2D estimation of the shear-wave velocity field. With each study since this one, I continue to be surprised at the accuracy of these surface-wave images and how well they have correlated with well information at a variety of sites. In my view, the MASW method has turned out to be a valuable asset for the near-surface geophysical community.

—Julian Ivanov

Suggested reading. "Delineating a shallow fault zone and dipping bedrock strata using multichannel analysis of surface waves with a land streamer" by Ivanov et al. (Geophysics, 2006). "Multichannel analysis of surface waves" by Park et al. (Geophysics, 1999). "Estimation of near-surface shear-wave velocity by inversion of Rayleigh waves" by Xia et al. (Geophysics, 1999). TLE