A SEG/KOC Workshop keynote address: A perspective on defining and addressing on-shore seismic processing challenges: recent advances and open issues

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What resides behind seismic processing failure and breakdown? All seismic methods have prerequisites and make assumptions. When they are satisfied the methods are effective, and when they are not the methods have problems and can fail. These seismic processing challenges contribute to dry hole drilling and suboptimal appraisal and development well placement. To know under what circumstances a given seismic method is (or is not) effective we recommend listening to seismic interpreters and drill placement decision makers in business operating units.

How to address seismic processing challenges? There are two ways to address the violation of assumptions behind seismic processing failures and challenges. One way is to find a new method that can satisfy the assumption and thus remove the assumption violation. The second way is to develop a fundamentally new approach and method, to achieve the seismic processing goal and objective, and that doesn't make (and therefore removes) the assumption. We adopt one or the other of these two distinct approaches for different links in the seismic processing chain. Every link in the processing chain is a necessary prerequisite for subsequent steps. In this presentation we will describe the different challenges that arise in every link in the processing chain and an approach for addressing them -and always remembering to define added value compared to current industry best practice.

A key obstacle to increased seismic capability and effectiveness. In the history of seismic processing, as methods for depth imaging and multiple removal became more effective they had a commensurate need for more accurate subsurface information. The industry trend to deep water and more complex offshore and onshore plays made that requirement increasingly difficult to satisfy.

A comprehensive response to that obstacle and challenge. In response, Green's theorem based methods were developed for marine towed streamer and OBC data to predict the reference wave, P0, and reflection data, Ps, without damaging either wave field. New de-ghosting methods were also derived to achieve source and receiver ghost removal. These Green's theorem based wave-field separation methods do not require subsurface information. Moving down the seismic processing chain, distinct isolated task subseries of the inverse scattering series (ISS)were pioneered and developed that were able to achieve free surface and internal multiple removal, depth imaging of primaries without a velocity model , Q compensation without needing to estimate or determine Q, and non-linear parameter estimation, all achievable directly without needing subsurface information We will provide examples of each of these distinct task specific ISS algorithms, and where each resides within the development and delivery of new tool box options.

What are the pressing challenges in land seismic data processing? A specific challenge in on-shore exploration derives from the complex and often ill-defined near surface. The separation of P0 and PS and de-ghosting can be a serious issue for on shore plays. Recent methods from M-OSRP demonstrate that those objectives can be achieved without damaging either wave field; furthermore, early tests suggest that is achievable without near surface information.

Primaries and Multiples. Migration is a concept that only has meaning for primaries. There are two kinds of primaries: recorded and unrecorded. For recorded primaries multiples must be removed before migration to avoid producing imaging artifacts when migrating with a smooth velocity model. For unrecorded primaries, a recorded multiple can (at times) have an unrecorded primary as a subevent- and the recorded multiple can be used to find an approximate image of

that unrecorded primary subevent. However, unrecorded multiples that are subevents of the recorded multiple must be removed. Hence to image recorded primaries, recorded multiples must be removed- and to image an unrecorded primary, unrecorded multiples must be removed. All multiples, recorded and unrecorded, must be removed. The use of multiples depends on the lack of an adequate collection of primaries. The removal of all multiples is required due to our use of smooth velocity models in migration. We do not foresee any time in the near future when we will migrate with an accurate discontinuous velocity model. Data acquisition is constantly becoming more complete. Hence multiple removal is a permanent issue whereas multiple usage is transient. In the interim we encourage progress on both.

A selection of recent advances. Multiple elimination. Removing multiples that interfere with primaries represents a major challenge for on shore plays and frequently for marine plays, as well. The industry standard SRME for free surface multiples can and will damage target and reservoir primaries that interfere with free surface multiples. The current high water mark of internal multiple removal capability is a combination of ISS internal multiple attenuation and adaptive subtraction. For interfering free surface multiples, the ISS free surface multiple elimination algorithm, can surgically remove the free surface multiple without damaging an interfering or proximal primary. For internal multiples the new and recently developed ISS internal multiple elimination algorithm, can surgically remove an internal multiple without damaging a proximal or interfering primary. These multiple elimination algorithms are only available from M-OSRP. **More effective migration.** All current migration methods (including RTM) make high frequency approximations. A new migration method has been developed that does not make high frequency approximations. The new migration method (that we label Stolt Claerbout III, or SCIII) is compared with RTM. Tests with a wedge model demonstrate that SCIII has significantly greater resolution capability compared to RTM. In addition SCIII derives greater added value from broad band data compared with RTM. **Q compensation without knowing, estimating and determining Q: a first practical algorithm.** This is a major advance in seismic processing with significant positive consequences for reservoir detection and delineation. **Onshore ground roll and reflection data prediction without injuring either, and de-ghosting for on-shore and offshore plays, including non-horizontal acquisition.** These advances have significant impact on all subsequent links in the onshore and offshore processing chain.

Open issues and the road ahead. The overall objective of seismic research is to increase the options in the seismic tool box, and thereby to improve the drill placement success rate. No seismic method is ever the last and final word. All seismic methods make assumptions, and progress can be viewed as a substitution of a difficult or impossible set of assumptions by a (hopefully) more achievable and attainable set, and recognizing that earlier steps in the processing chain are always prerequisites for the next step. Research is always a work in progress.

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