A new perspective on removing and using multiples — they have the same exact goal — imaging primaries — recent advances in multiple removal
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Removing and/or using multiples

Multiple removal and the usage of multiples have a single goal and objective: imaging primaries — recorded primaries and unrecorded primaries, respectively. To image recorded and unrecorded primaries requires that recorded multiples and unrecorded multiples must be removed. For a recorded multiple to be useful it must have an unrecorded primary as a subevent. To use a multiple, one needs to predict a multiple, and that requires all of its subevents to be recorded. If a multiple has an unrecorded subevent it cannot be predicted. Hence useful multiples are not predictable and predictable multiples are useless.

Even if a recorded multiple is useful, it must be removed before imaging recorded primaries. Hence, multiple removal remains a highest priority in seismic exploration.

Multiple removal

Subsurface information has been and remains a key requirement of (and major impediment and challenge for) many seismic processing methods — **and, that has been, and remains, the unmentionable elephant in the room.**

The inverse scattering series (ISS) free surface multiple elimination (ISS FSME) algorithm and the ISS internal multiple attenuation (ISS IMA) and ISS internal multiple elimination (ISS IME) algorithms taken together, represent the high water mark of current multiple removal capability. They can automatically accommodate specular and non-specular reflectors, curved reflectors, diffractive reflectors, including pinch-outs, without (knowing, estimating or determining) any subsurface information, or any knowledge of the generators of the multiples. They are the only methods with that set of capabilities. In this presentation we will provide a comparison and examples with SRME and ISS FSME, and when each would be the appropriate tool box choice, for isolated and interfering free surface multiples, respectively. Similarly, we will show a comparison between ISS IMA and ISS IME, and how they are the appropriate tool box choice for isolated and interfering internal multiples.

Challenges (e.g., complex and ill-defined near surface geophysics, thin sub-resolution reflectors and multiples)

Recent ISS Q compensation without knowing, estimating or determining Q, Zou and Weglein (JSE, December 2018) can improve the resolution of reflectors by restoring diminished high frequency data components. And the new Stolt CIII migration for heterogeneous media, from M-OSRP, that avoids all high frequency approximations, will particularly benefit the low frequency components, the latter providing added-value for resolution, amplitude analysis and illumination, compared to, e.g., all RTM methods. New and more

capable processing aimed at both the high and low end of the seismic spectrum can address resolution issues, including sub-resolution reflectors and improve amplitude analysis and illumination. New methods for effectively and efficiently computing the highly capable and highly compute demanding ISS IME are being developed within M-OSRP.

Near surface complexity remains a major issue and obstacle for on all shore seismic processing, see for example `https://seg.org/Annual-Meeting-2019/Schedule/Near-Surface`, Bridle et al. (2007); Golikov and Bakulin (2014); Knox (1967).

A recent advance (Weglein, 2019), provides a new concept and method that removes the need for knowing, estimating or determining any subsurface and **near-surface information (including no information needed at the Earth's surface)** for all on-shore and OBS seismic preprocessing and processing objectives. **The removal of near surface (and on the Earth's surface) information for on-shore seismic processing is a very new advance and development from M-OSRP.**

For an overview perspective, please see the Ecopetrol invited presentation in the video in this link. `https://drive.google.com/file/d/13Nv0MDJKDjxPYsQdBQ95stC3Z7Qwcjxs/view?usp=sharing`

In all of these ISS algorithms there is no indirect methodology, no model-matching of primaries or multiples, (e.g., no model matching as in FWI) or searching, no machine learning, deep learning, no data mining, or AI — just direct solutions that input data and output the processing objective. We appreciate the encouragement and support of our sponsors. Dr. Jim Mayhan is thanked for his assist in preparing this Abstract. We thank Dr. Adel El-Emam and the organizers of this SEG/KOC Workshop Dec. 3-5, 2019 in Kuwait, for this wonderful key-note invitation.

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