An inverse-scattering series method for attenuating multiples in seismic reflection data

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ABSTRACT CITING ARTICLES

Arthur B. Weglein,* Fernanda Araújo Gasparotto,‡ Paulo M. Carvalho,** and Robert H. Stolt§

*Schlumberger Cambridge Research Company, P.O. Box 153, Cambridge CB3 0HG, England

**Petrobras, S.A., Rua Acre 2504 Bloco M sala 12, 49080-010 Aracaju-SE, Brazil

‡Universidade Federal da Bahia, PPPG, Bahia, Brazil

§Geoscience and Reservoir Research 5RDW, Conoco Inc., 1000 South Pine, Ponca City, Oklahoma 74602-1267

We present a multidimensional multiple-attenuation method that does not require any subsurface information for either surface or internal multiples. To derive these algorithms, we start with a scattering theory description of seismic data. We then introduce and develop several new theoretical concepts concerning the fundamental nature of and the relationship between forward and inverse scattering. These include (1) the idea that the inversion process can be viewed as a series of steps, each with a specific task; (2) the realization that the inverse-scattering series provides an opportunity for separating out subseries with specific and useful tasks; (3) the recognition that these task-specific subseries can have different (and more favorable) data requirements, convergence, and stability conditions than does the original complete inverse series; and, most importantly, (4) the development of the first method for physically interpreting the contribution that individual terms (and pieces of terms) in the inverse series make toward these tasks in the inversion process, which realizes the selection of task-specific subseries. To date, two task-specific subseries have been identified: a series for eliminating free-surface multiples and a series for attenuating internal multiples. These series result in distinct algorithms for free-surface and internal multiples, and neither requires a model of the subsurface reflectors that generate the multiples. The method attenuates multiples while preserving primaries at all offsets; hence, these methods are equally well suited for subsequent poststack structural mapping or prestack amplitude analysis. The method has demonstrated its usefulness and added value for free-surface multiples when (1) the overburden has significant lateral variation, (2) reflectors are curved or dipping, (3) events are interfering, (4) multiples are difficult to identify, and (5) the geology is complex. The internal-multiple algorithm has been tested with good results on band-limited synthetic data; field data tests are planned. This procedure provides an approach for attenuating a significant class of heretofore inaccessible and troublesome multiples. There has been a recent rejuvenation of interest in multiple attenuation technology resulting from current exploration challenges, e.g., in deep water with a variable water bottom or in subsalt plays. These cases are representative of circumstances where 1-D assumptions are often violated and reliable detailed subsurface information is not available typically. The inverse scattering multiple attenuation methods are specifically designed to address these challenging problems. To date it is the only multidimensional multiple attenuation method that does not require 1-D assumptions, moveout differences, or ocean-bottom or other subsurface velocity or structural information for either free-surface or internal multiples. These algorithms require knowledge of the source signature and near-source traces. We describe several current approaches, e.g., energy minimization and trace extrapolation, for satisfying these prerequisites in a stable and reliable manner.

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