AAPG Datapages/Search and Discovery Article #90254 ©2016, GEO-2016, 12th Middle East Geosciences Conference & Exhibition, Manama, Bahrain, March 7-10, 2016

Can supergrouping enhance low frequencies needed for FWI of 3D land broadband seismic data?

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ABSTRACT

Successful implementation of multiscale full waveform inversion (FWI) hinges on the availability of reliable low frequencies such as 1.5 to 2 Hz that is at the edge of the spectrum of conventional broadband data. As such, the signal-to-noise ratio (SNR) for these low frequencies is typically even poorer. While most FWI pre-processing approaches are trying to improve SNR using various signal processing techniques applied to raw pre-stack data, we explore an alternative approach called supergrouping. It is inspired by practices from past decades when large source and receiver arrays were employed in Saudi Arabia to mitigate surface wave and backscattered energy so that reflections can be recorded with reasonable SNR. Modern seismic acquisition is steadily moving to smaller field arrays or point sources and sensors while typical distances between shot and/or receiver lines remain relatively large compare to inline sampling. Reducing the size of field arrays leads to a significant degradation of data quality that needs to be dealt with during processing. We propose a supergrouping approach that can be characterized as combination of "group and stack." Where dense sampling permits, it uses elements of group forming, whereas for coarser sampling it resorts to common-offset stacking.

We illustrate with a synthetic dataset that at low frequencies (< 8Hz) supergrouping preserves the signal without distortions. We then demonstrate supergrouping on a 3D land seismic dataset from Saudi Arabia acquired with a standard broadband sweep of 2 to 90 Hz. We show that supergrouping greatly improves the quality of pre-stack data making it almost ready for FWI using frequencies closest to the minimal frequency of the broadband sweep (2.5-3 Hz). For a real 3D field dataset where we have a huge number of shots this method allows significant reduction in the total computational time of FWI while allowing all shots to participate in the inversion as a part of supergrouped data.