Application of diffraction stacking to a surface seismic survey in the Kakkonda geothermal field

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A new type of prestack time migration method is presented. This method is a kind of prestack Kirchhoff time migration. One of the biggest advantages of this method is that data processing can be performed without a priori information about the velocity structure. The optimum constant stacking velocity can be determined at each image point from a stacking velocity analysis based on primary diffraction patterns. This proposed data processing method does not require multiples iterations for achieving the velocity structure in the case of prestack migration.The proposed data processing procedure was applied to surface seismic field data obtained in the Kakkonda geothermal field.

A conventional seismic reflection survey is a powerful tool to image geological structures of sedimentary basins. However it is often less powerful for a geothermal field because of its structural complexity. Pre-stack migration is often used for such a complex structure; however, it requires try-and-error type of velocity structure determination and consumes a lot of computer power and time.

This paper describes a new type of seismic reflection data analysis utilizing the pre-stack Kirchhoff time migration, named non-iterative pre-stack time migration (NPSM). The proposed data processing is based on diffraction stacking velocity analysis procedure to determine an optimum stacking velocity.

The data processing sequence of NPSM is as follows.

1. For making velocity analysis panels, amplitudes of observed data in a common source or receiver gather are stacked along the diffraction hyperbolic patterns for various sets of constant velocity.
2. High amplitude peaks are picked in the velocity analysis panels.
3. Final stacked section is obtained through amplitude staking along the diffraction trajectories using interpolated velocity functions made by picked values.

Advantages and characteristics of NPSM are as follows.

1. In case of a complex structure, NPSM is expected to obtain better subsurface image than the conventional CDP stacking is.
2. The optimum constant-stacking velocity, which provides the highest stacking efficiency for each imaging point, can be obtained from stacking velocity analysis. This yields non-iterative migration and saves time.
3. Data processing can be performed without a priori velocity information.

NPSM was applied to a surface seismic data set obtained in a geothermal field. It was found that the geological structure was imaged more adequately by application of diffraction stacking than CDP stacking. The reason was discussed from the viewpoint of S/N ratio. Our numerical experiments revealed that diffraction stacking generally has the ability to produce a seismic reflection image with higher S/N ratio than CDP stacking even for a flat and horizontal reflector. This can be explained by Huygens' principle. The velocity boundaries delineated by NPSM correlates well with those by sonic log and VSP.