A classification of slant stack imaging methods

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ABSTRACT

The twenty or so slant stack imaging methods (Table 1) are distinguished by (1) whether they are single or double slant stacks, (2) whether the slant stacks are picked before imaging, and (3) the coordinate of slant stacking.

Motivation

In SEP-28 I presented a classification of a half dozen slant stack imaging methods. Since then there has been much more research, particularly into methods employing two slant stacks, prompting the update of Table 1.

Overview

All these methods initially slant stack the data. They differ as to whether there is one or two stacks, the stacking coordinate, the stacking aperture size, and whether the stack is parameterized.

All methods then have an imaging procedure using the slant stacks as input. The imaging procedure may be a correlation, tomographic inversion, or a raytracing, finite difference, or f-k solution to the wave equation.

Now I will summarize the five categories in Table 1.

The *CDR (controlled directional reception)* methods do local slant stack in two separate coordinate directions, parameterize the slant stacks, then invert for an image or velocity model.

The *beam search* methods do local slant stacks twice in succession, thereby converting shot & geophone (or midpoint & offset) into a four dimensional space (shot & geophone & shot dip & geophone dip). Then they search this space for energy peaks which gives velocity and reflector location.

The most widely reported method migrates *shot profile* slant stacks. Alternatively, *common midpoint gather* slant stacks may be migrated. Finally, a *CDP-stacked section* may be dip-decomposed by slant stacking, then migrated.

Table 1: Slant Stack Imaging Methods

NAME & REFERENCES	SLANT STACKS	PICKING	IMAGING
CDR-Riabinkin et. al.(62)	shot & geophone	X	inverse ray tracing
CDR-Sword(87)	midpoint & offset	X	tomographic inversion
Gray & Golden(83)	geophone & shot	X	inversion
Biradial-Garotta(80)	shot & geophone		correlation
Harlan & Burridge(83)	midpoint & offset		inversion
Milkereit et.al.(86)	shot & geophone		correlation
P-Q-Pan & Gardner(86)	shot & geophone		correlation, ray tracing
Beam Stack-Biondi(87)	shot & geophone		correlation,optimization
Simplan-Taner(78)	geophone		finite difference
Schultz(76)	geophone		finite difference
Phinney & Jurdy(79)	geophone		inverse ray tracing
Treitel, et.al.(82)	geophone		inverse ray tracing
Reshef & Kosloff(84)	geophone	X	eikonal
Slant-midpoint-Ottolini(83)	CMP-offset		wave equation
Snell Trace-Ottolini(83,87)	CMP-offset	X	wave equation
Dip Domain- Robinson & Robbins(78)	midpoint		inverse ray tracing
Levin(80)	midpoint		fourier transform
Object Space- Bisset & Durrani(84)	midpoint		?

Motivations for slant stack imaging

Slant stacks can be imaged. Wave equation migration can be formulated in terms of planes waves or data time dips, i.e. slant stacks.

Correct imaging. Slant stack imaging methods handle offset and dip more accurately than conventional post-stack migration.

Velocity insensitivity. Conventional CDP stacking assumes a single-valued earth velocity model. Slant stacking makes no velocity assumptions. However, some of the slant stack imaging operations require a velocity model.

Signal discrimination. Perhaps the greatest advantage of conventional stacking and migration is noise reduction. Slant stacking retains this advantage to various degrees depending upon the slant stack method.

Dip filtering is another method of noise reduction. Slant stack discriminates the dips of noise spikes or unwanted events (e.g. multiples).

Locality. Slant stacks have an effective aperture narrower than conventional stacking or migration. This preserves lateral traveltime and amplitude variations for velocity and offset-amplitude analysis.

Velocity analysis. The verdict is not in yet, but looks promising because slant stacks permit new analysis methods. Some of the velocity analysis methods may work better because they occur late in the imaging sequence after noise has been reduced and reflectors located.

Economics. The CDR methods are cheaper than conventional processing because they shrink the dataset into a small parameter space. The other methods are more expensive because they increase the size of the wavefield or parameter space. Slant stacking itself adds a cost.

Caveats

Slant stack imaging as not proved that it can produce better enough images to be worth the additional cost. The velocity analysis story may turn out better as more results come in. The traditional drawback of slant stacking artifacts has been largely eliminated (Kostov, 1987).

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