Throw Away Your Paper Sections

Bert Jacobs and Jon Claerbout

Interactive movie displays of unstacked data may replace the CDP stacked section in the prominent role that stacked sections play in seismic interpretation. A CDP stack contains less information about the sub-surface than unstacked seismic data does. One reason that stacked sections play such a prominent role in geological interpretation is the difficulty associated with physically handling and mentally comprehending the great mass of data collected by a seismic survey. The stacked section is so useful because it can be plotted on a sheet of paper and treated more or less like a cross-section through the subsurface. Simplicity and convenience are two of the stacked section's greatest assets. On the other hand, if a fast and easy-to-use way of working with unstacked seismic data were available, then interpreters would be able to tap into more of the enormous pool of information about the sub-surface actually available to them.

SEP researchers can use a television screen to display unstacked data. The equipment and software at Stanford is still too primitive to replace the stacked section completely. The hardware is still too slow and the number of rasters available on the screen is still too small. The situation with software is probably even more backward. The available software allows one to clip, gain, and mark the data for display purposes. One can also control the speed of display. More sophisticated movie software might filter the data for apparent lateral motion as the movie advances, or superimpose ray trace diagrams on the frames. The ray trace diagrams could be made interactive. Such software is not available for SEP use at the present time. The situation is bright enough, however, to hope that interpretations based on unstacked data will soon be competitive with interpretations based on stacked data.

On the other hand, the speed with which SEP researchers can examine unstacked data is reasonable. This allows the unstacked data of a seismic line to be viewed efficiently from several different points of view. For instance, they can display the common shot profiles of

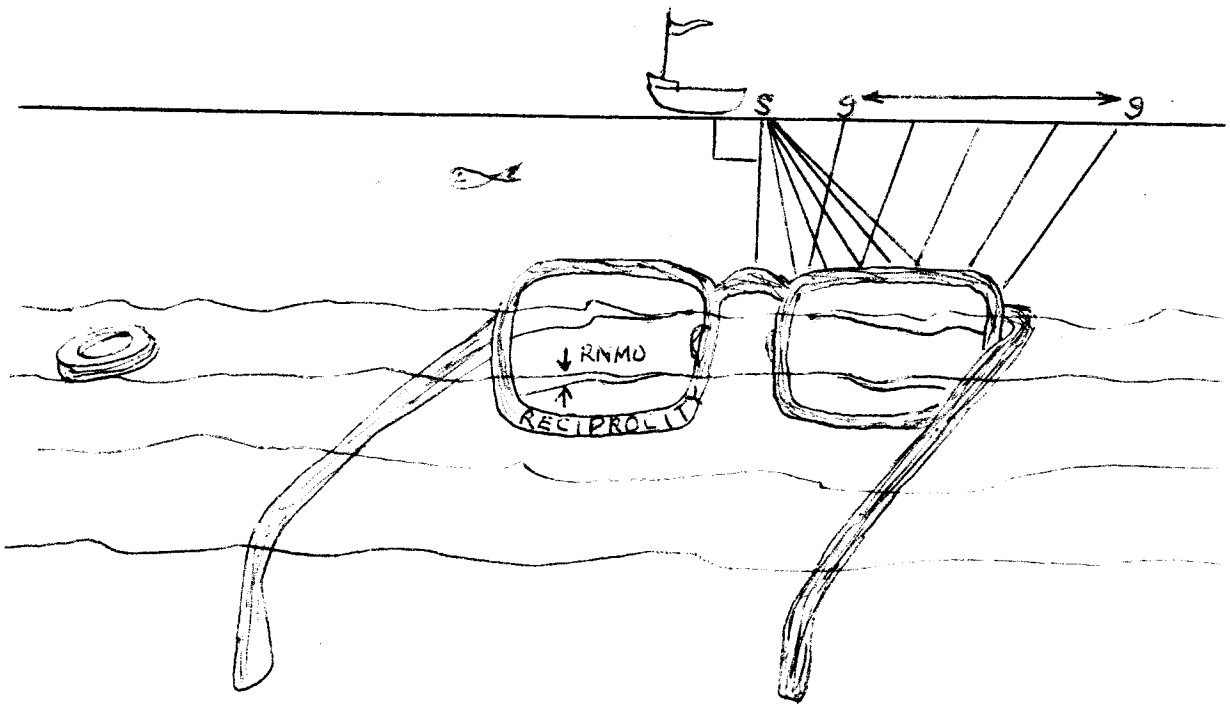

FIG. 1. Downward continuation is like looking through a pair of glasses. Looking at a movie of downward continued common shot profiles is like moving the eyeglasses to the side. Distortion in the image results from an incorrect choice of migration velocity.

a seismic line. They can either pan over offset by toggling a joy stick on their control panel or can change shot profiles serially. Consider the situation in the figure. The right lens of the glasses (television screen) displays a moveout-corrected, common-shot profile. Eyeglasses are used in the figure because moveout-correction is a rough imaging process, a primitive form of downward continuation. Simple distortion of the image results from residual normal moveout. The left lens of the glasses is blank because off-end recording omits that view of the earth. But reciprocity and later shots enable simulation of the left eye view. Keeping your eye fixed on one spot on the earth, while moving the glasses from side to side (moving the joy stick) gives scans over offset. Proper downward continuation should yield an undistorted earth image which does not change while you move (the joy stick). It is a job of geophysical interpretation to understand how a changing image arises from residual NMO, ground roll, lateral velocity variation, multiples, and approximations in the data-collection, downward-continuation process.

Several kinds of movies have proven useful in our research. One advances shot index at each successive frame, displaying a single common shot profile each time. Another kind

of movie does the same with common geophone gathers, advancing the geophone index each time the movie frame changes. For instance, one movie which can easily be made consists of frames containing a moveout-corrected common shot profile on the left and the corresponding profile without NMO correction on the left. Markers can be added to the bottom and top of the frames to keep track of the physical position of the traces.

The effect of dip on a CDP gather is to change the slope of the asymptotes of the hyperbolic events of that gather. Thus, a stacked section can be constructed which is valid in the presence of sub-surface dips. If the common geophone profiles of a seismic line are downward-continued and imaged, then the common shot profiles of the seismic line will consist of horizontal lines. This will be true whether or not there are dipping layers in the subsurface. To speak of the shot coordinate invariance of imaged common geophone profiles is another way of saying that valid earth models should be independent of illumination angle. Departures from shot coordinate invariance are diagnostic of errors in migration velocity. Velocity anomalies show up as non-zero slopes on the migrated common shot profiles.

Once a movie has been made, there are several display modes available. The movie can be run forwards or backwards. The most interesting display mode is the interactive mode in which one can select frames for viewing with a joy stick. By moving the joy stick one can pan across anomalous, intriguing, or exemplary frames. The result is much like the stop action and slow motion used by the networks at football games. One can interactively view movies of crucial events at any speed desired.

One advantage that movies have over stacked sections is that stacking depends on a large number of parameters which are hard to pick. Stacking requires a stacking velocity function which is a function of time and can also be a function of midpoint. Weights are commonly used to suppress truncation effects due to finite cable length and to suppress coherent noise (multiples). On the other hand, movies allow one to simultaneously view the input and the output of a processing step. Each frame of such a compound movie then contains side-by-side displays of an output file and its corresponding input.

What sort of phenomena can be observed better before stack than after stack? Residual NMO due to geometric effects like dip and residual NMO due to lateral velocity variation are the most important. In particular, the availability of movies will make it easier to use interactive ray tracing packages to model the travel times on interesting common-shot profiles. With video equipment one can get immediate feedback on the quality of the match between model profiles and real profiles. More exotic effects like high frequency textural variations, reflection coefficient as a function of incident angle, and elastic (as opposed to merely acoustic) wave conversions, will of course be more visible (so will multiples, interbed and sea-floor) on unstacked, as opposed to stacked data.

****

51. There are three caskets with two inscriptions on each one of them:

Gold: 1) The portrait is not in this casket.
2) It is in the silver casket.
Silver: 1) The portrait is not in the gold casket.
2) It is in the lead casket.
Lead: 1) The portrait is not in this casket.
2) It is in the gold casket.

On one of the lids, both statements are true. On another lid, both statements are false. On the other lid, one statement is true and the other statement is false. Where is the portrait?

****

52. The Dimville Dragons are an excellent baseball team, except for the out- fielders. They are so bad that they have to lie all of the time. The rest of the players always tell the truth. From the following interview, can you determine who plays what position?

Ken: Quick is the shortstop.
Jake: Ken is the right fielder.
Punky: If you ask Nick if Ken plays third base, he will say "yes". If you ask Luke if Oakie plays shortstop, he will say "yes."
Mike: If you ask Jake if Punky plays second base, he will say "no". Luke is the third basemen.
Nick: Jake is the center fielder.
Luke: Nick is the first baseman. Jake is the shortstop.
Oakie: Luke does not play left field. If you ask Ken if Mike plays first base, he will say "no."
Quick: Rick is the catcher.
Rick: Punky is not the shortstop. Oakie is not the first baseman, the third baseman, or the pitcher.

****

53. Rearrange the letters "secura" to spell a common English word.

****

54. A hobo finds that he can make a cigar out of five cigar butts. He finds 25 cigar butts. How many cigars will he be able to smoke?