AN INTERACTIVELY CONSTRAINED APPROACH TO LONG-PERIOD STATIC CORRECTIONS

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Introduction
Long-period static components, around or above a spread-length, distort reflection kinematics more than they degrade the CDP stack. They need to be determined before applying conventional methods (Taner et al, 1974; Saghy and Zelci, 1975; Wiggins et al, 1976) as their recovery using a classical four-term model becomes more and more uncertain with increasing spatial wavelengths. Paturet (1977) designed a maximum likelihood process to correct for the effects of these components on stacking velocity horizons. Likewise, Lynn and Claerbout (1982) proposed a straight raypath model to derive a solution using the second lateral derivative of the rms slowness, which was further expanded for stability improvement. We intend to extend these contributions to more complex kinematic cases while controlling the accuracy of the solution. This is particularly relevant for thick permafrost-related layers or for low-velocity anomalies located below the sea-bottom as seen earlier by Glogovsky et al (1983). We will then propose an interactively constrained 2D solution to facilitate the input of relevant data and a priori information.

Methodology
We first state that a near-surface velocity-depth model includes, within some layers, heterogeneities which distort CDP traveltime curves away from the hyperbolic shape. We then assume that we can compute a set of surface-consistent source and receiver static time-shifts to transform some prespecified CDP curves into hyperbolas. Let us consider a horizon stacked below the observed anomaly. The zero-offset curve t0(x) is derived from the time-picking of the horizon. A velocity horizon computed from CDP gathers yields a Vst(x) stacking velocity curve. If, after static corrections, each CDP curve becomes hyperbolic, it is possible to compute a new stacking velocity V*st(x) as a function of statics, t0(x) and total two-way times. After linearization, we obtain a system of equations (1) F(Sk-l, Sk, Sk+l) = 0, where k is the CDP index, l an offset-related index and S the unknown static set. This linear system is however ill-conditioned and needs an a priori constraint expressed as (2) R(Sk) = t*0(x) - (t0(x) - 2 Sk), where Sk is the current model static and t*0(x) an a priori estimate of a corrected t0(x) curve related to some form of interval velocity (hence of stacking velocity) regularization. The solution is obtained by minimizing the sum of the squares of expressions (1) and (2) with some additional weights. It may be proven that this choice leads to a well-conditioned linear system.

Interactive implementation
This algorithm has been implemented interactively within a system developed by Glogovsky et al (1996). An initial velocity-depth model is determined by inversion from the t0(x) and Vst(x) curves. The user may insert a priori information to derive t*0(x), select adequate weights and control the quality of the processing results. In addition, the process can be cascaded over successive deeper layers to progressively determine larger spatial wavelengths. Furthermore, the system can accommodate a multiline survey, which is convenient for addressing 3D survey issues.

Example
The above technique has been applied to both synthetic and real data. Some synthetic results are shown with a low-velocity layer anomaly (figure 1). We use the reflector below the base of the anomaly for static computation (it is difficult to interpret the base of the anomaly in real cases). The t0(x), Vst(x) curves and the velocity horizon spectrum are shown in figure 2. Note that the anomaly base and the reflector below are somewhat similar, which therefore requires a careful decomposition of structural, kinematic and static terms. The inverse kinematic solution from a constrained interpretation is given in figure 3 with a good degree of accuracy (around 5 m). Out of the 120 ms t0(x) anomaly, 70 ms are due to statics and 50 ms (as required) to structure. After static application, the new horizon velocity analysis is shown in figure 4.
Conclusion
This interactive technique uses a priori information available to the user to derive long-period static components. It is conveniently integrated in a global system which enables the user to combine horizon velocity analysis and velocity-depth model building via kinematic inversion. The method can therefore be applied to relatively complex cases.

References
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Figure 1- Initial model
Top: depth model with first layer 100 m deep, second layer 1000 m deep. Anomaly 2500 m wide.
Bottom: velocity model with first layer 800 m/s, second layer 2000 m/s.

Figure 2 - Horizon velocity analysis
Top: time response t0(x) of second interface at around 1.15 seconds.
Middle: horizon velocity spectrum.
Bottom: stacking velocity Vst(x).

Figure 3 - Restored model
Top: result with thick line, initial model with thin line.
Bottom: restored interval velocity.

Figure 4 - Horizon velocity analysis after static application
Top: time response t*0(x) of second interface at around 1.15 seconds.
Middle: horizon velocity spectrum.
Bottom: stacking velocity V*st(x).