SUMMARY.
Here we present a North Sea case history of 3D pre-stack depth migration, where the velocity-depth model has been built iteratively using a new pre-stack velocity updating scheme.

In order to assess improvement in image quality throughout the model building process, we analyse post-stack depth migration results, their corresponding pre-stack images, and image gathers for each iteration.

INTRODUCTION.
Prior to performing a full-volume 3D pre-stack depth migration (preSDM) it is necessary to be confident that the travel times are being computed through a reliable velocity-depth model. It is the derivation of such a reliable model that we concern ourselves with in this work.

Post-stack 3D depth migration (postSDM) has been employed for some years as a tool for iteratively updating layer geometries in velocity-depth model building (Jones, 1993). However, this approach is limited in that it can only deliver the correct 3D geometry of an interface if the preceding interval velocity estimates are accurate. (There is also the additional constraint that the model in question can be represented by layers).

Attempts to determine the 3D migration interval velocity field have been made variously using the simple flat-layer Dix assumption in conjunction with map-migration, 2D pre-stack migration (Jeannot, et al., 1986, Yilmaz & Chambers, 1984), and more recently with the Deregowski loop (Deregowski, 1990, Cabrera, et al., 1992) and 3D Tomographic inversion (Diet, et al., 1994).

In this paper, we apply a new velocity updating technique presented recently (Audebert, 1995; Jones et al., 1996) to iteratively update the interval velocity for a given layer prior to defining the associated layer geometry.

We commence by using 3D tomographic inversion to obtain a close starting model (Kapotas, et al, 1993). Thereafter we proceed to update the velocity field for a given layer using the new technique, and then specify the layer geometry for the horizon in question using 3D post-stack depth migration. This procedure is repeated as required for all layers of the velocity-depth model). In essence this processing flow comprises an inner loop for the interval velocity update (using 3D preSDM), and an outer loop for the layer geometry update (using postSDM).

THE METHOD.
The core of the new velocity updating tool relies on taking the travel-time table associated with the 3D preSDM, and making several renditions of it. Each rendition of the travel-time table is then perturbed so as to span a desired range of velocities.

A unique 3D preSDM is computed for each rendition of the table, so as to output image gathers on a suitable grid. For every grid node, we then have an image gather for each travel time perturbation. The velocity information can be assessed either by analysing sets of image gathers at each CMP (one gather for each of the perturbation percentages) with an interactive tool, or by using these ensembles of perturbed gathers to create a 3D preSDM velocity spectrum, from which the update velocities can be picked directly.
Remigrating with this velocity field should produce flat image gathers for the layer under investigation. This is because we are correctly assessing travel-time errors along the image-ray paths by this perturbation technique. Conversely, a Deregowski-loop approach (vertical update) would attribute the error observed in the (non-flat) image gather solely to the vertical position above that CRP location. Such a vertical update technique also suffers in that the computed gather will not be at its correct lateral position when the velocity field is in error.

RESULTS.
We apply the methodology described above to a complex North Sea data example. A thick chalk layer, with containing three velocity gradient regimes, is faulted with a vertical displacement of 1.5km. The zone of interest lies below the overhanging footwall of the fault.

Scans on image gathers for the different travel-time perturbations are produced for each iteration for all nodes in the coarse velocity grid. For example, we show results derived from the first iteration where a spatially and vertically variant correction field was picked so as to flatten the base-chalk event, and approximately flatten subsequent events. Following this (and each subsequent) iteration of velocity update, we perform a postSDM so as to determine the layer geometry for this layer by picking the horizon imaged directly in depth. After incorporation of the velocity update and layer geometry picking into the model, then recomputing the travel-times, and re-running the 3D preSDM, we found that the base-chalk event was flattened, and subsequent events were better imaged.

In the results from each of these iterations, we see a progressive improvement in horizon consistency under the fault overhang.

In figures 1 & 2 we compare the postSDM and preSDM results for the final model: imaging of the block-faulted Rotliegendes event (at about 2.5km depth) is improved in the preSDM result.

REFERENCES.

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Final model: 3D postSDM
cross-line 3350
Final model: 3D preSDM
cross-line 3350