Comments to "Seismic illumination" by Hubral, Hoecht, and Jaeger, TLE, November 1999

Note: In an initial reaction to the first version of this comment the authors referred me to the paper "Applications of the common-reflection-surface stack" by Mann et al., Expanded Abstracts, 1999 SEG Conference, and to the special issue 3/4 of the Journal of Applied Geophysics, vol. 42 on "Macro-model independent reflection imaging". This second version is modified somewhat after reading the paper by Mann et al.

In this very interesting paper Hubral et al give a tutorial description of the NMO/DMO/stack and the preSDM sequences. They also compare these sequences with the common reflection surface (CRS) stack procedure which they propose as an alternative imaging technique. The paper illustrates the advantages of the new technique with a common input data example, and indeed, the results obtained with the CRS approach are far superior to the other two approaches. Also, the real-data results shown in Mann et al. are very impressive indeed. So, why argue about this paper?

The authors call upon the reader to "getting illuminated in one's mind, looking for new imaging principles, and designing new imaging methods". They state "the following should clarify why preSDM and postSDM are not the best imaging procedures for arbitrarily curved reflectors", and "the following also will lead to a new reflection imaging principle …" Clearly, the intention is to label their new approach as a new imaging technique, far superior to existing imaging techniques. However, in my opinion, the technique is not an imaging technique, it is a hybrid technique: a combination of mapping with noise-reduction. The results of the technique might also have been compared with other coherency techniques, such as dip filtering, f-x filtering, KL-filtering and what have you. In the following, I will explain why.

One of the great challenges remaining in seismic processing is the identification and picking of events in the recorded prestack seismic wavefield. Traveltime inversion and prestack migration could benefit from that information. The authors put an important step in that direction: they characterize reflectors by local dip and curvature and determine whether the data contains a reflection time surface corresponding to that dip and curvature. A search is carried out for all possible combinations of dip and curvature. The technique is a refinement over techniques which only look for events with a given dip, and might also be of interest as a starting point in traveltime inversion.

(The technique is treated as a two-parameter technique: emergence angle of the ray at a surface position with normal incidence on the reflector at R and the radius of curvature of the reflector mirror at R. Both parameters are found by a search procedure for all points in the x-t plane. However, at least at first sight, it looks that an important third parameter must be given as well: the search radius defining the width of the area of the CRS included in the search procedure. If the radius is too large, the actual CRS starts to deviate too much from the searched-for CRS; if the search radius is too small, coherency is not maximal. Perhaps this radius is found by optimizing coherency, in that case no third parameter is needed for the searching procedure.)

The second step in the procedure is to stack all data on the CRS into the zero-offset output point. Hence, this stack also includes data which are reflections from neighbouring positions. In other words, the stack is a spatial mix along the reflection traveltime surface. As such it has a great noise-reduction effect. Moreover, in contrast to other mixing techniques, the resulting stack will not show serious smearing effects due to the mixing.

In principle, in the stacking process, it should be possible to reduce the width of the CRS to zero, i.e., use the CRS technique only to find all specular points. In that case, the process would be a pure mapping process (no mixing), with noise reduction only achieved by summation of the specular points at all offsets. This is what the technique seems to do (insofar I understand it now): it carries out DMO-correction by mapping all specular points to the zero-offset position, and the process achieves noise-reduction by stacking not just the series of specular points but also a range of specular points of neighbouring positions.

The CRS stack is clearly a powerful noise-reduction technique; and it produces a zero-offset section at the same time. However, it is confusing rather than illuminating to call it an imaging technique. The aim of imaging is to move the illuminated points to the correct positions. In prestack migration, there is only one point (per single-fold common-offset gather in this case), the specular point, which is put at the point of stationary phase. All other points inside the zone of stationary phase are needed to construct the image, but we would like to keep this zone of stationary phase (or zone of influence) as small as possible to ensure optimal resolution. This can be achieved by aiming for the shortest possible wavelet. In the CRS technique the specular points of neighbouring positions are mixed into the output, thus sacrificing resolution for better noise suppression. It may be necessary to carry out such a technique to get rid of the noise, but it is not really optimal for imaging, and should not be called an imaging technique.

Apart from problems with the used nomenclature, some critical remarks about the process itself are also in order. Although the results are very impressive, it should be realised that the procedure is based on a search procedure to look for events. This means that only a finite number of events will be identified. Weak events are likely to be ignored. If the weak events behave like the strong events around them, they may still be reconstructed properly, but if they have a different traveltime function, they will be lost. Also, intersecting events may not be fully identified. An example of this latter phenomenon may be seen in Figure 4 of Mann et al.: in the bottom right corner, around CDP 860, the steep salt flank event seems to have won from a flatter event. It would be interesting to see what happens with these events after migration. The one migration result I have seen up till now is very puzzling: why is the result of poststack migration in Figure 2b noisier than the input in Figure 2a?

All in all, it might seem a bit extravagant to make critical remarks about a process that produces such impressive results. However, I hope that these comments lead to a better understanding of the CRS technique and perhaps agreement on the use of nomenclature.