RECOMMENDATIONS FOR FUTURE GEOPHYSICAL DATA ACQUISITION AND PROCESSING
BWIP SITE
HANFORD, WASHINGTON STATE

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Introduction

Two separate seismic imaging problems occur at the Reference Repository Location (RRL), BWIP site. The first is delineation of the top-of-basalt (t.o.b.) reflection and of horizons within the shallow suprabasalt sediments; the second is identification of layering and structure within the basalts themselves. On the basis of past work in this area, it appears that problems peculiar to the imaging of the sediments include reduction of fold in the mute zone, significant static delays, and scattering of energy within unconsolidated surface layers. Problems arising in imaging the basalt layers appear to relate primarily to insufficient penetration of energy at depth caused by strong reflections from the layering above, although here also static delays are probably a complicating factor.

Because of these different complications associated with the depth of the target, different acquisition and processing techniques may be required to optimise reflections in the two zones. To resolve shallow structure, increased fold, the use of high frequencies, and adequate handling of statics are essential. For deeper targets, larger shots, lower frequencies, and the use of alternative seismic techniques, such as offset vertical seismic profiling (VSP), may be required.

For both shallow and deep targets, accurate velocity information is also required for use in time-to-depth conversion and interpretation. As described in the accompanying report (Interpretation of Geophysical Data, BWIP Site), these velocity data are presently sparse.

The following report discusses in more detail some of these acquisition and processing considerations, implementation of which could enhance future seismic data programs at the BWIP site.

Recommendations for Future Acquisition Parameters

The existing seismic reflection data on the Hanford Reservation, shot by SSC in 1978, was obtained using Vibroseis with 50 ft station spacing and 100 ft shot spacing. The resulting 12-fold data shows poor continuity of reflections within the suprabasalt sediments, both on the original sections processed by SSC and on the parts of lines 3,5 and 8 later reprocessed by Emerald Exploration. The inferred t.o.b. marker is fairly strong, except in regions where lateral changes in surface layering and/or reduction of effective fold occur. Reflections from layering within the basalt are not imaged well, however, and show large lateral changes in amplitude and continuity.

The latest set of seismic data, acquired by Walker Geophysical along a line approximately 1000 ft west of existing Line 5, shows much better resolution of reflectors within the suprabasalt sediments. However, reflections at and beneath the top-of-basalt horizon are less strong than on the SSC data. These new 28-fold data were obtained using small dynamite charges in shallow holes, and recorded using 40 Hz geophones with 25 ft shot and station spacing. The results of preliminary processing of these data were described in our trip report of August 1, 1985.

Probably the most important factor leading to improved resolution of structure within the suprabasalt sediments in the Walker Geophysical data was the doubling of fold, or number of traces within a common-depth-point (CDP) gather. During processing, correction for the different slant paths of traces (NMO) within a CDP results in stretching of the traces. This NMO stretch is largest at shallow depths and on the far traces. Before stacking the traces together, a mute is therefore applied to zero out these parts of the record. As a result, if the fold is low few traces contain shallow reflections after muting, leading to poor resolution of these events on the final stack. The use of a 25 ft shot and station spacing by Walker Geophysical was apparently sufficient to overcome this problem, and should therefore be used in all future seismic data acquisition programs designed to image shallow structure in this area.

The use of small dynamite charges and high-frequency geophones probably also helped in bringing out reflections within the sediments, but were, I believe, secondary factors. These would have provided more resolution of thin beds and pinchouts, but reflections from the primary lithologic horizons within the Hanford and Ringold formations should also be visible using lower frequency sources and geophones.

This last point is relevant to the problem of detecting reflectors within the basalts, for which the problem is not one of stretch muting, but rather one of obtaining sufficient penetration of energy. This means using lower frequencies and larger energy sources. Insufficient data is presently available to specify the optimum acquisition parameters for this purpose. Some reflections coming in after the inferred t.o.b. reflection are apparent on the reprocessed SSC sections, but it is unclear whether these are true reflections or multiples. The next phase of testing by Rockwell, using 20 Hz phones, may allow a more definitive answer to be given to this question.

One acquisition method which could be beneficial at the BWIP site is offset VSP. This method, which involves recording seismic data down a borehole from variable offset shots at the surface, is being increasingly used in the oil industry to improve resolution of horizons at depth, particularly during the reservoir development phase. A few offset VSP surveys at selected points on the BWIP site would provide (1) direct estimates of seismic velocity with depth, (2) reduced attenuation of seismic waves (since the travel path is cut in half), and (3) direct identification of marker horizons to aid in interpretation of surface seismic sections.

Finally, sonic logs should be routinely run in all future boreholes.

Recommendations for Future Processing

At the BWIP site, particular problems in processing occur. In attempting to image relatively shallow targets (less than 500 ms two-way time), the usual problems of stacking-velocity determination, multiple suppression, enhancement of steeply-dipping events, and statics are amplified. Routine processing may not therefore be adequate to bring the most out of the data.

One of the major problems which appears to exist at the site is large static shifts caused by variable near-surface structure. To date, this has usually been handled by the application of elevation corrections to a floating datum, followed by residual statics after NMO. As described in our report of August 1, 1985, however, this procedure does not take into account short-wavelength delays caused by shallow structure unrelated to topography. Residual statics programs are limited to corrections of one period of the wave or less and cannot adequately handle large short-wavelength time shifts between traces in a CDP gather. It is therefore strongly recommended that first-break-statics processing be applied to all future seismic data acquired at the BWIP site. These routines are now available through most major processing contractors.

In addition to statics, I also strongly recommend that some of the more recent developments in exploration processing be tried. These might include dip moveout for enhanced imaging of faults (see, for example, D. Hale, Geophysics, v. 49, p. 741, 1984), tau-p velocity processing, and frequency-domain filtering. If offset VSP data is collected, this should be processed to obtain a seismic cross-section around the borehole which can be compared with the surface seimic data.

In summary, future seismic acquisition and processing programs at the RRL should take into account past experience and the particular problems associated with the site. I believe that the recommendations outlined in this report would lead to improved resolution of reflecting horizons within the depths of interest and increased understanding of the tectonic history of this area.