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PRACTICAL CONSIDERATIONS IN THE USE OF COMMON REFLECTION POINT TECHNIQUES†

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The effectiveness of the common-reflection-point horizontal stacking technique is dependent upon the accuracy with which the desired signals (primary reflections), recorded with different travel paths, can be aligned in-phase for summation.

Inaccuracies can result from the application of an incorrect moveout function, improper corrections for near-surface effects, and variation in the signal waveform on the channels to be summed. The last effect can occur because of differences in the transmission path and/or changes introduced in processing.

A typical case is described to illustrate the magnitude of errors observed in one survey and the adjustments which were required to establish time coincidence of the primary reflections.

Theoretical considerations defining the maximum permissible errors in phase alignment for various numbers of channels indicate that the allowable error should not exceed one half the reflection period regardless of the number of channels, and that the required precision increases rapidly as the number of channels is decreased. For example, a twelve-fold stack will permit nearly twice the allowable error as a three-fold stack for the same end result.

INTRODUCTION

More than five years of intensive production use of the Common-Reflection-Point Data-Stacking Technique has yielded ample proof of its overall effectiveness. The effectiveness of the CRP method is entirely dependent upon the accuracy with which the desired signals (reflections) can be made additive, and the degree to which the unwanted energy (noise) is attenuated by the summation process.

Seismic noise is generally conceded to fall into two broad categories; systematic, or coherent noise, and random noise. We prefer to define coherent noise as any unwanted phenomena which consistently exhibit characteristics we can recognize and define. On the other hand, random noise is something we don't want, but which is either unique to our position in space or time, or which we cannot identify.

The degree to which coherent noises such as ground roll, reverberations, and multiple reflections are attenuated can be increased by special techniques in addition to the statistical improvement provided by the stacking.

Stacking attenuates the random noise largely by its "brute force" effect, and exhibits greater attenuation power largely because the effective dimensions of the equivalent common reflection point array are increased by an order of magnitude over ordinary arrays. It is axiomatic that establishment of perfect reflected signal coincidence will inevitably improve the signal-to-noise ratio unless we are unfortunate enough to preserve noise coincidence comparable to the coincidence we effect in the stacked signals.

EFFECT OF LATERAL VELOCITY VARIATIONS

As an example of the problems which may be encountered in effecting the desired precision, even in highly explored areas, Figure 1 shows the shotpoint map of an actual project. Expanded spreads were shot at locations A and B in the manner described by Al Musgrave (1962). Only integrated traveltime values from a continuous velocity survey in the vicinity of A were available and no overall check shots were made. The expanded spreads disclosed the presence of significant multiple reflections, but the data adequately established a reasonable vertical velocity distribution which confirmed the velocity survey results. Analysis of the moveout on the regular production spreads in the region between A and B, and comparison with the expanded spread results indicated that the moveout on the regular spreads could be used with confidence if care was taken to ignore possible multiple reflection in-

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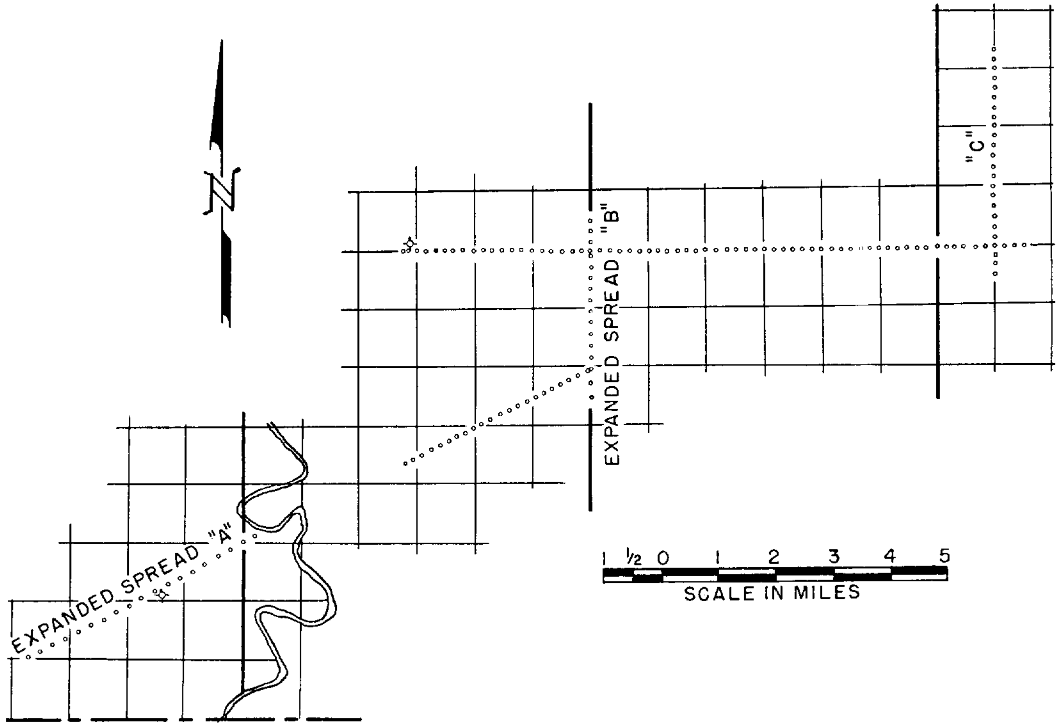

FIG. 1. Location map of typical area.

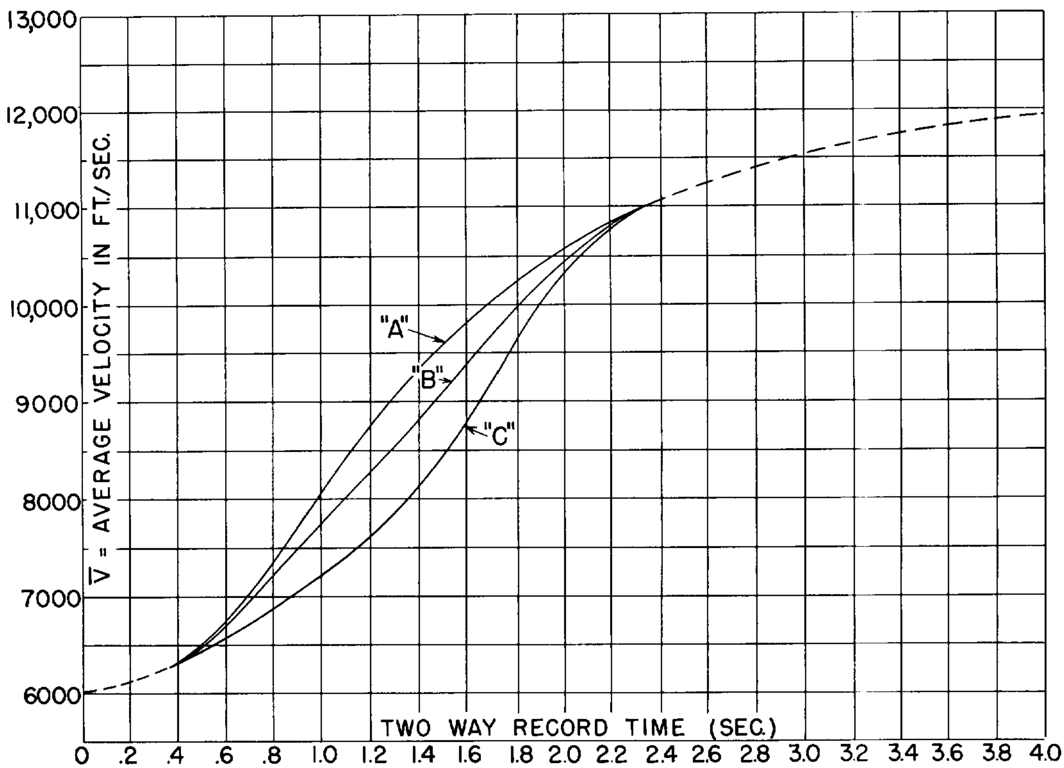

FIG. 2. Average velocity as a function of record time at indicated locations in the area shown in Figure 1. Based on expanded spread data and analysis of moveout on production spreads.

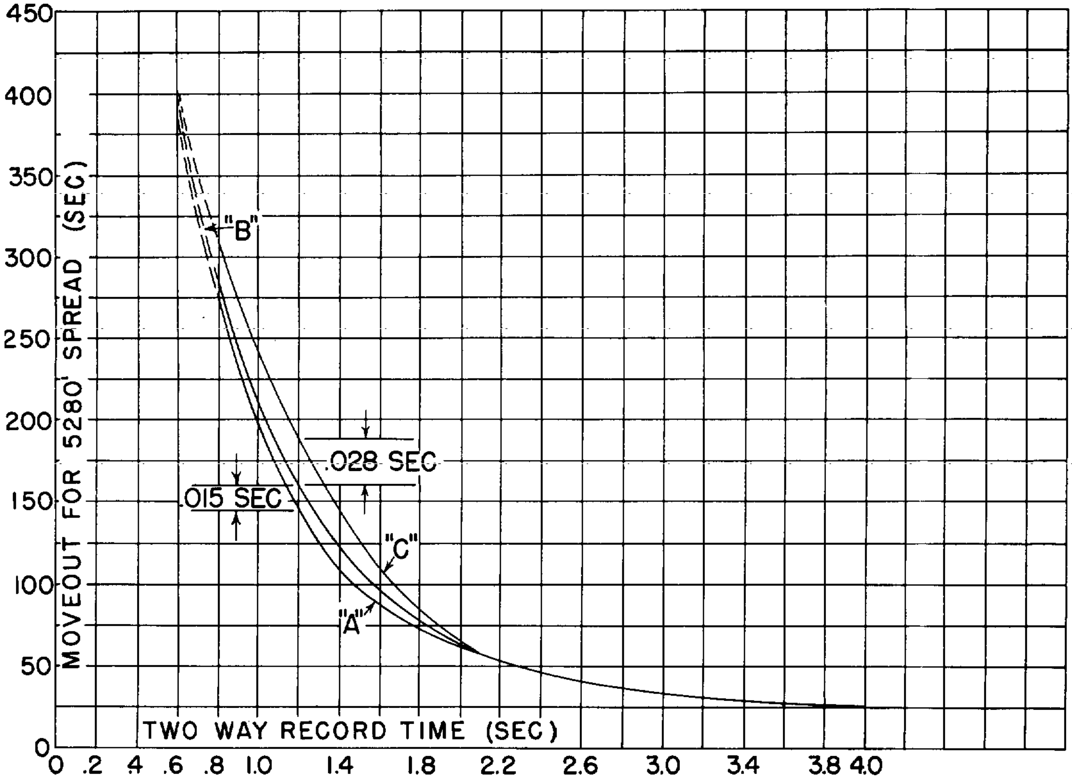

FIG. 3. Moveout corrections for 5280-ft spread as a function of record time. Based on the velocity information of Figure 2.

formation. The velocity distribution was thus extrapolated toward location *C*. Figure 2 illustrates the comparative average velocity values as a function of two-way time.

Figure 3 illustrates the corresponding moveout curves for a 5280 ft spread at each location. Since the period of the reflections recorded in this area varied from 25 to 40 ms it is easy to infer the adverse effects which will occur if the moveout associated with location *A* or *B* were applied to data at *C*. At 1.2 sec, for example, there is a difference of 43 ms in the moveout for one-mile spreads at locations *A* and *C*. Confidence in the reliability of this velocity gradient is established by the fact that data stacked using this gradation in the applied moveout function produced seismic well ties which could not previously be made.

In addition to potential errors resulting from such effects as these, we also have the uncertainties associated with the near-surface or datum corrections. Careful editing of trace-collections and/or corrected individual spreads was also used to determine supplementary static corrections which were applied prior to stacking. Magnitudes of 10 to 20 ms for these trimming corrections were quite commonly required to establish best overall reflection coincidence.

ACCURACY REQUIREMENTS

This raises a very basic question: How much error *can* be permitted before we not only lose the desired improvement, but even more tragically, end up worse off than we were initially?

Table 1 illustrates one set of criteria for the maximum deviations which can be permitted without actual degradation of the signal-to-noise ratio.

The first column gives the number of channels

Table 1. Maximum allowable alignment errors for reflections in terms of the number of stacked channels.

NO. OF CHANNELS K	t/T	MAX. ALLOW. TIME ERROR IN MS FOR T = 35 MS
2	.25	9
3	.382	13
4	.458	16
5	.524	18
6	.565	20
7	.597	21
8	.619	22
9	.646	23
10	.665	23
11	.684	24
12	.697	24

to be used in producing the summed output; the second the extreme variation in reflection phase, as a portion of the reflection period, which will result in the same signal-to-noise ratio in the summed output as existed in an individual channel; and the third column gives the maximum allowable time difference in milliseconds between the reflection extremes for a reflection period of 35 ms.

In deriving these values, the following assumptions were used:

1. The reflections in individual channels are sinusoidal, equal in amplitude and equally spaced in-phase over the indicated total interval.
2. The noise in each of the individual channels is random between channels and has the same amplitude with respect to the reflections in each.

Based on these assumptions, the noise amplitude in the resultant summation signal will be proportional to the square root of the number of individual channels. If the total phase shift between the reflections is predicated so that the amplitude of the vector sum of the reflections also has this value, the signal-to-noise ratio of the summed output will be the same as in the original individual channels.

Although this may appear to be the hard way to end up where we started, it does indicate the limits beyond which we *dare* not go, if actual deterioration is avoided.

Figure 4 graphically illustrates these maximum allowable relationships for reflections on 2, 4, 6, and 12 channel combinations.

Certainly we can *never deliberately* tolerate errors of these magnitudes, and best reflection coincidence must still be our goal. However, this line of reasoning does show that a total error spread of the order of one third of the reflection period will not be ruinous. For typical reflection periods, this indicates total time errors of no more than 8 to 12 ms for 4 to 6-fold multiplicities, and perhaps 12 to 18 ms for 12-fold multiplicity.

It is apparent that the higher multiplicities have a significant advantage insofar as the statistical margin of error is concerned.

GENERAL CONSIDERATIONS

The quality of the end result produced by any technique is still dependent upon the intrinsic quality of the raw material used. Neither the most sophisticated recording equipment, the most pedantically named processing procedures, nor such proven techniques as the Common Reflection Point method can compensate for basic inadequacies in the individual recordings made in the field. All of the traditional and proven standards of good field practice should be used to clarify the basic data and provide the best records obtainable. The CRP technique should never be used as a substitute for shotholes of proper depth, as a remedy for the wrong patterns of shotholes and detectors, or as a crutch to improve weak or noisy records.

It is particularly desirable to record the basic field data to be used in the CRP method with the widest permissible bandwidth; but noise that is obviously useless should *never* be allowed to occupy or exceed the dynamic range of the recording medium employed.

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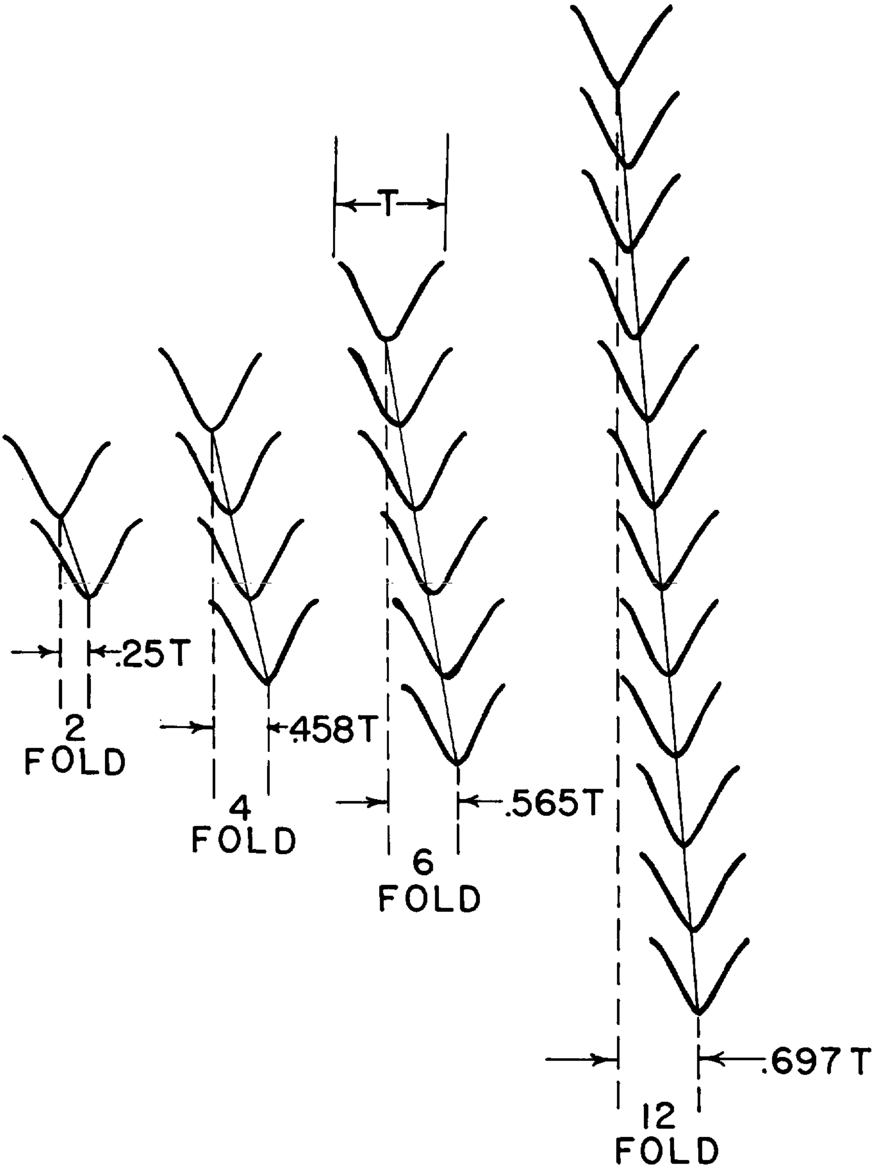

FIG. 4. Maximum difference in reflection phase which can be permitted when 2, 4, 6, and 12 channels are summed and the summed outputs have the same signal-to-noise ratio as existed in the original individual channels.

permission to prepare this paper is also appreciated.

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