INVERSION OF P CODA FOR ISOTROPIC SCATTERERS AT THE YUCCA FLAT TEST SITE

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ABSTRACT

Although many studies have addressed the statistical properties of P coda, there have been few attempts to analyze coda in a deterministic framework. In this analysis, 1050 teleseismic P-wave seismograms from 32 Yucca Flat explosions are inverted for the locations of any isotropic point scatterers in the source region that contribute coherent arrivals to the coda. A rectangular grid of potential scattering locations is constructed around the source array and the semblance (a measure of waveform ensemble coherence) for each point is computed by slant-stacking the full set of seismograms at various moveout velocities. The potential "resolution", or sensitivity, of the method for this data set is tested by constructing a corresponding suite of synthetic seismograms with direct arrivals plus arrivals from various point scatterers and calculating the semblance at each point on the grid. The particular source-station geometry produces better sensitivity near the array. Sensitivity is enhanced parallel to the trend of the elongated source array and diminished in the orthogonal direction. Stacking the data for a velocity of 2.5 km/sec yields relatively high semblance values in the central portion of the test site as well as about 10 km to the ENE, and moderately high semblance values about 10 km to the WNW. The latter two regions are associated with topographic highs. Simulations using synthetics with random arrivals in the coda indicate that incomplete suppression of random noise may explain the high semblance values in the central region, but probably not in the outlying regions. However, simulations of a circular distribution of random scatterers within 10 km of the test site produce high semblance about 10 km to the ENE, similar to that seen for the data, arising from variable sensitivity. Thus, two possible explanations for the high semblance values are scattering of higher mode surface waves to P waves off topographical irregularities, or random scattering due to heterogeneity in the immediate area of the test site.

INTRODUCTION

P coda, the complex waveform that follows the direct P arrival, has been studied from many different perspectives. Coda duration has been used for many years to determine the size of local earthquakes (Aki, 1969). P-coda amplitudes have also been used for teleseismic source size estimation, because it is generally believed that the coda consists of scattered waves, and therefore averages out the effects of lateral heterogeneity on wave amplitudes by sampling a large volume (Aki, 1982). The scattering models have led to widespread use of coda decay as a method for determining attenuation (Aki and Chouet, 1975). Several workers have applied random media theory (Chernov, 1960) to coda in order to define the strength and scale length of inhomogeneities under seismic arrays (Aki, 1973; Capon, 1974; Bertussen et al., 1975). Herraiz and Espinosa (1987) present a comprehensive review of coda research, and their terminology will be followed in this paper.

While there has been substantial success in explaining various properties of coda using statistically based methods, there have been only a few attempts to treat coda in a deterministic framework by identifying actual scattering structures. Key (1967)
was able to distinguish discrete arrivals in the $P$ coda recorded at the Eskdalemuir array and attributed them to scattering from specific topographic features near the array. Lay (1987) stacked $P$ coda from underground explosions at the Pahute Mesa test site in Nevada in an attempt to identify contributions from isotropic scatterers in the source region. However, most potential scattering locations that produced any waveform coherence also produced enhanced coherence in simulations using random noise, leading to some ambiguity in the final result. In this study, we apply the basic methodology introduced by Lay (1987) to explosions at the nearby Yucca Flat test site (Fig. 1), in an attempt to identify near-source isotropic scatterers.

There is some reason to anticipate that the Yucca Flat source array might be a more favorable site than the Pahute Mesa array for seeking scattering origins. The Yucca Flat source array is significantly denser, and there is less variation in explosion size. Also, a study by Lynnes and Lay (1988) demonstrated a strong correlation of coda excitation with position in the Yucca Flat source array, indicating significant near-source contributions to the $P$ coda.

**Methodology**

The methodology of the inversion for isotropic scatterers is summarized briefly below. A more complete development is given in Lay (1987). The technique essentially consists of: assuming an $x$-$y$ location where near-source waves traveling at horizontal phase velocity $v_s$ are scattered isotropically to teleseismic $P$ waves; computing the appropriate time lags for each source-station pair; stacking the seismograms using these time lags; and computing the semblance for a specified time gate. A high semblance value for a given $x$-$y$ location and assumed moveout velocity ($v_m$) indicates that a coherent arrival can be identified, suggesting the presence of a structure that can be approximated as an isotropic point scatterer. If forward or back scattering dominate rather than isotropic scattering, the coherence will diminish but should not be eliminated so long as many seismograms are used.
The scattered arrival time lags ($\tau_{ij}$), relative to the direct $P$ arrival, are given by

$$\tau_{ij} = [(x_s - x_i)^2 + (y_s - y_i)^2]^{\nu_s}[u_{s-1} - p_j \cos(\theta_i - \phi_j)],$$

where $x_i, y_i$ are the coordinates of the source, $x_s, y_s$ are the coordinates of the hypothetical scatterer, $p_j$ is the horizontal ray parameter for the secondary teleseismic $P$ waves traveling to the $j^{th}$ station, $\theta_i$ is the azimuth from the source to the hypothetical scatterer, and $\phi_j$ is the azimuth from the scatterer to the $j^{th}$ station (Fig. 2). The seismograms are then stacked after applying the appropriate time lags, and the semblance (Neidell and Taner, 1971) of the stack is computed in order to assess whether any waveform coherence can be associated with the given $x$-$y$ location and scattering velocity. The semblance for $N_s$ events and $N_r$ stations is

$$S(x_s, y_s, u_s) = \frac{\sum_{i=1}^{N_s} \sum_{j=1}^{N_r} \delta_{ij} s_{ij}(t + \tau_{ij}(x_s, y_s, u_s))}{M \left( \sum_{i=1}^{N_s} \sum_{j=1}^{N_r} \delta_{ij} s_{ij}^2(t) \right)},$$

where $T_s$ is the time gate over which the semblance is computed, $M$ is the total number of seismograms, $s_{ij}(t)$ is the seismogram from the $i^{th}$ source at the $j^{th}$ receiver, and $\delta_{ij}$ is 1 if there is an observation for the $i^{th}$ source at the $j^{th}$ receiver and 0 if there is not. The semblance can be viewed as the power of the stack normalized by the total power in the seismograms, and it varies between 0 and 1, unity being perfect waveform coherence. Semblance is also closely related to the energy-normalized cross-correlation (Neidell and Taner, 1971). The time gate ($T_s$) used in the semblance computations in this study is 2 sec, corresponding to the characteristic pulse duration in the short-period recordings. Tests on synthetic data using a longer time gate of 3 sec did not significantly change the semblances.

The $F$ test can be applied to a given semblance value to determine whether it is statistically significant. The $F$ value for a noncentral distribution ($F'$) is related to the semblance by the expression (Douze and Laster, 1979)

$$F'(N_1, N_2, k) = \frac{S(M - 1)}{(1 - S)}.$$
$N_1$ and $N_2$ are the degrees of freedom, and $k$ is the noncentrality parameter, defined (Blandford, 1974) as:

$$N_1 = 2BT_g$$
$$N_2 = N_1(M - 1)$$
$$k = N_1 \frac{P_S}{P_N}$$

where $B$ is the bandwidth of the signal, $P_S$ is the mean power of the signal and $P_N$ is the mean power of the noise in the frequency band under consideration. The $F$ statistic for a noncentral distribution ($F'$) can be approximated by the $F$ statistic for a central distribution (Zelen and Severo, 1964):

$$P(F' | N_1, N_2, k) \approx P(F | N_1^*, N_2)$$

$$F = \frac{F'}{1 + \frac{P_S}{P_N}}$$

$$N_1^* = \frac{(N_1 + k)^2}{(N_1 + 2k)} = N_1 \left[ 1 + \frac{(P_S/P_N)^2}{(1 + 2P_S/P_N)} \right].$$

The statistical significance can then be assessed from standard tables using the $F$ value with $N_1^*$ and $N_2$ degrees of freedom. The validity of the statistical measure requires assumptions about the noise properties, which are not generally satisfied by the raw data. However, weighting functions, such as those described in the data analysis section below, can be used to suppress correlated noise, allowing the use of the $F$ test.

**Data Analysis**

The $P$ waves that we analyze here were recorded on short-period instruments at 65 teleseismic ($25^\circ$ to $95^\circ$) WWSSN and Canadian Seismic Network (CSN) stations. Records from 32 underground explosions at the Yucca Flat test site were used, yielding a total of 1050 recordings. The first 25 sec of the $P$ wave train were digitized on all of the seismograms. In order to obtain a uniform database, the CSN records were multiplied in the frequency domain by the ratio of the standard WWSSN instrument response to the individual CSN instrument responses, thus equalizing the CSN seismograms to WWSSN-type recordings. A zero-phase three-pole Butterworth bandpass filter from 0.2 to 2.0 Hz was applied to minimize digitization, instrument, and earth noise. The seismograms were also normalized to the peak amplitude in order to suppress the amplitude effects of variable explosion yield, attenuation, and focusing/defocusing. In order to obtain more uniform azimuthal coverage, the seismograms within $7.5^\circ$ azimuth windows were averaged, reducing the number of independent observations from 1050 to 816.

The semblance procedure relies on correlating similar features occurring at different times in the full set of seismograms due to the directivity of the scatterer. Consequently, it is helpful to remove features that occur at the same time in a large
subset of seismograms. The most obvious such feature is the direct arrival itself, which normally has distinctive characteristics due to both source and receiver effects. Other coherent arrivals might be produced by slapdown or aftershocks, which would be common to all seismograms for a given source, and scattered arrivals from the vicinity of a given station, which would be similar for all seismograms at that receiver. In an attempt to minimize the effects of these features, time-dependent weighting filters were applied to the seismograms before stacking:

\[ s'_i(t) = s_i(t) [1 - w_e e_i(t)] [1 - w_r r_i(t)], \]

where \( w_e \) and \( w_r \) are constants between 0 and 1, \( e_i(t) \) is the normalized envelope of the stacked traces for the \( i^{th} \) event, and \( r_i(t) \) is the normalized envelope of the stacked traces for the \( j^{th} \) station. These filters downweight receiver effects and the direct arrival, which would otherwise dominate the semblance computations and result in high semblances centered on the source locations. A wide range of values and combinations of the weighting constants \( w_e \) and \( w_r \) was explored, with a value of 0.75 for both constants producing good results in simulations using synthetic data sets. This choice of \( w_e \) and \( w_r \) is kept fixed below.

**Tests Using Synthetic Data**

In order to assess the intrinsic ability of our particular source-station geometry to resolve the locations and scattering velocities of isotropic point scatterers, we conducted several synthetic experiments. Synthetic seismograms were computed comprising a direct arrival and a \( P \) wave scattered at a specified moveout velocity and location, with a prescribed amplitude relative to the direct arrival. The seismograms were formed using a modified Haskell source (Helmberger and Hadley, 1981), a short-period WWSSN instrument response, and a Futterman Q operator with \( t^* \) of 0.4 sec. A seismogram was constructed for each source-station pair contributing to the actual data set. The semblance was then calculated at each point on a square 19 by 19 grid centered on the Yucca Flat test site, with a grid spacing of 2 km. The \( x \) coordinate increases to the east, and the \( y \) coordinate increases to the north. The results of a simulation for a point scatterer with a horizontal phase velocity (\( v_h \)) of 2.5 km/sec are shown in Figure 3. The figure on the left (Fig. 3a) shows the grid points at which semblances were computed, with the closed circle indicating the position of the scatterer producing the “coda” arrival in the synthetic seismograms. A perspective plot of the semblance at each grid point computed for this seismogram suite, assuming a scattering velocity of 2.5 km/sec, is shown in Figure 3b. The highest semblance (1.0) is found at the correct location for the scatterer, although several neighboring locations also produce high semblance values due to spurious coherence, resulting in limited spatial sensitivity, or “resolution”. (Note that this is not a standard mathematical inversion in that the semblance at a given point is independent of the semblance at other points, and model parameters are not obtained directly. Hence, the resolution is not strictly defined, and behaves differently than for a linear inversion).

We also attempted to assess the effect of noise on the semblance calculations by adding arrivals with random delay times and amplitudes to the synthetic seismograms for a single point scatterer. The effect of adding 50 random arrivals to each waveform in the previous synthetic seismogram set is shown in Figure 3c. The random arrivals have uniform distributions of amplitude relative to the direct
arrival (with ratios between −0.5 and 0.5), and of arrival times within the window of the seismogram. The peak semblance is significantly reduced, as might be expected due to the addition of noise. However, the noise reduces the semblance values of the surrounding grid points even more, resulting in increased spatial sensitivity for the synthetic data set.

At first sight, the apparent enhancement of “resolution” with the addition of noise is somewhat paradoxical. The explanation lies in the nature of the semblance statistic. Since semblance is formed by summing lagged traces rather than multiplying them, small misalignments can still produce high semblance values if the waveforms are sufficiently similar. When random arrivals are added to the waveforms, they degrade the semblance at all of the locations. However, the large number of waveforms still produces a significant semblance at the precise location for which the waveforms are correctly aligned.

Another apparent paradox in the high resolution is that the time differences associated with nearby grid points are quite small, about 0.1-0.2 sec. Thus the resolution is better than might be expected from the high-frequency corner of the filter (2 Hz). This is due to the influence of phase information in the semblance technique, which can be recovered even from the lower frequencies.

The ability of the technique to resolve the horizontal phase velocity of the waves scattered by a point scatterer was tested by computing the semblances for several different assumed moveout velocities, using the same suite of synthetics as the above simulation of a point scatterer plus random noise (Fig. 4). The highest peak semblance value occurs for the semblances calculated for a velocity of 2.5 km/sec, the correct velocity (Fig. 4b). The low semblances for the other scattering velocities (Fig. 4a, c) indicate that the velocity can be resolved well for a single point scatterer in this source-station geometry. This is important for identifying what type of scattering is occurring.

Since the variation of delay times of scattered arrivals depends strongly on the source-station geometry, the peak semblance and spatial resolution may vary in different parts of the source region. To characterize these variations, we computed 81 suites of synthetic seismograms, assuming single point scatterers at x, y (E, N)
The peak semblances for all 81 simulations are shown in Figure 7. As mentioned above, point scatterers near the middle of the source array actually produce relatively...
Figure 5. Locations of the point scatterers used in 81 single point scatterer simulations, together with the grid of locations used in the semblance analysis of the synthetic data sets.

Figure 6. Semblances computed for point scatterers at four of the locations in Figure 5. The numbers in the upper left are the peak semblances for each simulation, and the numbers in the upper right are the x-y coordinates of the point scatterer (located at the closed circle).

low semblance values. Excluding these locations, the peak semblances are roughly equal for different positions in the source region.

We chose to characterize the variable spatial resolution by a two-dimensional "spread function." The spread function was computed by comparing the semblance at an actual scatterer location (S_{max}) with the semblances calculated at each of the
eight adjacent points. For each azimuth ($\phi$) from the actual location to the adjacent point, the spread ($\sigma(\phi)$) is defined in terms of $S_{\text{max}}$ and the semblance at the adjacent point in that direction, $S$, as:

$$\sigma(\phi) = 1 - \frac{\Delta S}{S_{\text{max}}},$$

$$\Delta S = S_{\text{max}} - S \quad \text{for} \quad \phi = 0^\circ, 90^\circ, 180^\circ, \text{and} \ 270^\circ,$$

$$\Delta S = \frac{(S_{\text{max}} - S)}{\sqrt{2}} \quad \text{for} \quad \phi = 45^\circ, 135^\circ, 225^\circ, \text{and} \ 315^\circ. \quad (7)$$

The spread in a given direction is equal to 1 for negligible spatial resolution over the given grid spacing ($S_{\text{max}} = S$) and is equal to zero for perfect resolution, ($S = 0$). Thus, the spread function is essentially reciprocal to the resolution. The results are presented as octagons, with the distance from the center to each vertex proportional to the spread function in that direction. A large octagon represents a large spread function in all directions, implying poor spatial resolution of a scatterer at that point, while a small octagon indicates a small spread function and good resolution. An equidimensional octagon would indicate equal resolution in each direction. However, most of the spread functions show a pronounced elongation in the NE-SW direction, indicating poorer resolution in this direction than in other directions. This is probably due to the roughly linear NW-SE trend of the source array. The best resolution (smallest spread function) appears to be immediately to the ENE and WSW of the array. These characteristics can be compared with the
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analogous variations for the Pahute Mesa array geometry examined by Lay (1987) to gain an appreciation for the effects of source distribution.

INVERSION OF REAL DATA

The actual data set was inverted for isotropic point scatterers using the same grid as in the synthetic cases (Figs. 4 to 7), for moveout velocities of 1.5 km/sec, 2.5 km/sec, and 3.5 km/sec (Fig. 8). All of the semblance surfaces have relatively high values in the center. The two higher moveout velocities also appear to have a high semblance area about 10 km to the ENE of the Yucca Flat source array, and a ridge of moderate values 10 km WNW of the array. Both of these areas are regions of fairly good resolution, according to the simulations (Fig. 7). However, the high semblance area in the data does seem to be somewhat elongated in the direction orthogonal to the trend of the source array (i.e., NE-SW), as predicted by the resolution experiment (Fig. 7). Semblances were also computed for moveout velocities of 1.0 km/sec, 2.0 km/sec, 3.0 km/sec, and 4.0 km/sec. The high semblance feature to the ENE appears for all velocities higher than 2.0 km/sec. All stacking velocities produce high semblances in the central region.

In order to test the stability of the results, the semblance was computed for three subsets of the data: the 16 most northerly events, the 16 most southerly events, and

![Fig. 8. Semblances calculated for the Yucca Flat data set, assuming three different scattering velocities. The peak semblance for each surface is shown in the upper left.](image-url)
the 16 largest events. In each case, the overall semblance values for all of the moveout velocities were higher by a factor of 2 to 3 for the subsets than for the full set of data. Qualitatively, the semblance surfaces for the subsets were quite similar to those for the full set, except that the semblances for the subsets were disproportionately high in the center of the region. This is probably due to spurious waveform coherences associated with the direct arrivals.

Unlike the simulations, the peak semblances for the full set of real data are extremely low, on the order of 0.02 to 0.03 (Fig. 8). However, these values are actually somewhat higher than those obtained for Pahute Mesa by Lay (1987) when station and event weighting were applied. In fact, a semblance of 0.02 yields an $F'$ value of 16.6, with degrees of freedom $N_1 = 7.2$ and $N_2 = 5868$. Of course, the statistical significance depends on the signal-to-noise ratio, which is unknown. If we assume a signal-to-noise ratio of 0, then $F = F'$, and a semblance of 0.02 is significant at the 99 per cent level. On the other hand, if we assume that the signal-to-noise power ratio is equal to 2, $F = F'/3 = 5.5$, and $N_1^* = 1.8N_1 = 13.0$, which is still significant at the 99 per cent level.

In any case, even the highest semblances in the real data are low enough to cause concern that they might be due simply to incomplete suppression of noise caused by the source-station geometry. To test this possibility, semblances were computed for a suite of synthetic seismograms comprising the direct arrival and 50 random arrivals at each station, varying in amplitude between -0.5 and 0.5 relative to the direct arrival. The synthetic seismograms were computed for the same source-station pairs as the data. The semblances were computed assuming a stacking velocity of 2.5 km/sec (Fig. 9a). The moveout velocity of 2.5 km/sec was chosen because it appears to produce more stable semblance surfaces for the data than the higher moveout velocities. A velocity of 2.5 km/sec is probably too fast for short-period fundamental mode Rayleigh waves, since the S-wave velocities of the basin sediments are about 1 km/sec and the Paleozoic basement is about 2.6 km/sec (Ferguson, 1982). However, this is a reasonable velocity for higher mode surface waves.

The peak semblance in the random noise simulation is surprisingly high (0.11), suggesting that many of the higher semblances in the data stacks may be artifacts. However, the high semblances are mostly confined to the center of the grid, in proximity to the source array. This is likely due to the residual coherence of the direct arrivals, which is not completely removed by the station and event weighting filters. The lack of appreciable semblance in the random simulations at outlaying locations suggests that random noise can not explain high semblance in the data (Fig. 9b) away from the central region of the source array. The random noise simulations produce simpler semblance surfaces than do similar simulations for Pahute Mesa (Lay, 1987), probably due to the closer spacing of the Yucca Flat events.

Since the highest semblance values occur in a region where the spatial resolution is greatest, it is also possible that the distribution of scatterers is random, but high semblances are found only for points where the spatial resolution is favorable. In order to test this hypothesis, we computed synthetic seismograms for a set of 70 scatterers with random amplitudes up to 0.2 the amplitude of the direct arrival, stacking velocity of 2.5 km/sec, and positions within 10 km of the center of the grid. No random noise arrivals were added to the seismograms. The locations and amplitudes of these scatterers are shown in Figure 9c. The semblance was then computed for each grid point assuming a scattering velocity of 2.5 km/sec (Fig. 9d). The semblances are again quite high (up to 0.24). In contrast to the random noise
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Fig. 9. (a) Map view of semblances calculated for a random simulation. (b) Map view of semblances from data. (c) Map view of randomly distributed scatterers used in random scatterer simulation. The size of the symbol indicates the amplitude of the scattered arrivals (relative to the direct arrival. (d) Map view of random scatterer simulation. Note the similarity to the map view of the data semblances. The peak value for each surface is shown below each graph, and a stacking velocity of 2.5 km/sec was used for all.

Case, however, the random scatterer simulation produces relatively low semblance values in the central region, but higher semblances in the area to the NE, where the high semblances were located in the data inversions. Thus, while the technique finds high semblance in some areas where scatterers are located, it fails in this case to locate other scatterers, apparently due to the sensitivity characteristics imposed by the array geometry.

Discussion

Several studies have indicated that topography is a major contributor to P-wave coda. Using a statistical approach, Greenfield (1971) was able to model the energy flux of coda from Novaya Zemlya explosions by hypothesizing Rayleigh → P scattering by the island coastline, river valleys, and other topography. Key (1967) used standard array analysis to determine the location and phase velocity of coherent arrivals in the P coda at the Eskdalemuir array. The locations were generally associated with topographic highs. Key (1967) found one particularly strong arrival to be associated with a river valley, with a phase velocity of 2.5 km/sec, suggesting P → Rayleigh scattering near the receiver. Synthetic calculations also indicate a scattering role for topographical highs. McLaughlin and Jih (1988)
computed 2-D finite difference synthetics for Rayleigh waves incident on a mesa. The resulting wavefield includes both forward and back scattered $P$ waves. In order to see if topography can explain the high semblance regions located in this study, the semblances computed from the data with a stacking velocity of 2.5 km/sec are superimposed on a topographic map of the region in Figure 10. Indeed, the isolated high-semblance area to the E is associated with a similarly isolated topographic high in the Halfpint Range. The ridge to the W also correlates with moderately high semblance values. Thus, waves scattered from topographical irregularities seem to be a plausible explanation for some of the early $P$ coda for Yucca Flat explosions. However, the semblances in the NW area of the grid, where the topography is the highest, are rather low. If the topography does produce the majority of the coda, the low semblances might be due to the shape of the topographic high. On the other hand, the random scatterer simulation indicates that an equally valid explanation of the semblances derived from the data would be random distribution of scatterers in the central region of the test site, which is quite flat.

In summary, the semblance technique has yielded somewhat ambiguous results in terms of identifying deterministic scatterers. Indeed, the simulations seem to indicate that random scatterers explain the data equally well. The main problem seems to be that the source array geometry exercises strong control on the sensitivity of the technique. This has been the case for the two-dimensional Pahute Mesa source array (Lay, 1987) as well as the linear Yucca Flat array.

However, an additional factor may be the limitations of the data set, which may obscure more significant features that would yield high semblance in areas of the

**Fig. 10.** Semblances from Figure 9b, superimposed on a topographic map of the region. The contours are in 1000' intervals.
test site that are not favored by the array geometry. For instance, the use of analog, rather than digital, data places a severe constraint on the frequency range that can be reliably used. Digital databases of substantial size are now accumulating for more recent events. Another factor that probably decreases the semblance of the waveforms is the influence of lateral heterogeneity on the travel time from the source to the scatterer. Accounting for this effect could result in improved alignment of the waveforms. Also, isotropic scattering was assumed, a condition that could be relaxed to allow for radiation patterns. For NTS, this assumption is not particularly unrealistic: due to the low velocities near the surface, the teleseismic $P$ waves leave the source area in a very narrow cone of rays. Furthermore, the synthetic results of McLaughlin and Jih (1988) indicate that Rayleigh $\rightarrow P$ scattering from topography is roughly isotropic for wavelengths that are significantly greater than the height of the irregularity. One modification of the technique that might produce some improvement in the results would be an inversion of the coda envelopes, rather than the seismograms themselves. This would mitigate the effects of phase incoherence and receiver and source characteristics that influence the dominant frequencies in the seismograms. However, the use of envelopes would dramatically decrease the bandwidth; also, the statistics of cross-correlation of such one-sided functions are not so well developed as for oscillatory waveforms.

**CONCLUSIONS**

$P$-wave seismograms from 32 Yucca Flat explosions were inverted for isotropic point scatterers in the source region by computing the semblance for hypothetical scatterers at a series of locations. Synthetic experiments show the ability of the semblance analysis to identify strong point scatterers, with the attainable resolution varying with position and direction in the source region. The resolution is generally best within a few km of the source array, and is better in the NW-SE direction than in the NE-SW direction due to the trend of the source array.

The semblances of the real data, while indicating much lower waveform coherence than for the simulations, are relatively high about 10-km ENE of the source array, and moderately high about 10 km WNW of the array, as well as in the immediate vicinity of the array, for a moveout velocity of 2.5 km/sec. Analysis of signals with random noise yields high semblances in the center as well, suggesting that semblances in this area may be artifacts of the source-station geometry and contamination by the direct arrivals. However, random noise does not appear to explain the high semblance values to the ENE and WNW. The high semblance area to the ENE is associated with an isolated topographic high, suggesting that topographic irregularities may play an important role in coda generation. However, a simulation of random scatterers produced high semblances in the same area ENE of the array as the data, indicating that a random distribution of scatterers in the vicinity of the test site might also explain the results.

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